Research Review of Supply Chain Risk Communication

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Abstract: In recent years, due to the impact of the epidemic situation, the living environment of supply chain enterprises has become increasingly complex and the uncertainty has increased, and the possibility of supply chain enterprises facing risk threats has greatly increased. Therefore, in-depth understanding and control of risks have become the key direction of supply chain management at this stage. From the perspective of supply chain risk communication, this study defines the concept of supply chain risk, and then combs and analyzes the relevant literature of supply chain risk communication and risk immunization strategy. It is found that the research on risk communication in supply chain mainly involves three aspects: quantitative analysis of risk transmission, application of virus model and transmission of various risk types. Most of the studies on risk immunization strategies are viral immunization strategies based on network models, and some studies refer to biological immunization strategies. Finally, on the basis of existing research review, and put forward the future research direction, to provide reference for further research.

1. Introduction

Restricted by the increasingly complex international economic structure, the global economic development has been greatly affected. The fragmentation of industrial chain in various countries has also hindered the rapid development and integration of global supply chains. In order to find a way out, the supply chain is accelerating the transformation of digitalization and informatization, and reconstructing the industrial chain pattern. In the process of industrial chain reconstruction, enterprises will pay more attention to supply chain risks [1]. In the complex environment of the epidemic, the enterprise supply chain will be greatly affected. The interruption of a certain link in the operation process of procurement, production, transportation and sales will lead to the chain reaction of upstream and downstream enterprises in the supply chain, which will bring great impact on the security of the entire supply chain. In 2021, the ship, called the Ever Given, has caused an epic maritime traffic jam of nearly 300 ships between Europe and Asia. It leads to the stagnation of most global supply chains. The risk chain spreads to the global market, causing huge losses and even bankruptcy to relevant enterprises [2]. In order to ensure the safe operation of the supply chain, we need to improve the supply chain risk response mechanism and strengthen the supply chain risk management ability. Therefore, the study of supply chain risk management is more important in the current situation, and supply chain risk has gradually become the research focus of enterprises and

scholars.

In the past, most studies on supply chain risk focused on risk identification, risk assessment and other fields of supply chain, while there were relatively few studies on the propagation process and risk immunity after the occurrence of risk. From the perspective of supply chain risk communication, this study defines the concept of supply chain risk, and then systematically combs the research literature in the field of supply chain risk communication and risk immunity, grasps the specific mode and process of supply chain risk communication, and expounds different risk immunity strategies, so as to provide corresponding theoretical reference for enterprises to suppress risk communication. Finally, summarize the existing research results, put forward the future development direction of supply chain risk communication research, provide guidance for scholars' in-depth study.

2. Concept of Supply Chain Risk

Supply chain is a complex system consisting of a series of links from raw materials to molded products, which is centered on core enterprises and linked with surrounding enterprises through information flow, capital flow, logistics and other media [3]. In the ever-changing supply chain system, there is information asymmetry between node enterprises, and the coordination function between enterprises is carried out through loose cooperation. But there are also unknown, potential conflicts of interest, so risk inevitably rooted in the supply chain.

Risk management was originally produced in the US insurance industry, and insurance management is to manage the risks in the operation process. During this period, the idea of operational risk management also came into being [4]. Up to now, there are different views on the definition of supply chain risk: the first view holds that supply chain risk is caused by the vulnerability of the supply chain itself; the second view holds that risks are caused by unpredictable uncertainties; the last view is to define the source of supply chain risk [5]. Different scholars discuss and analyze from different angles, but the general point of view is consistent: Supply chain risk refers to the supply chain enterprises due to their own vulnerability, affected by uncertain factors in the process of operation, risk occurs and passes, resulting in the actual expectations and expectations of node enterprises deviation.

3. Research Progress of Supply Chain Risk Communication

The essence of risk communication is a transfer and diffusion phenomenon of risk between adjacent affiliated enterprises. Risks arise from a node in the supply chain and produce a 'chain reaction' that produces further risks throughout the network and has an amplified impact. Ritesh et al. (2018) called this network cascading phenomenon risk communication [6]. Risk spreads to the entire network and beyond, and the impact of flow along the connection node is defined as interrupt propagation [7]. Supply chain disruptions spread along the supply chain network in a way similar to the product life cycle [8]. At the same time, Jihee et al. (2016) found that this risk impact not only spread along supply delivery, but also could rebound on upstream supply chain networks due to the dependence of different stakeholders in the network [9].

