Research on the Construction of Supply Chain Performance Model of Manufacturing Enterprises

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Abstract. This paper studies the relationship between manufacturing supply chain resources and capability and supply chain performance, explpres the fundamental mechanism for generation of manufacturing supply chain performance and builds a manufacturing supply chain performance model based on it. At the same time, this study determines the supply chain performance path coefficient based on the PLS-structural equation, proposes a construction method for supply chain performance modeling and evaluation and provides theoretical basis and tools for further promotion in other domestic manufacturing supply chains.

Keywords: Supply Chain · Performance · Manufacturing Enterprises

1 Introduction

The majority of the existing research on supply chain performance modeling is concentrated in the field of supply chain performance evaluation. As the basic means of supply chain performance evaluation, the specific content mainly includes the research on performance model and indicatorex system. The main idea is to construct a supply chain performance model and design a corresponding indicator system, collect actual supply chain data, synthesize and calculate the collected data in accordance with the indicator system to obtain the measurement results of the supply chain performance level, and then identify gaps in supply chain management by comparing with performance benchmarks. In this regard, many domestic and foreign scholars have done a lot of work. Especially, the more representative results are showed as below.

The Supply Chain Operations Reference Model (SCOR) proposed by the Supply Chain Council (SCC) [6] is the most influential and widely- used supply chain performance evaluation model now. It is used to measure the performance of five processes including planning, procurement, production, delivery and distribution and, returns in terms of supply chain distribution reliability, responsiveness, flexibility, cost and assets. The corresponding hierarchical performance indicators are set for these processes, while performance improvement is achieved through comparison toof industry and enterprise benchmarks.

D. Qiu et al. (Eds.): ICBBEM 2022, AHIS 5, pp. 1591–1601, 2023.
https://doi.org/10.2991/978-94-6463-030-5_160

Kaplan and Norton [3, 4] proposed the "Balanced Scorecard" (BSC) evaluation system. BSC uses a set of financial and non-financial indicators to describe the performance of an organization, emphasize the mission of an enterprise and identify the motivation for realizing the strategy and translate the motivation for realizing the strategy into specific goals and evaluation indicators. Kleijnen uses the BSC to evaluate supply chain performance and comprehensively measure supply chain performance from four perspectives: finance, customer, internal process, learning and innovation.

The ROF [1] system established by Beamon establishes a supply chain performance evaluation model by starting from three key factors that affect strategic goals, i.e. Resources Measures, Output Measures and Flexibility Measures. Especially, resources measures reflect efficiency level, output measures reflect customer service level and flexibility measures reflect responsiveness to environmental changes. Beamon believes that the evaluation on supply chain performance shall consider both quantitative and qualitative indicators. He believes that quantitative indicators include finance (cost minimization, sales maximization and profit maximization), customer responsiveness (satisfaction rate maximization, production delay minimization, shortest customer response time), while qualitative indicators include customer satisfaction, flexibility, integration of information and material flow, effectiveness of risk management and supplier performance.

The Supply Chain Council of China Electronic Commerce Association (CECA) (CSCC) is the unique industry organization in the field of supply chain management in China now. In 2003, CSCC launched the "Chinese Enterprise Supply Chain Management Performance Level Evaluation Reference Model" (SCPR), which is the China's first guiding tool for quantitative evaluation on supply chain management performance level and scientific implementation of supply chain management projects officially developed and recommended by national industry organization. SCPR quantitatively evaluates the enterprise's supply chain management level in five aspects including order response ability, customer satisfaction, business standard coordination, node networking effect and system adaptability.

Supply chain performance is a measurement of supply chain operations (including processes and results) over a period of time, reflecting the effectiveness of executing supply chain strategy. From the perspective of supply chain, the process of generating supply chain performance is the process in which node enterprises in the supply chain use various resources and relevant capability to carry out value-added activities and produce relevant results under the guidance of supply chain strategy. Based on the classification and analysis of the resources and capability in the manufacturing supply chain, it is required to further study the relationship between resources and performance, capability and performance and reveal the fundamental mechanism for generation of manufacturing supply chain performance [2, 5].

2 Manufacturing Supply Chain Performance Generation Mechanism

2.1 Relationship Between Resources and Supply Chain Performance in Manufacturing Supply Chain

On the whole, supply chain resources are not only the basis for the formation of supply chain capability, but also the object of supply chain capability. Supply chain resources are not the direct basis of generating supply chain performance, but the result of influencing supply chain performance from two perspectives: influence of resources on the formation process of capability and use of capability on resources.

