

Research on the Commercialization Strategy of University Scientific and Technological Achievements Based on the Triple Helix

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Abstract: In the era of globalization and knowledge economy, science and technology and innovation have become the core engine of regional economic development. As important suppliers of scientific and technological achievements, Chinese universities still have many problems in commercialization of their scientific and technological achievements. Based on the triple helix theory, this paper analyzes the current situation and dilemma of the commercialization of Chinese universities' scientific and technological achievements, and then proposes to build a commercialization system of universities' scientific and technological achievements based on the Triple Helix, clarifies the functions of universities, enterprises and the government, establishes a synergistic mechanism of cooperation, and optimizes the supportive environment of the triple helix system, in order to promote the in-depth fusion of regional collaborative innovation and the commercialization of the scientific and technological achievements of universities.

Keywords: Scientific and technological achievements, Commercialization, Triple Helix.

1. Introduction

In the era of globalization and knowledge-based economy, science, technology and innovation have become the core engine driving the dynamic development of regional economies. In recent years, China has made remarkable progress in science and technology innovation. As the gathering place of scientific and technological talents and the birthplace of advanced science and technology and innovation, universities have also increasingly become an important supplier of scientific and technological achievements. However, the commercialization of scientific and technological achievements of Chinese universities still has many problems. Therefore, how to achieve the smooth commercialization of scientific and technological achievements is an urgent problem for universities. Regional collaborative innovation can promote interaction and cooperation among government, enterprises, and universities, thus providing an effective way to enhance the efficiency of scientific and technological achievements transformation. The Triple Helix builds a theoretical framework for the integration of regional collaborative innovation and the transformation of university scientific and technological achievements, emphasizing the interaction and cooperation among universities, enterprises, and governments in the innovation process. This paper combines the university's own characteristics, based on the Triple Helix, analyzes the pain points and blockages of universities and enterprises in various aspects of commercialization of scientific and technological achievements, and puts forward a series of targeted recommendations and measures, aiming to promote the deep integration of regional collaborative innovation and commercialization of university scientific and technological achievements.

2. University Science and Technology Commercialization and the Triple Helix

2.1. Connotation of Scientific and Technological Achievements

Scientific and technological achievements are results of practical value produced through scientific research and technological development. Generally speaking, scientific research activities in universities are often carried out by teachers and researchers within the scope of their duties, and the production of results is closely related to their duties, so their scientific and technological results are usually regarded as scientific and technological results of their duties. The scientific and technological achievements of their duties refer to the scientific and technological achievements accomplished by carrying out the work tasks of research and development organizations, institutions of higher learning, enterprises, etc., or mainly by utilizing the material and technological conditions of the said organizations.

The scientific and technological achievements of the university present a variety of forms, such as theoretical research results, technical research and development results, and applied research results. Their specific content covers academic papers, academic writings, patented technologies, technical standards, software copyrights, and new products, processes, and services.

2.2. Commercialization of University Scientific and Technological Achievements

Commercialization of scientific and technological achievements refers to the subsequent testing, development, application, and promotion of scientific and technological achievements in order to improve the level of productivity until the formation of new technologies, new process, new materials, new products, and the development of new industries. For universities, the commercialization of

scientific and technological achievements refers to the process of further testing and maturing, in-depth development, practical application, and extensive promotion of the achievements made in scientific research activities through diversified channels such as scientific and technological platforms and scientific research bases, so as to form new products, new technologies, new processes, and new services. The commercialization of university scientific and technological achievements is mainly carried out in six ways: transfer, licensing, investment, technology development, consulting, and services.

2.3. Triple Helix

Triple Helix, proposed by Henry Etzkowitz and Loet Leydesdorff in the 1990s, describes the interaction and collaborative innovation mechanism between academia, business, and government. In the Triple Helix, universities (academia), enterprises (industry), and government are regarded as the three core players in promoting scientific and technological innovation and economic development [1], each of them assuming a different but complementary role, and through close cooperation and collaborative innovation, they jointly promote knowledge transfer, technology development, and market application. Specifically, universities provide knowledge and technology, enterprises transform research results into products and services, and the government facilitates cooperation between universities and enterprises by formulating policies and providing financial support [2].

The Triple Helix emphasizes the interactions and synergies among universities, enterprises, and the government, which is not just a simple addition of the three but promotes the optimal allocation of resources and the effective integration of innovation elements in a complex and non-linear way. Each subject maintains its own independent identity and function while supporting each other and developing together in cooperation.

