DLINE JOURNALS

Journal of Information Technology Review

Print ISSN: 0976-3511
Online ISSN: 0976-2922

JITR 2024; 15 (2)
https://doi.org/10.6025/jitr/2024/15/2/33-41

Mathematical Construction Analysis of Logistics Development Supply Chain Model Based on Time Series

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Received: 19 November 2023
Revised: 25 January 2024
Accepted: 3 February 2024
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ABSTRACT

With the deepening development of global economic integration, supply chain management is becoming increasingly important in logistics. This article explores the mathematical construction and analysis of a supply chain model for logistics development based on time series. Firstly, we introduced the basic concepts and construction methods of supply chain models, emphasizing the importance of time series analysis in logistics development. Next, we proposed a logistics development supply chain model based on time series and detailed its mathematical construction process. Finally, we validated the effectiveness and superiority of the model through empirical analysis.

Keywords: Time Series Mathematical Model, Manufacturing Industry, Supply chain, Logistics Chain, Operation

1. Introduction

Since the last century, the theme of world development has shifted to "peace and development". Under this trend, a lot of new technologies have been gradually applied to actual production and life. Especially with the development of information technology, the scale of economic globalization has been increasing in the present era, and the competition of the whole market economy has also gradually increased. As an important pillar industry in the development of the times, the development of the manufacturing industry has brought more important significance to meet people's material needs in the process of the times. However, the complex properties of the whole market economy shown during high-speed operation, as well as some other potential risk factors, have also directly or indirectly restricted the further improvement and development related to the industrial structure. Because of the continuous improvement of people's material and cultural levels, many customers have begun to pursue new products that are more personalized and diversified, thus bringing a certain challenge to the development of

the manufacturing industry. Gradually increasing demand also requires the manufacturing industry to shorten the production cycle of the whole product as much as possible in the manufacture of related products and to further adjust and optimize the industrial structure on the basis of the current demand situation of the market environment, so as to provide certain support for the rapid avoidance of certain risks and rapid response to the changeable environment of the market. Thus, in meeting customer needs, the industry and industry influence can be continuously improved, thus supporting the development of the industry's comprehensive level. In this paper, the operation status of the logistics chain, an important link in the manufacturing industry, was analyzed so as to provide a reference for the perfect development of the logistics chain in the manufacturing industry.

2. State of the Art

With the rapid development of the era economy, the fluctuation of the market economy environment and the risk have gradually increased, and customer demand for products has also tended to be personalized, thus posing a certain challenge for the development of the manufacturing industry [1]. Some studies have suggested that as the key link of connecting industry and customers, the logistics chain can effectively reflect the customer's needs to the manufacturing enterprises, thus providing theoretical support for the formulation of the enterprise's future planning. This kind of link method can effectively integrate and share the relevant information resources inside and outside the manufacturing enterprise, which has a very important impact on the development and progress of the entire industry [2]. Many scholars have begun to devote themselves to the study of the theory and operation of the logistics chain, and because of the continuous improvement and establishment of the mathematical model, there have been a lot of research results [3]. Some researchers have investigated large manufacturing enterprises and companies in the world and have found that the logistics chain theory and the continuous improvement of each link make the manufacturing enterprises and companies improve productivity and total production and reduce the product delivery time, thereby reducing the cost of the product and providing more accurate and reliable forecasting performance for the future development of enterprises [4].

3. Methodology

With the development of the times, the economic level of the world has been greatly improved. In the present era, unlike traditional economic conditions, the world's market economy is relatively unstable and has been at a relatively volatile level for a long time, which has posed certain challenges and pressures for the development of many industries. However, in the era of development trend, due to the increasing of people's pursuit for some products, the manufacturing industry has gradually become an important pillar industry in today's era in the development of market economy and has gained great advantages for development in the fierce competition in the market [5]. However, with the increasing competition among industries, how to better meet the needs of customers and further provide a certain impetus for the development of the industry itself has gradually become an important research topic. In the current trend of teamwork, the industry alone has been unable to meet the needs of the times. Therefore, it is necessary to find more enterprise partners, thus forming a certain chain structure and effectively transforming the products of the industry into important economic benefits in the process of development. Therefore, during the operation of the whole enterprise, the capital chain and product chain will not restrict the further development of the enterprise so as to ensure the ultimate sustainable development of the enterprise in the process of high-speed operation [6]. In this trend and background, the concept of logistics chain has been mentioned and studied. The management of the logistics chain is an invisible chain structure that links the whole process of the whole industry. The use of a logistics chain can coordinate and control all the relevant links in the whole industry process and realize the maximization of the overall interests in the process of industrial operation. Many scholars have found that through the use of a more efficient logistics chain management model, the efficiency of industrial income can be further realized in the process of enterprise operation. The cost of enterprise operation can also be further reduced (Fig.1). In the last century, PRTM consulting company investigated various industries' logistics chain management models in the current era. The report shows that, despite the rapid development of the existing background of the world, a large number of manufacturing enterprises have begun to attach importance to the development of the logistics chain gradually and have regarded it as the key link of enterprise development. However, only about 20% of enterprises have a strong logistics chain management level,

and most enterprises are still in a relatively backward management situation [7]. Therefore, the development of relevant theories of logistics chain is very important for promoting the world economic level.

