Identifying and determining the priority of financial supply chain optimization indicators for production improvement with using Hopfield artificial neural network

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ABSTRACT

Finding the relationship between the components of the financing chain and improving the performance of the production cycle requires identifying the gaps and gaps between these two important categories. In the current research, it was tried to first take the basic steps to identify these gaps, then formulate them to optimize the financing chain to improve production. After building and solving the model, it was implemented through mathematical algorithms and relevant software, and then a multi-objective problem was designed to analyze the results and compare each of the components. Using them, the output of the algorithm was analyzed as a result. Finally, to check the validity of the findings, an interview was conducted with the managers and experts of the production units and the results were applied in making decisions to provide mathematical and computational planning. The qualitative part of the research was also conducted using the opinions of managers of manufacturing companies and experts and professors in production and financial management. The statistical population in the quantitative part of the research is all the machinery and equipment industry companies accepted in the Tehran Stock Exchange, out of 20 companies, 17 active companies were considered. The results showed that the development of supply chain financial resources brings a new incentive for companies and society. In general, this research studies a model of the relationship between the financing chain and the production cycle and finally shows what factors can improve and promote the production cycle and can affect the performance of companies. Among the most important indicators counted in this process are liquidity indicators, inflation rate and current assets.

Keywords: Optimization, Financing chain, Improvement of the production performance cycle, Artificial neural network.

1. Introduction

The supply chain is a network of facilities and operations that are responsible for the processing and development of the product, procurement of materials from suppliers until the product reaches the final customer. (Latifiee & Shafiee, 2023).

The importance of paying attention to the intellectual paradigm of "sustainable development" and, on the other hand, the significant impact of supply chain management on the economic performance at both micro and macro levels have led to the emergence of a new concept called "sustainable supply chain" by incorporating the concept of the supply chain into the paradigm of sustainable development. With the increasing importance of sustainability, SCM researchers are integrating sustainability into SCM to boost the development of the field of SSCM (Dubey et al., 2017;Bui et al., 2021; Tsai et al., 2021). Supply chain management refers to SCM focusing on the simultaneous achievement of social, environmental, and economic contributions for long-term sustainable growth (Seuring and Müller, 2008). There is still a scarcity of models that effectively and efficiently operationalize the principles of sustainable development while maintaining integration (in the economic, environmental, and social dimensions) at the operational level of the supply chain (Arani & Torabi, 2018).

A sustainable supply chain is one that uses environmentally and socially sustainable practices at every stage to protect the people and environments across the whole chain. (Dai et al., 2021).

Financial factors directly impact various components of the supply chain, such as procurement, production, and distribution. Without proper financial flow, timely procurement, production, and distribution are not possible. Additionally, only with proper financial planning, the possibility of developing equipment, products, and market sales exists. Ultimately, the financial performance of the supply chain determines its success in increasing shareholder profits.(Mohammadi et al., 2017).

The risk factors in this study are divided into external risks and internal risks. In general, this study creates a model of the supply chain that examines the management and control of risks and obstacles, as well as the effects of financial supply decisions, and explores the relationship between financial supply chain management. Ultimately, it demonstrates the factors that can improve and enhance the production cycle and influence company performance. The incoming problems can be addressed as follows: Today, importers who have become manufacturers at the regional level require support and assistance, and the role of the government in this process is facilitation and serious support. The efforts of the free trade zone organization involve addressing the challenges faced by production units through coordination with provincial and national organizations and institutions. One of the biggest challenges in the production cycle in these organizations is the supply of raw materials. Imported raw materials, due to sanctions, the laws of the Islamic Republic, and currency fluctuations, have made it difficult for producers. Due to limitations in the training data, the translation may not capture the full context or specific terminology accurately. At the domestic level, business owners also either stockpile goods to sell at higher prices in the following months or lack the purchasing power for these materials due to price increases. Therefore, most raw materials lack the necessary quality. Furthermore, considering that a computational model has not been designed so far in a simulation format that can be practically applied and presented in organizations, this indicates a gap in the utilization of financial supply chain components and risks for optimizing and improving the performance of the production cycle. For these reasons, this research can be considered novel and innovative. Research investigations among the existing studies in this field have led to the conclusion that the current research suffers from a fundamental weakness in the design and presentation of a mathematical model, particularly regarding constraints and risks in the financial supply chain. This research strives to develop an effective model rooted in the organization's internal perspective and exploration of the internal phenomenon of financial supply chain management. Additionally, the utilization of the Hopfield neural network model is considered a significant innovation in this research. The overall goal of this model is to provide a machine or computer with a series of information in a way that it can comprehend and use it towards human objectives. In general, the objectives of this research can be stated as follows:

a) Identifying and determining the dimensions, components, and indicators of the financial supply chain.

b) Understanding the risks, obstacles, and constraints of the financial supply chain among the identified dimensions and components.
c) Awareness of the role and impact of each factor in the production cycle.
d) Providing an appropriate simulation method using a neural network model to enhance the production cycle through the financial supply chain.
e) Developing a mathematical model to determine the role and magnitude of the identified indicators for improving the production cycle through the identified components of the financial supply chain.

