DOI: 10.23977/socsam.2023.040304
ISSN 2523-5796 Vol. 4 Num. 3

Influencing Factors and Evaluation of Medical Supplies Supply Chain Resilience under the COVID-19 Epidemic

Zhiwen Zeng, Liuqian Xi*, Xiaocui Liu

School of Management, Hunan University of Technology and Business, No. 569 Yuelu Avenue, Changsha, China
**Corresponding author*

Keywords: COVID-19, supply chain resilience, medical supplies, ISM model, entropy weight method, TOPSIS method

Abstract: In the face of the sudden COVID-19 and a series of uncertain risks such as supply chain disruption and cash flow disruption, the establishment of a highly resilient supply chain has become an important means for enterprises to smoothly overcome operational difficulties and achieve sustainable development. This paper constructs an indicator system of influencing factors of medical supplies supply chain resilience from six dimensions prediction ability, response-ability, plan ability, recovery ability, adaptability, and development ability. ISM model is used to analyze the structure of influencing factors of enterprise supply chain resilience, and entropy weight TOPSIS method is used to evaluate the medical supplies supply chain resilience under the COVID-19 epidemic, and good results of resilience are obtained. In response to the weaknesses of the supply chain system exposed by the epidemic, development suggestions are proposed to achieve a reasonable restructuring of the supply chain crisis response system.

1. Introduction

Under the impact of COVID-19, many problems have emerged in China's medical supplies supply chain. There are risks such as shortage of raw materials and low inventory, which seriously threaten the safety of people's lives. At the same time, it reflects the weakness of the current supply chain system, which is more flexible but less flexible and resilient. Only by ensuring the smoothness of medical supplies to the maximum extent can we effectively face the impact of emergencies [1]. A highly resilient supply chain can reduce the risk of supply disruption for medical supplies enterprises, help them overcome difficulties, and achieve high-quality operation and sustainable development. Therefore, based on the urgent need for a highly resilient supply chain for medical supplies, this paper intends to analyze the structure of the influencing factors of the resilience of the medical supplies supply chain through the ISM model and evaluate the resilience of the medical supplies supply chain under the COVID-19 epidemic through the entropy weight TOPSIS method combined with the specific enterprise supply chain, to provide accurate and effective strategies for improving the resilience of the medical supplies supply chain.

2. Literature Review

2.1. Supply Chain Resilience

Regarding the definition of supply chain resilience, Liu Xiangli [2] stated that the so-called "supply chain" refers to the entire process from product planning and development to purchasing raw materials and parts for product production, product inventory management, product transportation, and product sales and consumption, which is also a supply chain that delivers products to end-users. Supply chain resilience refers to the ability to flexibly respond to new crises. Wang Chuanlei, Niu Chuanqiong, Jian Huiling, et al. [3] believe that supply chain resilience should refer to the ability to respond to shocks and disturbances using empirical prediction and analysis of previous shock data when disasters occur without changing the existing state of the supply chain system. Feng Kui [4] has some different definitions of supply chain resilience. He believes that a resilient supply chain can maintain the normal operation of the supply chain in the event of a disaster by quickly using pre-prepared plans or using temporary emergency measures. Zhao Ailing [5] pointed out that according to the statement of the Ministry of Economy and Industry, supply chain resilience can ensure the ability of national life and industrial material supply not to be interrupted in the face of disruption shocks. Liao Han, Hu Xiaolei, and Liu Suqian [6] all believe that a resilient supply chain should be easier to recover from fractures, that is, it should not only be able to resist risks when the supply chain is impacted but also be able to quickly and flexibly adjust the mode and quickly restore the original state or better state after the risks have caused certain fracture effects on the supply chain. This article believes that the so-called supply chain resilience refers to the ability of the supply chain to quickly recover to the starting state or adjust to a more ideal state after being impacted and interrupted, as well as the ability to prevent and respond to the possibility of the next interruption.