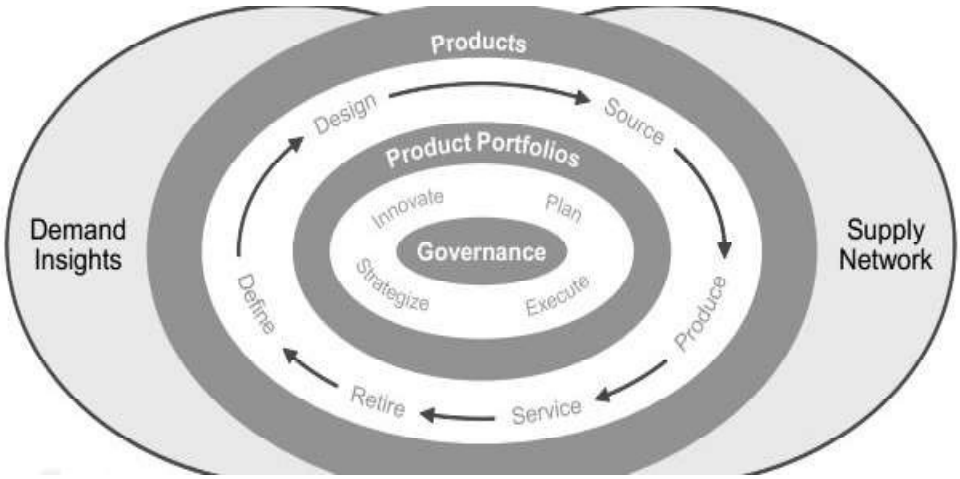

Figure 1. Development of Manufacturing Logistics Chain

Based on the insufficiency of the logistics chain of China's manufacturing industry and its research, the relevant theories of the logistics chain were further summarized in this paper. The relatively perfect theory of the logistics chain was determined. Based on the mathematical model of time series, a model system for the overall evaluation of the chain of manufacturing logistics in China was developed. Then, based on the combination of theoretical analysis and model evaluation, more practical final analysis results were obtained. Some reference was provided for optimising the industrial structure and promoting the comprehensive level of the manufacturing industry in the manufacturing industry, thus providing a more active role for the manufacturing industry in China to better cope with the market economy and avoid the market risk factors [8]. Related research ideas are as follows:

In this study, the current status of the world logistics chain was determined by reading and summarising the relevant literature. The theoretical research status of the evaluation system of logistics chain operation ability in various industries in modern times was analyzed, thus providing a theoretical basis for the study. On this basis, taking the logistics chain links and evaluation methods as the research focus, based on a time series mathematical model, the evaluation and analysis were carried out. Then, the relevant index of the supply chain performance evaluation system, which is used for the development evaluation of the manufacturing logistics chain, was studied.

Based on a clear understanding of the relevant theories, a time series mathematical model was constructed as an important performance evaluation model for the logistics chain of manufacturing enterprises in this study [9]. First of all, through reading the relevant literature, the current situation and main influencing factors of the logistics chain in China's actual manufacturing industry were further explored and analyzed, thus determining the main impact assessment indicators of the manufacturing logistics chain used for this study [10]. Performance evaluation factors related to the overall operation of the logistics chain are shown in Table 1.

Then, the mathematical time series model was constructed, and the main data of the above factors was analyzed. The mathematical model of the time series is shown as follows:

$$P_{ij} = L_{ij} / A_{ij}, A_{ij} = \sum_{i} \sum_{j} L_{ij} \quad (1)$$

Performance type	Performance type definition	Measurement index
Reliability of the logistics chain	The performance of the logistics chain (7R) during delivery: the right product, the right place, the right time, the right conditions and packaging, the right amount, the right documents, the right customers.	Order fulfillment rate
The reactivity of the logistics chain	The speed at which a supply chain delivers products to its customers	Order fulfillment lead time
Logistics chain flexibility	To speed up the reaction of market change, to obtain or maintain the market competitive advantage, the supply chain must have agility.	Upstream supply chain flexibility
		Upstream supply chain adaptability
		Downstream supply chain adaptation
The management cost of the logistics chain	Costs associated with supply chain operations	Cost of goods sold
		Total cost of supply chain management
Asset utilization in the logistics chain	When managing assets, customer needs and organizational efficiency should be met, including the management costs of all assets, such as fixed capital and operating capital.	Cash flow time
		Return on SC fixed asset
		Operating assets return