2. Literature Review

2.1. Theoretical

The changing organizational environment in the marketplace pushed managers to improve efficiency in the production and service delivery processes by increasing their ability to use the best practices of people management at the time. That is, employee management techniques or methods that would improve production, reduce service delivery costs, and at the same time ensure sustained availability of competent staff in the organization (Ranjbar,2023).
Therefore, in the following, each of the discussed variables has been explained. Finally, the technique used is also explained.

2.2. Financial supply chain

In a competitive global market, Identifying the most appropriate techniques to inform decision making on supplier's selection to lower the costs and achieve the highest benefit, is one of the most important management challenge in any organization (Darvish Sefat et al., 2023). The financial supply chain delivers the cash flow required to keep the doors open, the lights on, and the employees paid (Zhao et al., 2023). The financial supply chain is a term that describes a set of technology-based solutions aimed at reducing financial costs and improving business efficiency for buyers and sellers involved in sales transactions. (Yan & Sun, 2013). Financial Supply Chain Management originates from the financing institution's development of supply chain financing programs with new payable processes and payment arrangements. As a result, prominent participants' and external financial providers' financial services contribute to overall supply chain efficiency while remaining competitive (Tavani et al., 2022).

The financial supply chain, often known as "supplier finance" or "reverse factoring," encourages collaboration between buyers and sellers, countering the competitive dynamics that typically arise between these two parties. In traditional settings, buyers tend to delay payments while sellers prefer to receive payment as soon as possible (Yan & Sun, 2015).

2.3. Production cycle

Understanding the production cycle in manufacturing is important because enables manufacturers to identify areas where improvements can be made and helps them plan for future production needs. Furthermore, it helps manufacturers to identify and address any problems that arise during the production process (Mancini et al., 2022).

The production cycle, in a broader sense, refers to the manufacturing process that begins with raw materials and ends with the final product. In a narrower and more significant context, particularly in a business setting, the production cycle describes the duration that a product remains or undergoes processing from raw materials to completion within a company essentially encompassing various production-related processes occurring within the company. A unit cycle is a single period from the start of production to the end of production (Himma, 2017). The complete production cycle encompasses the following activities (Dengler et al., 2017):

Stage 1 Product Design
Stage 2 Procurement of a Materials Invoice
Stage 3 Sales Forecasting
Stage 4 Product Manufacturing
Stage 5 Cost Aggregation

2.4. Hopfield networks in optimization

Hopfield and Tank introduced the Hopfield network program in 1985 for solving the classical traveling salesman problem. Since then, Hopfield networks have been widely used for optimization. The idea of using Hopfield networks in optimization problems is simple: if a bounded/unbounded cost function can be expressed as the Hopfield energy function, then there exists a Hopfield network whose equilibrium points represent solutions for constrained/unconstrained optimization problems. Minimizing the Hopfield energy function achieves both the objective function minimization and satisfies the constraints, as the constraints are "embedded" in the synaptic weights of the network. (Ramsauer et al., 2020).

2.5. Experimental sections

Nazaraqai et al. (2019) conducted a research titled "Classification of Credit Risks of Individual Customers Using Collective Learning: A Case Study of Bank Sepah." The research findings demonstrate that the income and financial transactions of customers hold the highest importance in determining the credit risks of individual customers.

Khatami Firouzabad et al. (2021) conducted research titled "A Mathematical Model for Financing Small and Medium-Sized Manufacturing Companies in the Supply Chain." The research findings suggest that, in addition to proposing appropriate financial and physical flows in the supply chain, an adequate financial supply program using a factoring method for small and medium-sized manufacturing companies is recommended to ensure the necessary liquidity in each period and increase profitability.

Farsijani and Moradi (2019) conducted research titled "Identification and Prioritization of Risks and Their Impact on the Life Cycle of Renewable Energies Based on Performance and Risk." The result provides incentives for the energy system to support renewable electricity generation and contribute to increasing profitability in the life cycle of renewable energies.

