Mechanism to Improve the Innovation Capability of Late-developing Complex Product Manufacturing Enterprises Based on longitudinal case study of CRRC

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Abstract—Although China's manufacturing level has made great progress in recent years, the situation that key core technologies are controlled by others has not fundamentally changed. The improvement of innovation capability greatly affects the development of manufacturing enterprises. Therefore, based on the longitudinal case study of CRRC, this paper attempts to analyze the mechanism of innovation capability improvement of late-developing complex product manufacturing enterprises. The results show that the innovation capability promotion mechanism of late-developing complex product manufacturing enterprises includes power traction mechanism, collaboration innovation mechanism, talent cultivation mechanism and knowledge governance mechanism. Based on this, this paper believes that in the process of development, the late-developing complex product manufacturing enterprises need to carry out corresponding personnel training and knowledge management with the help of the state, under a good environment in the industry and on the premise of maintaining their own brands.

1 INTRODUCTION

The core of the innovation capability of a complex product enterprise is the innovation capability of a complex product system. Complex Product Systems (CoPS) were proposed in the mid-1990s to distinguish them from general product systems [1]. They refer to high R & D costs, large scale, high technological content, and single pieces, and large-scale products or systems produced in small batches [2]. Typical complex product systems include high-speed railway systems, aerospace systems, large-scale computer systems, and large-scale infrastructure engineering systems. Complex product system contains very dense high technology, which is widely distributed and at the forefront of the industry. Therefore, the innovation capability of complex product system plays a decisive leading role in improving the competitiveness of related industries and the overall competitiveness of the country. So, on the basis of literature review, this paper selects the case study method to discuss the mechanism for improving the innovation ability of late-developing complex product manufacturing enterprises.

2 LITERATURE REVIEW

A. Innovation Process of Complex Product System

Kash and Rycroft proposed the transformation mode of change, normal mode and leapfrog development mode [3]. The specific innovation process includes six steps: innovation idea, task decomposition, outsourcing selection, module development, integration coordination, delivery and tracking improvement [4].

B. Innovation Mode of Complex Product System

In the initial stage of a complex product system, it is appropriate to adopt the utilization type innovation mode. While in the higher level innovation stage, it is appropriate to adopt the exploration type innovation [3][5].

C. Innovation Capability of Complex Product System

Liu Yansong and Zhang Hongtao defined the innovation capability of complex product systems as an organic combination of elements needed to successfully complete the innovation process of complex product systems. It is a capability system integrated by

interrelated strategic elements, project elements, technical elements, functional elements and innovation networks [6].

3 RESEARCH METHODS AND DATA SOURCES

A. Basis for Case Selection

This paper uses the qualitative case study method and selects CRRC as the ideal sample enterprise for this study. The reasons are as follows: First, representativeness. CRRC has existed since 1986; Second, typicality. CRRC is one of the few enterprises in the high-end equipment manufacturing industry in China that ranks among the fortune global 500 and China top 100; Third, the accessibility of data. Zhejiang university, where the author works, has a long history of good cooperation with CRRC.

B. Souces,Collection Methods of Case Data

- Field work. In order to obtain real, valid and complete scientific data and materials, this paper conducted field work. The specific methods are as follows: Visit the headquarters of CRRC to understand the daily work of CRRC; visit CRRC subsidiaries, such as Zhuzhou, Sifang co., LTD., Puzhen company and Qishuyan; Using semi-structured interviews to get information from the words of the general manager, employees and employees at all levels of its subsidiaries.
- Second-hand data. The literature of CRRC is mainly from the journals and works of scholars on the websites of CNKI and web of science, CRRC official website and various media, such as People's Daily online, Tencent, SOHU news reports.

