Research on Supply Chain Risk Assessment Index System and Risk Countermeasures of Automobile Manufacturing Industry

Yan Chen, Yingjia Guo, and Songxian Liu[(✉)]

School of Economy and Management, Xiamen University of Technology, Xiamen, China
liusongxian@xmut.edu.cn

Abstract. The of automobile manufacturing industry supply chain (AMISC) is one of the most complex supply chain network systems in the world, and the accompanying supply chain risks will be more severe, so it is important to cope with and prevent the automobile manufacturing industry supply chain risks (AMISCR) and establish the research of its risk assessment index system. By combing the research results of existing literature and consulting experts in related fields, this study summarizes the endogenous risk sources faced by the AMSC as system risk, supply risk, information risk, financial risk and demand risk based on the typical structure of the AMSC. And on this basis, the indicators under each risk are analyzed in more detail, and targeted risk response strategies are proposed based on these indicators, in order to enrich the theoretical study of supply chain risk management in the automotive manufacturing industry.

Keywords: AMISCR · Index system research · Response strategy

1 Introduction

In the report of the 20th National Congress of the Communist Party of China, it was mentioned that "Efforts should be made to enhance the resilience and security of industrial and supply chains". This warns cross-border companies to take precautions in response to the increasing uncertainty factors and risks in the current international environment, especially the automotive manufacturing industry need to pay attention to such problems. Starting from the realistic complexity of the supply chain, advocates that today's corporate supply chain should establish a more resilient supply chain system with regard to the realistic scenarios of several unexpected problems occurring globally [1, 2].

By extension, the construction of a scientific and comprehensive risk target index system, the key risk factors that are likely to occur and more harmful can be identified to help managers grasp the risk information and make responses in advance [3]. Based on this, Yang Yang [4] categorized the sources of risk into three major aspects: internal risk, cross-border intermediate risk, and external risk, specific to the risk characteristics of cross-border supply chains. However, most literature divides the sources of risk into endogenous and external environmental risks. Endogenous risks include systemic risk

[3, 5], financial risk [4, 6], supply risk [10], logistics risk [11, 13], information risk [14], operational risk [12], and demand risk [8, 9]; while external environmental risks include natural risk, social risk, economic risk, and political risk. Because external environmental risk factors are difficult to control and influence artificially, some literature only constructs index systems for the endogenous risk of supply chains. Lei Xunping [7] constructed a risk index system of the automobile manufacturing supply chain covering seven aspects: demand, supply, logistics, information, technology, operation, and finance, as sources of risk. In summary, by incorporating the characteristics of the AMSC and its organizational structure, and combing through the supply chain risk research literature, this study aims to construct a supply chain risk assessment index system for the automotive manufacturing industry under five risk sources: systemic risk, supply risk, information risk, financial risk, and demand risk.

2   Typical Structural Features and Risk of the Supply Chain in the Automotive Manufacturing Industry

The AMSC is extensive, covering a sequence of processes such as raw material procurement, parts production, vehicle assembly, sales, and after-sales service. It represents a practical application of the organization model for supply chain and is considered one of the most complex and typical supply chain systems. The industry's stakeholders can further be divided into upstream, midstream, and downstream sectors. The upstream component encompasses raw material procurement and the production and configuration of auto parts, while the midstream is viewed as the critical component of the whole supply chain of vehicle manufacturing enterprises. The downstream component focuses on the industry of sales and after-sales services. As a result of coordinated capital flows, logistics, and information flows, automobiles are delivered to consumers. The cooperation of upstream suppliers, midstream production enterprises, and downstream sales enterprises results in an intelligent network.

Therefore, based on such a huge organizational network structure formed by the AMSC, the scope of the industry covered, the length of the chain, the scale of the ambassador AMSC has the following significant characteristics: First, the supply chain formed with the vehicle manufacturing enterprise as the core, so the risk response ability of the core enterprise is an important factor influencing the interests of upstream and downstream enterprises in the chain; second, when cooperating between enterprises in the chain, there is uncertainty in the sharing of information; third, the procurement, transportation, production and sales fields are worldwide, so the cultural differences, policy differences and market environment of foreign countries should be considered in the cross-border process.

