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Exploring the Barriers and Mitigation Strategies in Collaborative Network Development: A Case Study from Equipment Manufacturing Company

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Abstract. Recently, more and more manufacturing companies build collaborative platforms to improve collaboration ability, so as to cope with the the high complexity and uncertainty of the industrial market environment. As a new paradigm of cooperation, collaborative networks have attracted more and more attention. The development and evolution of CN is a long process, and there are some obstacles in practical application. Current research on CN is theoretical and there is a lack of exploration in practice in terms of organizational construction and operation of manufacturing companies. Therefore, this paper uses a case study to analyze four levels: value mechanism, structural mechanism, sharing mechanism and technology mechanism, taking an actual assembly and manufacturing company as an example. The purpose of this study is to analyze and summarize the key barriers in the practice of the company through empirical investigation. And based on the mitigation measures of the case company and relevant literature studies, we have made some relevant recommendations and research ideas to address the barriers.

Keywords: Collaborative Network Organization, Development Barriers, Mitigation Measures.

1 Introduction

In the face of the world's new technological revolution, dynamic changes in demand and the rapid explosion of innovation, how to continue to gain competitive advantages to cope with market uncertainty and complexity is a problem that enterprises are concerned about. The strength and height of enterprise growth depend on dynamic competitiveness, and synergy is the main dynamic competitiveness [1]. As a new cooperation paradigm, Collaborative Network (CN) has been applied in many fields and has certain development potential. CN members are autonomous and independent of each other in the cooperative relationship and share resources to achieve common promotion and optimization.

Whether the organization has truly achieved synergistic development is reflected in whether it has the characteristics of mutual benefit and symbiosis. These characteristics are embodied in the value mechanism, structural mechanism, sharing mechanism and technical mechanism [2]. The value mechanism is reflected in the

collaboration between partners based on the concept of mutuality and consistent values, which is the basis of the cooperative relationship. The structural mechanism includes the power and responsibility structure of network members, communication mechanism, governance principles, etc., which provide operational guarantees for the sustainable development of CN. Sharing is the driving force behind CN's continuous innovation. The generation of synergies primarily depends on the sharing mechanism, including the sharing of information, resources and knowledge. The continuous development of digital technology has enhanced the collaborative efficiency of CN, reduced the cost of information exchange, and improved organizational performance [3].

At present, some scholars have carried out research on various details of collaborative network theory, such as the classification of CNs and the basic elements of value creation [4], the consistency analysis of value systems in Collaborative Network Organization (CNO) and management [5], the business of strengthening cooperative relationships and process analysis [6], trust analysis and evaluation in CNs [7], etc. The establishment of collaborative relationship is based on an effective collaborative response mechanism, reasonable performance management and willingness of members to actively contribute knowledge. However, there are still some barriers in the practice of transforming enterprises from individual to collaborative network operation. Barriers such as partner individualism, lack of consistent values and interests, lack of autonomy and flexible response mechanisms can hinder synergy [8]. In order to deeply analyze the causes of these barriers, this paper uses the actual assembly manufacturing enterprise as an example to analyze and summarize the barriers and solutions.

The following two research questions will be the core of the paper:

A: What are the key barriers for companies in CN development?

B: What measures has the company taken to mitigate barriers during the development of CN?

The paper is structured as follows: after introducing and contextualizing the research question in section 1, section 2 presents the theoretical development of CNO and the main barriers. Section 3 provides a case and introduces the process of data collection and analysis. Section 4 then describes the CNO development barriers and mitigation measures of the case company from four aspects. Finally, section 5 presents the conclusion.

2 Related Works

2.1 Collaborative Network Organizations

CN is a knowledge-driven paradigm of collaboration. In the past few years, CNs have been organized in various forms, such as virtual enterprises, virtual communities, virtual laboratories, value units, supply chain collaboration, etc., which have created

opportunities for enterprises to seek heterogeneous resources to respond to dynamic markets agilely. With the emergence of collaborative value, various fields have begun to pay attention to and strive to promote the construction of CN, such as: the establishment of special courses for university alliances, the construction of information sharing platforms for government departments, and the sharing of medical resources. The above cooperation models inevitably revolve around the activities among members, including the determination of organizational structure and governance principles, which are collectively referred to as the construction of Collaborative Network Organizations (CNOs).

