



Research Paper

Assessing Key Performance Indicators in Blockchain-Based Supply Chain Financing: Case Study of Chain Stores

hamed Nozari^a, Javid Ghahremani-Nahr^{b1}

^a Faculty of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran

^b Faculty Member of Academic Center for Education, Culture and Research (ACECR), Tabriz, Iran

ARTICLE INFO

Received: 03 May 2022

Reviewed: 20 May 2022

Revised: 28 May 2022

Accepted: 12 June 2022

Keywords:

Supply Chain Financing (SCF), Supply Chain, Financing, Chain Stores, Blockchain Technology.

ABSTRACT

In recent years, due to the growth and development of financing tools and methods, financial institutions are always looking for new, efficient, and low-cost methods. In carrying out their daily production operations, companies are faced with different and diverse financial input and output flows from purchasing orders and inventory to receiving the price of sold goods, which are not the same in terms of time. Therefore, they will inevitably look for the financing of these processes, which is referred to as working capital financing. However, in the conditions of recession and lack of bank loans and considering the problems caused by the unilateral management of this issue, there is a need for innovative financial tools such as supply chain financing (SCF). In recent years, with the introduction and evolution of blockchain technology, this opportunity has also arisen in financial fields to make the most of this new technology. Considering the growth of this technology and the importance of supply chain financing, in this research, it was first tried to fully investigate the dimensions and key components of blockchain-based supply chain financing. chain stores were considered as a case study and the importance of supply chain financing was analyzed in them and the SCF framework was presented in these applied enterprises. In addition, the most important key performance indicators in a blockchain-based supply chain financing system are identified and evaluated with an emphasis on chain store processes. To evaluate the data, a non-linear hierarchical analysis method was used. The results show that transferring and reducing risks in different types is one of the most important performance indicators of the blockchain-based supply chain financing system.

¹ Corresponding Author
Javid.ghahremani@yahoo.com

1. Introduction

Today, the role of financial management in the success of companies and supply chains is discussed not only in developing countries but also in developed countries, and the ability of these companies depends on the potential of investing in innovation and quality. All these things require capital and as a result financing. Due to the role of financial management in the movement process of the company and due to the high financial risk, they face many problems in financing. While the problems experienced by the supply chain in relation to providing the required capital can come from several sources, the domestic financial market may not provide enough financial products and services, or due to the lack of appropriate supply mechanisms. financial and legal inflexibility or gaps in legal frameworks.

Companies are trying to address one of the new methods of financing these enterprises, i.e. supply chain financing (SCF). SCF, as one of the new financial innovations, is a service that only professional financial institutions can provide, and no legal institutions that are considered as institutions with strong financial resources can provide these services. Therefore, companies mainly examine and explain the importance of SCF and SME and how to solve the problem of financing by SCF as a new method of financing through debt. The financial performance of supply is one of the most important indicators to evaluate its performance and the degree of reaching predetermined goals. Financial ratios are used to evaluate financial performance. Ratios are methods that allow companies and their shareholders to evaluate themselves against others. Ratios are a means through which the shareholder can get all the results from the company's financial statements. In short, to ensure the financial health of the company, the financial statements of that company must be analyzed and here significant results can be obtained from the financial statements of that company with financial ratios (Chen et al., 2019).

Today, the competition in the retail industry has caused the increasing growth of chain stores. But on the other hand, how finance and create liquidity to supply chain stores and hypermarkets has always been a challenge for the managers of these businesses. The liquidity of any store is not enough to cover the necessary materials and the issues and concerns it has in the field of production with 100% of its resources during the period of buying, producing, and selling, or to solve its problems through personal capital. In fact, in this distance, the company definitely needs working capital and financial resources (Fallah et al., 2021).

Obviously, in a value chain that ends with a single finished product, the value of the product offered to the market is the same as the added value created in the supply chain of this product. In a precise and scientific definition based on economic literature, the new model of production chain financing has a specific definition. If we consider the production process from the beginning to the end, instead of portfolio management, risk management, and circulating capital management for only one company, the policymaker simultaneously performs all three tasks for all companies operating in a complete chain of a product. Analysis of financial ratios is one of the tools used to determine the financial position of companies. In fact, financial ratios reveal important facts about a company's operations and financial condition (de Morais et al., 2022). The benefit of calculating ratios is that the relationship between the major items of financial statements becomes accurate. Also, by using it, the problems, weaknesses and financial strengths of companies are determined. Of course, the ratios become more meaningful when they are compared with other ratios in the past of the same company or with similar institutions or with the desired standards of the related industry. Therefore, supply chain financing should be taken seriously (Omran et al, 2017).

In this research, due to the access of the authors to experts active in the field of supply chain financing in the chain store industry, this industry has been considered as a case study. This industry has one of the largest supply chains. So, it was tried to present the most important dimensions and components of supply chain financing in chain stores and the role of transformative technologies such as blockchain in this. The supply chain financing development model was also presented and the key performance indicators of a blockchain-

based supply chain financing system were evaluated. In order to analyze the data, a fuzzy nonlinear hierarchical analysis method was used and the results were evaluated using the opinions of experts active in supply chain financing in chain stores. Therefore, reading this paper can be an effective guide for implementing a smart financing platform in chain stores and avoiding the challenges facing it.

The structure of this paper is as follows. In the second part, the literature review is done. In the third part, a framework for the development of blockchain-based supply chain financing platforms is presented and the key performance indicators of the blockchain-based supply chain financing system are identified. In the fourth part, the research method is presented. In the fifth section, the results of the analyzes are presented, and finally, in the sixth section, the discussion and conclusions are presented.

2. Literature Review

Supply Chain Finance is a new approach to financing the working capital of economic enterprises, which can ultimately lead to economic growth and financial stability through the efficient and smooth allocation of financial resources, improving financial risk management, and increasing financial inclusion. The main difference between supply chain financing methods and traditional methods is that in chain methods, the entire supply chain is continuously covered by financing and risk management tools. In this new ecosystem, the design of financing and risk management models is implemented continuously for different links of supply chains (Tsai et al., 2017).

