

Supply Chain Information Sharing Model

From the Perspective of Structural Holes Theory

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Abstract—Information sharing is one of the important ways to improve the overall level of collaboration and performance in the supply chain. The social network structure of structural holes has an important impact on information interaction in supply chain networks. Based on information sharing theory and structural holes theory, we expound the related influencing factors of information sharing in the supply chain and summarizes the relevant characteristics of structural holes. Then, based on the structural hole theory, the supply chain information sharing model is established. On the basis of summarizing the previous studies, the network structure characteristics of structural holes and their influence on the information sharing process in the supply chain network are discussed. Studies have shown that in a mature supply chain network, structural holes affect the stability and trust level of members, but can bring heterogeneous resources. The supply chain needs to choose different strategies according to the external environment to improve the level of information sharing.

Keywords—information sharing; structural holes; supply chain

I. INTRODUCTION

Since the 1990s, due to the increasing pressure of globalization and production costs, consumers' demand has become more diversified, and competition between enterprises in the market has become increasingly fierce [1]. The competition in today's world market has expanded from the competition of individual companies to the competition between the entire supply chains. A supply chain is a production network composed of many individual companies, raw materials and components are transformed into final products through the network and delivered to customers in the consumer market. In the supply chain, close cooperation between members has become an important way to improve the competitiveness of the supply chain, it is impossible that every member can independently maximize their own benefits and gains [2]. In order to improve efficiency, many industries are engaged in supply chain improvement projects. Information sharing is a key component of any supply chain management system, and information sharing among supply chain members will bring long-term competitive edge to the organization. Information sharing can improve the overall cooperation level of the supply chain, promote material flow in the organization and cut inventory level, and enhance the integrity level of the supply chain [3].

At present, there are many problems in the field of information sharing in supply chain. There are controversies on the types, time, ways and objects of information sharing among partners in supply chain. Besides, these factors also have an important impact on the effectiveness of information sharing. In the process of information flow in the supply chain network, there exist some problems such as information delay and distortion. As members of the supply chain are different stakeholders, which leads to the opportunistic behavior and information asymmetry in the network. Organizational structure and individual standpoint within an organization may become obstacles to information sharing. Lack of equality among organizational members makes it difficult to exchange message, organizational structure largely determines the effectiveness of information sharing among organizational members [4].

In the current research of supply chain management, information sharing is one of the focuses of many researchers, and has produced many outstanding research results. The emphasis of information sharing in supply chain has shifted from the original research on the impact of information sharing on supply chain performance to the research on information sharing process. Some scholars have studied inter-firm communication based on social network theory, but there are few studies on the impact of structural holes on information sharing in supply chain organization, and structural holes theory is mostly used in the study of enterprise innovation. Based on the structure holes theory, this article studies the impact of this network structure on information sharing in supply chain organization, and establishes a supply chain information sharing conceptual model.

II. REVIEWS

A. Information Sharing in Supply Chain Management

Supply chain management is the premise of gaining competitive advantage and maintaining profitability in the global market environment, and information sharing is an indispensable key factor in each supply chain management system. Information sharing can coordinate the processes between trading partners, promote interaction between suppliers and customers, and minimize transaction costs and inventory levels [5].

Under this situation, in order to effectively respond to market changes, the participants in the supply chain often have to maintain a higher inventory level. However, this strategy leads to lower returns for members in the supply chain and higher production costs, which is known as the "bullwhip effect". In order to solve this problem, many academics such as Narasimhan R and Nair A emphasized the importance of enhancing information sharing between upstream and downstream enterprises in the production practice of the supply chain [6].

According to the organizational design economics theory, the structure of an organization has a key influence on the effectiveness and nature of information sharing within an organization, while the organizational behavior theory believes that the characteristics of partners in the entire organizational network will affect the effectiveness and nature of information sharing within an organization, which also plays a pivotal role. Anand K S, Mendelson H also discussed the relationship between organizational structure and information sharing [7]. Samaddar S, Nargundkar S and Daley M discuss the relationship between information sharing between organizations and supply chain configuration as well as the characteristics of partners. Supply chain network configuration includes various network patterns, company positions within the network, and relationship coordination structure among enterprises, while the characteristics of partners involve the problem of goal congruence among members. Network mode can have one or more phases that create different levels of complexity, resulting in different environments for information sharing. In addition, due to the distortion of information flow, the position of companies in the network has caused different information requirements and different consequences. To effectively manage information flow, we need to pay close attention to the coordination mechanism established among the member companies in the network. Furthermore, the degree of centralization may affect the nature and quantity of information shared through the network [8].

