Development and Evolution of Industry-University-Research Cooperative Innovation Mode in China

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Abstract: Industry-university-research cooperation is an important part of the national innovation system. This article introduces four typical industry-university-research cooperative innovation modes identified by the different roles of their subjects played, and analyzes their operational mechanism, structure, and function. Based on the results obtained we find the transitional rule of industry-university-research cooperative subject and the selection of industry-university-research cooperative mode. Then the article prospects the development of industry-university-research cooperative innovation modes. It concludes that to foster this cooperative innovation needs to clarify the division and contacts of parties involved, needs the government to play a more active role, but also needs to create a more mobile, flexible and efficient industry-university-research cooperative innovation mode.
Key words: Industry-university-research cooperation; Subject; Innovation mode

1 Introduction

Industry-university-research cooperative innovation refers to the cooperative innovative mechanisms enterprises, universities and research institutes established through some organization form in order to achieve their value objective[1]. Enterprises have the unique advantages of transforming the scientific and technological achievements into products, the sensitive mechanism of directly facing the market and understanding the market demand, and the conditions of sustained technological innovation; universities and research institutes are an important carrier of modern science and technology, are an important source of new knowledge and new ideas. Meanwhile they have the most valuable human and technical resources of transformation from the industrial economy to knowledge economy, have a set of trinity organization form of education, scientific research and technological innovation, and are more closely fused together with economic growth [2].

At present, in the background of vigorously promoting the independent innovation in China, researches on industry-university-research cooperative innovation have an important role, especially on cooperative innovation modes. According to the differences of target-oriented, Professor Wang zhangbao[3] divided industry-university-research cooperative mode into the type of personnel training, research and development, production and operation, and subject complex. Using the classification method Li yanyan[4] has classified industry-university-research cooperative mode into four types from the perspective of the subject role, such as government leading mode, enterprise leading mode, universities or research institutes leading mode, and common leading mode. This article will focus on analysis of operation system and their structures and functions of these four modes, summarizes and prospects the development of industry-university-research cooperative innovation mode in China. This can provide useful inspiration for industry-university-research cooperative innovation in China.

2 Industry-University-Research Cooperative Innovation Mode Analysis Based on the Subject Role

2.1 Government leading mode

This model is divided into government directive-type and government driven-type modes. Government directive-type mode is a product of the planned economy, in which the government directs all parts of industry-university-research to cooperate. In this mode, the

government is the real subject and is powerful. Enterprise, universities and research institutions are the executive subject, belonging to respective government department and in accordance with the instructions and requirements of departments to form a consortium of industry-university-research cooperative innovation, with relatively weak interaction among the various subjects, as shown in Figure 1. Through cooperative innovation, this mode achieved goals in aspects such as China's national defense building and security, led the development of technology, promoted the progress of the industrial economy and society, but also trained a large number of socialist construction talents. Most importantly, as this kind of cooperation is the first one of innovation modes in China, it is the beginning of industry-university-research cooperative innovation mode establishment which later modes all emerged from and develops based on.

Government driven-type mode is driven by the government providing policy guidance and markets service such as giving research programs and providing intermediary services. Government is dominant; universities and research institutes play a central role; and enterprises actively participate. Specifically, as shown in Figure 2, in the structure of this mode, the relationship of all subjects is relatively close in the process of industry-university-research cooperative innovation. The government, enterprises, universities, research institutes are all the subjects: the government is in a dominant position, play a role of decision making, coordinating management, assessment monitoring, information exchange services, et al. Universities and research institutes play a central role by virtue of research capability, and enterprises are in the position of active participation. At the same time, the relevant government departments provide intermediary services for industry-university-research cooperative innovation, and the function of social intermediary organizations and private foundations and other organizations is not obvious.

The function of government driven-type mode performs in the following three aspects, 1) to promote the start of China's high-tech industries, enhance the industry's R & D and innovation ability, train a group of outstanding talent, and provide the conditions for further deepening science and technology system; 2) to develop SMEs, promote local economic development such as "Spark Program", pushes some effective, quick and new technologies to large SMEs, particularly to rural township enterprises, and improve technological development capabilities and develop local economy; 3) to change the social attitudes. Series of government programs such as "863", "Torch Project" aroused the concern of the whole society, which promotes more people realized that the integration of high-tech and economic is so important that the notions of "science and technology are primary productive forces" and of "developing high technology and realizing industrialization" enjoys popular support.