The development of supply chain financing methods, in addition to helping production, is also important from the perspective of reforming the banking system. The development of the aforementioned methods, by reducing non-current claims, improving banks' cash flow, managing the underline items of banks' balance sheets, and using accrual methods in production financing, can help improve banking health indicators and stabilize banks' balance sheets (Yang et al., 2022). According to the definition, supply chain financing is the use of financing methods and operations and risk reduction to improve working capital management and supply chain processes. Supply chain financing is a method of financing in which the new method of "financing based on the actual flow of goods and services and providing credit along the chain" replaces the traditional method of "face-to-face and asset-backed facility payments"(Xia et al., 2022).

Correct manipulation of key variables of the fund's conversion cycle, such as inventory, receivables, and payables to reduce inventory carrying and capital costs, and reduces the overall cost of the supply chain. The result is greater customer value and increased competitive advantage for the collaboration network. Studies show that trade credit shortfalls also have a downstream spillover effect: liquidity shocks are likely to reduce trade credit offered to other customers, increasing default risk and payment delays. Reducing the stock of goods can also reduce the level of service and thus affect customer satisfaction (Xu et al., 2021).

These traditional solutions tend to consider increasing working capital from an individual perspective, either a buyer's attempt to delay payment/reduce payment volume or a seller's attempt to accelerate cash receipts, often pitting one party to a buy/sell transaction against the other. Gives. Therefore, most companies only focus on their supply chain issues and consider their own best interests instead of understanding the bigger picture and coordinating with supply chain partners (Xu et al., 2018). As a result, they fall into the classic dilemma of trapped capital. One of the most innovative solutions for this type of financing is the financing solutions based on the supply chain. These solutions will have countless benefits for companies and financial institutions by optimizing the required working capital as well as improving cooperation throughout the supply chain (Hamledari et al., 2021).

Supply chain financing is a general term for a diverse range of financing tools that are used to finance various companies in the supply chain. The four layers of the financing chain between the buyer and the supplier are shown in Figure (1).

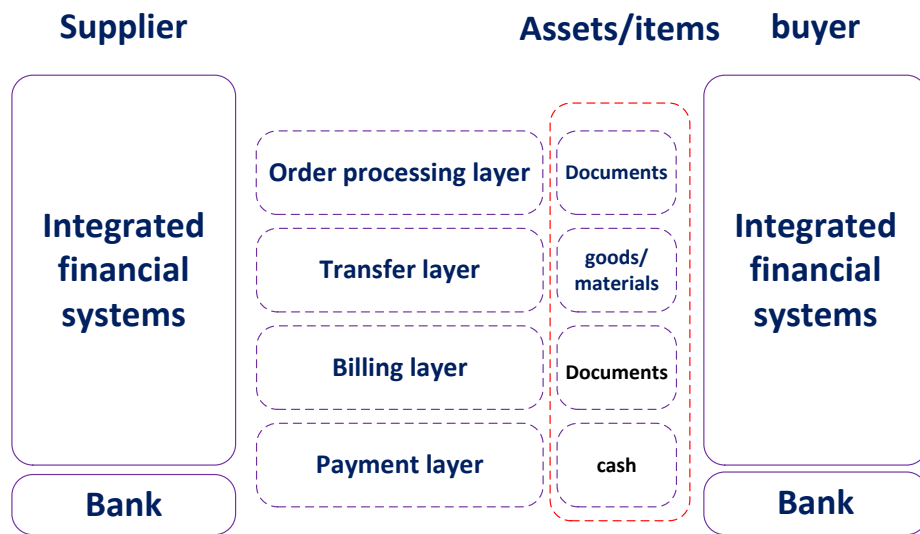


Fig. 1. Four layers of supply chain financing

Given that supply chain financing management usually includes the main supply chain companies, logistics and logistics companies, small and medium-sized companies supporting banks and other financial institutions, the challenges related to the flow of data related to materials, financial transactions and other relevant and desirable information of the parties are one of the main challenges in the efficiency of supply chain financing models. Many factors play a role in the success of a supply chain financing business plan, the absence of which can increase the challenges faced by organizations (Ghahremani-Nahr et al., 2022).

Blockchain technology is one of the innovative and technology-based measures that can help in reducing or eliminating the problems and obstacles of the financial chain financing solutions. Blockchain has great potential in improving supply chain collaborations, to accelerate change in the use of SCF tools, which can be seen in different types of participants in supply chains such as chain stores. In fact, blockchain is a digital technology based on computer programming that records and maintains data for security based on cryptographic algorithms in a block structure connected to each other in chronological order (Obaid et al., 2022).

In recent years, much research have been conducted in the field of supply chain financing and blockchain-based systems. Marchi et al., (2022) examined supply chain financing for improving and deteriorating products. Zhang et al., (2022) in the research predicted the credit risk of SMEs in supply chain financing by integrating demographic and behavioral data. They used a multimodal learning strategy to combine two different data sources. Dong et al., (2022) presented a model for deep-layer supply chain financing in the blockchain platform. Their main goal was to clarify how blockchain adoption affects agents' operational and financial decisions as well as profit levels in a multi-layer supply chain. Jiang et al., (2022) also presented a trust transition model of small and medium-sized manufacturing companies under blockchain-based supply chain financing. Their goal was to provide a new idea to evaluate the trust of small and medium-sized enterprises by creating a trust transition model. is, so as to address the role of added value and the transfer effect of the production industry chain and reduce financing problems for small and medium-sized companies. Chen et al., (2022) investigated the impact of supply chain financing on corporate social responsibility and shared value creation. The findings of this paper show that SCF can have a great impact

on supply chain management through functional and structural innovations throughout the supply chain and solve the problems of capital constraints in the process of agricultural development and the implementation of integration strategy as well as innovation in upgrade it. Natanelov et al., (2022) examined blockchain smart contracts for supply chain financing in the Australian meat supply chain. This study identified examples of how financial risks could be mitigated or mitigated with blockchain and smart contracts. Li et al., (2022) presented a blockchain-based secure storage and access control scheme for supply chain financing. To verify the performance of SCF, two sets of simulation experiments have been designed to simulate its effectiveness. Experimental results show that SCF achieves dynamic and fine-grained access control while maintaining high throughput in a simulated real-world operational scenario.