2.2. Research on the Construction of Factors Affecting Supply Chain Resilience

Wang Chuanlei, Niu Chuanqiong, et al. [3] have constructed a corresponding evaluation index system by evaluating and analyzing the influencing factors of resilient supply chains in the four dimensions of supply chain forecasting capability, risk forecasting, partner cooperation, and information sharing. The final result determines that resilient supply chains can play an important role when the supply chain system faces risks. Zhu Lei, Chen Jingyi, and Yuan Qingfeng [7] showed that using the ISM method to analyze the influencing factors that affect the resilience of the construction supply chain, it was concluded that the design unit, the level of supply chain information sharing, and the transportation capacity of logistics enterprises are the key influencing factors that affect the resilience of the construction supply chain. Only improving the key factors can directly improve the resilience of the supply chain. Fan Xuemei and Lu Mengyuan [8] believe that building a resilient supply chain plays a crucial role in preventing and responding to the "Black Swan" incident and the bullwhip effect. They constructed a supply chain resilience evaluation index system with five dimensions (prediction ability, adaptability, responsiveness, resilience, and learning ability), analyzed the hierarchical structure of the factors affecting the enterprise's resilience supply chain using the ISM model analysis method, and used the entropy weight TOPSIS method to calculate the enterprise's specific resilience indicators. After evaluating the supply chain resilience of automotive enterprises, they proposed improvement strategies. Zhu Xinqiu [9] adopted the ISM method to identify eleven main toughness factors that affect suppliers through classification and identification and divided them into three levels: target layer, intermediate layer, and base layer. Among them, the intermediate layer, which directly affects the toughness of suppliers, is the most important factor, and among them, there is a relationship of mutual influence and restriction among various influencing factors.

3. Construction and Structural Analysis of the Indicator System for Influencing Factors of the Resilience of the Medical Supplies Supply Chain

3.1. Construction of an Indicator System for Influencing Factors of Medical Supplies Supply Chain Resilience

The basic data indicators for constructing the supply chain resilience indicator system are derived from 18 documents related to the medical supplies supply chain and supply chain resilience searched from databases such as China HowNet and Web of Science using the literature analysis method. By combining the concept definition, era background, and expert supplementation of supply chain resilience, this article believes that the influencing factors of supply chain resilience are mainly divided into 6 primary indicators and 15 secondary indicators.

The first indicator dimension is the prediction ability of the supply chain. It mainly includes demand forecasting and supply chain visibility. Demand forecasting mainly forecasts supply demand, procurement capital demand, and factory production capacity. Quantitative data can be the ratio of predicted demand to actual demand. Supply chain visibility is the sharing of data achieved by visual information systems based on different terminal docking methods and advanced technology equipment to achieve control over the entire enterprise's supply chain operation process and thereby reduce the possibility of supply chain disruption.

The second indicator dimension is supply chain reactivity. Supply chain responsiveness refers to the ability of a supply chain to respond to sudden shocks as quickly as possible. It mainly includes three aspects of supply chain flexibility, agility, and synergy. Supply chain flexibility and agility refer to the ability of the supply chain to flexibly adjust in the face of environmental changes, respond to risks quickly, and reduce losses. Collaborative cooperation ability refers to the ability to coordinate and cooperate through supply nodes such as suppliers, manufacturers, distributors, and consumers, achieve mutual benefit and win-win results, and share risks to achieve common goals and maximize their respective interests.

The third first-level indicator is supply chain planning capability. A plan is a preparatory plan, which mainly refers to the ability to plan and provide alternative solutions to potential or potential unexpected events based on evaluation and analysis. It mainly includes the ability to prepare product substitutes, multi-functional production flexibility, and the ability of partners to assist.

The fourth first-level indicator is supply chain recoverability. The resilience is mainly supported by financial strength and logistics. In addition, the supply chain structure and delivery capacity are also important aspects, which play an important supporting role in the faster recovery of enterprises.

The fifth first-level indicator is supply chain adaptability. Redundant facilities or production arrangements with redundant capabilities, as well as multiple products, are crucial for diversifying supply chain risks. At the same time, due to the existence of outsourcing and outsourcing in various aspects of the company's supply chain, it can more effectively respond to the impact of uncertain risks, and also help the company pay more attention to the cultivation and development of the company's technological core capabilities.

The sixth level indicator is supply chain development capability. Development ability is the ultimate direction of resilience, and a highly resilient enterprise will always recover better than before after responding to shocks. The development ability mainly manifests in the enterprise's ability to learn and acquire knowledge, the exploitable market space, and the product innovation ability. The specific content is shown in Table 1 below.