The main driver of CNO is the dynamic alignment of resources in response to goals. CNOs have two organizational models, Virtual Organization (VO) and Virtual organizations Breeding Environment (VBE), which complement each other. VO has strong flexibility and can be established in a short period of time to respond to dynamic changes in the market. VO can be driven by continuous production or service provision activities, or by goals of seizing a single collaborative opportunity [9]. But generally, people decide to participate in CN based on a certain premise of trust. VO dissolves immediately after the end of cooperation, so it is difficult to build a trust relationship. VBE is a long-term strategic alliance, which is more conducive to establishing a good trust mechanism and governance principles between organizations.

In order to combine the advantages of the two organizations, Afsarmanesh, H [10] proposed a new paradigm of virtual network organization VBE-VO. VBE provides the resources and environment to support VO. When a business opportunity is identified by members of the VBE, a subset of the organization is selected to form a VO that responds positively to the opportunity. In this process, Afsarmanesh, H [11] emphasized the necessity of the establishment of VBE, which provided a nurturing environment for the dynamic and agile formation of VO driven by opportunity. On this basis, Liu Q [12] further proposed a three-layer collaboration framework for agile operation of small teams, that is, an operation layer is added between VBE and VO. The operation layer can rapidly schedule resources, track progress, and provide timely feedback. At the same time, it further strengthens the trust between organizations.

At present, how to promote the development of collaborative technology innovation is a major challenge facing manufacturing enterprises. The CNO theory emphasizes the dynamic response of the organization and the reallocation of resources, which gives manufacturing enterprises a new power to promote the development of collaborative innovation.

2.2 Developmental Barriers to CNO

The value-added logic of CNO symbiosis is mainly reflected in four aspects: value mechanism, structural mechanism, sharing mechanism and technical mechanism [2]. Its ultimate goal is to recognize that the overall value of the collaborative network is greater than the sum of the individuals. Nevertheless, the actual enterprise implementation process confronts challenges in these four areas because there are many obstacles in the complex transformation of enterprises from individual

operations to CN operations. The value mechanism is when partners establish the same values and common goals. However, when the goals of the individual enterprise conflict with the goals of the collaborative network, it is difficult to achieve collaborative innovation [13]. CN is a network formed by various entities (people, organizations, devices, etc.), which are largely autonomous and heterogeneous in geographic location, culture, values, and social capital [12]. The differences in various aspects lead to conflicts in collaboration, which ultimately fails to achieve the goal of synergy. In essence, conflicts are caused by members' different values and different views on cooperation results [5].

The structural mechanism refers to the power responsibility structure, communication structure and contractual relationship established between VBE enterprises for the stable development of collaborative relationship [2]. In order to promote the development of CN, it is necessary to decentralize the management of manufacturing enterprises. However, the redistribution of power is based on the improvement of the quality of managers, and blind decentralization will only lead to more serious accidents [14]. In addition, the inter-organizational communication system is inconsistent, resulting in a general atmosphere of communication, sharing, and collaboration [2]. At the same time, due to the instability of VO and the increase in the number of VBE alliance enterprises, high communication and coordination costs are also one of the difficulties faced by CNOs.

The sharing mechanism refers to the sharing of information, resources and knowledge among cooperative members. The barriers to sharing across organizations are mainly reflected in the perspectives of organizations and individuals. Research at the organizational level focuses on management, system, economy, technology, etc. Furthermore, the centralized hierarchy has a negative impact on knowledge sharing [15]. Individual barriers focus on incentive systems, individual trust, risk assessment, cultural factors, etc. [16]. For example, the innovation performance of VO members is affected by partners [17], and unfair behavior among CN members will increase distrust, resulting in reduced willingness and efficiency of information sharing [18].

The technical mechanism refers to the interactive platform provided for CN operations through various digital technologies. The abstract representation of attributes within a CNO is currently a challenge because of the large number of entities, roles, resources, governance principles, etc. within a CNO. Also members have barriers to resource sharing, instant access to resources and permission access [11]. Data sharing between organizations is also difficult due to the lack of standards for data sets and barriers to data processing [16].