3. Current Situation and Dilemma of Commercialization of Scientific and Technological Achievements of Chinese Universities

3.1. The Commercialization Model of University Scientific and Technological Achievements Is Gradually Diversifying

As an important position for scientific and technological innovation, universities play an increasingly important role in promoting regional economic development and social progress. In recent years, the government has paid more attention to scientific and technological innovation, and many universities have actively promoted the application of scientific and technological achievements through industry-university research cooperation and scientific and technological incubators, and the commercialization of scientific and technological achievements has gradually developed into a variety of modes.

First, inventors participate in the management of the company or delegate it to others (e.g., students) to establish a startup/small business [3] The university rewards the research team with part of the equity of the scientific and technological achievements realized, and part of the equity is held by the university or rewarded to the research team in the form of

equity income. For example, the research team of the Sichuan University of Science & Engineering calcium sulfate whisker material research team to establish a company is to use this model. The second is through a technology transfer or licensing agreement, the scientific research results will be transferred to enterprises to achieve industrialization, mainly including patent transfer, technology transfer, patent licensing, new varieties of production licensing, and other forms, which are the most used by the University of scientific and technological achievements of the commercialization of the way. Thirdly, it actively establishes production-university-research partnerships with enterprises to jointly research and develop new products and technologies; for example, Chongqing University of Technology cooperates with GENERTEC to form Genertec Guoce Time Grating Technology Co., Ltd., which applies the original nanometer time grid technology to the field of precision displacement measurement.

In addition, the university will use some other commercialization of scientific and technological achievements, such as the establishment of an open research platform, and provide technical advice and services to help enterprises solve technical problems.

3.2. Disconnect Between University Research Results and Market Demand

In 2023, China's domestic universities owned 794,000 effective invention patents. However, the number of patented technology achievements of universities is large, but the quality is not high and disconnected from the market demand, which restricts the commercialization of scientific and technological achievements.

On the one hand, universities lack patent system layout for a certain field, and researchers blindly apply for patents only to complete their tasks, which makes the systematic and innovative research on the front and back ends of related technologies insufficient and makes it difficult to realize commercialization. On the other hand, researchers are more concerned about publishing high-level papers and obtaining scientific research awards and pay less attention to the market demand, such as Zigong's lantern industry needs waterproofing and an aging cycle of the special lantern cloth (paper), but the university's many technologies are unable to achieve the low-cost requirements of the enterprise, and it is difficult to be accepted by the market. This makes many scientific research results in academic value, but in practical applications to meet market demand. In most cases, many technology products resulting from research happened to fail to be launched to the market due to the valley of death [4].

3.3. Lack of Integrated Planning for Commercialization of Scientific and Technological Achievements

The primary functions of universities are teaching, research, and service. Education is the fundamental objective of educators [5]. Universities are deficient in the presence of operational institutions and management systems that facilitate the commercialization of scientific and technological achievements. Despite the establishment of dedicated institutions for the commercialization of scientific and technological achievements, many universities lack the requisite professional service teams and the capacity to manage and operate these achievements in a market-oriented manner.

Firstly, the absence of a dedicated team to oversee the commercialization of scientific and technological achievements necessitates that researchers seek out potential partners, secure funding, and navigate the formalities independently, a process that is both time-consuming and labor-intensive. Second, universities' scientific and technological accomplishments are not precisely in line with business needs since there is no efficient system in place for communication, dissemination, and resource sharing. This has had the regrettable effect of preventing many important scientific and technological advancements from being commercialized at the most advantageous moment. Thirdly, the absence of expertise in the real world of industrialization and market demand among researchers makes scientific and technological advancements less feasible and realistic. Fourthly, some low-quality scientific and technological accomplishments may also be sold due to ineffective quality control and supervision, which could harm the university's reputation and image for its scientific and technological accomplishments.

3.4. Lack of Synergy and Interface Between Universities and Enterprises in Commercializing Scientific and Technological Achievements

The objectives of university research output are teaching, publishing, and basic research; but, due to time and financial constraints, applied research and collaboration receive less priority.