4 INNOVATION AND DEVELOPMENT STAGE OF CRRC

TABLE I. DEVELOPMENT STAGE AND CASE EVIDENCE OF CRRC GROUP

Division basis	**innovation capability**			
Division stage	Autonomous exploration stage	Technology introduction, digestion and absorption	The reinvention stage based on digestion and absorption	The stage of comprehensive independent innovation
Time node	1881-2004	2004-2008	2008-2012	2012-today
Innovation subject	CRRC, a few domestic institutions, organizations, etc	CRRC, foreign enterprises with advanced technology, domestic enterprises	CRRC, foreign enterprises with advanced technology, most of the domestic enterprises	CRRC, foreign enterprises with advanced technology, most of the domestic enterprises
Scope of resources	technology	Technology, a small number of personnel, funds, information and other resources	Technology, most personnel, capital, information and other resources	Technology, most personnel, capital, information and other resources
Types of independent innovation	**The original innovation**	**Integrated innovation**	**The second innovation**	**Comprehensive independent innovation**
Case evidence	More than ten types of high-speed trains such as "China Star" had been designed in vehicle manufacturing. In terms of line operation, Qinhuangdao-Shenyang high-speed railway had been put into operation.	In cooperation with foreign companies Alstom and Siemens, CRH series high-speed trains had been successfully developed.	The domestic CRH380 series of bullet trains rolled off the production line and the Beijing-Shanghai high-speed railway was put into operation	The construction of "eight vertical and eight horizontal" high-speed railway network; The Renaissance was first launched; International trade has a good growth momentum and so on

5 MECHANISM

A. *Dynamic Traction Mechanism*

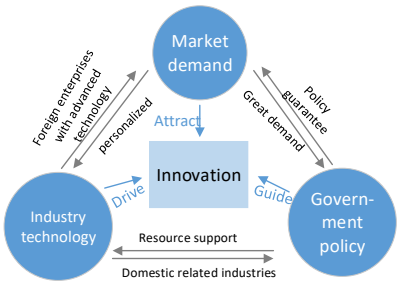

Figure 1. power traction mechanism

As shown in fig. 1, the dynamic traction mechanism for the innovation capability of late-developing complex product manufacturing enterprises consists of market demand, industry technology and government policies. Among them, the market demand has the characteristics of personalized and great demand. The personalized demand needs the introduction of foreign advanced technologies, while the great demand needs the protection of government policies. The industry technology needs the support of domestic related industries, and the government coordinates resources. In the end, the attraction of market demand, the drive of industry technology and the guidance of government policies jointly provide innovative directions and promote the innovation of late-developing complex product manufacturing enterprises.

B. *Collaboration Innovation Mechanism*

Collaboration innovation emphasizes that stakeholders such as universities, research institutes, suppliers and competitors play a synergistic effect in the creative generation, research and development and experimental stages of innovation chain, and the transaction logic is economic [7].

1) Adhere to the game mechanism of independent brands.

The collaboration between CRRC and foreign enterprises with advanced technology is a game. When it comes to discussing whether to introduce technology, the leadership of the Ministry of Railways had some objections. Because the "market for technology" itself is highly controversial, China's automobile industry has implemented this idea, resulting in a large number of market shares occupied by foreign investment, while its own technological capability and innovation capability have always lagged behind others. For the automobile industry, it takes time and effort to conduct independent research and development after the introduction of foreign capital. However, selling cars directly by assembling parts can achieve immediate profits, so the research and development autonomy of the automobile industry is reduced, and the establishment of independent brands is even more impossible. Relatively speaking, the complex product industry has always insisted on its own autonomy and developed its own brand in this game, so it has not entered the traditional ending of "market for technology".

