

Research on domestic and international industry-university-research cooperation model

Liu Jin, Wu Xiujie*, Wang Shuyang, Zhu Wen

Shandong Academy of Innovation and Development, Jinan, 250101, China

*Corresponding author

Keywords: industry-university-research cooperation; model; development status; countermeasures

Abstract: With China's reform and opening up and rapid economic and social development, the role of industry-university-research cooperation in the national innovation system is becoming increasingly important. China began to implement the "joint development project between industry, academia and research" in 1992, and after more than 30 years of development, the government has strategically positioned the cooperation between industry, academia and research as a key link in building an innovative country and enhancing the capability of independent innovation, and has given strong support in terms of policy and funding. Since the report of the 19th Party Congress, it has been clearly put forward to "deepen the reform of the science and technology system, establish a technological innovation system with enterprise as the main body, market-oriented, deep integration of industry, academia and research, strengthen the support for small and medium-sized enterprise innovation, and promote the transformation of scientific and technological achievements." Innovation-driven development is a major development strategy put forward by the CPC Central Committee according to the characteristics of economic and social development in the new period, and the core idea of the strategy is to promote the in-depth integration of industry, academia and research, and the cooperation mode of industry-academia-research fully realizes the organic integration of knowledge and information creation, acquisition, transmission, transformation and application. Based on this, the article firstly describes the research status quo and typical mode of University-Industry-Research Cooperation at home and abroad, and then analyzes the development status quo and problems of University-Industry-Research Cooperation in Shandong Province as an example and puts forward targeted countermeasure suggestions, in order to provide reference for the government to formulate relevant policies.

1. Mode and characteristics of foreign industry-university-research cooperation

Under the impetus of the industrial revolution, the thinking concepts of colleges and universities have also been transformed, and the germ of the idea of University-Industry-Research Collaboration (UIRC) first arose in the United States^[1], which created the "Silicon Valley Model" and played a great role in promoting the development of the economy and society. Influenced by the United States^[2], many other developed countries have also begun to carry out in-depth research and exploration of the University-Industry-Research Cooperative Model, such as Germany, Japan and so on.

1.1 United States industry-university-research cooperation model

The United States was the first country to conduct practical research on industry-university-research cooperation, and has formed a variety of practical cooperation models in the course of practice. Among them, the more influential ones are roughly divided into five: science and technology park mode, high-tech enterprise mode, business incubator mode, patent licensing and technology transfer mode, industry-university cooperative research center and engineering research center mode. In general, the U.S. industry-university-research cooperation model is characterized by strong goals and practicality^[3]. On the one hand, universities and government departments cooperate closely in industry-university-research, especially the programs designated by the U.S. government departments are practical and in place, which correctly guide university students and enterprise R&D

personnel to actively participate in the field of scientific research and development, and meet the needs of the public; on the other hand, the government has set up the "state-industry-university" cooperative research centers and the "industry-university" cooperative research centers. On the other hand, the government has set up "state-industry-university" cooperative research centers (intermediary institutions) and set up special funds to subsidize enterprises and their alliances in the field of industry-university-research collaborative innovation.

1.2 German Industry-University-Research Cooperation Model

Germany's industrial economic strength ranks first in Europe, with the continuous development of society, the demand for the "social service" function of higher education institutions is also becoming stronger and stronger, so the mode of industry-university-research cooperation has become the main development trend. At present, there are mainly two modes of cooperation: university-enterprise cooperative research centers and off-campus research organizations and enterprises. University-enterprise cooperation research centers mainly include New Material Simulation Research Center and E.ON Energy Research Center. The main external research organizations are the Franz Josef-Gesellschaft (IFG), the Leibniz-Gesellschaft (LG), the Max-Planck-Gesellschaft (MPG) and the Helmholtz-Gesellschaft (HG). The long-term and stable industry-university-research joint development model formed in Germany is, on the one hand, attributed to the completeness of the national legal and regulatory system, which safeguards the legitimate rights and interests of all parties in the industry-university-research sector through law; on the other hand, it is attributed to the moderate participation of the government, which not only strengthens the connection between the industry-university-research sector and reduces the cost of risk by moderately supervising and guiding the process of industry-university-research sector.