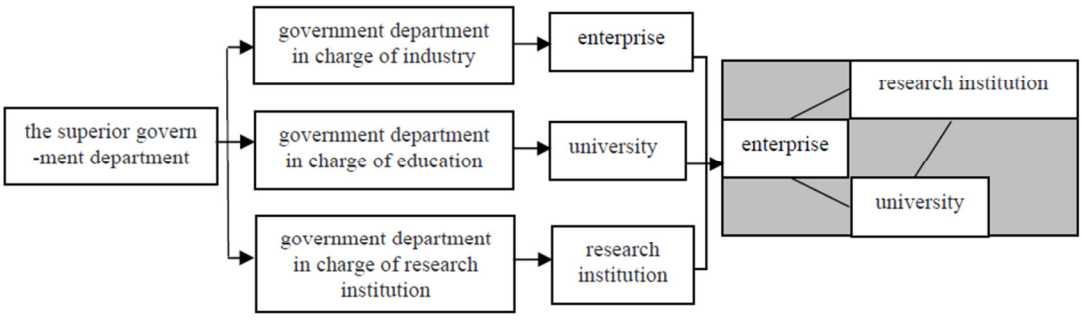

Figure 1 - Government Directive-Type Mode

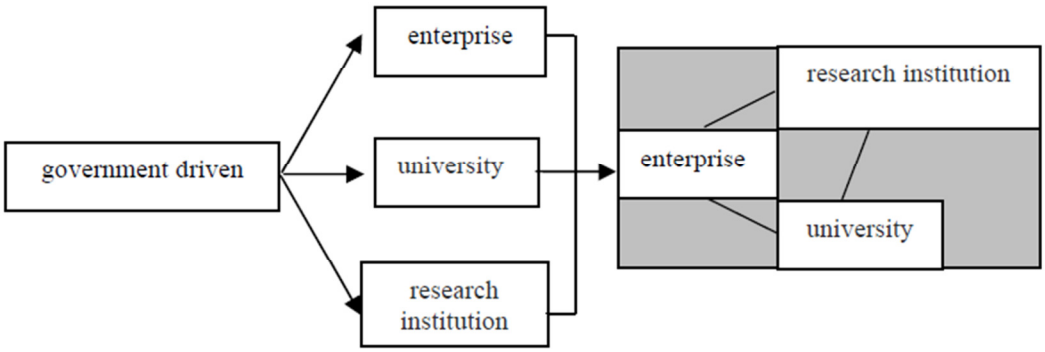

Figure 2 - Government Driven -Type Mode

2.2 Enterprise leading mode

Enterprise leading industry-university-research cooperative innovation mode is strategic focus of deepening the research system and building the national innovation system currently, is the important measure for enterprise to withstand international completion and future challenges[5]. As Figure 3 shows, in this mode, the enterprises strive to upgrade its research and development capabilities, and at the same time to seek for technical support, consulting and services of universities and research institutes in the form of commissioning development, cooperative development, building research institutions and so on. Enterprise is in a dominant position, and assumes the corresponding risks of development and conversion. Technology innovation of universities and research institutes meet the needs of the enterprises which decided their R & D activity content, form and scope; That is, they are the participants. In this mode, the enterprise is at the core position. It accounts for the initiative in the partner selection, the close relationship and distribution of benefits, and bears the most risk. Universities and research institutes join corporate research and development as an active part. Government's role is bleak, mainly to provide policy support and legal environment for intellectual property protection; social intermediary agencies began to actively play a role in providing intermediary services; other organizations, such as private foundations generally provide funds and other services.

The function of enterprise leading mode performs in the following three aspects: (1) This mode is conducive to enhance technological innovation and competitive advantage of enterprise. On the one hand, enterprises as market economy entity are responsible for their own management decisions, self development, and participate in the fierce market competition. Objectively, they should improve their own technological innovation. On the other hand, subjectively, enterprise itself needs to survive and develop. Technological innovation is an important part of enterprise value chain, but in general it is difficult for enterprises to complete the technology development process, so it must be supported by means of research and development capabilities of other organizations. Therefore, through this partnership, the enterprise can create a more attractive environment for overseas investors, fully absorb and use the research and development capabilities of universities and research institutes. (2) This mode is an important way of technology commercialization and marketization. A new technology, need to go through a series of processes of experiments, pilot, market testing. Enterprise leading industry-university-research cooperative innovation mode has timely access to the information of market demand and changes, and thus quickly completing this process to achieve the goal of the market. (3) The role of intermediaries has been increasingly important. As the goals, interests and other factors related to respective parties, enterprises and universities, research institutes, government prone to conflict and dispute. It needs to increase the lubricant among their interface, and these social intermediary organizations will be a good choice in this aspect.