However, the primary issue of any inter-organizational interface is trust and opportunism. Even though firms are embedded in a common ownership structure, are from the same functional area, or engage in very simple tasks, this is still a problem. Social network links between parties at organizational boundaries in supply chains are important for building trust, cooperation and coordination among participants that facilitate information exchange [9]. When information sharing and collaboration are closely related to the success of supply chain alliances, it is necessary to further determine the basis for contributing to partner exchanges. Studies have shown how status and power affect long-term positioning and relationship behavior toward partners [10]. Therefore, it is necessary to study the network structure of supply chain in the research of information sharing of supply chain.

B. Structural Holes

In the research of social network, structural holes theory, as an important part of it, has been paid more and more attention in the field of information exchange of enterprise

alliance organization. Burt defined structural holes as network gaps between several unrelated actors, which occupy the gaps in the network and thus connect these unrelated actors. These actors are called brokers [11]. The absence of cohesion and structural equivalence are two important criteria for judging the existence of structural holes. Structural equivalence refer to the fact that two actors in a network have the same third-party contacts at the same time, while cohesion refers to the existence of strong ties or direct ties between each actor in the network, and the same network resources and information can be obtained by contacting any member in the network [12]. In his book [11], Burt provides evidence showing that when there are a large number of non-redundant customers and suppliers in the market, and manufacturers are closely connected, the marginal profit level of the industry will be increased.

However, with regard to the role of structural holes in organizational networks, Ahuja's longitudinal study of the International Chemical Industry Corporation (ICIC) shows that both direct ties and indirect ties have a positive effect on corporate innovation, but in interfirm collaboration networks, increasing the number of structural holes has a negative impact on innovation. On the other hand, although from the perspective of structural holes theory, for organizational networks, the weaker ties among network members are better than the stronger ties among members. Nevertheless, by checking a network with a large number of structural holes, from the point of view of network resources sharing, the conclusion is almost exactly opposite to the previous [13]. Coleman argues that the benefits of resource sharing come from the combination of skills, knowledge sharing, and conducting joint projects to achieve scale economy, all assuming strong trust between partners. Without trust and a common code of conduct, sharing knowledge, combining skills, and making extensive joint investments can be hard and futile in any case [14]. Furthermore, the impact of the existence of structural holes in the network on the realization of network members' target performance has been paid attention by relevant scholars. Shipilov A V, Li S X studied British speculation from 1992 to 2001 and came to the conclusion that a more open network is conducive to timely access to information on opportunities, but because members are not closely linked and lack mutual trust, it has a negative impact on the sharing of information and other resources. Besides, they also suggested that structural holes can help enterprises accumulate status in the network, but have a negative impact on the performance of mutual market collaboration between enterprises. Simultaneously, there is a positive reciprocal relationship between corporate status and market performance in the structural holes theory [15].

III. SUPPLY CHAIN INFORMATION SHARING MODEL WITH STRUCTURAL HOLES THEORY

A. MOA

MOA theory, as one of the relatively mature theories in organizational theory, was originally used to study people's behavior choice and information reception. The primary coverage of MOA model is divided into three parts:

Motivation, Opportunity and Ability. Initially, MOA theory comes from the combination of basic concepts in psychology, and then gradually extends to other application fields [16]. In the current structural holes researches, MOA theory is often used to explain the causation for the construction behavior of structural holes. When the motivation, opportunity and ability to construct structural holes are satisfied at the same time, the enterprises in the supply chain will take measures to construct structural holes.