1.3 Japan's industry-university-research cooperation model

Japan's industry-university-research collaboration model began after the Second World War and has been gradually explored and researched, and there are now three main types: the joint research model, the commissioned research model, and the model of creating technology transfer centers. University-Industry-Research Collaboration is characterized by three main points: firstly, University-Industry-Research Collaboration is a basic national policy of the country, and the government constantly adopts new measures to promote the sustainable development of University-Industry-Research Collaboration; secondly, in the process of combining universities and industries, great importance is attached to the cultivation of high-level scientific research and technological talents; and thirdly, many universities and colleges have set up science parks, such as the University of Tsukuba's High-Tech Science City. By using science parks as a vehicle for cooperation with specialized scientific research institutions and enterprises, universities not only promote teaching reforms in universities, but also develop new technologies and products that are compatible with society, thus promoting the development of industry-university-research cooperation.

2. Domestic Industry-University-Research Cooperation Models and Typical Cases

China's research on industry-university-research cooperation started relatively late and has a relatively short history compared to the contemporary sense of industry-university-research cooperation^[4]. With the construction of national innovation system and the understanding of the necessity of the cooperation between industry, academia and research, the combination of industry, academia and research in China has been developing rapidly, with a variety of cooperation modes of organic fusion, long-term coexistence and joint growth, which are summarized into five main modes: innovation strategic alliance mode, "1+1+1" joint innovation platform mode, docking cooperation between colleges and universities and localities, university science and technology park mode, and five-in-one mode of government, industry, academia, research and finance. There are five main modes: innovation strategic alliance mode, "1+1+1" joint innovation platform mode, docking cooperation mode between universities and localities, university science and technology park mode^[5],

and government-industry-academia-research-finance five-in-one mode.

2.1 Strategic alliances for innovation

As a new mode of joint development between industry, academia and research, strategic innovation alliances are characterized by large-scale, wide-ranging and high-level cooperation, and are an effective way of realizing the enhancement of the overall strength and core competitiveness of enterprises. For example, six national ministries and commissions, through the establishment of the "Coordination and Guidance Group for Promoting Cooperation among Industries, Academics and Research Institutes", have created industrial technology innovation strategic alliances covering four fields, and brought together 26 leading and backbone enterprises, 18 first-class colleges and universities, and 9 backbone scientific research institutes to create an effective docking system for design, research and development, production and market.

The whole chain of technological innovation activities has broken the bottlenecks in the technological industry, broken the monopoly of core technologies, and adequately solved the limitations of China's industry not being centralized, not having a strong capacity for original innovation in technological areas, and not having enough supply of key common technologies.

2.2 "1+1+1" Joint Innovation Platform

The "1+1+1" joint innovation platform is an industry-university-research joint development mode led by government departments. The government has established technological innovation service platforms such as research institutes, research and development bases, national key laboratories and branches of engineering centers through long-term collaboration with higher education institutions and scientific research institutes, and has stepped up its efforts to introduce higher education institutions to localities or to interface and cooperate with enterprises. Local or docking cooperation with enterprises. For example, since 2006, the Guangdong Provincial Government has cooperated with more than 50 institutions of higher education and scientific research institutes in China for a long time, and created more than 20 technological innovation service platforms, 21 institutions of higher education have set up offices, and 18 institutions of higher education have created research institutes. The government of Taizhou City, Zhejiang Province, has co-founded more than 30 innovation platforms by striving to introduce institutions of higher learning to Jiaojiang District to establish research and development organizations or to cooperate with enterprises.

2.3 Cooperation between universities and localities as a whole

Universities and research institutes to use their scientific research advantages and local professional towns two-way choice and all aspects of docking cooperation, all-round service to the community, opened up a new field of universities and colleges to serve the local economy. For example, the Guangzhou Municipal Government, Foshan City Government and Sichuan University, Beijing Institute of Technology and other institutions of higher learning signed 23 comprehensive collaboration projects. Through two-way selection with more than 100 specialized towns in Guangdong Province, institutions of higher learning have established long-lasting, stable collaborative partnerships, significantly improving the technical content and core competitiveness of the specialized towns' unique and famous products, and further improving the comprehensive competitiveness of the county and private economy.

2.4 University Science and Technology Park

Starting from the actual needs of the local high-tech industry, well-known institutions are used as carriers, higher education institutions and local resources are properly integrated, and the mode of university science and technology parks jointly created by the university and the local community and a park with multiple schools is adopted, so as to establish a base for the introduction and cultivation of high-level talents, the transfer and transformation of scientific and technological achievements, and industrialization. For example, Shenzhen has established the Shenzhen Virtual University Park through the introduction of 53 renowned universities at home and abroad, such as Peking University and the University of Alberta in Canada. A total of 12 laboratories of the Hong Kong Productivity

Council have joined, creating 71 R&D centers in Shenzhen and 93 university-enterprise collaboration projects.