Ghadimi and colleagues (2019) conducted research titled "Modeling and Analysis of Sustainable Supply Chain: Past Issues, Current Challenges, and Future Perspectives." They analyzed the following viewpoints: (1) Number of publications per year, (2) Articles with high citations over time, (3) Authors, institutions, and influential countries, (4) Relevant frameworks related to the supply chain, (5) Applied research methods, (6) Types of images, and (7) Industries of interest.

Gugoluto (2020) conducted a research titled "A Novel Assessment Study on the Dynamic Analysis of Hydrodynamic Journal Bearing Performance: Optimization Using Fuzzy Taguchi Approach." This analysis aims to describe the application of fuzzy logic-based Taguchi analysis for optimizing performance parameters.

Chen et al. (2020) conducted a research titled "A Blockchain-Based Supply Chain Financing Program for the Automotive Retail Industry." In the future, we aim to support the complete automation of SCF workflow with smart contracts, enhancing transaction efficiency.

Li et al. (2021) conducted research titled "Artificial Intelligence-Based Algorithms for Multi-Access Edge Computing in Optimizing Performance of a Benchmark Microgrid." Ultimately, an optimal control strategy is applied to a benchmark microgrid system to demonstrate the effectiveness of performance optimization.

Morto and Caniau (2021) conducted research titled "Can Supply Chain Finance Help Reduce Financial Disruptions Caused by COVID-19?" It encompasses new solutions, stakeholders, collaborations, technologies, regulations, and performance, based on probabilistic theory and resource coordination theory.

Latifi & shafiee (2023) published a paper with the title of Implementation of two assessment models Based on Failure Rate and NDEA in production supply chains with the approach of choosing the right supplier. The results showed that both presented approaches are suitable for evaluating the performance of the supply chain, because the performance rating of both models has high resolution.

Based on the study and review of the literature and theoretical background of the research, the influential components in Supply Chain Finance (SCF) and improving the production cycle, referred to as the research variables, have been initially collected by experts. These variables are presented in Tables 1 and 2.

Table 1. Influential Components in Supply Chain Finance (SCF)

Effective components in the financing chain	examples	Reference	Interview with managers of the organization
Credit risk	Exchange restrictions exchange rate Inflation Liquidity	(Shahbandarzadeh & Kobagani,2017)	×
Economic factors	exchange rate GDP Inflation rate	(Yang et al.,2019) (Moreto & Caniatto,2021) (Farsijani & Moradi,2019) (Sadeghi Moghadam et al.,2016)	×
Interest rate risk	Changes in the value of assets or liabilities of the institution	(Nazar Aghaei & Khah Chafi,2018)	×
Sales growth	Net sales value	(Hajilo et al,.2018)	
Company profitability	Debt to asset ratio size of the company Capital to asset ratio	(Asgrenjad Nouri & Mozhai,2017) (Sedaghat ,2010) (Hajilo et al.,2018)	×
return on assets (ROA)	Net profit Company assets	(Shahbandarzadeh & Kobagani,2017)	×
Working capital	Obtaining facilities from banks Non-current claims Increase the cost of the product	Central Bank of the Islamic Republic. Production chain financing department (2021)	×

Table 2. Factors affecting the improvement and promotion of the production cycle

Factors affecting the promotion of production	examples	References	Interview with managers of the organization
Production costs	The cost of raw materials Employee salaries transport cost Factory maintenance cost The cost incurred for advertising	(Hajilo et al.,2018) (Moraes et al.,2014) (Moreto & Caniatto,2021) (Salehi et al.,2014)	×
Product demand in a production period	-	(Moraes et al.,2014)	
The time required to produce the final product	-	(Moraes et al.,2014) (Salehi et al.,2013)	
Factors of just-in-time production	Planning Performance Quality of communication Evaluation of resources Delivery performance	(Hajilo et al.,2018)	×

3. Methodology

The present study is theoretical and analytical mathematical research. In this research, a mathematical model is designed, and mathematical software is used to solve the model and implement the solution algorithm. The research methodology is based on library studies (literature review and previous research works). To gather information, library studies, articles from reputable international journals, and relevant books, as well as utilizing the Codal system and the database of accepted companies in the stock market and over-the-counter market from 2020 to 2021 were used. Finally, to further examine the validity of the work, interviews were conducted with managers and experts from production units, and the obtained results were incorporated into decision-making processes for the presentation of mathematical and computational planning.