2) to build a relationship transaction

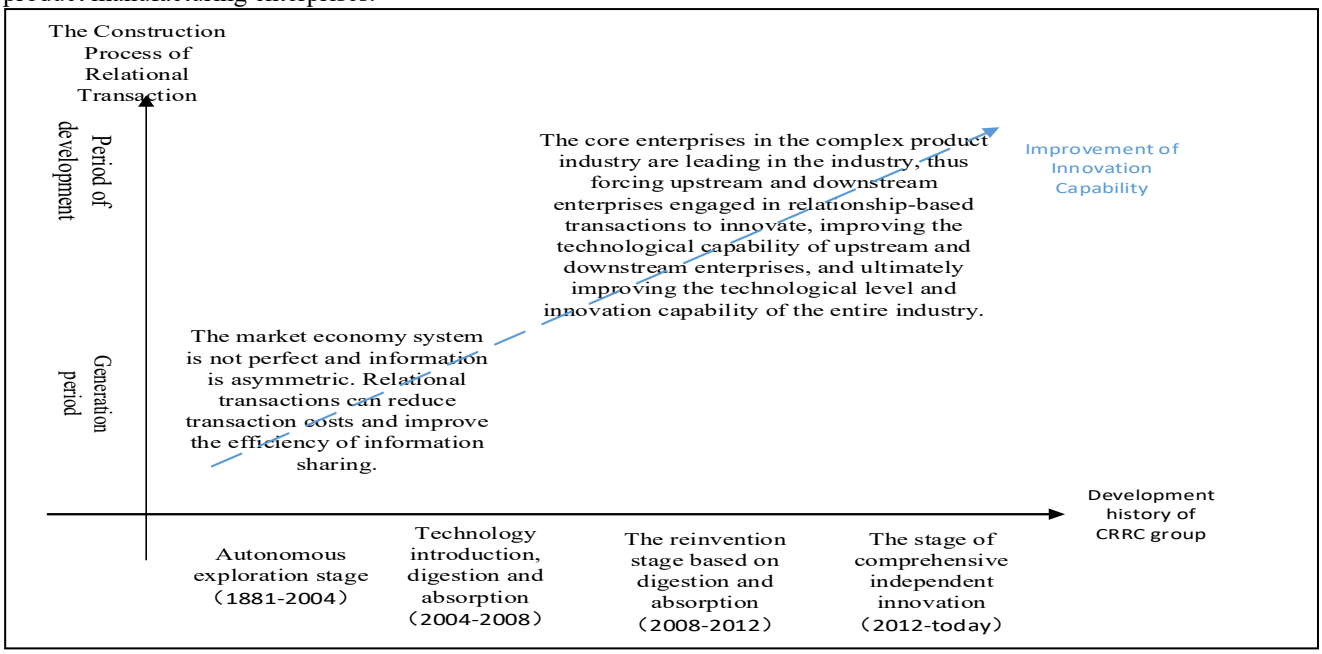

Figure 2. construction of a relational transacation

Relational transaction refers to the business transaction formed by the relationship contract among enterprises, organizations and institutions. It is a kind of transaction formed by mutual trust rather than formal governance mechanism (Kong X,2011). For CRRC, in the process of innovation, the original ministry of railways or general railway is at the top of the industrial chain where CRRC is located, and the connection between partners and suppliers is a relational transaction.

C. Talent cultivation mechanism

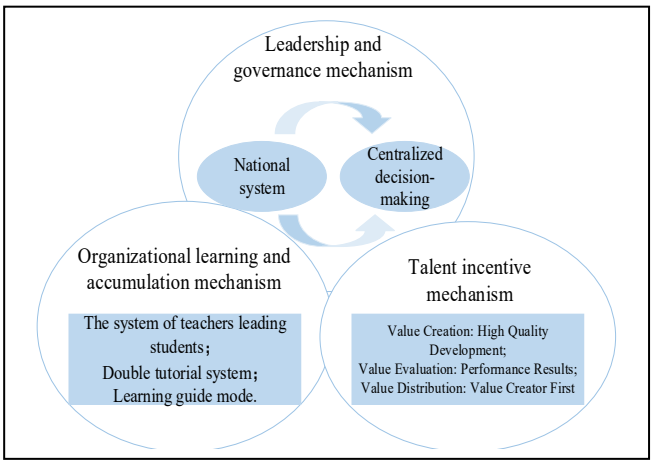

Figure 3. Talent cultivation mechnism

The complex product industry is characterized by intensive technology and requires the joint efforts of a large number of high-tech talents. CRRC is a joint-stock enterprise with the background of a state-owned enterprise, and it controls a transportation enterprise that is related to the lifeline of the country. Therefore, centralized and unified leadership enables it to concentrate the best talent resources in the country to solve technical problems and improve the allocation efficiency of talent resources. In terms of leadership and governance mechanism, leaders tend to be more like politicians. They have no decision-making right on the direction of operation, and are mostly responsible for the coordination and allocation of resources. In terms of governance, they operate under the strict constraints of national policies and regulations. CRRC is still developing in parallel with other businesses centered on technological innovation. Therefore, in organizational learning and accumulation mechanism, most of the training is technical training for internal personnel of the enterprise. In view of the characteristics and nature of CRRC itself, the principle of value-creation-oriented and the incentive mechanism with enterprises as the main payers are implemented in the talent incentive mechanism.