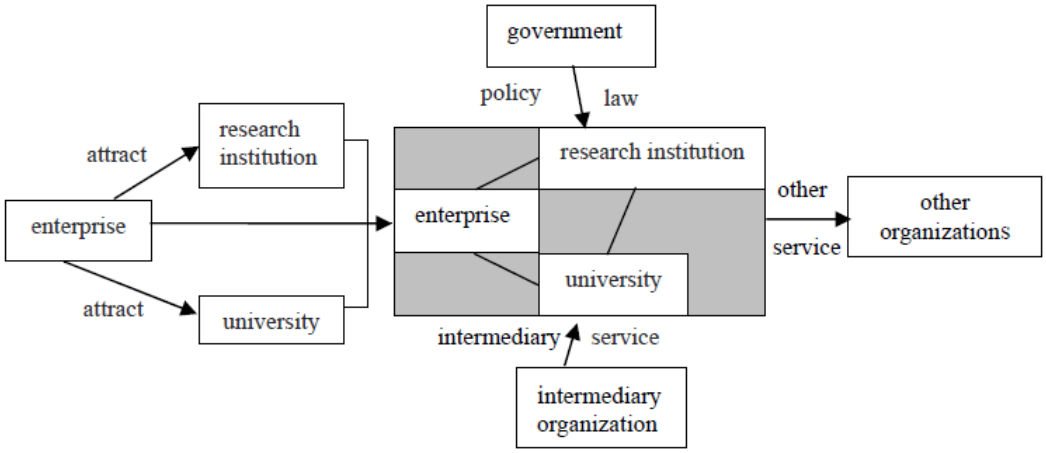

Figure 3 - Enterprise Leading Mode

2.3 Universities or research institutes leading mode

University or research institutions engage in technological innovation with their superiority of technology and talents. After results ripened, they were provided for enterprises, particularly SMEs which need them in the form of technology transfer, patents trade and so on, to achieve technology transformation from those results to the market and benefit. As shown in Figure 4, in this mode, universities or research institutes are in the dominant position. As technology provided is often the core power of enterprise development, so it can decide the close degree of cooperative partners and cooperative relationships, undertake the risk of technology research and development, entitle to advantages in the distribution of benefits. Enterprise is the carries to achieve its goal of market-oriented and practice venues of universities or research institutes. The role of governments and intermediary institutions is basically the same as those of enterprise leading mode.

The function of university or research institutions leading mode performs in the following three aspects, (1) broaden the funds raise channels for universities or research institutes. As government funding has been unable to meet their development needs, it need to develop ways to raise funds, one of which is cooperation with enterprise; (2) promote scientific and technological achievements transformation of university or research institutions, to better achieve their function of scientific research and social services. Through the cooperation with enterprises, they can easily bring the research results to the market, smooth the resources flow channels with market; (3) be more suitable for the development of SMEs. Due to weak technical capabilities of SMEs, they can achieve technological innovation by virtue of scientific research efforts of universities or research institutes.