3.1. Building a Supply Chain Finance (SCF) Model

In the models designed in previous studies, aspects of variables and variable selection methods were presented without considering the opinions of relevant managers and experts. This section introduces an innovative aspect of modeling compared to previous models. First, we focus on constructing the Supply Chain Finance (SCF) model.

$$SCF = \sum_{t=1}^{T} (-w_1 * Er_1 - w_2 * Ex_t - w_3 * IR_t + w_4 * CASH_t - w_5 * GDP_t - w_6 * IP_t + w_7 * IS_t - w_8 * TTL_t + w_9 * SIZE_t + w_{10} * CA_t + w_{11} * NTS_t + w_{12} * E_t + w_{13} * BF_t - w_{14} * PC_{kt})$$

3.2. The Production Performance Cycle (EP)

Based on the study and review of the literature and theoretical background of the research, influential components in Supply Chain Finance (SCF) and production performance improvement, referred to as research variables, have been collected for initial examination through expert consultations, which are presented in Tables 3 and 4.

$$Max\ TCP\ t * Min\ D_t * Max\ TRP_t * Min\ JIT_t \leq EP_t \leq Min\ TCP_t * Max\ D_t * Min\ TRP_t * Max\ JIT_t$$

Cronbach's alpha coefficient was also used to measure reliability. According to the results, the alpha of the variables is equal to 0.811 and the alpha of the indices is equal to 0.814, which shows that the reliability is confirmed. In order to analyze the reliability of financing methods, goals, parameters and important variables in the construction of the model from the point of view of experts based on the index of the content validity ratio has been used. Based on this, the variables of the above model are defined in the following table:

Table 3. Indices and model parameters in the financing chain (SCF)

Index	i = raw materials
	k = final product
	l = customer
	j = supplier
	t= time
	n= financial index
Parameters Effective in SCF	CR = credit risk
	Er_t = Exchange restrictions of period t, w1: coefficient of exchange restrictions
	Ex_t = Exchange rate changes at the end of period t, w2: exchange rate coefficient
	IR_t = Inflation rate changes at the end of period t, w3: inflation rate coefficient
	$CASH_t$ = amount of liquidity available at the end of the period t, w4: coefficient of the amount of liquidity available at the end of the period.
	GDP_t = Gross Domestic Product at the end of period t, w5: coefficient of gross domestic product at the end of the period.
	IP_t = Interest paid at the end of period t, w6: the coefficient of interest paid which is calculated through the following formula: $IP_t = (LTR_t * LTL_t) + (STR_t * STL_t)$ LTR_t = long-term interest rate at the end of period t LTL_t = firm's long-term debt at the end of period t STR_t = short-term interest rate at the end of period t STL_t = short-term debt of the company at the end of period t
	IS_t = growth (Increase) of sales at the end of period t, w7: coefficient of growth (increase) of sales
	TTL_t = Amount of company's debt to assets at the end of period t, w8: coefficient of company's debt to assets. which is calculated through the following formula: TTL= $LTL_t + STL_t / E_t$ LTL_t = I [illegible] end of period t STL_t = Short-term debt of the company at the end of period t E_t = Company's assets at the end of period t
	Size = The size of the company at the end of period t (the size of the company is equal to the natural logarithm of the

Parameters Effective in SCF	book value of the company's assets) and w9 (the coefficient of the company size in period t). which is calculated through the following formula: *Size*= L_n (*MVAL*)$_t$ Ln = Natural logarithm MVAL $_t$ = book value of the company's assets in period t
	CA $_t$ = Current Assets (accounts receivable) at the end of period t, w10: coefficient of current assets at the end of the period.
	NTS $_t$ = Net profit from sales at the end of period t, w11: coefficient of net profit from sales at the end of the period.
	E $_t$ = Company assets at the end of period t, w12: coefficient of company assets at the end of the period.
	BF $_t$ = Bank Facilities received at the end of period t, w13: coefficient of bank facilities received at the end of the period.
	PC$_{kt}$ = Variable costs for the production of product k at the end of period t, w14: coefficient of variable costs for the production of product k at the end of the period, which is calculated through the following formula: $TPC_t = \sum_{k=1}^{K} (PC_{kt})$

4. Results

4.1. Implementation of the Hopfield neural network model

First step: *the weights obtained from the algorithm using the Hebbian principle are initialized*.