2.5 "Government, industry, academia, research and finance" five in one

"Cooperation among government, industry, academia and research institutes is an effective means of fully integrating technology, education and the economy at home and abroad, and of promoting the transformation of scientific and technological achievements into productive forces. Among them, "government" is the leader and monitor, "industry" is the main body of innovation, "academia" and "research" are the catalysts, and "gold" is the supporter. The "gold" for the supporters. Such as Zhejiang Deqing County through the operation of the "government, industry, academia, research and gold" mode, more than 80% of high-tech enterprises have set up a provincial high-tech enterprise R & D centers, industry leading backbone enterprises to create a large number of industry radiation leading capacity of the pilot base, research institutes and engineering and technology research centers and, significantly enhance the independent innovation and R & D capabilities and the transfer of scientific and technological achievements into production, production, research and development. This has greatly enhanced the enterprises' independent innovation and R&D capability and the ability of transferring and transforming scientific and technological achievements.

3. Development status of industry-university-research cooperation in Shandong Province

Shandong Provincial Party Committee and Provincial Government have always attached great importance to the cooperation and innovation of industry-university-research, and vigorously promote the collaboration and docking of industry-university-research, and have held the Industry-University-Research Exhibition and Fair for 33 consecutive years since 1991, and have planned and purposely coordinated and arranged a variety of industry-university-research activities. In the party committees and governments at all levels of strong, measured, effective, the province's industry-university-research collaborative innovation has been to the depth of the level of progress, collaboration and docking mode is increasingly deepening, the industry-university-research cooperation has been turned into the province's enterprise technology innovation concept and brand. So far, the provincial government has signed strategic cooperation agreements with 24 famous universities and scientific research institutes at home and abroad on the collaboration between industry, academy and research; 179 national enterprise technology centers and 1524 provincial enterprise technology centers in the province have constructed long-term and stable cooperation relations with universities and scientific research institutes, and more than 95% of the technological innovation projects of the enterprises are accomplished in the way of cooperation between the industry, academy and research, the role of cooperation between the industry, academy and research has been increasing day by day. The role of industry-university-research cooperation has been increasingly enhanced.

3.1 Industry-University-Research Cooperation Model in Shandong Province

The Outline of Medium- and Long-term Scientific and Technological Development Plan of Shandong Province (2006-2020) proposes to "improve the technological innovation system that combines enterprise as the main body, market as the guide, and industry, academia and research." Universities in Shandong Province are highly integrated with research institutes and enterprises, realizing innovations and breakthroughs in industry-university-research cooperation. At present, the mode of cooperation between industry, academia and research has shown a diversified development trend, with the following five main modes: the technology transfer mode between universities and research institutes, the co-production mode in which universities and enterprises build research institutions, the mode in which universities and research institutes build business entities, the mode in which the scientific and technological achievements of the unit are transformed, and the mode of cooperation between the government, industry, academia and research business.

(1) Mode of technology transfer from universities and research institutions

Colleges and research institutes publicize their scientific and technological research and

development results to the society through scientific and technological information and other information dissemination channels, and enterprises independently select suitable scientific and technological research and development results according to their own development reality, thus promoting the effective transformation of productivity. The advantage of this type of cooperation is that the transformation of scientific and technological achievements is fast, scientific research institutions can convert R & D results into scientific research funds in a short period of time, and enterprises can quickly enter the market through the use of scientific and technological achievements, resulting in good economic and social benefits. Therefore, universities and research institutions basically prefer this mode of cooperation.

(2) Universities and enterprises to build research institutions collaborative production model

By taking advantage of their own scientific research and talent resources, colleges and universities build research institutes, engineering technology centers and other scientific research institutions with enterprises, and organize the scientific researchers of colleges and universities and technicians of enterprises to carry out relevant technological research together through targeted enrollment, joint training and other forms. The model not only breaks through major technical problems for enterprises, but also effectively solves the problem of introducing and cultivating research funds and applied talents in universities.

(3) Universities and research institutions to build a business entity model

This model mostly adopts the shareholding system of cooperation, universities and research institutions with R & D results as the cost of shares, and enterprises with hardware such as R & D sites, instruments and equipment as the cost of shares, the cooperation between the two sides through the play of their respective strengths, the success rate of scientific and technological achievements into a substantial increase, while in the short term can effectively obtain the benefits of economies of scale.