3. Blockchain-Based Supply Chain Financing

Considering the high cost of financing in the traditional way and its leverage effect, as well as the weak support of companies, most companies seek to expand commercial credit and postpone payments and expedite their receipts. This can be called individual liquidity risk management. The adoption and implementation of individual liquidity risk management may be beneficial to the company at first glance, but with a closer look, this causes the risk to be transferred to the entire supply chain and causes defects in the performance of the entire supply chain, both in the physical and financial dimensions (Hofmann et al., 2017). This process has been facing changes in recent years and many companies are looking for innovative and less expensive ways to finance their production activities, which mainly emphasizes the optimization of liquidity through expanding the cooperation of supply chain members. Optimizing cash flow in operational processes of supply chains not only brings the satisfaction of stakeholders, but also increases the efficiency of the supply chain and leads to a win-win approach for both financial institutions and supply chain member companies. One of the most innovative solutions for this type of financing is the financing solutions based on the supply chain. These solutions will have countless benefits for companies and financial institutions by optimizing the required working capital as well as improving cooperation throughout the supply chain (Dong et al., 2021).

Supply chain financing is a general term for a diverse range of financing tools that are used to finance the various companies in the supply chain. SCF refers to the use of short-term credits to balance the working capital between the buyer and the seller and minimize the cost of the entire supply chain. Blockchain has great potential to improve supply chain collaboration, to accelerate change in the use of SCF tools. While applications of blockchain technology to improve supply chain operations are currently being explored, one of the less studied applications of blockchain is its ability to facilitate supply chain financing. The open and distributed nature of blockchain is well suited to enable a new level of collaboration among supply chain actors and increase the integration of the flow of goods and money (Huertas et al., 2018).

Blockchain is able to digitize SCF-related documents on a shared ledger that is accessible or visible to all parties involved in the supply chain. A supplier and buyer together with all participants can update information and each transaction alone, which leads to increased efficiency and higher confidence. Also, it cannot be distorted or changed, thus reducing the possibility of corruption or fraud (Bal and Pawlicka, 2021).

3.1. Blockchain-based supply chain financing platform in chain stores

A chain store consists of several retail stores under common and centralized ownership. Major duties and functions of a chain store (business, advertising, rental, etc.) are controlled by a central command unit or a central management. Suppliers are considered as one of the important pillars of the large and chain store organization and in the position of its most important business partner. A retail organization has two main processes, the process of supplying and buying goods in bulk from suppliers and the process of selling goods in retail to customers (Zhang et al., 2019). In the process of supply of goods, one of the most important parts and in fact the topic of supply chain management can be considered the contracts of supply of goods. In fact, chain stores have the longest chain length in their supply processes due to the variety of products they provide to the audience. The type of supply can be definite, trust or commission. The settlement period, purchase and sale prices, supplier discounts and all other agreements can be recorded in the supplier contract and be the basis of the commercial and financial transactions of the parties (Obaid et al., 2022).

According to the structure of chain stores and the way they contract with suppliers, being in the financing chain can have an increasing value for the suppliers of these companies, which have a large volume of products and a very large number of suppliers, and are always concerned about the cash flow of claims. be in their times. Also, buyers can use financial rebates and increase their profits. For this reason, it seems that this chain is of high importance and brings maximum benefits to all players in the FMCG sector. The framework of supply chain financing systems in chain store companies is shown in Figure (2).

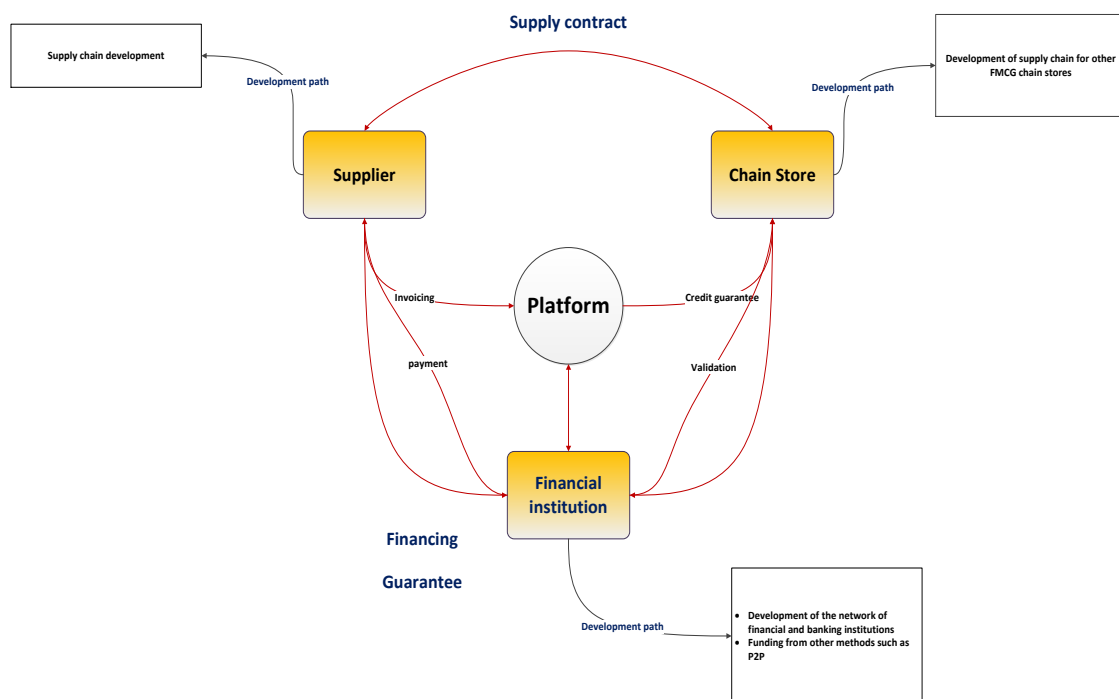


Fig. 2. Supply chain financing framework in chain stores

In the financing network of the supply chain, according to the type of contract of chain stores with their suppliers, financial institutions can facilitate both cash payments and periodic payment guarantees, and according to this facilitation When they receive a favorable cash discount from the supplier (Obaid et al., 2022). The platform will also charge a fee for each transaction created in the network. This chain facilitates the supply process and maximizes financial transparency throughout the supply chain with the help of technologies such as blockchain.