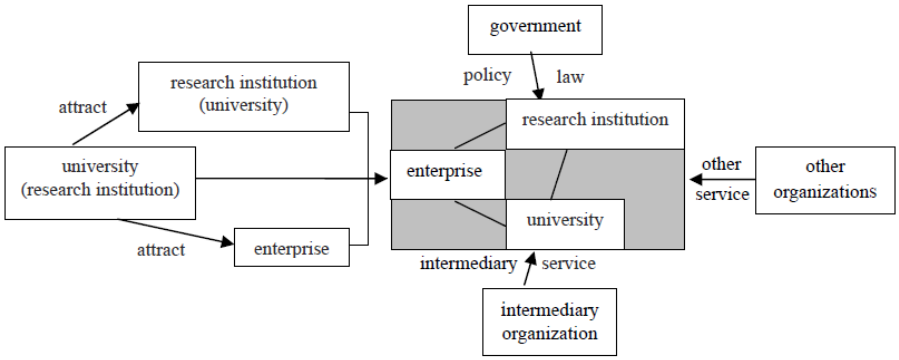

Figure 4 - Universities or Research Institutes Leading Mode

2.4 Common leading mode

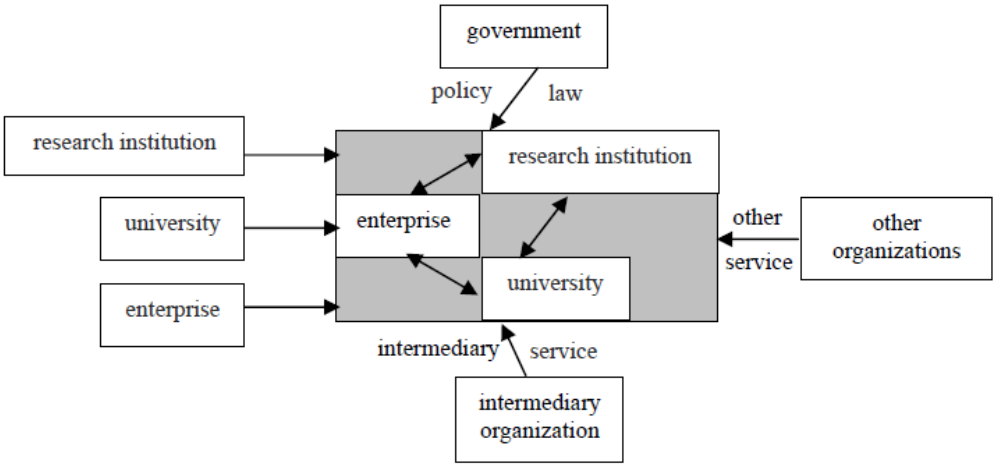

Figure 5 - Common Leading Mode

As shown in Figure 5, in the common leading mode, the cooperation status of all parts is equal, thus there is no absolute leader, but the interaction degree is deepening, and cooperation is more closely and strictly regard to the contract as the foundations of the cooperation. All parts have clear contracts or agreements which clarify benefits distribution and risk-sharing in legal form in order to explore their respective advantages in funds, equipment, technology, talent and market, and thus jointly promoting technological innovation market development, risk sharing, shared interests. If all the powers, responsibilities, and profit are not clear that such common leading mode will not exist. Universities and research institutions will provide human resources, scientific research strength, technological achievements; Enterprises provide funds and practical field; Government provides the laws and regulations environment to strictly safeguard the validity of contracts and research and development rights of researchers; Intermediary institutions play a significant role as a bridge between the parties, provide market information for industry-university-research cooperative parties, or even risk-sharing and credit guarantee, to promote and ensure the smooth progress of industry-university-research cooperative innovation. Therefore, the common leading mode is the most direct and close industryuniversity-research cooperative innovation mode.

The function of common leading mode performs in the following three aspects, 1) the common leading mode is the development and evolution of all past modes. It develops along with the education, technology, economic development; 2) It guarantees the equality of cooperation status of all parts. Scientific achievements, benefits distribution and risk-sharing are based on cooperation contracts, and any part will not enjoy privileges; 3) It promotes policies and regulations of China. The most basic external environment need of the common leading mode is laws and regulations to ensure the effective cooperation by contract.

3 Implications

By analyzing the operating mechanism, structure, and function of four industry-universityresearch cooperative innovation modes above, the article obtained changes law of industry-universityresearch cooperative subject and selection method of industry-university-research cooperative mode.

3.1 Change of industry-university-research cooperative innovation subject

Industry-university-research cooperative innovation subject changes with operation and development of cooperation. In general, in basic research stage, universities and research institutes share the leading position. For the enterprise, only large state-owned or multinational enterprises could be more concerned about basic research. In applied research stage, the company's R & D institutions join, and fight for taking the lead, their status begin to rise. In the experimental stage, due to the different location of specific experiments,

enterprises more likely dominated with things carried out in enterprises,and universities more likely dominated with things carried out in universities. In the test, manufacture and commercialization stage, the enterprise no doubt becomes the subject, universities and research institutes provide technical advice and services. The government, in the whole process of cooperation and innovation, primarily provides the soft environment of cooperation and development, are generally not dominant. Intermediary organizations, private foundations and other organizations provide their services accordingly. With the further maturation of the market economy, their importance of role will be increasing, and cooperative innovation mode which appears to regard them as the subject is likely coming into being.