(4) Mode of transformation of scientific and technological achievements in the unit

By founding scientific and technological enterprises themselves, creating scientific and technological research test sites, and carrying out the transformation of scientific and technological achievements into production within the enterprises they founded, universities and scientific research institutes can not only obtain more scientific and technological research funds, improve the educational and scientific research environment, but also enhance the success rate of the transformation of scientific and technological achievements, thus laying a solid foundation for taking the practical path of collaboration between the industry, universities and research institutes.

(5) Mode of cooperation among government, industry, academia, research and business resources

Under the premise of socialist market economic system, Shandong Province, in order to realize the strategy of developing the country through science and education, explores and applies the new mode of cooperation of "government, industry, academia, research, business and capital" - government, industrial enterprises, colleges and universities, scientific research institutes, business enterprises, and financial risk investment industry. This model has become a model for the long-term and stable development of the combination of industry, academia and research.

3.2 Constraints on Industry-University-Research Cooperation in Shandong Province

(1) Incomplete intellectual property protection system and management system

Intellectual property is essentially an intangible property right, which is an inevitable product of the knowledge economy era, and should be included in the regular affairs management of colleges and universities, scientific research institutes, enterprises as well as industry-university-research organizations. Since the construction of intellectual property protection system in our province started late, the construction of relevant legal system and management system is not sound enough, so it is relatively difficult to protect intellectual property rights in the cooperation of industry-university-research, which increases the risk of the combination of industry-university-research. In addition, the existence of vague concepts of intellectual property rights, unclear rights and responsibilities of the cooperation subjects and the lack of legal constraints have seriously hindered the long-term and stable development of the cooperation between the industry-university-research institutes.

(2) Inadequate benefit-sharing mechanisms

Before the cooperation between industry, academia and research, the vague definition of the relationship between rights, responsibilities, and benefits or the lack of implementation, the lack of clear requirements for the distribution of the fruits of labor in the process of cooperation, such as the transformation of scientific and technological achievements, and the lack of a basis for dealing with disputes over interests will cause hidden problems for the distribution of interests in the future. In the process of cooperation, in order to maximize individual interests, all parties will inevitably harm the overall interests, which will ultimately lead to the interruption of the process of cooperation among industries, universities and research institutes, and the fundamental reason is the lack of a good mechanism for the distribution of interests.

(3) Imperfect science and technology intermediary service system

The number and types of science and technology consulting services and intermediary institutions in our province are small, especially the lack of specialized intermediary institutions for technology transfer, evaluation, information consulting, science and technology enterprise incubation, investment and financing. Compared with the management personnel of foreign industry-university-research intermediary organizations, there is still a big gap between the comprehensive quality of the practitioners of industry-university-research intermediary organizations in our province, and there is an urgent need to improve the ability to provide all-round services for the scientific and technological innovation activities and the development of high-tech industries, so as to ensure the better combination of scientific research and actual practice.

(4) The level of independent research and development of enterprises is weak, and the secondary transformation of scientific research results is insufficient

The biggest problem encountered by enterprises in the process of transferring and transforming scientific and technological achievements through University-Industry-Research Cooperation is the insufficient secondary transformation of scientific research achievements. At present, most enterprises only focus on the introduction of international advanced technology and lack of digestion, absorption and re-innovation, enterprises have not become the main body of scientific and technological innovation in the real sense, for the secondary development of scientific research results, the promotion of the application and transformation of insufficient attention.

(5) The government in the industry-university-research collaboration guidance to be strengthened

The implementation rules of the relevant science and technology programs issued by the government to support the University-Industry-Research cooperation has clear provisions, but the government departments focus on supporting the University-Industry-Research cooperation mode lack of guiding assessment criteria, especially the conditions and forms of support are not clearly defined, the form of University-Industry-Research cooperation centered on the industrial technology innovation chain lacks a clear policy orientation, "labeling The signs of "labeling" are increasingly visible.