Table 1: Index Table of Factors Affecting Supply Chain Resilience

Primary indicator	Secondary indicators	Indicator Type	Quantitative methods
Prediction ability A1	Demand Forecast Accuracy [2-3] A11	+	Forecast order quantity/total order quantity
	Supply Chain Visibility [3] A12	+	Transportation real-time tracking rate
Reactivity A2	Flexible [8] A21	-	Lead Time
	Agility [2-4] A22	+	Production and sales speed
	Logistics Support Collaboration [10] A23	+	On-time arrival rate of orders
Plan capability A3	Standby capability [4] A31	+	Multifunctional work and multi-functional pipeline quantity
Recoverability A4	Financial strength [11-12] A41	+	Sales profit margin
	Supply Chain Structure [7-9] A43	+	Number of suppliers
	Inventory turnover rate [6] A44	+	Cost of goods sold/average inventory balance
Adaptability A5	Redundancy [5] A51	+	Maneuver resource ratio
	Product Diversity [13] A52	+	Product type and quantity
	Outsourcing and Outsourcing [13-14] A53	+	Proportion of outsourcing and outsourcing
Development capability A6	Learning acquisition ability [15] A61	+	Number of supply chain training and education
	Market Extension [16] A62	+	Market development rate
	Product Innovation [17] A63	+	Number of new product research and development

Note: Indicators are derived from literature collection and expert supplement

3.2. ISM Model Construction of Factors Affecting Supply Chain Resilience

The ISM interpretative structural model analysis method is generally divided into three steps, which are described in the following order:

Step 1: Create an adjacency matrix. Convert the conceptual system into an adjacency matrix, and provide the adjacency matrix by "establishing an ISM expert group, and the expert members of the group determine a directed relationship between elements.". This ISM expert group was proposed by Professor Warfield, the proponent of ISM. Let the range of values for the element A_{ij} in the adjacency matrix D be as follows:

$$A_{ij} = \begin{cases} 1, A_i \text{ has an effect on } A_j \\ 0, A_i \text{ has no effect on } A_j \end{cases} \tag{1}$$

Step 2: Construct a reachability matrix. Based on the first step of adjacency matrix or element-directed graph, use Boolean matrix operation rules to perform power operation to obtain a reachable matrix $E=(A+i)^{i}$ that satisfies $(A+i)^{i-1} \neq (A+i)^{i+1}=(A+i)^{i}$, and I is the identity matrix.

Step 3: Hierarchical structure division of influencing factors. According to the solution results of the reachability matrix, the hierarchical levels of each factor are divided and ranked.

Step 4: Graphically draw the hierarchical structure of the supply chain resilience model based on the hierarchical ranking results obtained in Step 3.

4. Construction of Supply Chain Resilience Evaluation Model Based on Entropy Weight-TOPSIS

4.1. Determination of Index Weight Using Entropy Weight Method

The entropy weight method is an objective weighting method. The indicator evaluation system determines the weight by calculating the "entropy" of the indicators. Its principle is to determine the weight of each indicator based on the degree of difference in the initial value of each indicator to obtain a comprehensive index for evaluation. Its main calculation steps are as follows:

(1) Construct the original indicator data matrix and normalize it. That is, the original data matrix composed of m evaluation objects and n evaluation indicators is $B=\{b_{ij}\}$. After normalization, the result will be $C=\{c_{ij}\}$. Indicators are also divided into positive indicators P and negative indicators N. The definitions of positive indicators and negative indicators are also very simple. The larger the indicator, the more beneficial it is, the positive indicator, and the opposite is the negative indicator. The specific normalization formula is as follows:

$$\text{Positive index:}C_{ij} = \frac{C_{ij} - \min\{C_{ij}\}}{\max\{C_{ij}\} - \min\{C_{ij}\}} \tag{2}$$

$$\text{Negative index:}C_{ij} = \frac{C_{ij} - \min\{C_{ij}\}}{\max\{C_{ij}\} - \min\{C_{ij}\}} \tag{3}$$

Note that if the normalized index has a value of 0, the matrix needs to be translated.

(2) Dimensionless processing. Namely, data is uniformly standardized for units, and the result of standardization is p_{ij}. The processing formula is as follows:

$$P_{ij} = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}}, i = 1,2,3,L,m;\ j = 1,2,3,L,n \tag{4}$$

(3) Calculate the entropy value e.

$$e_j = -\frac{1}{\ln m}\sum_{i=1}^{m} P_{ij} \ln P_{ij}, i = 1,2,L,m;\ j = 1,2,L,n \tag{5}$$

(4) Calculate the weight of W.

$$W_{ij} = \frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)}, j = 1,2,3,k,n \tag{6}$$

4.2. TOPSIS Model Construction

The TOPSIS analysis method is based on the weight ratio obtained by the entropy weight method by detecting the distance value between the positive ideal solution and the negative ideal solution of the evaluation system object to perform the ranking evaluation.