3.2 Related legal system follow-up of industry-university-research cooperative innovation

While the laws and regulations of China's patent law, technology contract law, and science and technology law have produced good protection and catalytic role on the establishment of industry-university-research cooperative innovation mode. But in practice, we found some legislation system are not perfect, some policies and regulations are deficient to encourage the development of intermediary institutions and private foundations, and the obligation of technology brokers, intermediaries, private organizations is not clear and rights can not be guaranteed. In addition, the development of judicial institutions can not keep up the steps of industry-university-research cooperative development. There is a phenomenon that the speed and efficiency of law enforcement agencies in handling cases is lower. Infringement cases appeared from time to time, some can not be dealt with promptly, seriously dampened the enthusiasm of all parties. To a certain extent, these hampered the development of industry-university-research cooperative Innovation. Therefore, the related legal system of industry-university-research cooperative innovation need further develop and follow-up.

3.3 How to select industry-university-research cooperative innovation mode

Apart from government leading mode that exists in the particular planned economy years, other modes analyzed above exist in the market economy period. Each has advantages and disadvantages; it is hard to simply arrange the order from good to bad. Therefore, it is recommended that we should select the appropriate mode according to the changes in internal and external environmental factors, as well as the coupling and interaction degree of science, technology and other elements. In addition, a series of indicators system can also be set up, such as the provision of financial and human resources, risk sharing capacity and benefit-sharing ratio, to determine the suitable mode.

4 Conclusions

According to the different function of industry-university-research cooperative subject, the article introduces four typical industry-university-research cooperative innovation modes, analyses their operational mechanism, structure, and function, and in terms of the analysis results obtains the changes law of subject and selection method of modes. From the above analysis and revelation, it can see that we have successful experience and lessons of failure in the development process of industry-universityresearch cooperative innovation course of China. Therefore, more deep works are needed in the following three aspects in order to make industry-university-research cooperative innovation course to achieve more fruitful results in the future.

4.1 The division and contact of industry-university-research cooperative parties need to be clearer

Industry-university-research cooperative innovation involves activities and interests of all parties, so the division and contact must be clear. Government controls large projects related to the level of comprehensive national strength and national defense mainly by way of economic and legal means which are supplemented by way of administrative means. Universities and research institutes which are the source of innovationand which engage in basic research and applied research, must maintain their tradition of academic freedom and

scientific research freedom, make a number of new ideas, new technologies continually emerged from the university. Enterprises are the subject of innovation, carry on a small amount of basic research according to their own survival and development and market requirements, and are mainly engaged in applied research. Intermediaries provide intermediary services, dredge the communication obstacles of all parties, and build a bridge between the parties. For the contact of cooperative innovation parties, it should be neither too tight nor too loose and the general principle is that it can fully guarante all kinds of explicit and implicit resources, such as scientific and technological achievements, knowledge, talents, smooth flow in accordance with the cooperation requirements.

4.2 The government needs to play a more active role

The government is an advocate, regulator, strategic decision maker, technical communicator and environment creator of industry-university-research cooperative innovation, and therefore must play its active role to intervene industry-university-research cooperation, mainly in the following aspects, (1) to further improve the technology contracts, intellectual property and other laws, regulations, to protect industry-university-research cooperation smoothly progress by legal means, to maintain the interests of all cooperation parties; (2) to provide funding for scientific research and use the direction and scale of financial input to reflect the government's technology development strategy and planning; (3) to support and promote industry-university-research cooperation through tax relief; (4) to provide various support measures for industry-university-research cooperationand set up official service agencies of industry-university-research cooperation; (5) to attach importance to the international industry-university-research cooperation, encourage domestic organizations and institutions involved in international exchanges and cooperation, and make full use of advanced technology and research capabilities from other countries. In addition, in making policy the government should pay attention to maintain the continuity and stability of the policy, which plays a very important role for the success of industry-university-research cooperative innovation.

4.3 The need to create more mobile, flexible and efficient cooperative innovation mode

With the rise of the knowledge economy and the arrival of the innovation explosion era, virtual cooperative innovation mode based on network technology is born out. This invisible cooperation mode is more mobile, flexible and efficient, thus it reduces the time of the “market demand - R & D - Manufacturing - to meet the needs”, achieves the integration and sharing of resources, and improves the cooperation performance and the use efficient of social resource. On the current development trends, virtual cooperative innovation mode will be increasingly used. Industry-university-research cooperative innovation mode has a process of historical evolution. In the 21st century and the era of knowledge economy and information explosion, in a more macro and complex social logic and historical picture, industry-university-research cooperative innovation mode of China will be toward more mobile, flexible, efficient. The new mode is bound to supplement or replace the existing mode, so industry-university-research cooperative innovation will glow new vigor and vitality in the new century.

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