Business flow is the foundation of forming supply chain and driving factor of operating supply chain. The generation of business flow marks the beginning of supply chain operation and indicates that supply chain performance will gradually emerge; logistics is the flow of physical objects in supply chain, which mainly bears the supply chain performance. The operation and level of logistics are the core content of supply chain performance; capital flow is the flow of funds in supply chain, which mainly bears the supply chain performance. The operation and level of capital flow is another core content of supply chain performance; information flow is the flow of information in supply chain. It can affect the operation of logistics and capital flow in supply chain through the coordination and control of information flow, thereby affecting the supply chain performance; knowledge resources and relationship resources are the set of factors forming supply chain capability, while human resources and organizational structure are the carriers of supply chain capability, so they are an important basis for generating supply chain performance.

2.2 Relationship Between Capability and Supply Chain Performance in Manufacturing Supply Chain

On the whole, supply chain capability is the direct cause of generating supply chain performance. It is a process performance to use, configure and create supply chain resources and engage in supply chain value-added activities by using knowledge and relationships. The effect of this process performance on supply chain resources is reflected in a certain level of supply chain performance. Therefore, in a sense, the object of supply chain performance evaluation is actually the operation result of supply chain capability on supply chain resources. In other words, the measurement of supply chain performance level is the measurement of the effect of supply chain capability.

2.3 Manufacturing Supply Chain Performance Generation Mechanism

Based on the above analysis results of the relationship between resources, capability and performance in manufacturing supply chain, this paper believes that supply chain performance shall reflect the direct effect of the value-added operation of supply chain, since the ultimate purpose of operating supply chain is to achieve value-added. In addition, the value-added process is realized through the transfer of the use value and value of

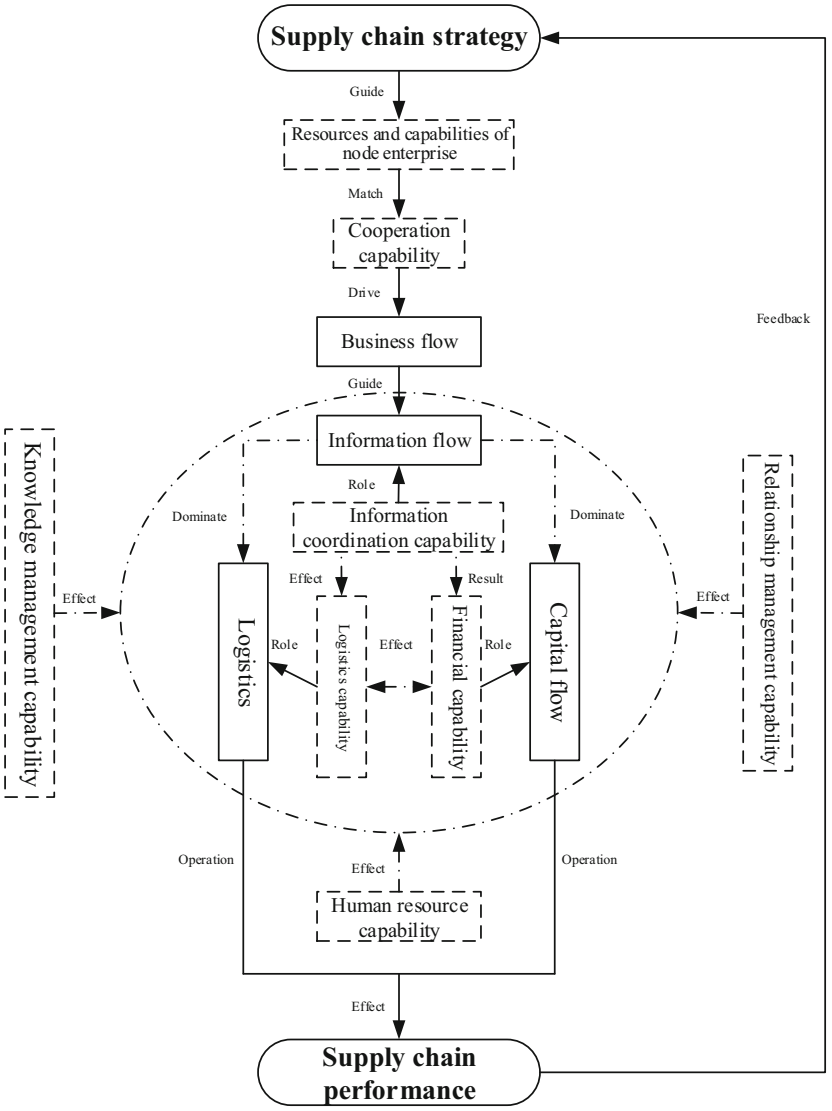

Fig. 1. Manufacturing supply chain performance generation mechanism.

physical resources in supply chain, so this direct effect is actually manifested in the situation that the supply chain determined by the logistics capability provides products and the supply chain determined by the financial capability is profitable. This is the essence of supply chain performance. The understanding of the supply chain performance in this paper clearly points out that supply chain performance is ultimately the operation of the logistics and capital flow in supply chain. It actually corresponds supply chain performance to supply chain strategy and masters the essential characteristic that supply chain performance is the feedback to the execution result of supply chain strategy.