(1) Calculate the positive ideal solution c+and the negative ideal solution c^-, that is, define the maximum and minimum values of the matrix $C=\{c_{ij}\}$.

$$C^+ = \{C_1^+, C_2^+, K, C_n^+\} = \{\max c_{ij} \mid j = 1,2,...,n\} \tag{7}$$

$$C^- = \{C_1^-, C_2^-, K, C_n^-\} = \{\max c_{ij} \mid j = 1, 2, ..., n\} \tag{8}$$

(2) Calculate the Euclidean distance. That is, the Euclidean distance between the positive ideal solution d^+ and the negative ideal solution d^-, whose calculation formula is as follows.

$$d_i^+ = \sqrt{\sum_{i=1}^{n} (c^+ - c_{ij})^2}, i = 1, 2, K, m, j = 1, 2, K, n \tag{9}$$

$$d_i^- = \sqrt{\sum_{i=1}^{n} (c^- - c_{ij})^2}, i = 1, 2, K, m, j = 1, 2, K, n \tag{10}$$

(3) Find the approximate value g. The closer the approximation value g is to 1, the closer it is to the ideal solution, which means that its performance is better. On the contrary, it is worse. The calculation formula is as follows:

$$g_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{11}$$

5. Empirical Research

This article conducts empirical research with the help of Q Medical Supplies Enterprise (hereinafter referred to as Q Enterprise) and evaluates its supply chain resilience using the model constructed in the previous article. Enterprise Q is mainly engaged in the research, development, production, and sales of cotton products. It is a leading health enterprise in various fields, including medical and health care, personal care, home care, maternal and infant care, and home textile clothing. It is also a benchmark enterprise in the medical consumables industry in China. In 2023, Enterprise Q has passed the most difficult period affected by the epidemic with safety and development, and its achievements to the present are inseparable from its supply chain management level.

The specific evaluation steps are as follows: (1) Invite three enterprise supply chain managers with more than 5 years of experience, as well as two scholars with bachelor's degrees or above, to evaluate the direct impact of the relationship between the various factors affecting supply chain resilience, and summarize the scoring table on an average to obtain the vector relationship between the factors. (2) By using the ISM model to analyze the hierarchical level of factors affecting supply chain resilience, the direct factors, deep factors, and indirect factors that affect supply chain resilience are finally obtained. (3) Referring to the ISM model, the entropy weight method is used to calculate the proportion of Q enterprise's supply chain resilience. (4) Evaluate the resilience of the supply chain of Enterprise Q based on the calculated resilience score, analyze its short shift factors during repeated conflicts, and propose improvement strategies for their shortcomings.

5.1. ISM Analysis of Factors Affecting Supply Chain Resilience of Enterprise Q

(1) Based on the indicators in Table 1, five experts conducted a correlation discussion and scoring on the indicators of medical supplies supply chain resilience and its influencing factors. After averaging the data stored by the experts, an adjacency matrix was finally determined, as shown in Table 2. Element A represents supply chain resilience, and elements A1, A2, A3, A4, A5, and A6 are the first-level indicators in Table 1 in order of prediction ability, contingency ability, responsiveness, resilience, adaptability, and development ability.

Table 2: Adjacency Matrix

	A	A1	A2	A3	A4	A5	A6
A	0	0	0	0	0	0	0
A1	0	0	0	1	0	0	0
A2	1	0	0	0	0	0	0
A3	0	0	1	0	0	0	0
A4	1	0	0	0	0	0	0
A5	0	0	0	0	1	0	0
A6	1	0	0	0	0	0	0

(2) The initial reachability matrix can be obtained from the directed graph of element relationships, as shown in Table 3. The data calculation is mainly performed using the Spssau tool. The number in the reachability matrix indicates that "one element" will directly reach "another element" after passing through various paths. The number 1 in the reachability matrix indicates that there is a path between one element and another element, and the number 0 indicates that there is no path between one element and another element.

Table 3: Reachability Matrix

	A	A1	A2	A3	A4	A5	A6
A	1	0	0	0	0	0	0
A1	1	1	1	1	0	0	0
A2	1	0	1	0	0	0	0
A3	1	0	1	1	0	0	0
A4	1	0	0	0	1	0	0
A5	1	0	0	0	1	1	0
A6	1	0	0	0	1	0	1

(3) According to the solution results of the reachability matrix, different levels of supply chain toughness influencing factors are divided and ranked. A factor intersection table is available, as shown in Table 4.