D. knowledge governance mechanism

Knowledge governance is a rising process, which includes knowledge search, knowledge flow and knowledge reconstruction. The process of knowledge search for late-developing complex product manufacturing enterprises includes the search for relevant knowledge of domestic and foreign enterprises such as technology, experience, talents, etc. The flow of knowledge includes the flow of foreign enterprises with advanced technology to CRRC, as well as the flow between subsystems and modules. The reconstruction of knowledge is the reconstruction of knowledge imported from abroad and the reconstruction of related knowledge at home. Because foreign technology may not be suitable for the geological environment and engineering environment of the developing countries, but also because of the complexity and coupling characteristics of the complex product system itself. Only through the reconstruction of knowledge can the relevant knowledge be more suitable for the developing countries and the innovation of complex product manufacturing enterprises.

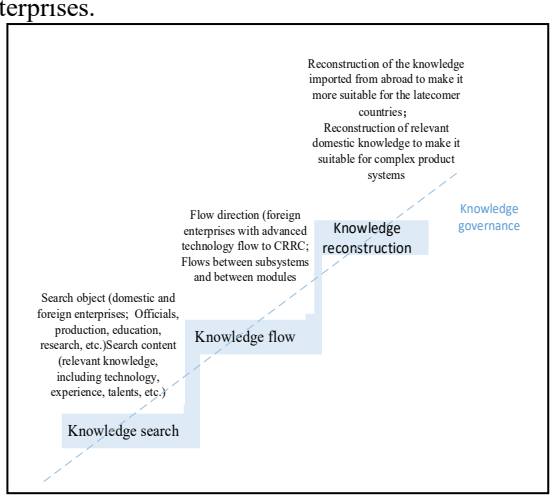

Figure 4. Knowledge governance mechanism

6 CONCLUSION

Based on the case study of China Automobile Group, this paper systematically discusses the mechanism of improving the innovation capability of late-developing complex product manufacturing enterprises from the micro level of enterprises. The study found that: The mechanisms for improving the innovation capabilities of late-complex product manufacturing companies include a power traction mechanism that provides innovation., and a collaboration innovation mechanism and a talent training mechanism to provide technology, talents, information, funds and other support for complex product manufacturing enterprises, and a knowledge governance mechanism to keep knowledge in a virtuous circle.

A. For the country,

The attraction of market demand, the drive of industry technology and the guidance of government policies are indispensable, providing innovative directions for complex product manufacturing companies;

B. For the industry

The relational transaction reduces the transaction cost, and the breakthrough of core enterprise technology can force the innovation of upstream and downstream enterprises, thus driving the development of the whole complex product industry. Therefore, it is necessary to adhere to the relational transaction and maintain a good industrial environment.

C. For enterprises

The most important thing is to adhere to and protect their own brands. In terms of talent cultivation, we should maintain the existing leadership and governance

mechanism, organizational learning and accumulation mechanism and incentive mechanism, and actively explore mechanisms more conducive to the subsequent development of CRRC. With regard to the governance of knowledge, it is necessary to continue the cycle of the internal governance of the knowledge governance mechanism, to continuously cycle the knowledge search, the flow of knowledge, and the reconstruction of knowledge, so as to maintain the good operation of knowledge, which is more conducive to developing countries and more Innovation for complex product manufacturing companies.

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REFERENCES

1. Hobday M, Rush H. Technology management in complex product systems (CoPS)-ten questions answered[J]. International Journal of Technology Management, 1999, 17(6): 618-638.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
2. Hansen K L, Rush H. Hotspots in complex product systems: emerging issues in innovation management[J]. Technovation, 1998, 18(8-9): 555-590.
3. Kash D E, Rycoft R W. Patterns of innovating complex technologies: a framework for adaptive network strategies[J]. Research Policy, 2000, 29(7-8): 819-831.
4. Zhou Yongqing, Chen Jin, Jing Jinsong. Research on Innovation Process of Complex Product System-Taking HL Company's Large Power Station Distributed Control System as an Example [J]. Economic Management, 2004(14):4-10.
5. Hobday M. Product complexity, innovation and industrial organisation[J]. Research policy, 1998, 26(6): 689-710.
6. Liu Yansong, Zhang Hongtao. Composition and management strategy of innovation capability of complex product systems [J]. Science and Technology Management, 2009,30(10):90-94.
7. Gao Liangmou, Ma Wenjia. Open Innovation: Connotation, Framework and Chinese Context [J]. Managing the World, 2014(06):157-169.