In summary, the current theoretical research on CNO is comparatively mature, but there are still some barriers to the actual operation of the enterprise. The next section analyses and summarizes the barriers and solutions measures, taking the equipment manufacturing company as an example.

3 A Case Study

3.1 Company Background

The data for our study comes from a Chinese equipment manufacturing general assembly company (hereinafter referred to as CompanyE), which is responsible for the integrated assembly business. Integrated assembly plays an important role in the equipment manufacturing process and is a key and core technology for assembly manufacturing. CompanyE was established in 1983 as a wholly owned subsidiary of a group. The group's business can be split into two parts: drawing design and R&D production. The drawing design is done by the internal design institute of the group, while the R&D production is carried out by the research institutes under the group. In the past few years, the research institutes within the Group have all focused on the research and development of their respective core technologies, and there is business overlap in processing and trial production and material selection services.

On the one hand, however, the importance of collaborative innovation among institutions is becoming more and more evident. This is because product performance targets become higher and higher, traditional technologies are no longer able to meet functional requirements, and the solution of technical problems is increasingly shifting towards integrated functional solutions. On the other hand, collaboration between all parties is required at the requirements analysis stage to optimize and refine the entire design solution. This is because the supply side needs to constantly adapt the design, develop the production and improve the component models as the customer's customization requirements increase. CompanyE acts as a connector between all parties, connecting design institutes and research institutes upstream and component suppliers downstream, forming a large pool of resources. CompanyE takes advantage of the connection and actively builds a collaborative platform to connect all parties in order to respond to customized needs in an agile manner, forming integrated and innovative design solutions and ultimately realizing R&D and production.

In December 2020, CompanyE began to focus on technology synergy and requested authorization and resources from the Group's headquarters to build a synergy platform. Under the authority of the head office, CompanyE began to build the synergy network organization, design its operational framework and related governance principles, and decided to focus its synergy business on technical advisory services and technical research services. On the one hand, the technical consulting service is to form a technical team to interact with the designers immediately when the institutes are faced with the demand from the design institutes, and eventually form a professional group to prepare technical solutions according to the demand. On the other hand, the technical support service is a collaborative effort between the technical staff of each institute to determine the solution to a difficult part of the equipment development and production. In short, both business types are driven by organizational synergy, but there are a number of obstacles in E's practice of building a collaborative network organizational structure as well as in the operation process.

3.2 Data Collection

Exploring the barriers in the development of CNO requires an understanding of the group's organizational structure and strategic objectives, which leads to further analysis of the barriers to development and solutions in driving the operation of CNO's collaborative framework in CompanyE. This paper uses in-depth interviews as the main way to obtain data and conducts a follow-up study and several interviews to obtain valid information on the development of CNO in CompanyE. We selected managers and technical staff from different institutes to ask questions about various aspects such as the technology collaboration model, elements of collaborative innovation, factors influencing collaborative innovation performance, indicators and methods of performance evaluation, and the sharing and utilization of innovation resource elements, the specific information of which is shown in Table 1. At the same time, we also collected a large number of textual reports from CompanyE to better understand the development context and strategic planning of the company.

Table 1. Key information and descriptions of the interview

Key information for the interview	Descriptions
Identity of the interviewer	Manager of the Strategic Planning Department, Director of the Process Research Institute, Director of the branch plant, three operational staffs and two technically competent staffs.
Examples of interview questions	(1) A brief introduction to the CompanyE's key businesses, culture and strengths in driving technological synergy and innovation. (2) Is there currently a platform for information sharing or transfer between the CompanyE and other Group companies? (3) What are the reasons, objectives and dilemmas for the company's technological co-innovation?
Key Responses from Respondents	(1) Connect to many resources. (2) On the technical side, there is currently product data management system, mainly for sharing design drawings. On the business side, for the time being, contact is made via an internal company email address as well as by telephone. (3) Difficulties in transcending traditional organizational structures, building collaborative platforms, evaluating collaborative performance etc.

During the interview, we adopted a flexible and responsive approach, respecting the wishes of the interviewees to express themselves. No questions were guided when the interviewees did not deviate from the questions, leaving them free to fully express their views and ideas [19]. The interviews were conducted using a semi-structured scheme, with questions asked of the interviewer based on questions prepared in advance, and questions asked flexibly during the interview based on the key points of the interviewer's answers [20], to obtain as complete information as possible (Table 2).