3.2. Key performance indicators of blockchain based supply chain financing

The existence of a blockchain-based solution, interoperability, availability and reliability of information allows the independence of peer-to-peer information systems. Blockchain technology is a promising technology platform to create transparency, automation and trust for supply chain financing tools. With blockchain technology, financial flows are increasingly simplified, where all involved partners are able to share and monitor financing-related information such as the latest invoice status, credit limit checks, and payments in a transparent manner. The new digital infrastructure environment allows all participants to easily access SCF information in real time (Obaid et al., 2022).

Participants can continuously control the details of goods and transactions digitally. Such a comprehensive infrastructure relies on a common office that provides any information related to the supply chain and simultaneously ensures the integrity and security of data and information. This will significantly reduce the costs and complexity of today's systems (Seifert and Seifert, 2011). In general, it can be said that the increased transparency, trust, safety and decentralization caused by blockchain can have clearer effects on the supply chain in the areas of sharing, security, transparency and automation of supply chain financing processes. Considering the importance of using these transformative technologies in supply chain financing, it can be seen that understanding the key performance indicators can have a tremendous impact on the effective implementation of these platforms. In Table 1, these key performance indicators are shown in three main sections. In the following, these indicators will be explained.

Table 1. Key performance indicators of blockchain-based supply chain financing systems

Dimension	Key performance indicator	code	References
Process W ₁	Real time operation	W ₁₁	(Li et al., 2020) (Chen et al., 2020)
	Easy & fast supplier onboarding	W ₁₂	(Omran et al, 2017)
	Risk transfer	W ₁₃	(Yu et al., 2021) (Huang et al., 2021)
	Transparency	W ₁₄	(Rijanto, 2021)
Collaborative network W ₂	Increase efficiency	W ₂₁	(Yu et al., 2021) (Kucukaltan and colleagues, 2022)
	Traceability	W ₂₂	(Liu et al., 2022)
	Creating knowledge	W ₂₃	(Kaur et al., 2022) (Xiao et al., 2022)
Platform W ₃	Fast response	W ₃₁	(Ioannou et al., 2022)
	Interoperability	W ₃₂	(Nelaturu et al., 2022) (Patel et al., 2022)
	Information sharing	W ₃₃	(Elrefae et al., 2022)

Blockchain technology can be considered an effective solution to solve the problems in traditional procedures. In recent years, this tool has been very popular in financing platforms, especially supply chain financing. This popularity is due to the great features of blockchain such as security, sharing, transparency and smart contracts. Undoubtedly, blockchain is the foundation of the future of the information world. In the following, each of the key performance indicators presented in Table (1) is briefly described. As shown in Table (1), key performance indicators are divided into three general categories according to experts' opinions and the nature of supply chain financing (with emphasis on chain stores as a case study).

- **Real-time operation:** Blockchain technology offers many benefits in the SCF space, including more efficient invoice processing, real-time invoice validation, irreversible transactions, and easy and fast supplier onboarding. Among these benefits, invoice processing efficiency is considered the most

important, as it directly determines how quickly suppliers receive the working capital they need. The faster this process, the more working capital can be unlocked (Li et al., 2020).

- **Easy & fast supplier onboarding:** Supply chain financing requires three main parties: a buying organization, its suppliers, and a financial institution. Not surprisingly, supplier presence is seen as a major factor in program success, mediocrity, or failure. In the case of an SCF solution provider, this means having dedicated teams to lead and access the supplier. It is also important to choose an SCF provider that provides accessible support services to all users once the program is up and running (Omran et al, 2017).
- **Risk transfer:** Credit risk associated with SCF has attracted the attention of government, companies, and universities. However, due to the lack of data and misinformation, traditional risk assessment methods have often failed to assess credit risk in SCF, especially for small and medium enterprises (SMEs). The presence of blockchain technology due to its powerful record-keeping reduces the amount of these risks (Huang et al., 2021 and Nozari et al., 2021).
- **Transparency:** Blockchain provides visibility and tracking of information/documents as they move from one side to another. This way banks/lenders/buyers know what they are financing, so they can proactively reduce their exposure to fraud and credit risk. The technology also includes smart contracts, which essentially enable all parties to a supply chain financial solution to operating on a shared ledger. Bank/finance has access to smart contracts and can track processes like manufacturing, shipping, and order fulfillment at any specified time (Rijanto, 2021).
- **Increase efficiency:** Efficiency is considered the most important benefit of a supply chain financing system because it directly determines how quickly suppliers receive the working capital they need. The faster this process is, the more working capital can be opened. A blockchain is a suitable tool for growth and increasing work in SCF (Yu et al., 2021).
- **Traceability:** Blockchain provides visibility and traceability of information/documents while moving them from one side to another. This way banks/lenders/buyers know what they are financing, so they can proactively reduce their exposure to fraud and credit risk. The technology also includes smart contracts, which essentially enable all parties to a supply chain financial solution to operating on a shared ledger (Liu et al., 2022).
- **Creating knowledge:** Blockchain technology has the capacity that in addition to initial testing or data collection, all remaining parts of the research cycle can be performed on a blockchain system. Documentation, data, data post-processing, publication, research evaluation, motivation, and distribution of research funds are thus made comprehensible, open, and provable to the outside world (Xiao et al., 2022).
- **Fast response:** Today, the delivery speed of SCF solutions is very slow and lacks sufficient control due to rigid systems and processes (such as bill of lading, letter of credit, invoicing, goods receipt confirmation and payment). A smart contract based on blockchain technology can do all this in seconds based on set conditions (Ioannou et al., 2022).
- **Interoperability:** Building interoperability into a first-class blockchain platform in the future will be key to maximizing efficiency. Interoperability between blockchains is directly facilitated by facilitating the transfer of data loads (Nelaturu et al., 2022).
- **Information sharing:** Mutual supervision among members in the blockchain-based supply chain financing model enables the sharing of reliable credit information. In addition, blockchain autonomy effectively reduces management complexity, risks of a single point of failure of a centralized system, and potential issues arising from data sharing such as ownership, usage, and circulation path problems, ultimately leading to a Shared and open, process becomes transparent and traceable with technology-driven identification (Zheng et al., 2022).