Table 1. Indicators of Overall Operation Performance Evaluation of Manufacturing Logistics Chain

i and j represent the above major performance evaluation factors, respectively; P_{ij} is the probability of logistics performance evaluation affected by different factors at the same time; L_{ij} represents the correlation coefficient between arbitrary and different influencing factors.

$$H_{ij} = -P \log_2 P_{ij} \quad (2)$$

H_{ij} represents the time entropy of any two common evaluation factors that affect the operation of the whole logistics chain.

$$H_1 = \sum_i^n \sum_j^m H_{ij} = -\sum_i^n \sum_j^m P_{ij} \log_2 P_{ij} \quad (3)$$

As the logistics chain of different manufacturing enterprises is in synergy, H_1 represents for the entropy of time when any performance evaluation factor plays a role in the operation of the entire logistics chain.

$$H_{1m} = \log_2 A_1 = -\log_2 \sum_i \sum_j L_{ij} \quad (4)$$

H_{1m} represents the maximum aging entropy of the entire manufacturing industry operating system when the logistics chain among different manufacturing enterprises has a synergistic effect.

$$R_1 = 1 - H_1 / H_{1m} \quad (5)$$

R_1 is the final prescription for the whole chain of logistics systems for manufacturing industries, which is usually between 0 and 1.

Based on the construction of the relevant models and the understanding of the relevant theories, in this paper, a manufacturing enterprise was taken as a case study; the main influencing factors in the development of the logistics chain of the manufacturing enterprise were analyzed by using the time series mathematical model. Through the actual case, the operation efficiency of the logistics chain was evaluated. Furthermore, the improvement of the logistics chain in the manufacturing industry and the feasibility of the time series mathematical model were confirmed.

The analysis of the system operation effect verified the correctness and feasibility of the index model and evaluation algorithm proposed in this paper. The actual case chosen in this study was the manufacturer of new energy vehicles in a certain area. The logistics system used by the manufacturer now includes two different forms: the cooperative logistics chain operation model and the traditional logistics chain operation mode [11].

4. Result Analysis and Discussion

As the pillar industry in the development of the times, the manufacturing industry has a very important influence on promoting the national economic level. The development of this industry has brought great development power to all sectors of the world. At the same time, it has brought positive effects to the solution and distribution of related human resources [12]. As an important emerging enterprise in the development of a new era, the development of new energy enterprises plays an important role in the balance of ecology and the sustainable development of the whole world economy. Nowadays, the development of new energy enterprises has gradually become the most important thing in the development of the times. However, in the process of the development of the industry, the start time of the new energy enterprises is relatively late, and there is no relatively perfect development concept and theory so there are still many shortcomings in the process of the development of the industry. Especially in the management of the logistics chain, because the scale of this industry is smaller than that of other industries, there are still many loopholes and deficiencies in the management of the logistics chain, which directly or indirectly affects the comprehensive level of new energy enterprises in China at a certain level [13]. Therefore, in the actual development and operation of new energy enterprises, how to manage the new energy industry chain logistics, find out the shortcomings of, and evaluate the operation efficiency of the whole logistics chain has gradually become one of the important issues to solve in today's era of the new energy industry. In the development of a new energy industry, through continuous improvement and optimization of the logistics industry chain, the actual needs of customers can be more clearly understood so as to provide the development strategy for the future development of the enterprise planning and then provide the theoretical basis for the progress of the whole industry and the promotion of the economic level [14].

Based on a clear understanding of the relevant theories, in this study, a new energy enterprise was taken as an example [15]. The manufacturer's relevant logistic chain operation pattern is shown in Figure 2 and Figure 3. The operation modes of different logistics chains were analyzed and discussed. Thus, based on determining the relatively perfect logistics chain, a theoretical reference for the further development of other industry chains and a scientific support for the comprehensive development of China's manufacturing industry and other industries were provided

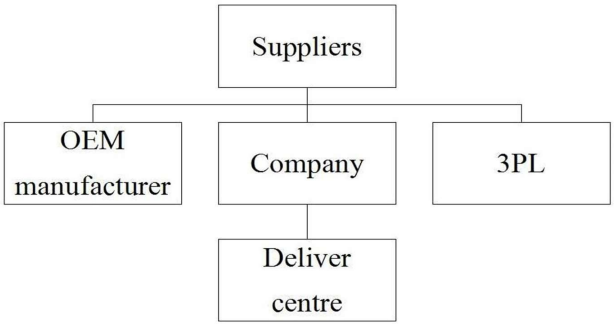

Figure 2. Operation model of the collaborative logistics chain of a new energy automobile company