There are two contradictory viewpoints on the motivation of enterprises to build structural holes in the network: one is that the main motivation of enterprises to build structural holes is to obtain the advantages of position, information and control. Once the structural hole is formed, the interaction of information and other resources in the network must pass through this node [17]. Another view is that although this sparse network structure can bring the advantages of position, information and control to the enterprises occupying the node, it has a negative impact on the collaboration and coordination between the entire enterprise network and the level of trust between each other [18]. On the other side, as the core of the network, the enterprises with abundant resources and strong strength are usually faced with the problem of coordinating the whole supply chain. Increasing the number of structural holes will lead to the increase of the enterprises cost and add additional burden.

In terms of opportunities, first of all, the core enterprises in the supply chain have a higher status because of their strong resource strength. Facing fewer constraints in the construction of structural holes, higher autonomy makes the core enterprises more opportunities to take action. Then, because the core enterprises have a higher reputation and a better product impact in the industry in which they are located, other weaker and smaller enterprises actively contact the core enterprises in order to enjoy the profit margin increase and the accumulation of status [15], this situation has virtually increased the opportunity for core enterprises to build structural holes.

In terms of the ability to build structural holes, it is obvious that high-status enterprises with larger scale and stronger capital have stronger ability to meet the needs of building structural holes. Firstly, for the core enterprises in the network center position, they can have access to more information resources and control advantages, thus effectively reducing the cost of finding cooperative partners, supervising their behavior and searching for information [19]. Secondly, due to the strong strength of high-status enterprises themselves, they can more effectively integrate

the resources scattered throughout the network, thus promoting the coordination among partners in the network [20].

B. Information Sharing

The model of information sharing and collaboration on supply chain performance proposed by Wu L, Chuang C H, Hsu C H, as shown in "Fig. 1" reveals the influencing factors on supply chain performance [21]. They believe that Trust, Commitment, Reciprocity and Power are the main factors that affect information sharing. They put forward that these four elements have a positive impact on information sharing and cooperation, and have been proved in their research. Through the dynamic influence of these factors, information sharing in the supply chain promotes cooperation among members; meanwhile information sharing and cooperation further improve the performance level of supply chain.

Trust is an enterprise's belief that whether it has the ability to supervise or control partners, their partners will take beneficial actions to the interests of the entire supply chain. When the enterprise is in a highly trusted network, they will actively share their own information and also believe that information from partners, so they will be more proactive for the purpose of maintaining the relationship between the two sides. The essence of commitment is the assurance that partners try their best to achieve in order to maintain the relationship between them.

Commitment helps to establish a stable relationship between supply chain members, so it requires compromise and sacrifice between partners. Studies have shown that stable relationship commitment can promote communication between members and coordination between upstream and downstream [22].

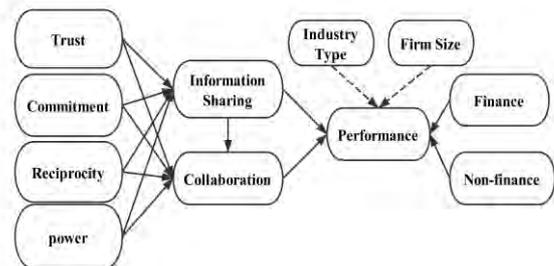


Fig. 1. Impact of information sharing and collaboration on supply chain performance.