In summary, this paper believes that the fundamental mechanism for generating manufacturing supply chain performance is: under the guidance of supply chain strategy, take the matching of node enterprise resources and capability, guided by the business flow driven by cooperation ability, focus on the information flow under the control of information flow of ability control, affected by the knowledge management ability, relationship management ability and human resource ability. Finally, based on the operation of logistics and capital flow, form a certain level of logistics operation and capital flow operation status by logistics ability and financial ability. This is supply chain performance. The manufacturing supply chain performance generation mechanism is showed in Fig. 1.

3 Manufacturing Supply Chain Performance Model

Combined with the characteristics of manufacturing supply chain in operation, specific factors are selected as follows:

3.1 Factors Reflecting the Results of Logistics Operation: Logistics Time, Logistics Quality, Logistics Cost

Logistics operation is the fundamental means to realize value-added supply chain and meet the needs of final customers. The results of logistics operation must reflect in three aspects as a whole, i.e.: How long did it take to meet certain customer needs? How about the quality of products and services? How much did it cost? Therefore, three factors of logistics time, logistics quality (including product quality and service quality) and logistics cost are used as the concentrated expression of supply chain logistics performance.

3.2 Factors Reflecting the Results of Financial Operations: Financial Profitability, Capital Turnover

The capital flow operation is the fundamental means to realize the benefit of supply chain in the value-added process of supply chain. Since capital itself has value, the result of capital flow operation must reflect in two aspects as a whole, i.e.: how much profit did you get from the tasks meeting certain customer needs? How efficient is the use of funds? Therefore, two factors of financial profitability and capital turnover are used as the concentrated expression of supply chain capital flow performance.

3.3 Factors Reflecting the Level of Production Technology Capability: Production Equipment Status, Technical Management Level

Carrying out manufacturing activities is not only a basic feature of manufacturing supply chain, but also a main way to realize value-added products. According to the broad understanding of logistics capability, production technology capability is actually a part of logistics capability, but different from other parts of logistics capability. Production technology capability is not reflected in logistics operations, but are more dependent on material resources and knowledge resources. It mainly includes two parts: production equipment status and technical management level.

3.4 Factors Reflecting the Level of Information Coordination Capability: Information Coordination Foundation, Information Sharing Level

The information flow plays a dominant role in the value-added operation of supply chain. Generally, it is used to drive the movement of logistics and capital flow. Information coordination capability affects the effect of logistics capability and financial capability on related resources to a large extent through the transmission and control of information, so it is the key influence capability of supply chain performance. The level of information coordination capability is mainly measured in two aspects: information coordination foundation reflecting the technical basis for realizing information coordination and information sharing level reflecting the breadth and depth of realizing information sharing.

3.5 Factors Reflecting the Level of Knowledge Management Capability: Knowledge Innovation Capability, Knowledge Diffusion Capability

Knowledge resources refer to patents, technologies, processes and skills related to products. Its formation roughly includes five stages: knowledge acquisition stage, knowledge transfer stage, knowledge sharing stage, knowledge exertion stage and knowledge update stage. The process of knowledge management is also completed at these five stages. In terms of knowledge management, the manufacturing supply chain gives the most concerns to continuous innovation and cross-enterprise sharing of knowledge. The former can be reflected in the knowledge innovation ability and emphasizes the technical characteristics of manufacturing enterprises taking products as the core; while the latter can be reflected in the knowledge diffusion ability and emphasizes the demand characteristics of cross-enterprise cooperation in the supply chain.

3.6 Factors Reflecting the Level of Relationship Management Capability: Cooperation Degree, Relationship Coordination Condition

A good supply chain relationship, especially the mutual trust and mutual support among node enterprises in cooperation, can greatly reduce transaction cost, which is conducive to decision-making from the perspective of the overall interests of supply chain, thereby promoting the improvement of overall performance of supply chain and performance level of node enterprises. The level of relationship management capability is mainly measured in two aspects: cooperation degree reflecting the stability and trust of the cooperative relationship among node enterprises and relationship coordination condition reflecting the situations of decision-making for the interests of the entire supply chain.