Table 4: Factor Intersection Table

	Reachable set R	Antecedent set Q	Intersection A=R} Q
A	A	A,A1,A2,A3,A4,A5,A6	A
A1	A1,A2,A3	A1	A1
A2	A,A2	A,A2,A3	A2
A3	A,A2,A3	A1,A3	A3
A4	A,	A4,A5,A6	A4
A5	A,A4,A5	A5	A5
A6	A,A4,A5,A6	A6	A6

The specific hierarchical method is to observe whether the reachable set and intersection set of various factors is equal. If they are equal, it indicates that they are at the same level. As shown in Table 4, only the reachable set and intersection set of A in A-A6 are equal to A. Therefore, the first level is A, which is supply chain toughness. Remove the rows in the first level, and then remove the reachable set of subsequent A1-A6 and the A set in the previous set to retain other sets. Then, making the above judgment, It can be concluded that the second level is A2, and A4 refers to reactivity and recoverability By pushing back in order, the third level is A3, A5 (plan capability and adaptability), and the fourth level is A1, A6 (prediction ability and development ability). The details are shown in Table 5 below.

Table 5: Hierarchy Table

Hierarchy	Set S	Reachable set R	Antecedent set Q	Intersection A=R} Q	Hierarchy Set
The first floor	A	A	A,A1,A2,A3,A4,A5,A6	A	A
	A1	A1,A2,A3	A1	A1	
	A2	A,A2	A,A2,A3	A2	
	A3	A,A2,A3	A1,A3	A3	
	A4	A,A4	A4,A5,A6	A4	
	A5	A,A4,A5	A5,A6	A5	
	A6	A,A4,A5,A6	A6	A6	
The second floor	A1	A1,A2,A3	A1	A1	A2,A4
	A2	A2	A2,A3	A2	
	A3	A2,A3	A1,A3	A3	
	A4	A4	A4,A5,A6	A4	
	A5	A4,A5	A5,A6	A5	
	A6	A4,A5,A6	A6	A6	
The third floor	A1	A1,A3	A1	A1	A3,A5
	A3	A3	A1,A3	A3	
	A5	A5	A5,A6	A5	
	A6	A5,A6	A6	A6	
The fourth floor	A1	A1	A1	A1	A1,A6
	A6	A6	A6	A6	

(4) ISM interpretative structural model

The graph can most intuitively see the hierarchical structure of the system, transforming the hierarchical division table in Table 5 into a hierarchical explanation structure model diagram, as shown in Figure 1. From the figure, it can be intuitively seen that reactivity(A2) and recoverability(A4) are the most direct factors that affect supply chain resilience(A), while prediction ability (A1) and developmental capability (A6) are the underlying factors of supply chain resilience, namely, deep factors, while plan capability (A3) and adaptability (A5) are intermediate contributing factors, It is to promote the rapid recovery and response of the supply chain based on its predictive and developmental capabilities, thereby indirectly achieving the goal of improving the resilience of the supply chain.

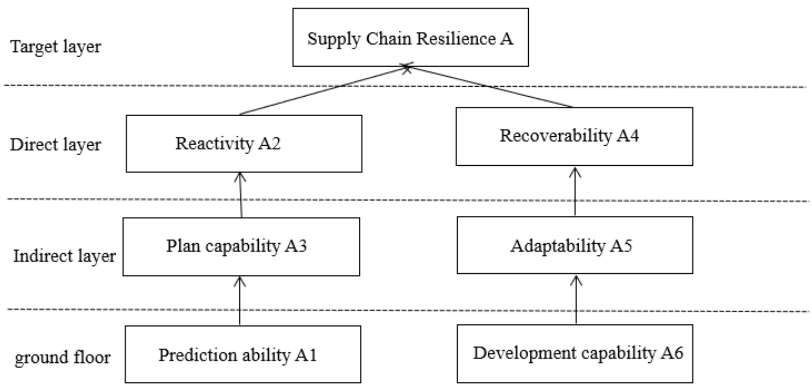

Figure 1: Explains the structural model

5.2. Construction of Q Enterprise Supply Chain Resilience Evaluation Model Based on Entropy Weight-TOPSIS

5.2.1. Index Weight Calculation

Table 5: Original Data Table

	A11	A12	A21	A22	A23	A31	A41	A42	A43	A51	A52	A53	A61	A62
January	0.864	0.966	2.182	0.856	0.806	30	0.694	109	0.863	0.388	456	0.337	2	0.423
February	0.899	0.957	2.301	0.85	0.831	33	0.712	115	0.977	0.342	457	0.275	2	0.45
March	0.779	0.948	3.927	0.961	0.714	33	0.598	117	1.164	0.721	459	0.431	1.001	0.531