3.1. Quantitative Analysis of Risk Communication

3.1.1. Quantitative Modeling Method

Scholars have tried to quantitatively model the supply chain enterprise network to study risk communication, and there are abundant analytical tools, including structural equation model,

dynamic copula model, CoVaR based on risk value. In addition, interrupt network analysis, agent-based modeling and system dynamics are also used to simulate and analyze risk propagation.

In terms of risk interruption network analysis, Ritesh et al. (2018), aiming at the long-term impact of multi-node multi-cycle interruption on supply chain network variables, constructed the overall quantitative method of Bayesian network model to predict the complex behavior of supply chain enterprises in risk communication, so as to improve supply chain risk management [10]. In terms of system dynamics, based on the theory of system dynamics, Jiang et al. (2019) constructed the risk contagion model from the perspective of risk management decision-making behavior of supply chain enterprises. Research shows that enterprises with different risk resistance have different control ability of risk contagion, and need to start risk control under different conditions [11]. Zhou et al. (2021) established the dynamic model of airworthiness certification risk propagation system, studied the complex propagation mechanism of airworthiness certification risk and proposed the optimal decision [12]. Huang et al. (2019) combined with system dynamics theory to build STELLA model to simulate and analyze the evolution trend of technology risk communication under government intervention [13]. Zhang et al. (2017) used the system dynamics model to simulate and analyze the risk propagation process of enterprise network. The results show that enterprises in the network show certain vulnerability and have limited risk self-regulation ability [14].

3.1.2. Network Model

With the in-depth study of interdisciplinary, the literature on the risk of supply chain enterprises based on network model has gradually increased, and many research results have been achieved. In terms of complex networks, Wu et al. (2021) constructed a two-tier transaction counterparty risk contagion network model. According to the comprehensive node degree study, it is found that there is a strong correlation between debts in non-financial enterprises [15]. Zhang et al. (2018) proposed a four-stage model to describe the cascade propagation process of risk in two interdependent R&D networks. The study found that when the tolerance parameter value exceeded the critical tolerance threshold, the cascade propagation risk could be completely prevented in the interdependent R&D networks [16]. Based on the modeling of various simulation methods, Deng et al. (2019) used Tropos target-risk framework to build a three-dimensional model of risk propagation in perishable product supply chain enterprises, which provides methodological support for studying the risk propagation mechanism of sustainable operation of perishable product supply chain enterprises [17]. Kim et al. (2019) developed a Bayesian network model based on risk propagation ontology to measure the dynamic risk propagation of supply chain fresh enterprises, and solved the problem of large-scale model construction [18].

3.2. Application of Risk Communication Virus Model

Scholars apply the virus propagation model to the network structure model to further analyze the mechanism of enterprise risk propagation. Based on the directed weighted network structure, Li et al. (2021) constructed the internal risk contagion model of enterprise group combined with SIRS model, and analyzed the risk transmission mechanism [19]. Based on the SI virus model, Fu et al. (2020) constructed the financial default risk propagation model of building materials supply chain. The research shows that the factors that have a greater impact on risk propagation are the ability of enterprises to resist risks and the number of default enterprises [20]. Based on the similarity between epidemic spreading and risk spreading, Liu et al. (2020) used UAU-SIS model to study the interaction between consciousness and risk spreading in R&D networks considering enterprise heterogeneity. The results can provide a basis for improving the robustness of dependent networks

under risk spreading [21]. Wu et al. (2018) proposed a new risk propagation model SIS-CA based on SIS model and CA model, which can better simulate the dynamic changes of risk propagation in real networks [22]. Tie et al. (2018) used BBV model to construct the technology risk propagation dynamics model of R&D network; The results showed that the technology risk can always propagate rapidly, but in the edge-weighted scale-free network, its propagation speed is relatively slow [23].

3.3. Different Types of Risk Communication

From the perspective of research risk types, the current research mainly focuses on the spread of corporate risk of systemic risk, debt risk, financial risk and credit risk. In terms of systemic risk, taking financial institutions as the research object, Wang (2021) used CCA model to analyze the influence of leverage ratio on systemic risk contagion mechanism. The increase of leverage ratio will promote the spread of systemic risk among national economic sectors [24]. Ren (2018) used CoVaR model to study the systemic risk contagion in the financial industry, and puts forward the focus on controlling the risk of the securities industry, followed by the banking and insurance industry [25]. In terms of debt risk, Cui et al. (2020) used the data of listed companies to study the contagion between different departments. The results show that the ability of listed companies to resist systemic risk is generally reduced, and most departments have a significant downward trend [26]. In terms of financial risk, Zheng (2020) deeply studied the construction of supply chain financial risk transmission control system to control the transmission ability of financial risk in the supply chain [27].