Supply chain/trade finance providers around the world are already embracing blockchain technology to power their supply chain candidate platform. For this purpose, understanding and evaluating these key performance indicators can help to effectively implement these platforms with higher efficiency.

4. Research Methods

This research, with a quantitative approach, seeks to investigate key performance indicators in blockchain-based supply chain financing systems in order to effectively implement these systems. In this research, in order to investigate the key performance indicators, first by using the subject literature review and the opinions of academic and active experts in financing companies and by using questionnaire distribution and based on the 5-level Likert spectrum, 10 indicators were extracted as the most important indicators. For this purpose, 16 expert professors from Iran's top universities and experts working in companies developing SCF platforms and having experience working with chain stores (7 academic experts and 9 experts active in the industry) were surveyed. The reason for choosing these people was the access to authors and the work and research records of experts in the field of study. A fuzzy nonlinear hierarchical analysis technique was used to prioritize the most important key performance indicators in Thomson Financial blockchain-based supply chain. In this research, Cronbach's alpha method was used to measure the reliability of the relevant questionnaires and using SPSS software. Cronbach's alpha value of all questionnaires was 0.922, which is considered favorable. Due to the fact that 10 indicators have been selected as the most important indicators in this research, a separate factor analysis has been done for each of the indicators. The research framework is shown in Figure (3).

In the following, the quantitative analysis method used in this research is described.

4.1. Non-linear method of fuzzy ranking of Mikhailov

In this research, a fuzzy nonlinear hierarchical analysis method, known as the Mikhailov method (Nozari et al., 2022), was used to prioritize the most important key performance indicators in blockchain-based supply chain financing systems. The steps to use this method are as follows:

- 1- Hierarchical structure drawing: which is shown in table number (1).
- 2- Forming the matrix of fuzzy pairwise comparisons: consensus matrices of fuzzy judgment are formed based on the opinions of experts. For this reason, fuzzy numbers have been used to express the preferences of experts in this research. Linguistic variables and their fuzzy scale are presented in table number (2).

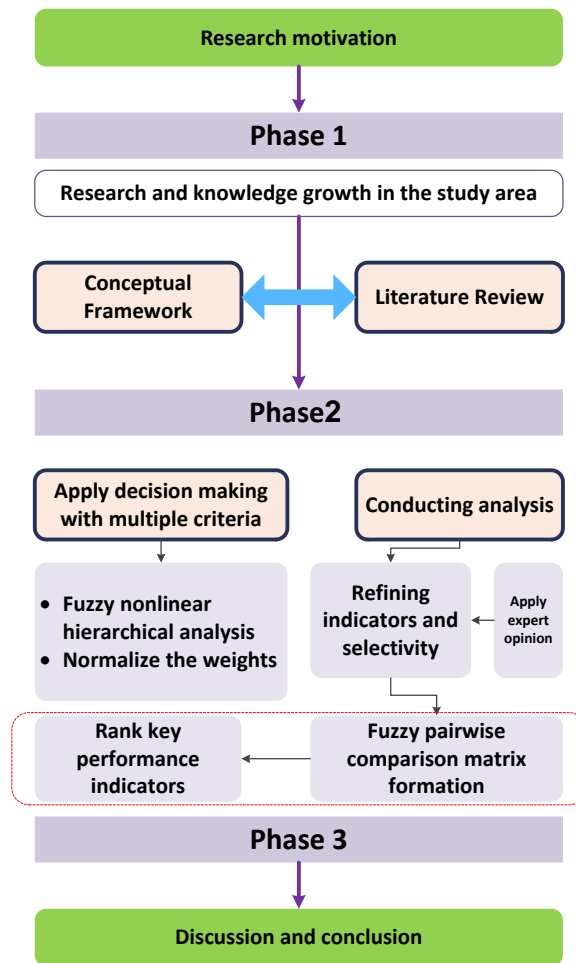


Fig. 3. Research framework

Table 2. Linguistic variables for pairwise comparisons (Nozari et al., 2019)

Linguistic variable	Triangular fuzzy scale
very low	(1,2,3)
Low	(2,3,4)
medium	(3,4,5)
High	(4,5,6)
very High	(5,6,7)

As can be seen in Table (2), fuzzy triangular numbers have been used for language scales, which is one of the types of fuzzy numbers that are represented by three real numbers as $F = (l, m, u)$. The upper limit indicated by u is the maximum values that the fuzzy number F can take. The lower limit indicated by l is the minimum values that the fuzzy number F can take. The value of m is the most probable value of a fuzzy number.

- 3- Formulating the model and solving the problem: In this method, it is assumed that the fuzzy pairwise comparisons are triangular fuzzy numbers. The deterministic weight vector $w = (w_1, w_2, \dots, w_n)$ is extracted in such a way that the priority rate is almost within the range of the basic fuzzy judgments. In other words, the weights are determined in such a way that the following relationship is established.

$$l_{ij} \leq \frac{w_i}{w_j} \leq u_{ij} \quad (1)$$

Each deterministic weight vector (w) with a degree applies to the above fuzzy inequalities, which can be measured through the linear membership function of the following relation:

$$\mu_{ij}\left(\frac{w_i}{w_j}\right) = \begin{cases} \frac{(w_i/w_j) - l_{ij}}{m_{ij} - l_{ij}} & \frac{w_i}{w_j} \leq m_{ij} \\ \frac{u_{ij} - (w_i/w_j)}{u_{ij} - m_{ij}} & \frac{w_i}{w_j} \leq m_{ij} \end{cases} \quad (2)$$

Considering the specific form of the membership functions, the fuzzy prioritization problem becomes a nonlinear optimization problem in the following form.

max λ

Subject to :

$$(m_{ij} - l_{ij})\lambda w_j - w_i + l_{ij}w_j \leq 0$$

$$(u_{ij} - m_{ij})\lambda w_j + w_i - u_{ij}w_j \leq 0 \quad (3)$$

$$i = 1, 2, \dots, n-1, \quad j = 2, 3, \dots, n, \quad j > i,$$

$$\sum_{k=1}^n w_k = 1 \quad w_k > 0, \quad k = 1, 2, \dots, n$$

Considering the non-linearity of relation (3), it is obvious that it is not possible to solve it without using software. Therefore, GAMS software was used to solve the models created in this research. The positive optimal values for the index (objective function) indicate that all weight ratios apply completely to the initial judgment, but if this index is negative, it can be understood that the fuzzy judgments are strongly inconsistent and the weight ratios are almost applied in these judgments.