3.7 Factors Reflecting the Level of Human Resources Capability: Basic Quality of Personnel, Learning and Training Status

Human is a special resource in supply chain management. Human is the executor of supply chain operations and have an important impact on supply chain performance. The level of human resource capability is mainly measured in two aspects: basic quality of personnel reflecting the mastery of general knowledge and basic skills, learning and

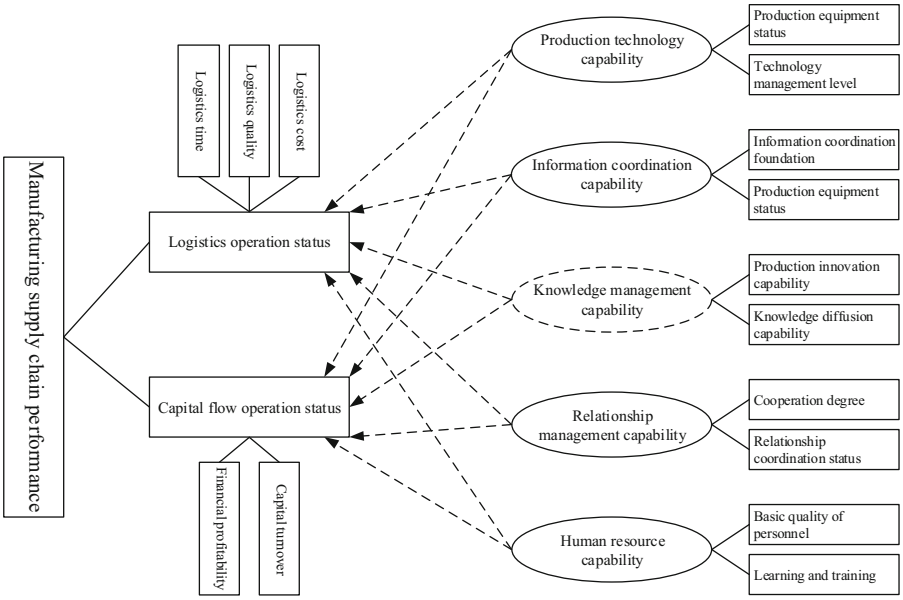

Fig. 2. Manufacturing supply chain performance model.

training status reflecting the mastery of the specific knowledge and special skills required by the enterprise's actual and work tasks.

Based on the above analysis, the corresponding manufacturing supply chain performance model is constructed as shown in Fig. 2.

4 Performance Evaluation

4.1 Analysis on the Correlation of Supply Chain Performance Factors Based on PLS-Structural Equation Modeling

Structural Equation Modeling (SEM) was developed on the basis of statistical theory put forward by scholars Karl. Joreskog and Dag. Sorbom in the 1970 s. It is a comprehensive application and improvement of statistical methods including exploratory factor analysis, confirmatory factor analysis, path analysis, multiple regression and variance analysis.

In the structural equation model, the path model with latent variables represents three kinds of relationships, namely internal relationship, external relationship and weight relationship. The internal relationship represents the relationship among latent variables and the equation describing this relationship is called the structural equation; the external relationship represents the relationship between the explicit and latent variables used to observe latent variables and the equation describing this relationship is called the measurement equation; and the weight relationship is used to estimate the values of latent variables.

(1) Internal relationship (structural equation)

The internal relationship describes the relationship among latent variables representing concepts, experiences or theoretical meanings, while its structural equations in mathematical expression are also called internal models, structural models, core models and epistemological models.

$$\eta = B\eta + \Gamma\xi + \zeta \tag{1}$$

Where: is endogenous latent variable vector, is exogenous latent variable vector, is residual vector and is path coefficient vector.

(2) External relationship (measurement equation)

External relationship describes the relationship between explicit variables and latent variables. There are two types of mathematical expression measurement equations: reflective model and formative model. The former means that explicit variables are the result of reflecting-latent variables, while the latter means that explicit variables are the cause of forming latent variables.

1) Reflective model

The relationship between latent variables and explicit variables in the reflective model is defined as:

$$\begin{aligned} y &= \Lambda_y \eta + \varepsilon_y \\ x &= \Lambda_x \xi + \varepsilon_x \end{aligned} \tag{2}$$

Where: and are the endogenous and exogenous latent variables, and are the observed measure of and, namely explicit variables, and are load matrices that describe the relationship between latent variables and their observed measures, is the residual error, usually interpreted as measurement error or noise.