Table 2. Types of data collected and descriptions

Type of data	Descriptions
Onsite semi-structured interviews	15 hours of recorded audio interviews with people from different departments and positions, including technical staff, branch directors and the head of development planning.
Organizational documentation	(1) Approximately 330 pages of the Synergy Network Organizational Design Planning Report, Risk Assessment Report, Performance Assessment Methodology, Program Report on Operational Mechanisms, etc. (2) Approximately 845 pages of the Technology Innovation Capacity Assessment Methodology, Business Management Methodology, Risk Handling Regulations, etc. (3) Approximately 105 pages of PPT report on the project of building a technological innovation collaborative network organization, including background description, problem analysis, principles of collaborative operation, financial analysis, etc.
WeChat Chat Records	The research process included interviews with the company's internal management and technical staff via WeChat, and the information was collated together as a basis for analysis.

3.3 Data Analysis

In interviewing activities, data analysis begins during data collection, and analysis while collecting improves the quality of the data [20]. The raw data obtained from the interviews are descriptive transcripts such as text or audio recordings, translated or collated into text-based data that needs to be filtered and interpreted to make sense of them. We used a selective coding technique to code the text data. When a class of data could be interpreted in terms of thematically consistent literature, we combined them under a core class concept. When new themes emerged that were not explained by sufficient literature, we conducted secondary targeted interviews. This is done until the final coded core genus concept is reviewed by experts and companies and found to be logical and correct [21].

To answer our research question: What are the barriers companies face in promoting CN? We collected interview transcripts from respondents and extracted key messages that were important in driving the research.

The CompanyE has gone through a total of four stages of thinking and design in promoting CN construction. First, in terms of the value mechanism, the basis of collaborative innovation is to have a unified philosophy and goal between collaborators. Therefore, a common value must be established among collaborators to ensure the sustainable growth of CN. The second is the structural mechanism. The CompanyE is bound by the power of the group head office, and the promotion of CN must be approved and decentralized by the group head office. The third is the sharing mechanism. If the willingness to share is not obvious among organizations, it will lead to inefficient resource allocation. Fourthly, in terms of technology, digital technology provides the "predictability" of risk for empowering organizations to work

together in symbiotic networks, allowing them to achieve greater synergy. Therefore, it is necessary to build a synergistic platform.

4 Barriers and Mitigation Measures in CNO Development

This section presents the obstacles in the process of CNO promotion for companies, and summarizes the corresponding mitigation measures with relevant theoretical analysis and suggests solutions that can be referred to.

4.1 Barriers and Mitigation Measures in the Value Mechanism

If goals are not aligned between organizations, this can create many obstacles to the development of collaborative networks. The competing relationship between organizations depends on the degree of overlap between different organizations in terms of resources and knowledge. Although some of the research institutes under the group have different core technology research, they have overlapping business in some processing and trial production and material selection services, and there is a greater possibility of competition between the institutes in the overlapping business during the promotion of CNO, which makes it difficult to achieve efficient synergy.

In the process of collaborative network operation, it is important to promote continuous cooperation between organizations. Daming You [22] suggests that the high interconnectedness of technical resources is reflected in the fact that different organizations have heterogeneous resources that are interdependent on each other. Each branch and each institute has its own core technology, so it is easier to achieve synergy in technological innovation. However, because CNO theory emphasizes that VO is a goal-driven organization, goals cannot be achieved without the processing and piloting and validation of technological innovation solutions by some organizations, and some organizations have overlapping resources and competitive relationships in these operations. More serious conflicts can lead to different organizations not being able to cooperate in technological innovation. To address this issue, CompanyE has attempted to account for the performance of technology innovation research and processing and pilot production separately, with organizations' processing and pilot production operations being competitively bid for. This formed a win-win, competitive technology innovation alliance between different organizations.

Measure 1: When there is competition between organizations in the associated side business of the synergistic main business, the associated side business is abstracted to account for performance separately. Construct a goal-focused cooperation system that drives organizational behavior and business activities with goals.

4.2 Barriers and Mitigation Measures in the Structural Mechanism

In terms of power structure, CompanyE belongs to the general assembly company of the group enterprise, with insufficient voice and control, and it is difficult to drive

synergy development through itself due to the limitations of the section-based organizational structure. Therefore, establishing a person responsible for technical synergy operations is the first key obstacle.