At this stage, the weight coefficients between neurons are determined using selected sample patterns from all classes. This stage represents the training phase of the network, where each pattern is compared to itself. In the Hopfield networks, the linear stimulus function "satlins" is used, which returns a value of -1for inputs less than -1 Satlins, the same input value for inputs between 1 and -1, and a value of 1 for inputs greater than 1. This network can be tested with 1 or more input vectors, which are applied as initial conditions to the network. Once the initial conditions are provided, the network generates an output that is itself the input for the network. This process is repeated until the output remains constant and the network reaches equilibrium. When a new input is given to this network for identification, the weights and bias values for the input are determined as mentioned above, and this recursive state is repeated until the output reaches a constant value and the network reaches equilibrium. Then, each output vector converges to one of the fixed point vectors, which is closer to the input.

Second step: *the initial activation of the network equal to the external input vector X is executed as follows*.

In this study, input patterns are fed into the network based on the inputs and their effects as outputs to the network. As shown in Table 5, the first 15 rows represent the inputs, and the next 11 rows represent the objectives of the model, which are added alongside the input to the Hopfield neural network model. This is because the Hopfield network is an unsupervised learning network. In this table, each column represents a training pattern. Since we are considering 15 applied input effects, there are 11 different patterns in the table, each indicating the conditions under which that effect occurs. In the last 11 entries of the table, which are the target vectors, each column is equal to 1, while the other rows are -1, indicating that only output is generated if the inputs of that column occur.

Third step: *The net input of the network is calculated as follows*.

After adjusting the weights and training the network, the output is imposed as an unknown pattern. This way, the network converges to its final solution. This property enables the network to generate the correct pattern if a distorted pattern is presented to it. Hopfield networks use an optimization model to learn the weight parameters so that the weights can capture positive and negative relationships between the features of the training sets. After creating the Hopfield neural network in MATLAB, the weights, and biases of all neurons were randomly initialized. Additionally, TCP (Total Cost Performance) index was divided into two subsets: TCPD representing direct costs, which is the sum of raw material costs and wages, and TCPI representing indirect costs, which is the sum of transportation costs, maintenance, and advertising costs were categorized due to the large diversity of subsets.Due to the recurrent nature of the network, the outputs are again applied to the network, and the weights and biases of the neurons are modified, resulting in new output. This new output is then fed back into the network as input, and this process is repeated until the network reaches a state of equilibrium, where the weights and biases of the neurons are adjusted in such a way that the output of the network no longer changes. From now on, the network continues its work by receiving a scalar input, which in this case consists of 26 numbers. The initial 15 numbers are the inputs, which are assigned values of 1 and -1 based on the opinions of the desired experts, and due to the researcher's lack of knowledge about the output, the last 11 rows are assigned values of -1 The weights of the different connections in this stage consist of 26 rows and 17 columns, where each of these neurons is connected to itself and other neurons, and these connections have weights.

Table 5. input patterns to the Hopfield network

Indicator / Companies	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Credit risk (CR)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Exchange Restriction (Er)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Exchange rate (Ex)	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
Inflation rate (IR)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
The amount of cash (CASH)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1
Gross Domestic Product (GDP)	1	1	1	1	-1	1	-1	-1	1	-1	1	1	1	1	1	1	1
Interest payment (IP)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
Increse of sales (IS)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
debt-to-asset ratio (TTL)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	-1
company size (Size)	1	1	1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	-1	1
Amount of current assets (CA)	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	1	1
Net sales profit (NTS)	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	1	1
Company assets at the end of the period (E)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bank facilities (BF)	1	-1	1	1	1	1	1	1	1	1	1	-1	1	1	1	1	1
Variable costs of product production (PC)	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Indirect Costs (TCPI)	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Direct costs (TCPD)	1	-1	1	1	1	1	1	1	1	-1	1	1	1	1	1	1	1
Demand (D)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Maximum production capacity (UCAP)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1
just-in-time production (JIT)	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	1
Raw materials(i)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
Finished Product (K)	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	-1
Customer (L)	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	-1
Supplier (j)	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	-1	1	-1
Time (t)	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	-1	1	1
financial index(n)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fourth step: *To calculate the output, activation is applied to the net input as follows.*

Fifth step: *The output yi is broadcast to all other units.*

To compute the optimization function in a perceptron, besides the actual output of the network, we also need the desired output of the network. Therefore, we need another method to compute the optimization function that is compatible with the structure of this network. The value of this function should be directly proportional to the error and the magnitude of the weight coefficients and supplied patterns to the network should also influence its value. As shown in Figure 1, the optimization landscape resembles a wave-like panorama, covered with hills and valleys, pits, and mountains. As the network converges towards the solution in the iterative process, this point on the optimization landscape moves towards one of the pits. The solution is obtained when this point reaches the deepest position on the surface, and since all the surrounding points are in higher energy positions, it remains stable in that position. Each of the pits on the optimization landscape represents a stable state of the network and represents one of the stored patterns in the network. The pits are points with the minimum optimization in the generation, indicated by a darker color, and the peaks are points with the maximum optimization in the generation, indicated by a lighter color.