3 Establishment of Supply Chain Risk Index System and Index Metrics for Automotive Manufacturing Industry

3.1 Establishment of Supply Chain Index System of Automobile Manufacturing Industry

According to the supply chain management theory, enabling the index system reflect comprehensively and measure the overall risk of the operation of the AMISC system, this study combines the characteristics of the AMISC, based on the existing research results on the index system of the supply chain risk, but considering the uncontrollability of the exogenous risk and the fact that there is no recognized index factor to measure the external environmental risk, this study only establishes the index system for the main endogenous risks in the AMISC. The study only establishes an indicator system for the main endogenous risks in the AMISC system, which are specifically divided into the following five categories: system risk, supply risk, information risk, financial risk and demand risk, where each risk source can continue to be refined into multiple sub variables. The final indicator system established in this study includes 5 indicators at the criterion level and 16 indicators at the indicator level. See Table 1.

3.2 Analysis of Supply Chain Index System of Automobile Manufacturing Industry

(1) System risk refers to the instability of the state of each node enterprise itself and the overall system connection of the supply chain. Wan Chundong [3] concluded that the system risk of supply chain is measured by the indicators of core business capability of major node enterprises, structural stability, and insufficient technological innovation capability of enterprises; Shu Tong [5] considered the system risk in three aspects: innovation input expenditure of core enterprises, number of suppliers and business capability of major node enterprises. Therefore, after summarizing the previous research results, this study decided to measure the system risk by three indicators: the number of suppliers of core enterprises, the reliability of node enterprises and the innovation efficiency of core enterprises.

(2) Supply risk is the risk caused by the damage, delay, and shortage of raw materials due to unexpected events. Lei Xunping [7] used the capabilities of suppliers of core enterprises as the entry point to design indicators to assess supply risk, specifically listed as suppliers': innovation capability, inventory level, delivery accuracy, production flexibility and product qualification; Yang Yang [4] reflected supply risk from product qualification rate, inventory adequacy rate and capacity shortage risk. This study decided to reflect the supply risk by the three indicators of supplier production efficiency, supplier delivery failure rate and supplier production flexibility in a comprehensive manner.

(3) Information risk refers to the fact that in the process of transmitting information between enterprises in the chain, omitted key contents, transmitted to the wrong target, and then the wrong information will be transmitted downward or upward with the nodes of the supply chain. Xue Weilian [10] conducted a study to assess the information risk of supply chain in the context of e-commerce, in which she

Table 1. Supply chain risk assessment index system of automobile manufacturing industry

Guideline layer	Indicator layer	Explanation of indicators
System Risk	Core Business Capabilities of Major Node Companies	Reflected by the production scale, product quality, service capability, technology level, market development capability, credibility, and collaboration spirit of member enterprises
	Number of suppliers	The smaller the number of suppliers to the core business, the more unstable the structure is and the greater the risk
	Enterprise technology innovation efficiency	Sales revenue of major node enterprises / R&D expenses of major node enterprises
Supply Risk	Supplier Productivity	Expected order demand / actual product production
	Supplier delivery failure rate	Number of unmet deliveries for the period/total number of deliveries for the period (where the meaning of "unmet deliveries" includes delayed delivery, insufficient quantity and low quality of products)
	Supplier production flexibility	Number of order changes not fully met / Number of user order changes in a given period
Information Risk	Bullwhip effect intensity	|Final order demand - actual market demand| / actual market demand
	Data storage and transmission failure level	A comprehensive index reflecting data storage insecurity, information transmission delay, information transmission incompleteness and error in the supply chain between node enterprises and each other
	Information technology and equipment major failure rate	Number of major IT and equipment failures in a given period
Financial Risk	Funds flow obstruction degree	Average accounts receivable balance/net sales revenue
	Final product cost increase ratio	|Product Actual Cost - Product Planned Cost|/Product Planned Cost
	Quick ratio of major node companies	Quick assets/current liabilities

Table 1. (*continued*)

Guideline layer	Indicator layer	Explanation of indicators
	Market share	The number of sales of a product of the company in a certain period / the total number of sales of the product in the market
Demand risk	Market demand forecast accuracy	1-(|Actual demand - Forecast demand|/Forecast demand)
	Demand fluctuation range	|Sales volume in the current period - sales volume in the previous period|/ sales volume of products in the previous period
	Key customer churn rate	Number of key customer churn / Total number before churn

    expressed the risk of information uncertainty in terms of two indicators: node information uncertainty and shared information uncertainty. In this study, it was decided to measure information risk in terms of the intensity of the bullwhip effect, the degree of data storage and transmission distortion, and the rate of major failure of information equipment.