2) Formative model

The relationship between latent variables and explicit variables in the formative model is defined as:

$$\begin{aligned} \eta &= \Pi_\eta y + \delta_\eta \\ \xi &= \Pi_\xi x + \delta_\xi \end{aligned} \tag{3}$$

Where: and are endogenous and exogenous latent variables respectively, and are the observed measures of and, is multiple regression coefficient and is regression residual.

3) Weight relationship:

In structural equation modeling, the values of latent variables are estimated by weight relationship:

$$\begin{aligned} \eta &= \omega_\eta y \\ \xi &= \omega_\xi x \end{aligned} \tag{4}$$

Where: is weight. The estimated value of a latent variable is a linear combination of its empirical indicators.

Depending on the mode of the measurement model, is defined in different ways. When the model is reflective, its load is the modified weight (making the variance of the latent variable as 1); when the model is formative, the multiple regression coefficient between latent variable and explicit variable is the weight.

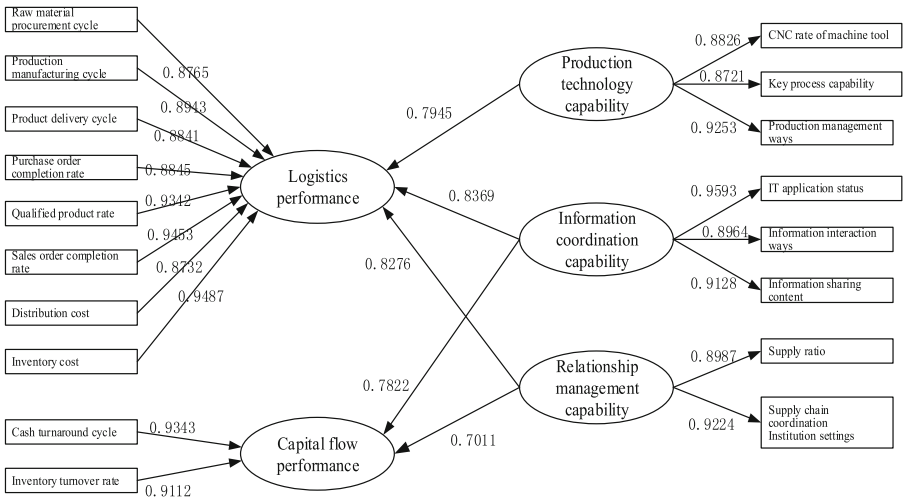

Fig. 3. Performance evaluation system

4.2 Determine Path Factor

In this paper, SmartPLS2.0 is used as the structural equation analysis tool. Based on path optimization and determination of various index coefficients, the most important performance evaluation system is obtained, as shown in Fig. 3.

5 Conclusions

5.1 Seven Major Resources and Corresponding Capabilities Existing in the Supply Chain in the Value-Added Process

Seven major resources and corresponding capabilities are business flow and cooperation capability, logistics and logistics capability, capital flow and financial capability, information flow and information coordination capability, knowledge resources and knowledge management capability, relationship resources and relationship management capability, human resources and human resource capability. The supply chain performance generation process is the process where node enterprises in supply chain use various resources and relevant capabilities to carry out value-added activities and produce relevant results under the guidance of supply chain strategy.

5.2 Supply Chain Performance Generation Capability and Supply Chain Performance Influence Capability

It is directly related to the value-added process of supply chain. The capability to really generate supply chain performance through the effect on supply chain resources is called

supply chain performance generation capability, including logistics capability and financial capability; while the capability closely related to the value-added process of supply chain to really affect the level of supply chain performance through direct or indirect effect on the operation of value-added process is called supply chain performance influence capability, including cooperation capability, information coordination capability, knowledge management capability, relationship management capability and human resource capability.

5.3 Proposed Supply Chain Performance Modeling Analysis Theory for the First Time

It mainly includes three parts: supply chain strategy performance management, supply chain performance modeling analysis and supply chain performance modeling analysis. Firstly, based on the concept of supply chain strategy and supply chain performance, propose the concept of supply chain strategy performance management and deeply analyze its connotation, further construct the implementation framework of supply chain strategy performance management and study its key implementation elements. On this basis, give the basic concept, purpose and function, basic principle and overall framework of supply chain performance modeling analysis. Finally, propose the construction method of supply chain performance modeling.

5.4 Proposed the Expansion of Practical Application

Further promote and apply the theoretical method of supply chain performance modeling analysis proposed in this paper in other domestic manufacturing supply chains, obtain enterprise feedback information in practice, summarize and implement experience and lessons, so as to continuously revise and improve the original design, further improve the theoretical methods of supply chain performance modeling analysis. In addition, expand the research on the mechanism of supply chain performance to other industries and study the performance models of supply chains in other industries to lay the foundation for cross-industry practice.

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