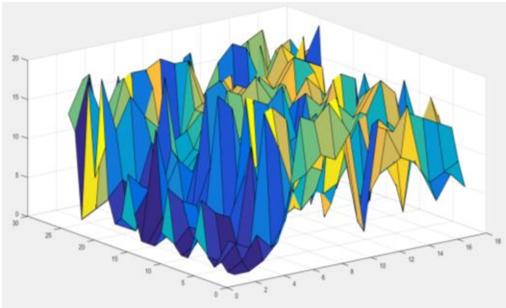

Fig 1. Production optimization function according to the changes of two weighting coefficients

Also, the bias of the network neurons is stored based on the input patterns, which are presented in Table 6

Table 6. Bias table of network neurons

Row	Indicator	weights
1	Credit risk (CR)	1.025522.075
2	Exchange Restriction (Er)	13.8407
3	Exchange rate (Ex)	2.3749.2278
4	Inflation rate (IR)	0.1.9863
5	The amount of cash (CASH)	0.75
6	Gross Domestic Product (GDP)	8
7	Interest payment (IP)	4
8	Increse of sales (IS)	1
9	debt-to-asset ratio (TTL)	1
10	company size (Size)	1
11	Amount of current assets (CA)	0.2.9354
12	Net sales profit (NTS)	1.25
13	Company assets at the end of the period (E)	2.5
14	Bank facilities (BF)	1.75
15	Variable costs of product production (PC)	2.25
16	Indirect Costs (TCPI)	2
17	Direct costs (TCPD)	0.25
18	Demand (D)	4
19	Maximum production capacity (UCAP)	1.5
20	just-in-time production (JIT)	0.75
21	Raw materials(i)	0.75
22	Finished Product (K)	0.25
23	Customer (L)	0.5
24	Supplier (j)	0.5
25	Time (t)	0.5
26	financial index(n)	0.75

4.2. Network test

Sixth step: *the network is tested for connectivity* (Ramsauer et al., 2020).

In this stage, to ensure the proper functioning of the network, various patterns and states that lead to research credit allocation are tested. Three general states of research credit allocation can be examined in the testing network. Here, one state is provided as an example :In this state, a matrix of input patterns stored in the network is fed into the network. The following matrix is based on the inputs that lead to optimization in the generation. Since the network has 26 neurons, the matrix should have 26 components. The first 15 components are set to 1, and for the 11 final components, to indicate the lack of knowledge about the output, they are set to -1. Table 7 shows the 11 numbers at the end of the 26-component output matrix. As you can see, in the fourth stage, there is only one positive number related to the optimization of the supply chain, indicating that the network's solution has fully converged to the expected solution, which is the optimization of generation.

Table 7. network response to applied inputs

Number	first stage	second stage	third stage	fourth stage
1	-1	1	-0.8	-1
2	-1	-1	-1	-1
3	-0.97	-1	1	-1
4	-0.58	0.314	-1	-1
5	-1	-1	-1	-1
6	-1	-1	1	1
7	-1	-1	-1	-1
8	-1	-1	-1	-1
9	-0.37	-1	-0.11	-1
10	-1	0.36	0	-1
11	-1	0.18	-1	-1

5. Discussion and Conclusions

In the modern business landscape, supply chain optimization has become critical in ensuring a company's success and growth. As businesses strive to meet customers' evolving demands and stay ahead of the competition, an efficient and optimized supply chain can be the key to achieving these objectives. In this comprehensive guide, we will delve into the concept of supply chain optimization, its importance, the various phases involved, and the benefits it can bring to your organization (D'Avanzo et al., 2013). The financial flows between companies of the supply chain, however, were often neglected and have only recently found greater attention in the academic SCM literature (Chen et al. 2021). The primary goal of supply chain optimization is to ensure that the supply chain functions at its peak efficiency while minimizing costs and maximizing profits. It involves effectively using resources, technology, and strategic planning to achieve a seamless and cost-effective supply chain process (Liu & Hendalianpour, 2021). Therefore, the results of the present study are in line with the results of studies Nazaraqai et al. (2019), Khatami Firouzabad et al. (2021), Farsijani and Moradi (2019), Ghadimi and colleagues (2019), Gugoluto (2020), Chen et al. (2020), Li et al. (2021), Morto and Caniau (2021). Based on this, according to the confirmation of the existing literature, the objectives of the research have been given in the form of answers.

a) Identifying and determining the dimensions, components, and indicators of the financial supply chain.