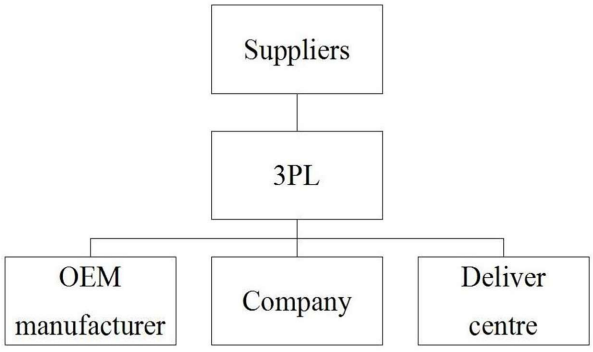

Figure 3. The traditional logistics chain operation model of a new energy automobile company

Using the time series model mentioned above, the validity of two different logistics chain management models was calculated. The results are shown in Table 2. The results show that the collaborative model of logistics chain management is better than the traditional model.

Logistics chain model	H1	H2	R1	R2	R = R1 + R2
collaborative	3.722	2.156	0.219	0.281	0.500
Tradition	3.626	2.000	0.139	0.333	0.472

Table 2. Comparison and Analysis of Effectiveness of Different Logistics Chain Models

Then, using the relevant algorithms, the coordination of the new energy enterprises and the traditional logistics chain management model was optimized and coordinated. The results are shown in Table 3. As can be seen from Table 3, the execution cost of the collaborative logistics chain operation model was relatively low, and the total time of its completion was relatively short.

	Collaborative α=0.7,β=0.3	Traditional α=0.4,β=0.6
Execution sequence	(3,4,2,3,1,2,3,1,4,2,1,4)	(2,3,2,1,2,3,1,4,3,1,4,4)
Execution mode	(1,3,5,4,2,1,5,2,6,3,1,6)	(5,1,3,2,3,6,4,2,5,2,4,1)
Start time	(4,6,14,14,16,18,20,22,24,26,28)	(2,4,6,8,12,14,16,16,20,22,30,38)
Execution cost	264(44+60+80+80)	280(52+76+80+72)
Execution time	92(14+20+34+24)	112(22+32+34+24)

Table 3. Decision Coordination Results of Different Logistics Chain Models

Finally, the evaluation index value of each logistics chain in the operation process of the new energy enterprise in 2016 was calculated. The results are shown in table 4. The results show that different modes of logistics link have a certain impact on the operation of the whole new energy enterprise. Compared with the traditional logistics chain, logistics chain synergy can reduce the order completion effect, cost, and production cycle of the product to a certain extent and can ultimately improve product efficiency. Therefore, a collaborative logistics chain has better management efficiency than a traditional logistics chain.

Measurement index	Collaborative logistics chain	Traditional logistics chain
Order fulfillment rate	0.65	0.35
Order fulfillment lead time	0.23	0.38
Upstream supply chain flexibility	0.88	0.83
Upstream supply chain adaptability	0.68	0.45
Downstream supply chain adaptation	0.84	0.78
Cost of goods sold	0.31	0.49
Total cost of supply chain management	0.45	0.68
Cash flow time	0.02	0.03
Return on SC fixed asset	0.15	0.17
Operating assets return	0.91	0.

Table 4. Operation Effects of Different Model Logistics Chains

5. Conclusion

With the development of the times, the world's economic level has greatly improved. Under this trend, the manufacturing industry has become an important pillar industry in the development of

the world economy gradually, which not only brought important economic benefits for the countries and regions in the world at the same time but also solved the problem of human resource allocation. As a new type of manufacturing industry in the development of the times, new energy enterprises have an important influence on the sustainable development of the economy and thus have gradually become the mainstream industry in the development of the times. As an important link in the development of manufacturing enterprises, supply chain logistics plays a decisive role in the cost and profit of enterprises. However, due to the late start of the new energy enterprises, there is no relatively systematic logistics chain management model, thus indirectly affecting its development. Because of this situation, the related theories of the logistics chain were summarized in this paper. A new energy enterprise was taken as an example, and the model of a collaborative logistics chain was compared with the traditional one. It is considered that the logistics chain has a positive impetus to the development of the enterprise, and the collaborative logistics chain is better than the traditional logistics chain. The theory involved in the research is still scarce, and there are some defects, but it can still provide a reference for the improvement of the logistics chain.

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