5. Research findings

The process of ranking key performance indicators in blockchain-based supply chain financing systems in order to effectively implement and create comprehensive benefits for key stakeholders and other participants in this study is divided into two main parts:

- 1- Determining the matrix of pairwise comparisons based on the integration of experts' opinions
- 2- Using mathematical modeling in order to rank and obtain the weight of indicators in the research model.

In order to prioritize the final 10 indicators extracted in this research, fuzzy questionnaires using language variables were sent to 16 experts working in the field of supply chain financing, as well as university professors with related research records. 14 questionnaires were completed and received. These paired comparison tables are shown in tables (3) to (6). These tables have been used for calculations by the Mikhailov method.

Table 3. Pairwise comparison matrix for the general category

	W1			W2			W3		
W1	-	-	-	-	-	-	-	-	-
W2	2.1	2.5	3.6	-	-	-	-	-	-
W3	1.6	2.4	4.3	3.2	3.7	4.1	-	-	-

Table 4. Matrix of paired comparisons for KPIs in the Process section

	W11			W12			W13			W14		
W11	-	-	-	-	-	-	-	-	-	-	-	-
W12	2.1	3.1	4.25	-	-	-	-	-	-	-	-	-
W13	1.11	2.42	4.1	1.65	2.65	3.5	-	-	-	-	-	-
W14	2.25	2.74	3.21	2.01	2.32	3.25	1.55	2.74	3.11	-	-	-

Table 5. Matrix of paired comparisons for KPIs in the Collaborative network section

	W21			W22			W23		
W21	-	-	-	-	-	-	-	-	-
W22	1.75	2.54	4.1	-	-	-	-	-	-
W23	3.1	3.3	5.7	2.1	3.4	5.7	-	-	-

Table 6. Matrix of paired comparisons for KPIs in the platform section

	W21			W22			W23		
W21	-	-	-	-	-	-	-	-	-
W22	1.5	3.21	4.01	-	-	-	-	-	-
W23	3.21	4.2	5.61	3.1	3.64	5.6	-	-	-

By placing the data obtained from tables number (3) to (6) in the non-linear model (3) as a model providing weights and ranks based on hierarchical analysis and solving the model using Lingo software, the weight and rank of each Which of the evaluation indicators obtained in general dimensions as well as in exclusive categories. The calculation results related to solving the non-linear model for general categories and individual indicators are shown in tables (7) to (10).

Table 7. Weight and ranking of the main categories

Category	Code	Weight	Rank	Objective function(λ)
Process	W1	0.391994	1	0.3522
Collaborative network	W2	0.257992	3	
Platform	W3	0.349994	2	

Table 8. Weight and ranking of KPIs for the process category

Category	Code	Weight	Rank	Objective function(λ)
Real time operation	W11	0.185998	3	0.4574
Easy & fast supplier onboarding	W12	0.174306	4	
Risk transfer	W13	0.397849	1	
Transparency	W14	0.248811	2	

Table 9. Weight and ranking of KPIs for the Collaborative network category

Category	Code	Weight	Rank	Objective function(λ)
Increase efficiency	W21	0.281241	3	0.4252
Traceability	W22	0.410001	1	
Creating knowledge	W23	0.311478	2	

Table 10. Weight and ranking of KPIs for the Platform category

Category	Code	Weight	Rank	Objective function(λ)
Fast response	W31	0.432211	1	0.4521
Interoperability	W32	0.269997	3	
Information sharing	W33	0.301041	2	

As can be seen in the tables (7) to (10), a positive value for the compatibility index indicates the acceptable compatibility of the matrices. After obtaining the weight of the general categories and the weight of the indicators in different categories, we can obtain the overall weight of all the indicators regardless of the category and their overall rank by normalizing the weights. The normalized calculation results are shown in table number (11).

Table 11: The normalized calculation results

Category	Weight	Indicator	Weight	Normalized weight	Rank
process	0.391994	Real time operation	0.185998	0.072910	8
		Easy & fast supplier onboarding	0.174306	0.068327	10
		Risk transfer	0.397849	0.155954	1
		Transparency	0.248811	0.097532	5
Collaborative network	0.257992	Increase efficiency	0.281241	0.072558	9
		Traceability	0.410001	0.105777	3
		Creating knowledge	0.311478	0.080359	7
Platform	0.349994	Fast response	0.432211	0.151271	2
		Interoperability	0.269997	0.094497	6
		Information sharing	0.301041	0.105363	4

Figure (4) shows the normalized weight of key performance indicators for a blockchain-based supply chain financing system.