4. Suggestions for Deepening Industry-University-Research Cooperation in Shandong Province

4.1 Improving and perfecting the management system for intellectual property protection

Firstly, to create a favorable legal environment for people who participate in University-Industry-Research cooperation and innovation, and to form a long-term mechanism combining self-discipline, mutual discipline and other discipline, and to raise the awareness of responsibility of enterprises and universities. It will incorporate University-Industry-Research Cooperation into the legal construction system, strengthen the supervision of intellectual property rights, and guarantee the lasting and healthy development of University-Industry-Research Cooperation. Secondly, it is necessary to improve the intellectual property protection system, respect each other's intellectual property rights, mutual constraints, and establish a good intellectual property relationship. By making full use of legal means to protect intellectual property rights, the parties involved in the innovation system of industry-university-research cooperation have jointly created an

intellectual property rights alliance, set up a special organization for the protection of intellectual property rights, ensured the smooth industrialization of scientific research results, and effectively protected the legitimate rights and interests of the patentee.

4.2 Improvement of a fair and reasonable benefit distribution mechanism

First, establish a management system for the distribution of innovation benefits that closely combines contributions and benefits, and promote the distribution of benefits among universities, scientific research institutions and enterprises based on the contribution of resources and the rate of transformation of scientific research results. Secondly, an arbitration and mediation mechanism will be established to maximize the coordination of the differences in the interests of the participating subjects and to avoid the trust crisis caused by the deviation of interests. Thirdly, it is to establish an innovative mechanism for sharing benefits and risks, realizing the decomposition of risk control responsibilities by process and level, and realizing the long-term development of industry-university-research collaboration.

4.3 Improvement of the public technology platform and service system for industry, academia and research

First, accelerate the construction of an information exchange platform for cooperation among industries, universities and research institutes, so as to realize the interconnection and effective symmetry of information. The second is to accelerate the construction of a technical support platform for the transfer and transformation of scientific and technological achievements, so as to narrow the distance between the supply and demand of scientific research institutions and enterprises. Third, accelerate the construction of professional intermediary institutions for industry-university-research cooperation, give full play to the professional advantages of information exchange, technology assessment and legal consultation, and improve the business level. Fourth, make full use of the advantages of industry associations to play the role of organizing and coordinating industry-university-research cooperation within the industry.

4.4 Enhancement of the rate of secondary transformation of enterprises' scientific research results

First, R&D needs to meet the actual needs of society. Scientific and technological research is carried out through the joint efforts of schools and enterprises. Take the project as a carrier, the introduction of major scientific research projects for industry-university-research joint. Strong support for universities to undertake to participate in various types of scientific and technological research and development projects at all levels, to solve the technical bottlenecks of the front-line production of enterprises. Secondly, the government allocated special funds to establish pilot bases, selective investment in high-tech or products with good market prospects to carry out pilot and engineering research, so as to achieve systematization, engineering, industrialization, and then transferred to the enterprise to transform, enhance the enterprise scientific and technological achievements of the second transformation rate.

4.5 Increase government support for industry-university-research integration

First, the proportion of financial investment should be increased, and a variety of investment methods should be used to actively guide the organic integration of industry, academia and research. The second is to make full use of banks and other financial institutions to actively explore the creation of a socialized industry-university-research joint guidance fund. Thirdly, it will effectively guide the cooperation between industry, academia and research, and improve the mechanism for reviewing the funding of industry-academia-research cooperation projects. Fourth, for units that meet the conditions for industrial technology innovation strategy alliances, government departments organize them to implement major industrial technology innovation projects.

Acknowledgement

Supported by Shandong Province Key Research and Development Program (Soft Science Project), "Exploring the Construction of Proof-of-Concept Center Based on Future Industries" (Project No. 2023RZB02022).

References

- [1] Yao Xiaoying, Wei Ping, Li Jian. The heterogeneity of industry - university - institute cooperation modes and its influential factors—The micro - survey data based on Chinese strategic emerging industries [J]. *Scientific Research Management*, 2017, 38(8):1-10.
- [2] Wang Guohong, Liu Liming, and Jing Rui. Analysis on Influential Factors of Integrated Innovation of Industry - University - Institute Cooperation Based on Relationship Perspective [J]. *Research on Science and Technology Management*, 2017, 37(8):106-111.
- [3] Ding Guixiang. A preliminary exploration of the cooperation mechanism of industry-university-research[J]. *Business Manager*, 2013(17): 130.
- [4] JIANG Tongtong. Research on Collaborative Innovation Mode and Operation Mechanism of Industry-University-Research[J]. *China University Science and Technology*, 2017(6):61-63.
- [5] WU Wei. Establishment of government-industry-university-research collaborative innovation mechanism under the background of supply-side structural reform Research--Taking Liaoning Province as an Example[J]. *Economic Research Guide*, 2016(29):26-27.