What are the dimensions, components, and indicators of Supply Chain Finance (SCF)?

In this study, in-depth interviews were conducted with experts and managers of machinery and equipment manufacturing companies to gather their opinions. Then, the Delphi method was used to identify and select the final dimensions that were considered important from the perspective of experts. In addition, the use of scientific foundations was employed to select the dimensions, components, and indicators of optimizing the Supply Chain Finance, which was used as input for the Hopfield neural network, as presented in Table 5.

b) Understanding the risks, obstacles, and constraints of the financial supply chain among the identified dimensions and components

Among the identified dimensions and components, what are the risks, obstacles, and bottlenecks of the financing chain?

Supply Chain Finance risk refers to the uncertainties that may occur in structures, human activities, information, and product/service delivery processes. As a result of the growing relationships with suppliers, the supply chain has become an exceptional source of risk for many companies. In this study, control methods employed by component manufacturers were utilized to examine the management of risks associated with intensified collaboration with supply chain partners. Supply chain relationships have been considered important company assets that can serve as leverage to improve the company's competitive position. In Table 8, the obstacles and constraints of supply chain finance are indicators that have a weight lower than 1. Among them is the liquidity indicator, as low liquidity reduces purchasing power, leading to market and customer loss. The current asset indicator is related to the supply of raw materials, and its scarcity creates problems in company performance and assets. One of the most significant constraints is the inflation rate. As the inflation rate increases, financial supply becomes more challenging, resulting in increased risk and market loss.

Table 8. Dimensions and components andindicators of the financing chain along with their weights in Hopfield neural network

dimension	component	Indicator	g
Customer	Financing - supply of parts	Restrictions on exchanges	.
Economic environment	ranking	(GDP)	8
Financing	Interest	interest paid	4
assets	efficiency	Company assets at the end of th period	5
Market	Risk	exchange rate	3
Customer	Financing	Variable production costs	2
income	Debt	Bank facilities	7
income	Financing	Net profit	2
sale	Financing	Credit risk	0
Market	market share	Sales growth	1
Obligations	lever	debt ratio (the amount of the company's debt to assets)	1
Development and growth	Fund	size of the company	1
Market and customer	Buying and selling power	Amount of liquidity	7
assets	efficiency	Current assets	2
Market	Risk	Inflation	1

c) Awareness of the role and impact of each factor in the production cycle.

What is the role and effect of each factor in the production cycle?

When it comes to performance improvement, financial performance is discussed, which includes sales, net profit, gross margin, or other absolute financial and accounting options. The effort to improve these factors can be beneficial in evaluating the growth of a manufacturing company over different time periods. Factors in the production cycle include raw materials, labor costs, overhead, and production capacity. According to Table 8, some indicators directly and some indirectly affect these factors. For example, the inflation rate indicator directly affects raw materials, while indicators such as net profit, liquidity, and variable production costs directly impact labor costs and overhead. Transaction constraints and credit risk indicators also directly affect production capacity, causing its increase or decrease. The remaining mentioned indicators indirectly affect these factors. An unknown pattern acts as a focal point on the optimization surface of production. As the network converges towards a solution in the repetitive process cycle, this point on the optimization surface moves towards one of the valleys. The solution is obtained when this point reaches the deepest position on the surface and remains stable there, as all the points around it are in higher-energy positions. Each of the valleys on the optimization surface represents the stable states of the network and represents one of the stored patterns in the network. Valleys are points with the least optimization in production, indicated by a darker color, while peaks are points with the highest optimization in production, indicated by a lighter color. Companies, based on their financial statements and specific profit and loss statements, should focus more on the valleys and reinforce them while preserving the peak points.

d) Providing an appropriate simulation method using a neural network model to enhance the production cycle through the financial supply chain.

How can the production cycle be improved by using neural network simulation?