At present, there is a lot of interactive information between assembly companies and institutes and design houses, so synergy is essential. However, who is responsible for the construction and operation of the synergy network is the company's first problem. Generally speaking, the more innovation resources a company possesses, the more quickly it can absorb and use external resources [23]. The CompanyE has set up four R&D studios and a process research institute, bringing together senior technical engineers from within the company who have developed several projects. Not only have they won several awards in the group's technology innovation competitions, but they have also published a number of technical breakthrough articles in the industry's best journals. In addition, E actively builds innovation platforms and carries out R&D capacity building by establishing several laboratories in conjunction with universities; It actively promotes its external achievements. E accumulates the advantages of technology and talent and therefore applies for authorization from the group, which gives E the corresponding authority to promote the development of CNO.

Measure 2: In the Group's section hierarchy management model, companies with the appropriate qualifications and capabilities are authorized to actively promote the operation of CN, and the Group increases its financial, equipment and personnel support.

4.3 Barriers and Mitigation Measures in the Sharing Mechanism

Knowledge transfer in VO organizations is a key link for VO members to absorb external technological resources, and it is also an important way to improve the organization's innovation capability to gain sustainable competitive advantage [24]. Knowledge sharing among VO members is conducive to identifying market opportunities and conducting innovative R&D to quickly capture the market, as many opportunities lurk in the uncertainty of the dynamic environment [25]. However, the data from the E interviews show that alliance members are not strongly willing to share resources for three reasons. First, some members felt that the willingness of some members to contribute knowledge was not evident when partners were more of a soliciting type of member, which was not considered to be a fair way of acquiring knowledge. Secondly, the willingness of technical staff to contribute knowledge is not strong due to the single reward channel and insufficient reward. Thirdly, the increasing awareness of intellectual property rights and the enhanced risk perception of enterprises in the era of big data have caused difficulties in knowledge sharing [25].

In CNs, enterprises optimize and improve their knowledge reserves through knowledge contribution and knowledge acquisition, thus enhancing their own innovation capabilities [27]. The company has established a set of feedback mechanisms to promote information sharing among VO members and to avoid the negative cooperative attitude of soliciting members. On the one hand, mutual evaluation data between members is returned to the operating platform after VO

cooperation is completed; On the other hand, the AI assistant of the operation platform analyzes the activity of members according to the discussion of each meeting initiated by VO. By combining the two feedback evaluations, if a member is recorded as not actively participating in the knowledge contribution process three times, he or she is restricted from applying to join the VO organization. This reduces the resistance to knowledge contribution to a certain extent, advances information sharing among VO members, and improves the expression of each subject's knowledge.

In terms of reward channels, currently organizations only have one form of reward, namely increased production value, which is a performance indicator used by the Group to account for the amount of value of employees' work at the end of the year. In order to motivate members to participate in knowledge contributions in technological innovation, E Company has tried to increase incentives at the request of its members, and has developed a method for evaluating the innovation capability of technical staff, taking into account feedback from members and the operating platform. e Company has conducted a comprehensive evaluation of the innovation capability of technical staff through financial and non-financial indicators to encourage and guide all staff to take the initiative in technological innovation [24]. In addition, CompanyE has established incentive allowances for its core cadre, which are paid by the group headquarters, to increase incentives for process technicians.

Alliance members cannot avoid focusing on individual interests when implementing their tasks, and the ownership of intellectual property rights is a key concern for members. To address this issue, E has attempted to establish a third-party monitoring and evaluation body, consisting of industry experts, to determine the attribution of intellectual property rights based on the degree of contribution made by each institute in the innovation project and the members. This creates a level playing field for alliance members and allows them to maximize their own interests while collaborating on technological innovation.

Measure 3: Focus on the influencing factors of VO members' willingness to contribute knowledge, include non-financial indicators in the assessment, and seek feedback from members on a regular basis.