Research on the spread of corporate credit risk is relatively more concentrated in the field of financial enterprises. Qian et al. (2021) used the double-layer network topology to construct the enterprise credit risk contagion model, and studies the mechanism of the interaction of correlation on the credit risk contagion effect [28]. Liu (2019) studied the inhibitory effect of corporate social responsibility factors on credit risk contagion, and the results show that it can effectively inhibit the adverse effects of contagion process [29]. The study of default risk is mostly included in the credit risk. Li et al. (2021) innovatively introduced the achievements of engineering field to construct the default risk contagion model of accounts receivable pledge financing, paying attention to the dynamic and conductive characteristics of default risk [30].

4. Risk Immunization Strategy

At first, the application of immune strategy in epidemiology was proposed by researchers to alleviate or avoid the loss caused by viruses, hoping to block the transmission of viruses by immunizing some network members. Risk immunity in supply chain enterprises is to reduce or prevent risks by controlling and optimizing working procedures [31]. The application research of risk immunization strategy based on complex network theory has become an important research direction in the field of risk communication. Based on the characteristics of large number of nodes and complex relationship, it is difficult to achieve comprehensive immunization of complex networks, which takes long time and high cost. The typical immune strategies currently studied include random immunization, acquaintance immunization and target immunization.

Different types of complex networks have different immune effects. The random strategy randomly inoculated a certain number of nodes in the network, regardless of the degree of nodes, but it needed to inoculated 80%-100% of the nodes to control the propagation, and the efficiency was not high [32]. The acquaintance strategy also makes a random selection, but it lets the random neighbor of the selected node vaccinate. In the scale-free network, the larger the degree of the node is connected to more nodes, so the higher the centrality of the node is more likely to become the

neighbor of the randomly selected node [33]. Therefore, in scale-free networks, acquaintance strategy performs vaccination more effectively. RADU (2007) regarded target strategy as the most effective strategy [34]. In the target strategy, a few nodes with the largest degree have immunity, blocking the propagation path of the virus and reducing the possibility of outbreak.

In the study of the efficiency and effect of risk immunity under limited conditions, Hu et al. (2021) introduced the importance of network nodes and direct immunity rate to study the immune strategy of risk propagation model. The results show that the nodes with greater importance in the immune control network can better control the scale and rate of risk propagation of traffic congestion factors [35]. Luo et al. (2020) simulated the risk evolution network of building collapse accident based on immune theory, and used random immunization and target immunization strategy to immunize nodes according to node centrality index, and concluded that the target immunization strategy of degree centrality was the optimal immunization strategy [36].

5. Conclusion

This study discusses the concept of supply chain risk, expounds the research progress of supply chain risk communication from three aspects of quantitative analysis of risk communication, application of virus model and communication of various risk types, and reviews the risk immune strategy of risk communication. The main conclusions are as follows:

(1) Risk communication in supply chain. From the perspective of risk communication types, it involves systemic risk, debt risk, financial risk and credit risk. Among them, the study of credit risk accounts for the majority, and the study of operational risk of supply chain enterprises is rarely involved. Operational risk is very important for supply chain risk management, and more attention should be paid to this type of risk. From the perspective of research methods, research is based on a static or dynamic method, such as system dynamics, complex networks, virus propagation model. In future research, dynamic simulation and static simulation can be combined to study the corresponding characteristics of risk communication, which can better analyze the mechanism of supply chain risk propagation.

(2) The research on risk immunization strategy is basically based on the typical virus immunization strategy or the improvement strategy on this basis. Other scholars are based on biological immune point of view, such as immune algorithm, pathogen theory. These are based on the overall risk immunity, from the entire supply chain enterprise macro risk spread phenomenon to prevent or slow down the risk. Existing research lacks the control of risk factors within the supply chain enterprises. Future research directions need to focus on the micro level of supply chain risk, identify and analyze the factors affecting risk transmission, and solve risk problems.

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