(4) The lack of financial strength of an enterprise will lead to financial risk, and the so-called financial strength refers to the enterprise's market share, strategic alliances, economic strength, etc., which can provide financial support for the supply chain [12, 13]. Therefore, in this study, it was decided to measure the degree of blockage of capital flow, market share and quick ratio of major node enterprises.

(5) In the automotive supply chain, demand risk arises mainly due to the excessive error in the forecast of market demand. Based on this, Lei Xunping [7] used the indicators of demand forecast accuracy, the magnitude of demand fluctuations, the resilience of market demand changes and the degree of impact of new technology substitution to assess the demand risk of the automotive manufacturing supply chain; Guo Xiaozhi [14] pointed out that changes in market demand would cause demand risk in the supply chain, so he took customer satisfaction, changes in customer preferences, the magnitude of demand fluctuations and the number of substitute products as the key indicators for assessing demand risk. In this study, decided to measure namely key customer churn rate, market demand fluctuation magnitude and market demand forecast accuracy.

4   Countermeasures and Conclusions.

(1) System risk response strategy: First, for the automotive manufacturing supply chain, the raw materials required by the core enterprise will be all over the world, so the appropriate number of suppliers can promote the stability of this supply chain system, thereby reducing risks. Secondly, through the qualitative evaluation of these

members in the automotive manufacturing supply chain, the members with insuf-
ficient capability can be screened out to prevent the occurrence of major problems
in the chain caused by them. Thirdly, the innovation efficiency of core enterprises
reflects the ratio of innovation investment to sales revenue, and the low innovation
efficiency will make the core competitiveness of enterprises decline, so sufficient
attention and reasonable arrangement should be given to the investment in product
R&D talents and innovation capital.

(2) Supply risk response strategy: First, Automobile companies should prepare in
advance according to the expected number of orders and improve the production
efficiency of the supplier enterprise, which will help to reduce the supply risk. Sec-
ond, suppliers need to carry out strict control in the production process of products to
ensure product quality while completing the delivery of goods within the agreed time,
so that it will not affect the normal business activities of downstream enterprises and
ensure the smooth implementation of the work in the supply chain. Thirdly, when
the demand of the downstream customers changes, the upstream suppliers need to
make a timely response, improve the flexibility of the production plans, and provide
sufficient material support for the downstream enterprises.

(3) Information risk response strategy: First, start with the bullwhip effect and the prob-
lem of data storage and transmission failure. As a result, advanced information
processing system is needed to establish a common network data transmitter within
the supply chain as well as relational database, which can guarantee the integrity
of the information in the process of transmission by encryption and other means
not to be tampered with and replaced. Second, the more equipment accidents that
occur in a certain period of time, the greater the instability of the supply chain. So
that, such major equipment should be checked regularly and the firewall function of
information processor should be upgraded in time to enhance the security of data
storage.

(4) Financial risk response strategy: First, the blockage of financial flow problem can
be addressed by adopting a just-in-time strategy to shorten the order-to-cash cycle
as a way to reduce the number of days in accounts receivable and speed up the
flow of funds. Secondly, the core enterprises in the automotive manufacturing sup-
ply chain should investigate new trends in market demand, develop new products
that meet customer requirements, and increase the profitability and acceptability of
product sales. Thirdly, the core enterprises need to improve the asset changes and
debt repayment ability of the supply chain enterprises, by paying attention to asset
quality, strengthening inventory management and accounts receivable management,
and controlling the indebted assets within the controllable range.

(5) Demand risk response strategy: First, due to the abundant supply of products in the
automotive market, making customer demand diversified and unstable, so the enter-
prises can broaden the product surface and provide customized services to meet the
diversified requirements of customers as much as possible and reduce the magnitude
of demand fluctuation. Second, they can also grasp the correct market demand trends
and customer preferences by improving the accuracy of market demand forecasts,
and update products and services in a timely manner based on the forecast infor-
mation to effectively reduce the occurrence of such risks. Third, companies should
develop corresponding solutions according to the direction of past key customer

churn, and take the initiative, and on this basis to screen out quality customers, to guide customer consumption.

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