On the one hand, university professors and researchers must devote a significant amount of their time and energy to teaching. They have comparatively less time to dedicate to practical research and working with businesses because they have to prepare classes, deliver lectures, and oversee students. For instance, a university professor might have to dedicate ten hours or more a week or more to teaching and mentoring students in the classroom, which leaves very little time for working with businesses on applied research projects.

However, the phenomena of "only papers, only titles, only qualifications, only awards" has long persisted in university grading systems. To promote their titles and get academic reputation, researchers frequently invest a great deal of time and effort into producing and publishing academic papers. Furthermore, basic research findings are typically more easily published in prestigious academic publications, which encourages researchers to prioritize basic research over applied research that is tightly entwined with businesses. Concurrently, fundamental research frequently necessitates prolonged investment and investigation. The predominant source of funding for such endeavors is derived from government research grants and other constrained avenues. Consequently, universities engaged in applied research and those engaged in collaborative endeavors with enterprises often face significant constraints in terms of financial resources.

3.5. Much of the University's Research Results Are Not Available to Meet the Needs of Enterprise

For enterprises, the ability to obtain economic benefits represents a crucial factor in determining their ability to survive and develop. Consequently, the pursuit of high returns on investment and the creation of market competitiveness

represent the core objectives of such enterprises. To illustrate, a technology enterprise may prioritize technology R&D projects that can be productized and brought to market within one or two years. This approach allows the enterprise to gain market share and profits in a relatively short period of time. Concurrently, in order to establish a presence in a highly competitive market, enterprises must consistently develop competitive advantages. This necessitates the expeditious transformation of research projects into products or services that exhibit innovation and market advantages.

The scientific and technological achievements of universities are frequently at the laboratory stage, with a notable discrepancy between this and their practical application. The transformation process may require a considerable length of time and a substantial capital investment. This gives rise to concerns among enterprises regarding the investment risk associated with collaboration with universities.

3.6. Lack of Both Service Platforms and Professionals

In order to effectively support universities and researchers in the areas of intellectual property management, accurate demand matching, consultation on commercialization of achievements, policy and legal affairs, investment and financing, and more, public service platforms and intermediary service institutions for the commercialization of scientific and technological achievements still need to be developed and nurtured. Furthermore, there is a pressing need for professional service talent with a dual understanding of scientific research and the market, as well as high qualifications in policy, legal affairs, negotiation, and intellectual property rights. The development of university talent for commercialization services also needs to be strengthened.

4. Building a Commercialization System of University Scientific and Technological Achievements Based on the Triple Helix

We urgently need to create a set of effective triple helix systems for the commercialization of scientific and technological achievements that closely connect university, enterprises, and the government, dismantle their isolation, and create an interpenetrating intra-regional synergistic cooperative relationship. These systems should be led by the innovation-driven development strategy. With the use of this system, a more flexible, varied, and effective platform for collaboration and communication can be created, one that will facilitate the exchange of ideas and information, improve the applicability of university technology research and development, better align it with business needs in terms of technological business models, lower the costs associated with individual enterprise R&D, and foster the high-quality growth of the economy and society.

4.1. Clarify the Functions of Universities, Enterprises and The Government

The process of commercializing scientific and technological achievements is essentially the process of matching the supply of scientific and technological achievements with the demand of the market. In order to establish a link between the two, the key is to build an

enterprise-oriented, demand-driven, smooth scientific and technological innovation chain, from tracking innovation to source innovation, to form a "science-technology-products-industry" development path, and to open up the path of scientific and technological achievements from samples to products and then to commodities. To realize this goal, we must integrate the resources and strengths of universities, enterprises and the government to form an effective cooperation mechanism.

4.1.1. University

Scientific and technical discoveries are commercialized through a chain that includes basic research, applied research, technology development, productization, and commercialization. Universities are centers of new knowledge generation and play a fundamental role in the development of new products and technologies, being at the front end of the commercialization of scientific and technological achievements [6]. Universities can conduct cutting-edge basic and applied research with a wealth of resources and specialized scientific research skills, offering theoretical support and technical reserves for scientific and technology innovation. To effectively translate scientific and technological advancements into useful applications, colleges cannot merely rely on their internal capabilities. In order to do this, it is vital to make sure that all of the links in the chain of innovation in science and technology function smoothly and to improve collaboration and synergy between academic institutions, enterprises, the government, and other stakeholders.