Due to the large number and volume of variables and influential indicators in optimizing production with a focus on the financial supply chain, manual and traditional computational methods are not capable of identifying the functioning of each of them in interaction with each other. Therefore, innovative models such as simulation in neural networks like the Hopfield neural network are one of the approaches to overcome this limitation. In recent studies, artificial neural networks, fuzzy neural networks, and genetic algorithms have commonly been used as non-linear approximation tools. These models can identify linear and non-linear relationships between data and variables based on training data and discover the underlying relationships among them, and then generalize the discovered relationships to other data. This can lead to improved efficiency and effectiveness by selecting the appropriate data and proper modeling. Efficiency focused on maximizing the outcome, is determined by the organization or economic entity and is associated with concepts such as effectiveness and productivity, while also being distinct from these concepts.

e) Developing a mathematical model to determine the role and magnitude of the identified indicators for improving the production cycle through the identified components of the financial supply chain.

How can these dimensions and indicators be determined in a computational model to determine the role and size of each?

As observed in Table 9, using the Hopfield neural network, all dimensions, components, and optimization indicators of the financial supply chain have been weighted and classified based on their importance in promoting production. The higher the weight assigned to these dimensions and indicators, the greater their significance in optimization. As seen, in both models, certain indicators such as gross domestic product, company assets, and bank facilities hold high importance. The maximum production capacity indicator has relatively moderate importance in both models, while indicators such as just-in-time production, liquidity, and inflation rate are considered constraints. Some indicators, like current assets in the Hopfield neural network, which are based on real financial data and company performance, are considered constraints due to their weight being less than one, although experts consider this indicator to be moderate.

Additionally, the utilization of the Hopfield neural network model is considered a significant innovation in this research, while in other researches, the financial supply chain has not been considered from the perspective of Hopfield's neural network.

Table 9. Bias of Hopfield neural network neurons in the order of weights along with index ranking

Row	Indicator	Hopfield weights
1	Exchange Restriction (Er)	13.84
2	gross domestic product (GDP)	8
3	interest payment (IP)	4
4	demand (D)	4
5	Company assets at the end of the period (E)	2.50
6	Exchange rate (Ex)	2.37
7	Variable costs of product production (PC)	2.25
8	Indirect Costs (TCPI)	2
9	Bank facilities (BF)	1.75
10	Maximum production capacity (UCAP)	1.50
11	Net sales profit (NTS)	1.25
12	Credit risk (CR)	1.02
13	Increse of sales (IS)	1
14	debt-to-asset ratio (TTL)	1
15	Size of the company (Size)	1
16	just-in-time production (JIT)	0.75
17	raw materials (i)	0.75
18	financial indicators (n)	0.75
19	The amount of cash (CASH)	0.75
20	Customer (L)	0.05
21	supplier (j)	0.05
22	time (t)	0.05
23	current assets (CA)	0.29
24	Direct costs (TCPD)	0.25
25	The final product (k)	0.25
26	changes in the inflation rate (IR)	0.19

5.1. Practical suggestions

- Due to the increasing demand in the industrial machinery market and the existence of sanctions that restrict the importation of machinery, as well as currency fluctuations, customs clearance prices have increased. Therefore, companies cannot avoid entering into the establishment of new production lines in the coming years. Thus, the need for technical knowledge in this field has been felt, and companies are currently planning to produce new products in the coming years.

- • Companies have faced the challenge of increasing the total cost of finished products, which is related to the purchase of domestic raw materials. The company management has focused on establishing a price analysis unit (consisting of the economic, commercial, and industrial engineering deputy departments) to carry out effective negotiations for purchasing at the minimum price.
- • The relationship between financial indicators examined in this study, such as liquidity, asset return, working capital, and sales growth, will be investigated to improve the production cycle of machinery and equipment companies listed on the Tehran Stock Exchange.

5.2. For Future research

- It is recommended that variables related to financial indicators such as liquidity, financial leverage, and sales growth, which have correlation and interdependence, be first calculated and examined for their correlation coefficients separately in future research, and then incorporated into the loading model.
- The present study focused on the machinery and equipment industry. This issue is one of the limitations of the research. For the comprehensiveness and scope of this research, it is suggested that future researchers also investigate and analyze this study in other industries and market sectors.

5.3. Limitations

- Considering that the qualitative part of the foundation's data research is based on an in-depth interview conducted by the researcher, and the information analysis should be done from the interviews and previous research, therefore, whatever the research is considered to be free from the researcher's opinions, but However, the studied organizational climate and past studies will affect the process of interpreting the results. Therefore, this limitation should be taken into account when generalizing the results.
- In the data theory of the foundation, the qualitative part requires in-depth and time-consuming interviews, and when the subject of study is the category of financial management and supply chain, it was very difficult to coordinate the interview sessions with senior managers. He got it from the researcher.
- Some managers do not have enough expertise in all areas of the financing chain, so searching for other managers and experts in this research took a lot of time from the researcher.

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