Table 6: Index Weight Table

Primary indicator	Weight	Secondary indicators	Weight
Prediction ability	0.117	Accuracy of demand forecast	0.056
		supply chain visibility	0.061
Reactivity	0.227	flexibility	0.054
		Collaboration rate	0.119
		Agility	0.055
Plan capability	0.054	Backup capability	0.054
Recoverability	0.227	Financial strength	0.104
		Complexity of supply chain structure	0.055
		Inventory turnover rate	0.068
Adaptability	0.188	redundancy	0.05
		Product Diversity	0.071
		Proportion of outsourcing and outsourcing	0.066
Development capability	0.187	Learning acquisition ability	0.054
		Market extension	0.079
		Product innovation	0.054

The impact of various influencing factors on the resilience of the medical supply chain obtained through the ISM model provides a reference for subsequent weight calculation. This article selects actual data from Q Company's demand forecast accuracy, real-time transportation tracking rate, average delivery cycle, production and sales speed, delivery completion rate, multi-functional production and multi-functional assembly line volume, sales profit margin, supplier quantity, inventory turnover rate, the utilization rate of mobile resources, product types, and quantity, the proportion of outsourcing and outsourcing, supply chain training and education frequency, market share, etc. from January to March 2022 as the original matrix data, and the specified data is shown in Table 5. The steps and formulas of the entropy weight TOPSIS method were applied for calculation, and the final weight ratios calculated are shown in Table 6. The difference in the weight proportion obtained from it and the degree of influence obtained from the ISM interpretive structural model is not significant.

5.2.2. Q Enterprise Supply Chain Resilience Evaluation

The calculated approximate value table, namely the supply chain toughness evaluation table of Enterprise Q, is shown in Table 7.

Table 7: Q Enterprise Supply Chain Resilience Evaluation Form

Evaluation object	Positive ideal solution distance D+	Negative ideal solution distance D-	Relative proximity C
January	0.234	0.134	0.364
February	0.129	0.247	0.657
March	0.138	0.247	0.642

In the entropy weight TOPSIS method, when the evaluation solution object is positive, the closer its optimal value is to the number 1, the better the evaluation object is. On the contrary, when it is a negative object, the farther away it is from the number 1, the better. In this article, toughness is a positive object for supply chain development, that is, 1 is the optimal value of enterprise toughness. When the relative degree of toughness c is closer to the number 1, the better the supply chain toughness of the enterprise is. From the data in the supply chain resilience evaluation table of Enterprise Q, it seems that the level of resilience is not high, but the evaluation results based on the data without combining the actual situation are not accurate enough.

From Table 7, it can be seen that the resilience level of Enterprise Q was the lowest in January 2022, with a relative approximation value of only 0.364. The main reason is that the epidemic broke out in multiple points and small areas before the year. As of January 31, there were 6 high-risk areas, 52 medium and high-risk areas, and many regions of the country were in a state of blockade. The protective materials of the enterprise could not be delivered or incurred detention fees during the delivery process, as well as the procurement services and logistics transportation of goods was restricted, Making it difficult to predict link costs, coupled with the lack of raw materials in factories, a series of issues have led to a decline in the competitiveness of enterprises. In February 2022, the resilience level of Enterprise Q's supply chain reached a maximum of 0.657, with a linear increase compared to January. The resilience level in February 2022 was very close and reached a moderate or higher level. After the beginning of February 2022, the epidemic in Shenzhen eased somewhat, and by March, the epidemic began to recur again. However, although the resilience of Q Enterprise has declined compared to February, it has not fluctuated significantly. The main reason is the particularity of medical supplies enterprises in the context of the epidemic, its supply chain demand is relatively strong, and the enterprise has made emergency control adjustments in logistics. It understands how to consolidate and develop the collaborative ability between supply chain partners, Due to the high complexity of the structure of its suppliers, when the epidemic suddenly strikes, Enterprise Q can quickly seize the opportunity to react despite being temporarily affected and impacted by its resilience. Finally, combining the evaluation data with the actual background situation, it can be concluded that although the supply chain of Enterprise Q is not highly resilient, its resilience level is developing, and it can be rated as a medium resilient supply chain. Achieve an excellent level of resilience, Enterprise Q still has a way to go in terms of supply chain resilience, which also indicates that there is still considerable room for improvement in Enterprise Q's supply chain resilience.