4.1.2. Enterprises

Enterprises are important participants in scientific and technological innovation activities and the demand side of fruit transformation, with keen market perception and mature industrialization capabilities. The R&D activities of enterprises are more in line with the actual needs of industrial development than those of universities [7]. However, the independent scientific and technological innovation ability of enterprises varies; only 37.3% of enterprises above large-scale have carried out research and experimental activities, and a large number of small and medium-sized enterprises are even more difficult in scientific and technological innovation due to the lack of resources, funds, talents, and other problems. Therefore, through in-depth cooperation with universities, enterprises can not only undertake scientific research projects together, realize the optimal allocation and sharing of scientific research resources, but also effectively promote the precise docking of scientific and technological achievements with market demand, thus accelerating the commercialization process of scientific and technological achievements.

4.1.3. Government

The government also plays an indispensable role in this process. It provides all-round support and guarantee for the commercialization of university scientific and technological achievements by formulating and implementing a series of incentive policies, providing the necessary financial support, and constructing service platforms and technology transfer agencies for the commercialization of scientific and technological achievements. In addition, strengthening the protection of intellectual property rights not only respects and protects the innovation achievements of researchers, but is also the key to stimulating the innovation vitality of researchers and promoting the continuous emergence of scientific and technological achievements.

4.2. Establishment of Synergistic Cooperation Mechanisms

4.2.1. Promote the Deep Integration of Industry, Academia and Research

The core of promoting the in-depth integration of industry, academia, and research lies in building a solid cooperation mechanism and ecosystem. Specifically, the establishment of an industry-university-research cooperation platform is the first task, which requires the government to play the role of a bridge, encouraging and guiding enterprises, universities, and scientific research institutions to break down barriers and establish multi-level and wide-ranging cooperation platforms and to ensure long-term and stable cooperative relationships in an institutionalized and regularized manner. These platforms not only provide all parties with the convenience of information exchange and resource sharing but also lay a solid foundation for in-depth cooperation.

Joint R&D, as a key link in promoting the deep integration of industry, academia, and research, should be fully supported. The government can set up a special fund to incentivize enterprises, universities, and scientific research institutions to work together to carry out cutting-edge, innovative joint R&D projects, focusing on advantageous resources to jointly overcome industry technical problems. Through joint R&D, not only can we accelerate the output of scientific and technological achievements, but also ensure the practicality and market adaptability of scientific and technological achievements, paving the way for their subsequent industrialization and application.

In terms of talent cultivation and exchange, education, scientific research, and industry should be closely connected. To this end, joint training bases should be actively explored and established so that universities, enterprises, and scientific research institutions can realize in-depth integration in talent training. Through the establishment of interdisciplinary and cross-field courses and programs, students are provided with opportunities to contact the industrial frontiers and participate in scientific research practices, so as to cultivate composite talents with solid theoretical foundations as well as familiarity with market demands. It is important for researchers to understand the long-term technology and product markets, as the success of technology commercialization depends on the practicality and affordability of the products [8]. Therefore, regular academic exchange activities are carried out to promote the cross-border dissemination of knowledge, technology, and experience, stimulate innovative thinking and cooperative inspiration, and continuously inject new vitality into scientific and technological innovation and achievement transformation.

4.2.2. Benefit- and risk-sharing mechanisms

In the triple helix model of commercialization of scientific and technological achievements, universities, enterprises, and governmental entities each have their own interests. Universities expect to gain academic reputation, research funds, train talents, and perform social service functions through cooperation with enterprises. Enterprises pursue economic benefits, technological innovation, expanding market share, and accessing human resources to enhance competitiveness and increase profits. Governments are committed to promoting economic growth, social development, building an innovation ecosystem, and realizing national strategic goals. Commercialization of scientific and technological achievements has become a key

link to satisfy the interests of all parties and promote economic and social progress.

To achieve the same goal of commercialization of scientific and technological achievements of universities, enterprises, and the government, the key is to coordinate the core interests of the three spiral parties, reduce the “free-rider” behavior in the transformation process through risk-sharing and benefit-sharing mechanisms, and reduce the “internal friction” brought about by the game of interests of the three parties.