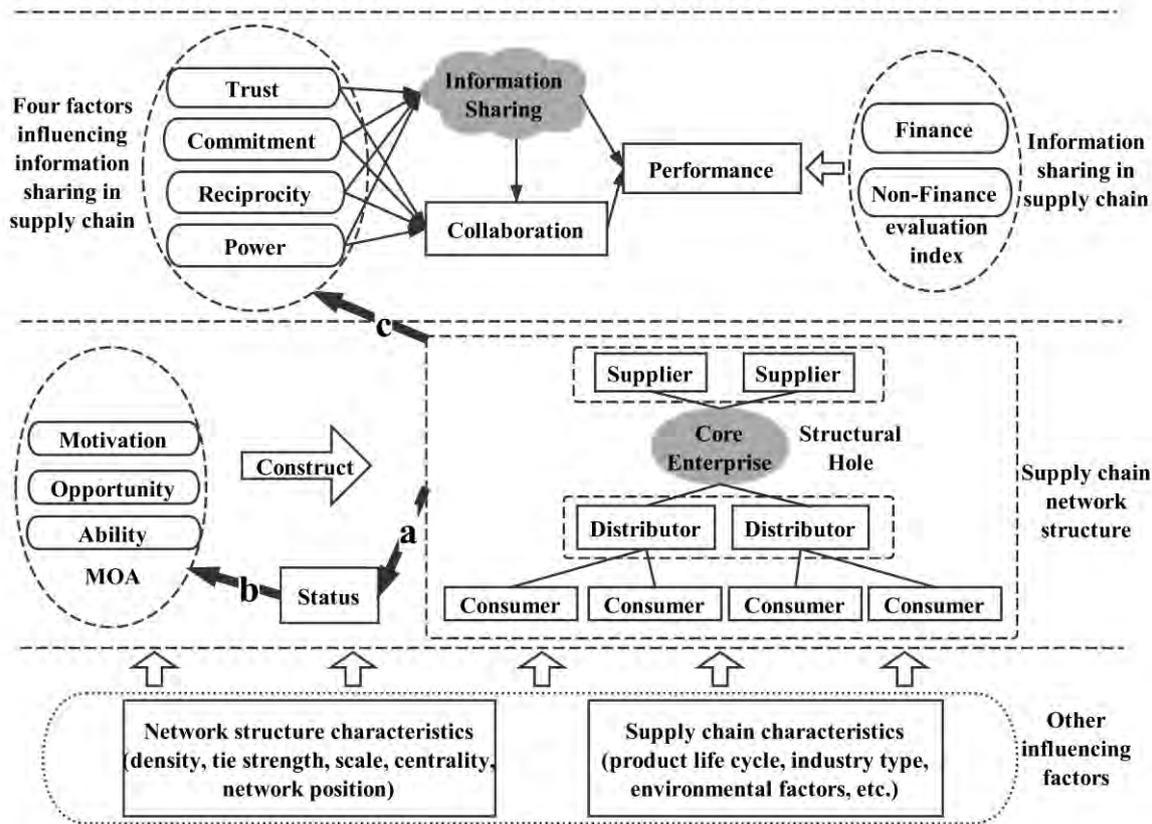


Fig. 2. Supply chain information sharing model with structural holes theory.

^a. Note: The core enterprises in the supply chain network have high status due to their own enterprise strength.

The high status enables the core enterprises to have more opportunities and a better ability to construct structural holes. However, in terms of motivation, the characteristics of partners should be taken into account.

Because of the existence of structural holes, trust, commitment, reciprocity and power among members of the supply chain social network will be affected differently.

Reciprocity is one of the important foundations for the formation and stability of supply chain, which can effectively promote the formation of stable cooperation opportunities and mechanisms. Reciprocity can effectively promote information sharing, upstream suppliers can obtain valuable information, and thus better manage production-based activities, and downstream demand side can get products that better meet their needs.

The generation of power is the dependence caused by the unequal quantity and quality of resources controlled by members in the supply chain. Participants with high status in the supply chain can force other lower status members to share their relevant business information through the resources they control, thus promoting the sharing of different types of information between the whole system, effectively improving the level of cooperation of the entire organization.

This information sharing model explores the relationship between information sharing and the four influencing factors of information sharing in supply chain, and also considers the effect of industry type and enterprise scale. However, this model mainly focuses on the social relationship among members, and does not deal with the characteristics of the social network structure of the whole supply chain network. Therefore, starting with the classical structure hole theory in social network, we discuss the influence of structure holes in supply chain network on information sharing between partners, and builds a model on this basis.