6. Countermeasures and Suggestions

In summary, the impact and impact of the epidemic on the medical supplies supply chain is limited, and its main impact focuses on the short-term detention of dynamic logistics and the rise in human and material prices. For example, medical supplies orders are blocked during detention due to the impact of closures, and cannot be delivered to customers. The shortage of medical supplies leads to a rise in raw material prices, as well as operational impacts such as the suspension and resumption of work due to the closure and detention policy. Enterprise Q's supply chain resilience benefits from both the impact of the epidemic and the promotion of the epidemic policy and demand. Therefore, as long as the level of impact of various influencing factors on the supply chain resilience of medical supplies and the actual supply chain situation of Enterprise Q are combined, experience is summarized, a reasonable layout of the enterprise's supply chain is carried out, and an emergency response system is established, which can effectively improve the enterprise's supply chain resilience, It can achieve the goal of preventing the impact of supply chain disruption from developing to a better state.

6.1. Plan Ahead and Strengthen Risk Prediction and Demand Prediction Capabilities

Enterprises' ability to improve risk prediction can be divided into three aspects. (1) Take risk management and control measures, develop flexible contingency plans, collect short-term corporate and social risk dynamics, master demand and wind trends, and develop plans to respond to demand. (2) In the medium term, the main focus of risk demand should be on balancing supply and demand, reducing fluctuations caused by risks by increasing safety stocks and buffer stocks, and ensuring the safety of key raw materials required by factories under force majeure. (3) In long-term demand forecasting, it is necessary to monitor the distribution of dynamic demand indicators to establish a set of critical indicators that deviate from the normal level. When a certain critical indicator is exceeded, it is an early warning response signal for the onset of a crisis. Based on experience, various emergency scenarios are substituted to develop forward-looking and feasible emergency plans for different emergencies, providing a rapid response time for the supply chain operation management team to achieve benign and efficient forecasting.

6.2. Stabilize and Strengthen Your Own Recovery and Responsiveness

The most influential factor in supply chain responsiveness is the synergy rate of the supply chain. It is based on the enterprise itself that it should continue to establish strategic partnerships, form a shared profit cake with more suppliers in the supply chain, enhance the complexity of the supply chain structure, diversify risks, and achieve a win-win situation in which both parties share risks and achieve mutual benefit. In the implementation of specific strategies, enterprises can document the capabilities of existing partner suppliers, and develop multi-level and multi-regional partner suppliers, outsourcing suppliers, and third-party logistics suppliers to cooperate. Determine the production plan, regularly review the secondary and tertiary partner suppliers, ensure that they can supply the components and materials they need at any time, establish sustainable business development, and ensure a balance between supply and demand.

6.3. Keeping Pace with the Times and Improving the Adaptability of the Enterprise's Supply Chain

Through the development of learning technology, create intelligent supply chains, thereby further improving the adaptability of enterprise supply chains. (1) In terms of learning, appropriately increase supply chain education and training as well as supply chain management lectures and meetings to deepen members' theoretical understanding of the supply chain and promote knowledge sharing among members. (2) Using new technologies such as the Internet of Things and cloud computing, as well as advanced theories, methods, and skills in modern supply chain management, a comprehensive integrated system of intelligent, digital, visual, automated, and networked modern information technology and management systems has been formed within and across companies and industries, as well as between various ports and links in the supply chain. Enterprises achieve more visual supply chain links through end-to-end traceability, thereby providing support for predictive monitoring. (3)

In product innovation, encourage the development of new products and preemptive strategies. It is necessary to carry out appropriate industrial cooperation, personnel outsourcing, and collaborative manufacturing, strengthen the optimal allocation of resources, achieve the technological growth effect of enterprises, and build a high-quality industrial cluster of medical supplies. (4) In the process of selecting suppliers, it is necessary to carefully evaluate their production capacity and safety, and make adequate preparations for obstacles such as insufficient raw materials and production progress that cannot be resisted.