First of all, a reasonable benefit distribution mechanism should be established to ensure that the proceeds from the commercialization of scientific and technological achievements can be fairly and reasonably distributed to all participants. For example, through the establishment of scientific and technological achievements transformation funds, equity incentives, etc., to motivate enterprises and universities to actively participate in the commercialization of scientific and technological achievements. Second, there are risks and challenges in the commercialization of scientific and technological achievements. In order to reduce risks and increase the success rate, a risk-sharing mechanism needs to be established. The government should reduce the financial burden of enterprises and universities by providing risk compensation and loan interest subsidies, etc. At the same time, enterprises and universities should also strengthen their cooperation and work together to meet the risk challenges.

4.3. Optimizing the Supportive Environment of the Triple Helix System

4.3.1. Policies and regulations

The government should further improve the policy and regulation system of commercialization of scientific and technological achievements of universities, strengthen the protection of intellectual property rights to provide legal protection for the commercialization of scientific and technological achievements, clarify the rights and obligations of the government, universities, and enterprises in the commercialization of scientific and technological achievements, and standardize the process of the commercialization of scientific and technological achievements and behavior. At the same time, the government should also increase the policy support for the commercialization of scientific and technological achievements, such as the introduction of tax incentives, financial subsidies, financial support, and other policy measures, to encourage universities and enterprises to actively carry out the commercialization of scientific and technological achievements.

4.3.2. Financial Security

In order to promote the commercialization of scientific and technological achievements, the government should increase the investment and guidance of funds, which is manifested in the establishment of a special fund, focusing on supporting projects with market potential and strategic value and providing the necessary start-up and R&D funds; at the same time, through the government's guidance fund, venture capital and angel investment and other channels, to actively attract and guide the participation of social capital and to build a diversified, multi-level capital investment system. At the same time, we actively attract and guide the participation of social capital through various channels, such as government guidance funds, venture capital, and angel investment, so as to build a diversified and multi-level capital investment system and provide solid financial guarantees for the

commercialization of scientific and technological achievements.

4.3.3. Market Environment

First of all, it is necessary to build an open, transparent, and efficient market for the trading of scientific and technological achievements, providing a fair and impartial trading platform for both the supply and demand sides of scientific and technological achievements. This market system should cover the registration, display, evaluation, trading, and settlement of scientific and technological achievements to ensure the smooth circulation of scientific and technological achievements and maximize their value. At the same time, the market system should also have the function of collecting and releasing information, reflecting the market demand and price dynamics of scientific and technological achievements in a timely manner, and providing decision-making references for both parties in the transaction.

Secondly, accurate assessment of scientific and technological achievements is the basis for ensuring reasonable pricing and smooth commercialization. Therefore, it is necessary to establish a scientific, objective, and fair assessment system for scientific and technological achievements and conduct a comprehensive and in-depth assessment of the technological advancement, market potential, and economic value of these achievements. The assessment process should be open and transparent, and a third-party professional organization should be introduced to ensure the authority and credibility of the assessment results. In addition, it is necessary to establish a feedback and application mechanism for the assessment results to provide follow-up support for the commercialization of scientific and technological achievements.

Regular events, such as technology fairs and displays of scientific and technological achievements, are essential to facilitating the successful docking of scientific and technological breakthroughs with the market. In order to draw in businesses and investment groups, these events may highlight the newest scientific and technology developments as well as technological products. They can encourage direct docking between the supply and demand sides of scientific and technological advances and hasten their commercialization through on-site interactions, demonstrations, and negotiations. Furthermore, these endeavours may furnish a crucial forum for the advancement and dissemination of scientific and technological innovations, so amplifying their prominence and impact.

4.3.4. Service optimization

The government must take the lead and join hands with industry associations, universities, scientific research institutions, and social capital to strengthen the construction of public service platforms and socialized intermediary service institutions for the commercialization of scientific and technological achievements. These platforms and service institutions must be well-functioning and effective. These platforms and service institutions must be comprehensive, covering a full range of services. This includes management of intellectual property rights, precise matching of demands, consultation on commercialization of achievements, policy and legal consultation, and matchmaking of investment and financing. They must provide a one-stop solution for universities and scientific researchers. We will provide universities and researchers with one-stop solutions. Professional teams must be introduced to carry out specialized operations and explore market-oriented operation

modes.

Universities must also build stronger teams to support commercialization. They should set up special funds to attract and train top talent, developing professionals who understand both scientific research and the market across different fields. These professionals should also have strong policy, legal, and negotiation skills, as well as expertise in intellectual property rights. Universities must also create effective incentives to attract and retain top talent, motivating them to excel and innovate.

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