C. The Model

Supply chain network configuration includes a variety of network structures, the position of the enterprises involved in the network and the coordination structure to manage the relationship between enterprises. Partner characteristics involve the consistency of objectives among enterprises in the network, so there are different information sharing

environments. For the purpose of maximizing profits, enterprises in the supply chain construct structural holes in the network to obtain the corresponding position, information and control advantages, as well as the impact on the entire supply chain network; the following will be related to the elaboration. Structural hole, an open network structure, can bring information and other resources to enterprises in different regions and industries. From the perspective of a single enterprise, occupying the position of structural hole has tremendous benefits to its market position and benefit acquisition. However, for the entire supply chain, this is not conducive to the transmission of partners' information. For most social networks, members of the network are more willing to gather together and connect with each other through a dense network structure. Members know each other, understand the same types of opportunities, obtain the same types of resources, and share the same types of standpoints [23]. In order to further understand the factors influencing the construction of structural holes in supply chain networks and the influence of structural holes on information sharing. Based on the structural hole theory and MOA model theory, considering the related factors of information sharing, this paper constructs the supply chain information sharing model from the perspective of structural holes, as shown in "Fig. 2".

D. Relationship Between Structural Holes and Four Influencing Factors

1) *Relationship between structural holes and trust:* structural holes have an adverse effect on the establishment of stable and solid trust relationships among the members of the organization. According to the structural holes theory, redundant ties lead to the same participants, access to the same knowledge and the same types of resources. Ego networks with structural holes mean the need for interconnected partners and many different flows of information. Therefore, maximizing the number of structural holes or reducing the redundancy among partners is an important way to build an efficient and informative network [12]. From the perspective of structural holes, the ego networks that are not connected between the company's partners takes precedence over the network in which its partners are closely connected to each other, but it is necessary to examine the impact of a network with rich structure on resource sharing benefits. The conclusions revealed by the network are almost identical to the conclusions that relate knowledge spillovers or information benefits to the same network structure. The benefits of collaborative resource sharing come from companies combining their skills, sharing their knowledge, and executing joint projects to achieve economies of scale, all of which are based on significant trust among partners [14]. The network in which its partners are densely tied to each other, opportunistic behavior is less likely to occur, because a loss of reputation can invite punishment from the rest of the organization. However, in a sparse network, the

probability of opportunistic behavior will increase enormously.

2) *Relationship between structural holes and commitment:* in terms of commitment, studies have shown that the hierarchical links between high status core enterprises and other partners in a closely connected network can improve the level of commitment of partners. A good level of commitment among partners can play an important role in coordinating conflicts across the organizational network, resolving common difficulties, and improving the stability and frequency of communication among members [24]. For high status enterprises that build structural holes in the network, various kinds of information and other important resources in the network are obtained because they occupy the central position of the network or by virtue of the ties established with other members. With these advantages, the core enterprise can maintain favorable control and influence over other members, thereby increasing the dependence of other enterprises on it [25]. From this perspective, due to the stable dependence of other enterprises on core enterprises, it is impossible to carry out strong checks and balances on core enterprises' performance of commitments. Structural hole, an open network structure, has adverse effects on commitments in supply chain.

3) *Relationship between structural holes and reciprocity:* The network structure of the structure holes has a negative influence on the reciprocity of participating enterprises in the supply chain. In the theory of structural holes, enterprises build structural holes by reducing redundant ties in the network and increasing non-redundant ties. The transmission of information flow and other resources in the supply chain must go through this node position. By occupying this vital network position, enterprises can obtain abundant enterprise operating resources and thereby greatly enhance their control over other participating enterprises. Because of this unequal power gap, core companies may force other companies to make concessions in terms of interests to expand their own earnings. Simultaneously, Dyer J H, Nobeoka K in their classical study of the Toyota supply chain show that a sparse network structure like a structural hole may lead to the occurrence of opportunistic behavior, increase the cost of execution and supervision of the entire supply chain, which can also lead to lowering the frequency of mutual resource exchange between members, is not conducive to the whole supply chain collaboration and reciprocity [26].

4) *Relationship between structural holes and power:* Structural holes can enormously enhance the number of heterogeneous information and the opportunities for different types of cooperation that enterprises occupying this node position can access. As mentioned earlier, an open network structure is helpful to obtain new business opportunities, due to the advantages of the face a lot of choice of cooperation, in the node position of enterprises can choose higher status and stronger partners, which is

beneficial to enterprises gradually accumulated in the network node position. Open networks emerge when a company's main suppliers are connected to other intermittent partners, crossing through structural holes. This viewpoint derives its theoretical uniqueness from Burt's relevant articles, that a company with a strong network relationships can cultivate performance advantages by obtaining timely information about business opportunities and control over its partners [12]. By acquiring the advantages of position, information and control through the structure hole, the enterprise gradually accumulates its status in the network, which can effectively improve its power level in the whole supply chain.