4.4 Barriers and Mitigation Measures in the Technical Mechanism

The process of promoting technological synergy involves many participants who often need to transfer and exchange information, so an operational platform for information sharing needs to be built. Through analysis of interview data, we found that CompanyE faced two main obstacles in building the operation platform. On the one hand, there are many independent systems in the group companies, such as the product data management system, the metering apparatus management system and the Skylark mail system. There was no data interoperability and data integration between different systems, so the duplication of data entry and authenticity made the operational staff work less efficiently, while bringing a lot of uncertainty to the business. On the other hand, the communication and coordination between the institutes of the group is based on telephone interviews, which leads to a lack of valuable information being recorded and reused. In addition to the formal corporate

information system, technical communication between organizations takes place by telephone or through tools such as WeChat, which contains a great deal of corporate data and knowledge and the wisdom of a large number of technical staff.

Afsarmanesh, H. [13] proposed the concept of VBE management system (VMS), which provides the mechanisms and tools required to meet the operational and evolutionary needs of VBE, and this provides an idea for the construction of an operational platform. According to the analysis of the interviews, CompanyE has been working to eliminate obstacles to data sharing and system integration. In terms of system integration, the information technology team of CompanyE has attempted to define data interfaces to enable data sharing and information transfer, and has sorted out the data resources required for several collaborative scenarios such as electronic drawing sharing, design sign-off, document preparation and technical seminars, and has first broken through the data interoperability function for important scenarios on the operation platform.

Information interaction between organizations in the group usually takes place through a combination of email and telephone. On the one hand, the timeliness of email delivery is poor, and on the other hand, when there are too many design participants, it is necessary to send multiple copies of the same email and dock multiple participants at the same time, which increases the workload of the contact person and causes duplication of information in the system. In order to provide a fair and secure cooperation environment, CompanyE advocates transferring all information resources delivered through informal channels to the operation platform and actively developing relevant functional modules on the operation platform to achieve openness of data and information and structure of communication data. At the same time, based on the principle of confidentiality of technological collaboration and innovation, the platform only provides keys to the collaborators involved in the project to participate in seminars and view documents. All documents are approved, copied and printed by specific personnel, and the system leaves a trace.

Measure 4: Focus on the factors that hinder the construction of the enterprise operation platform and the informal channels of information transfer, and solve the problems through the professional information technology team targeted.

Based on the results of the interviews, this section dissects and proposes mitigation measures for the barriers that exist in four areas: value mechanisms, structural mechanisms, sharing mechanisms, and technology mechanisms, preparing the groundwork for the development of CNO-based technological innovation synergies in CompanyE. Table 2 summarizes the main discussions in Section 4.

Table 2. Barriers and measures in DBE development

CNO's four mechanisms	Barriers	Corresponding measures
The value mechanism	Inter-organizational objectives cannot be aligned and their competitive and cooperative relationships are influenced by the extent of overlap between organizations in terms of resources as well as knowledge.	Measure 1

The structural mechanism	Group molecules do not have enough voice and control to drive CNO operations.	Measure 2
The sharing mechanism	1. Inequitable access to knowledge. 2. Single channel of reward and insufficient reward. 3. Enhanced awareness of property rights and increased risk perception.	Measure 3
The technical mechanism	1.Data interoperability and data fusion between different systems is not achieved. 2.Communication between institutes is mainly by telephone, resulting in a lot of valuable information not being recorded and reused.	Measure 4

5 Conclusion

This study analyzed the barriers to CNO development and the corresponding mitigation strategies. The conclusions are presented in three main areas. First, this paper utilizes a case study approach to interview employees and managers of CompanyE in different capacities. The analysis of the interview data summarizes The barriers and mitigation measures faced by CompanyE in the process of developing CNO in four aspects: value, structure, sharing and technology.

Second, in the field of practice, CNO rollout is a complex system project that requires companies to go through a long process of change. CompanyE in this case connects designers who design based on customers' needs upstream and parts suppliers downstream, connecting many resources, and tries to build CNO and build a collaborative platform to achieve agile response to demand and collaborate to obtain new value, which provides a reference for manufacturing companies that play the role of "connector" to develop CNO.

Thirdly, existing CNO research mainly focuses on theoretical level, and more case studies are needed to bring new research questions to the academic community. This paper focuses on the main obstacles and mitigation measures faced by enterprises in the process of CNO development, which complements the literature in the field of CNO development and provides new ideas and methods for CNO-related research.

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