7. Conclusion

Based on the urgent need for a high toughness supply chain for medical supplies, combining qualitative and quantitative methods, using the ISM model to construct a hierarchical graph of the direct, indirect, and deep influencing factors of supply chain toughness for Q medical supplies enterprises. The entropy weight TOPSIS method is used to weigh the indicators by referring to the impact degree of various factors obtained from ISM on toughness, and the toughness of Q enterprises is evaluated based on the comprehensive evaluation index obtained. The following conclusions are obtained:

(1) Resilience is a newly emerging term in recent years, with different definitions of its connotation in different fields. This article defines supply chain resilience as the ability to quickly recover to its initial state or adjust to a more ideal state after a supply chain is impacted and interrupted, as well as the ability to prevent and respond to the possibility of the next interruption.

(2) After literature analysis and expert summary, six first-level indicators and 15 second-level indicators that affect the resilience of the medical supply chain were obtained, providing a reference for the construction of the evaluation index system for the resilience of the medical supply chain.

(3) After analyzing and comparing the evaluation results from January to March, it is found that the supply chain resilience of the enterprise is medium. Finally, strategies to improve supply chain resilience are identified based on the exposed weaknesses.

References

[1] Dong Ming. (2020) On the Supply Chain with Community of Human Destiny: Connotation, Mission and Framework. Supply Chain Management, 1 (05): 5-13.

[2] Liu Xiangli. (2021) Enhancing the Resilience of the Supply Chain: The Introduction and Direction of Japanese Policy. Contemporary Economy of Japan, (06): 1-14.

[3] Wang Chuanlei, Niu Chuanqiong, Jian Huiling, Li Congchun. (2021) Single-handedly or Side by Side? Journal of Shandong Technology and Business University, (05): 70-78.

[4] Feng Kui (2020) Fully considers trends and risks to enhance the resilience of global supply chains. China Business Daily, A11

[5] Zhao Ailing. (2021) The epidemic forces the pace of global supply chain restructuring to accelerate. China's Foreign Trade, (11): 62-63.

[6] Liao Han, Hu Xiaolei, Liu Suqian. (2021) Analysis of Chinese Supply Chain Resilience under Adverse External Shock. Enterprise Economics, 40 (10): 50-59.

[7] Zhu Lei, Chen Jingyi, Yuan Jingfeng. (2020) Research on Critical Factors Influencing the Resilience of Prefabricated Building Supply Chain Based on ISM. Journal of Civil Engineering and Management, 37 (05): 108-114.

[8] Fan Xuemei, Lu Mengyuan. (2020) Influencing Factors and Evaluation of Auto Companies' Supply Chain Resilience under the COVID-19. Journal of Industrial Technological Economics, 39 (10): 21-28.

[9] Zhu Xinqiu. (2010) Analysis of Supply Chain Resilience Influencing Factors Based on ISM. Value Engineering, (35): 45-46.

[10] Wang Minghua. (2020) Based on the analysis of influencing factors of supply chain elasticity of ISM steel enterprises. Journal of Liaoning Technical University (Social Science Edition), 22 (05): 368-374.

[11] Cai Yongmei, Li Xinying, Meng Lingwei. (2022) Evaluation and Demonstration of Regional Economic Resilience Based on Normal Cloud Model. Statistics & Decision, 38 (06): 55-59.

[12] Li Ligang, Zhang Pingyu, Tan Juntao, Guan Haoming. (2019) Review on the Evolution of The Resilience Concept

And Research Progress On Regional Economic Resilience. Human Geography, 34 (02): 1-7+151.
[13] Zhu Xinqiu. (2010) Analysis of Supply Chain Resilience Influencing Factors Based on ISM. Value Engineering, (35): 45-46.
[14] Ruiz-Ben íez R, L ópez C, Real J C. (2018) The lean and resilient management of the supply chain and its impact on performance. International Journal of Production Economics, 203: 190-202.
[15] Lv Yimiao, Shi Zhaoying, Ning Pengfei. (2022) Analysis of Factors Affecting Supply Chain Resilience Based on SWARA. China Market, (10): 167-170.
[16] Xu Wenping, Zhang Yuwan. (2022) Resilience Evaluation of Cold Chain Supply Chain of Fresh Agricultural Products Based on Fuzzy ANP-TOPSIS. Logistics Sci-Tech, 45 (13): 136-141.
[17] Sun Huaping, (2020) Wei Wei.The Resilience and Operation Risk of China's Embeddedness into the Global Value Chain under the Background of the COVID-19 Pandemic. Review of Economic Research, (06): 91-98.