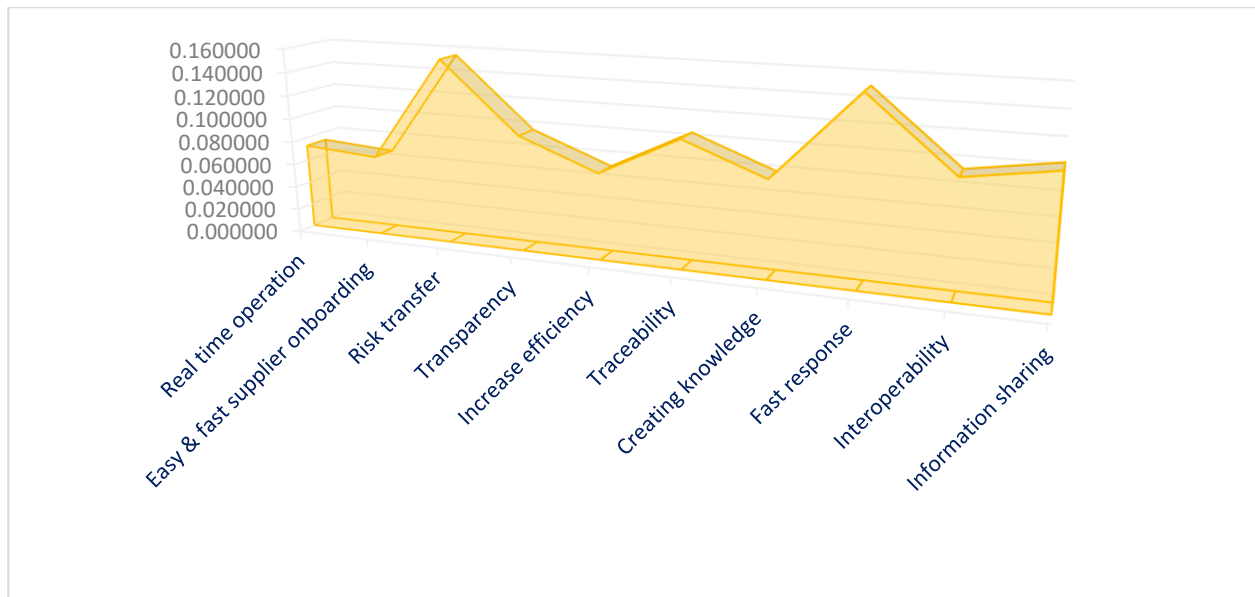


Fig. 4. Normalized weight of key performance indicators in blockchain-based supply chain financing system

As can be seen in Figure (4), reducing the number of risks in various possible modes is the most important performance indicator of supply chain financing platforms with an emphasis on transformative technologies such as blockchain. Quick and timely responses to all types of transactions, as well as the powerful ability to track all types of data, are also of great importance and are among the key performance indicators of supply chain financing. The results are favorable and verifiable according to the key capabilities of the supply chain. The obtained results were consistent with the opinions and predictions of key experts active in supply chain financing companies (chain stores as a case study) as well as academic experts who had research records in the field of study and were confirmed by the experts.

6. Conclusion

Financing of the supply chain, through the conversion of reducing the need for liquidity from the channel of converting liquidity into credits, plays an important role in optimizing financial flows and improving the working capital management of production enterprises. Supply chain financing tools are increasing due to political pressures, digitization and electronicization of invoices, and the transformation of the corona epidemic as well as supplier relationships. Therefore, companies should look for ways to eliminate manual work, increase transparency and create more flexibility in chain financing through credit financing.

Chain financing is one of the few initiatives that provides a win-win deal between buyers and suppliers; This means that buyers want to extend their payment terms and can do so using supply chain financing. Suppliers, on the other hand, want to get paid sooner and can do so with supply chain financing. Therefore, supply chain financing is very important in various industries and businesses.

In recent years, with the introduction and evolution of blockchain technology, this opportunity has also arisen in financial fields to make the most of this new technology. Due to the nature of blockchain, actors in supply chain (SC) networks work widely and transparently to have a reliable, convenient and traceable business. The relative automation of SCF workflow through blockchain-based smart contracts reduces human errors and reduces disruptions compared to traditional supply chain financing. Such transparent and secure features show the possibility of implementing blockchain in SCF.

For this purpose, in this paper, an effort was made to identify and examine the most important key performance indicators (KPIs) in these systems by examining the dimensions and components of blockchain-based smart financing systems. financing (with an emphasis on chain stores due to the authors' access to these experts and the importance of this store and the very long supply chain in these industries) as well as academic experts with relevant research records were used. For this purpose, the most important key performance indicators were extracted and refined using the literature review and experts' opinions. In this research, in order to evaluate the data, a fuzzy nonlinear method was used. The evaluation results show that the reduction of all types of risks in blockchain-based supply chain financing is the most important performance indicator, and the ability to track and trace as well as transparency throughout the chain is the next priorities. These results were validated and confirmed using the opinions of active experts in the field of supply chain financing in chain stores.

References

- Bal, M., & Pawlicka, K. (2021). Supply chain finance and challenges of modern supply chains. *LogForum*, 17(1).
- Chen, J., Cai, T., He, W., Chen, L., Zhao, G., Zou, W., & Guo, L. (2020). A blockchain-driven supply chain finance application for auto retail industry. *Entropy*, 22(1), 95.
- Chen, X., Liu, C., & Li, S. (2019). The role of supply chain finance in improving the competitive advantage of online retailing enterprises. *Electronic Commerce Research and Applications*, 33, 100821.
- Chen, X., Wang, C., & Li, S. (2022). The impact of supply chain finance on corporate social responsibility and creating shared value: A case from the emerging economy. *Supply Chain Management: An International Journal*.
- de Moraes, C. E., Paschoioto, W. P., Bernardes, L. D. S., Sehnem, S., & Salgueirinho de Andrade Guerra, J. B. (2022). Finance sustainable supply chain: An analysis looking for B corporations and agency theory. *Environmental Quality Management*, 31(3), 187-199.
- Dong, C., Chen, C., Shi, X., & Ng, C. T. (2021). Operations strategy for supply chain finance with asset-backed securitization: Centralization and blockchain adoption. *International Journal of Production Economics*, 241, 108261.
- Dong, L., Qiu, Y., & Xu, F. (2022). Blockchain-enabled deep-tier supply chain finance. *Manufacturing & Service Operations Management*.
- Elrefae, G., & Nuseir, M. (2022). Blockchain in global finance make-over: Exploring the mediating role of supply chain flexibility. *Uncertain Supply Chain Management*, 10(3), 983-992.
- Fallah, M., & Nozari, H. (2021). Neutrosophic Mathematical Programming for Optimization of Multi-Objective Sustainable Biomass Supply Chain Network Design. *Computer Modeling in Engineering & Sciences*, 129(2), 927-951.
- Ghahremani-Nahr, J., Aliahmadi, A., & Nozari, H. (2022). An IoT-based sustainable supply chain framework and blockchain. *International Journal of Innovation in Engineering*, 2(1), 12-21.
- Hamledari, H., & Fischer, M. (2021). The application of blockchain-based crypto assets for integrating the physical and financial supply chains in the construction & engineering industry. *Automation in construction*, 127, 103711.
- Hofmann, E., Strewe, U. M., & Bosia, N. (2017). Supply chain finance and blockchain technology: the case of reverse securitisation. Springer.
- Huang, X., Sun, J., & Zhao, X. (2021). Credit risk assessment of supply chain financing with a grey correlation model: an empirical study on China's home appliance industry. *Complexity*, 2021.