E. Other Influencing Factors

Different social networks have different structural characteristics, and the indicators reflecting the characteristics of social networks generally include density, tie strength, centrality, position and scale, etc. The flow of information has different performance characteristics in different network structures.

Related studies have shown that communication coordination and mutual trust can be improved in networks with high density and strong tie strength. At the same time, due to the close connection of members, the internal network will tend to be homogeneous, which also enhances the stability of the network itself [27]. The sparse network structure enables group members to connect with other groups and enjoy the benefits of diversified information. However, this structure is flawed in terms of rapid collaboration and resource movement due to the lack of alliances among members [28].

For the problem of network position, the more enterprises are in the center of the network, the more they can obtain different information and cooperation opportunities, and control the flow of resources in the network, thus producing a stronger influence and control over partners. It also has a strong promoting effect on improving information exchange and resource sharing among members in the network [29]. Meanwhile, some scholars point out that a higher level of centrality not only enlarges the boundary of information dissemination and speed of flow, but also reduces opportunistic behavior in the network [30]. A larger network can bring abundant information, while a large number of partners can bring additional resources, thus leading to better alliance performance. However, an overlarge scale brings great pressure to the management and coordination of the entire enterprise alliance [31].

For the impact of product life cycle and environmental factors, environmental uncertainty affects the degree to which an enterprise must improve existing technologies and find new opportunities. In unstable environments, companies must allocate more resources for exploration, while in more stable environments; the opposite is true, where there is less uncertainty about the future direction and less external interference. In the early exploration stage of the product life cycle, weak ties in the network are beneficial [32]. In addition, the type of industry is also an important factor

influencing the performance of supply chain. In highly active industries such as high-tech industry, the product life cycle of the company is short and the time of listing is crucial. These companies show higher revenue volatility and customer churn rates compared to low-dynamic industries. Large companies are more likely than small ones to affect supply chain implementation because they have the resources and capabilities needed to execute complex processes across partners [33].

IV. CONCLUSION

Based on the structural holes theory and information sharing theory, we study the factors that influence the behavior of enterprises in supply chain to construct structural holes, and makes corresponding analysis from the aspects of motivation, opportunity and ability. Furthermore, the influence of structure holes on trust, commitment, reciprocity and power related to information sharing in supply chain network is discussed by us. Considering the influence of external environment, the information sharing model of supply chain is constructed from the perspective of structural holes. Relevant research findings are as follows:

For the behavioral motivation level of enterprises, building structural holes can bring a large number of heterogeneous resources and different information flows for enterprises. At the same time, it can bring status accumulation for enterprises by the bridge between different individuals or groups. From the perspective of opportunity, the strong enterprises in the supply chain network have more opportunities to connect different groups to implement the construction behavior. In terms of ability, enterprises with high status in supply chain network have sufficient implementation capacity because of their own resources. Besides, the reputation brought by high status makes other enterprises more proactive to contact with it and expect to form a stable relationship. As for the impact of structural holes on trust, commitment, reciprocity and power in the entire supply chain network, as mentioned earlier, an open network structure helps to obtain different business information and opportunities, while facilitating the accumulation of corporate status and enhancing the level of power in the network. However, members are more closely related and more stable in a network which has a higher density and stronger trust between each other. Enterprises occupying structural holes can enjoy the benefits of different types of information and resource convergence, but they may rely on their strengths and status to force other members to make concessions, which will have adverse effects on reciprocity and commitment.

For the impact of external environment, when the industry is in a period of initial instability, open networks are conducive to different information exchanges in the network and access to new business opportunities, more easily accessible to external information and resources; when the industry is in a stable period, the network with dense ties is more helpful to the establishment of network members stabilizing the relationship, improving the overall level of collaboration, reducing barriers to information sharing and improving the speed of resource flow. At the same time,

enterprises located in the center of the network have more possibilities to build structural holes, strengthen the control over the entire network, and reduce the occurrence of opportunistic behavior.

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