- Huertas, J., Liu, H., & Robinson, S. (2018). Eximchain: Supply Chain Finance solutions on a secured public, permissioned blockchain hybrid. Eximchain white paper, 13.
- Ioannou, I., & Demirel, G. (2022). Blockchain and supply chain finance: a critical literature review at the intersection of operations, finance and law. *Journal of Banking and Financial Technology*, 1-25.
- Jiang, R., Kang, Y., Liu, Y., Liang, Z., Duan, Y., Sun, Y., & Liu, J. (2022). A trust transitivity model of small and medium-sized manufacturing enterprises under blockchain-based supply chain finance. *International Journal of Production Economics*, 247, 108469.
- Kaur, J., Kumar, S., Narkhede, B. E., Dabić, M., Rathore, A. P. S., & Joshi, R. (2022). Barriers to blockchain adoption for supply chain finance: the case of Indian SMEs. *Electronic Commerce Research*, 1-38.
- Kucukaltan, B., Kamasak, R., Yalcinkaya, B., & Irani, Z. (2022). Investigating the themes in supply chain finance: the emergence of blockchain as a disruptive technology. *International Journal of Production Research*, 1-20.
- Li, D., Han, D., Crespi, N., Minerva, R., & Li, K. C. (2022). A blockchain-based secure storage and access control scheme for supply chain finance. *The Journal of Supercomputing*, 1-30.
- Li, J., Zhu, S., Zhang, W., & Yu, L. (2020). Blockchain-driven supply chain finance solution for small and medium enterprises. *Frontiers of Engineering Management*, 7(4), 500-511.
- Liu, F., Feng, Z., & Qi, J. (2022). A Blockchain-Based Digital Asset Platform with Multi-Party Certification. *Applied Sciences*, 12(11), 5342.
- Marchi, B., Zavanella, L. E., & Zanoni, S. (2022). Supply chain finance for ameliorating and deteriorating products: A systematic literature review. *Journal of Business Economics*, 1-30.
- Natanelov, V., Cao, S., Foth, M., & Dulleck, U. (2022). Blockchain Smart Contracts for Supply Chain Finance: Mapping the Innovation Potential in Australia-China Beef Supply Chains. *Journal of Industrial Information Integration*, 100389.
- Nelaturu, K., Du, H., & Le, D. P. (2022). A Review of Blockchain in Fintech: Taxonomy, Challenges, and Future Directions. *Cryptography*, 6(2), 18.
- Nozari, H., Fallah, M., Szmelter-Jarosz, A., & Krzemiński, M. (2021). Analysis of security criteria for IoT-based supply chain: a case study of FMCG industries. *Central European Management Journal*, 29(4), 149-171.
- Nozari, H., Najafi, E., Fallah, M., & Hosseinzadeh Lotfi, F. (2019). Quantitative analysis of key performance indicators of green supply chain in FMCG industries using non-linear fuzzy method. *Mathematics*, 7(11), 1020.
- Nozari, H., Szmelter-Jarosz, A., & Ghahremani-Nahr, J. (2022). Analysis of the Challenges of Artificial Intelligence of Things (AIoT) for the Smart Supply Chain (Case Study: FMCG Industries). *Sensors*, 22(8), 2931.
- Obaid, H. S., & Nozari, H. (2022). Examining Dimensions and Components and Application of Supply Chain Financing (In Chain Stores). *International Journal of Innovation in Management, Economics and Social Sciences*, 2(4), 81-88.
- Omran, Y., Henke, M., Heines, R., & Hofmann, E. (2017). Blockchain-driven supply chain finance: Towards a conceptual framework from a buyer perspective.
- Patel, R., Migliavacca, M., & Oriani, M. (2022). Blockchain in Banking and Finance: is the best yet to come? A bibliometric review. *Research in International Business and Finance*, 101718.
- Rijanto, A. (2021). Blockchain technology adoption in supply chain finance. *Journal of Theoretical and Applied Electronic Commerce Research*, 16(7), 3078-3098.
- Seifert, R. W., & Seifert, D. (2011). Financing the chain. *International commerce review*, 10(1), 32-44.

- Tsai, C. H., & Kuan-Jung, P. (2017). The FinTech revolution and financial regulation: The case of online supply-chain financing. *Asian Journal of Law and Society*, 4(1), 109-132.
- Xia, T., Wang, Y., Lv, L., Shen, L., & Cheng, T. C. E. (2022). Financing decisions of low-carbon supply chain under chain-to-chain competition. *International Journal of Production Research*, 1-24.
- Xiao, P., Salleh, M. I., Zaidan, B. B., & Yang, X. Research on Risk Assessment of Blockchain-Driven Supply Chain Finance: A Systematic Review. Available at SSRN 4126017.
- Xu, S., Tang, H., & Lin, Z. (2021). Inventory and ordering decisions in dual-channel supply chains involving free riding and consumer switching behavior with supply chain financing. *Complexity*, 2021.
- Xu, X., Chen, X., Jia, F., Brown, S., Gong, Y., & Xu, Y. (2018). Supply chain finance: A systematic literature review and bibliometric analysis. *International Journal of Production Economics*, 204, 160-173.
- Yang, H., Zhen, Z., Yan, Q., & Wan, H. (2022). Mixed financing scheme in a capital-constrained supply chain: bank credit and e-commerce platform financing. *International Transactions in Operational Research*, 29(4), 2423-2447.
- Yu, Y., Huang, G., & Guo, X. (2021). Financing strategy analysis for a multi-sided platform with blockchain technology. *International Journal of Production Research*, 59(15), 4513-4532.
- Zhang, T., Zhang, C. Y., & Pei, Q. (2019). Misconception of providing supply chain finance: Its stabilising role. *International Journal of Production Economics*, 213, 175-184.
- Zhang, W., Yan, S., Li, J., Tian, X., & Yoshida, T. (2022). Credit risk prediction of SMEs in supply chain finance by fusing demographic and behavioral data. *Transportation Research Part E: Logistics and Transportation Review*, 158, 102611.
- Zheng, K., Zheng, L. J., Gauthier, J., Zhou, L., Xu, Y., Behl, A., & Zhang, J. Z. (2022). Blockchain technology for enterprise credit information sharing in supply chain finance. *Journal of Innovation & Knowledge*, 7(4), 100256.



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).