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Research on the Construction of Mission-Driven National Laboratory Intellectual Property Management System in China

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Abstract

The national laboratory undertakes the critical mission of achieving original innovation breakthroughs, tackling key industrial technologies, and promoting technology transfer. Yet their current intellectual property (IP) management is plagued by prominent problems including fragmented institutional structure, low-quality patent output, inefficient achievement transformation, and misaligned benefit distribution mechanisms, which have severely hindered the fulfillment of their strategic missions. Drawing on the institutional logics theory, this paper analyzes the core requirements of missions for the IP management of national laboratories, constructs an analytical framework for mission-driven national laboratory IP management, and clarifies the intrinsic coupling relationship between mission-driven IP management, institutional logics, national innovation systems, and mission-oriented innovation policies. By drawing on the experiences and insights from the IP management systems of national laboratories in developed countries, this paper identifies the key shortcomings of China's national laboratories in organizational structure, talent allocation, achievement transformation, and standard and patent layout. It further proposes targeted construction paths, including the establishment of integrated specialized institutions, the building of professional talent teams, the implementation of the "shared patent right + pay-after-use" mechanism, the optimization of benefit distribution rules, and the cultivation of Standard Essential Patents. This study theoretically enriches the research on IP governance of public research organizations, and practically provides operational policy references for national laboratories to fulfill their strategic missions and enhance industrial self-reliance and controllability.

Keywords

Intellectual property; National laboratory; Mission-driven; Management

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1. Introduction

The competition among major countries in today's world is a competition of comprehensive national strength, with scientific and technological innovation at its core. National laboratories are an important component of the national innovation system, and the Central Committee of the Communist Party of China (CPC) and the State Council attach great importance to the development of the national laboratory system. The newly revised *Law of the People's Republic of China on Scientific and Technological Progress* in 2021 explicitly stipulates the "development and strengthening of national strategic scientific and technological forces, with national laboratories, national scientific and technological research and development institutions, high-level research universities, and leading science and technology enterprises as core components". The 20th National Congress of the CPC called for the formation of a national laboratory system, the Third Plenary Session of the 20th Central Committee of the CPC required the "improvement of the national laboratory system", and the Outline of the 15th Five-Year Plan clearly defines the goal of "forming a mission-driven, task-oriented, and efficiently coordinated national laboratory system". As a critical national strategic scientific and technological force that embodies the will of the state, fulfills the national mission, and represents the country's highest-level institutions in this regard, national laboratories shoulder the responsibility of achieving breakthroughs in original achievements, tackling core industrial technologies, and making fundamental, strategic, and forward-looking contributions to scientific and technological innovation.

Intellectual property is a core element of national strategic resources and competitiveness, and protecting IP is protecting innovation. *The Outline for Building a Powerful Intellectual Property Country (2021-2035)* issued by the CPC Central Committee and the State Council in September 2021, explicitly requires improving an efficient and smooth operation mechanism with full realization of value and promoting enterprises, universities, and research institutions to establish and improve a sound IP management system. Intellectual property is not only the output of scientific and technological innovation, but also an institutional guarantee to incentivize innovation. IP management refers to the systematic efforts of universities, research institutes, or enterprises to ensure the orderly conduct of IP affairs, effectively leverage the core functions of the IP system, stimulate original innovation, and cultivate it into independent intellectual property rights (Jiang, 2007). It covers the creation, utilization, and protection of IP, and involves the organized, coordinated, planned, and strategic management of IP through legal and technical means by professional IP managers (Zhu, 2010). Strengthening the IP management of national laboratories is not only an inherent requirement for implementing the innovation-driven development strategy, but also an effective way to improve the efficiency of scientific and technological innovation and accelerate the transformation of scientific and technological achievements into real productive forces (Liu, 2024). However, the IP management of China's national laboratories is still in its initial and exploratory stage. Due to the lack of a top-down scientific and technological achievement commercialization system covering the decision-making, management, and implementation levels at the macro level (Li *et al*., 2025), and the failure to align with the mission of national laboratories, the performance of national laboratories in technology commercialization remains unsatisfactory (Fang, 2024). Academic research on the IP management system of national laboratories in China is incomplete and insufficient. The existing IP management system of national laboratories has not been systematically constructed, adjusted, and optimized based on its mission orientation, resulting in a structural contradiction with the mission requirements.

To address the above problems, this paper analyzes the core requirements of the mission for the IP management of national laboratories through institutional logic theory, combined with the positioning differences between national laboratories, universities, and research institutions in China. Drawing on the experience and insights from the IP management systems of national laboratories in developed countries, and combined with the management practice and prominent problems in the construction of IP management system of China's national laboratories, this paper proposes the construction path and supporting policies for the mission-driven IP management system of national laboratories. Compared with existing literature, this paper makes three core academic contributions. First, theoretical innovation. Based on the multiple institutional logic theory, it constructs an analytical framework of "Mission-Institutional Logics-IP Management", filling the research gap in the theoretical study of national laboratory IP governance. Second, perspectival innovation. It systematically identifies the four core contradictions in China's national laboratory IP management from a mission-driven perspective, breaking through the limitations of previous studies that focus mainly on descriptive analysis of phenomena. Third, mechanistic innovation. Integrating the characteristics of China's institutional context, it proposes the "shared patent right + pay-after-use" mechanism and an optimized benefit distribution scheme, providing a localized solution for the transformation of scientific and technological achievements in public research organizations.

2. Conceptual Analysis of Mission-Driven IP Management in National Laboratories

2.1. Mission-Driven positioning of main national strategic scientific and technological strength in China

The Outline of the 15th Five-Year Plan proposes to optimize the positioning and layout of the national strategic scientific and technological strength, including national laboratories, national research institutions, high-level research universities, and leading science and technology enterprises. The theory of multiple institutional logics is an important perspective in sociology and organizational research. It emphasizes that multiple institutional logics often coexist in specific social and organizational fields (Wu and Yu, 2018). These logics interweave, compete, or collaborate with one another, and collectively shape and guide the behavioral choices and practical approaches of individuals and collectives (Zhou and Ai, 2010). Within the institutional field of the national innovation system, national laboratories, national research institutions, and high-level research universities all serve as core carriers of national strategic scientific and technological forces. However, driven by different institutional logics, they have developed distinct positioning and behavioral paradigms. General Secretary Xi Jinping put forward the requirement of "staying true to the original aspiration and keeping the mission firmly in mind" in the report to the 19th National Congress of CPC, which profoundly reveals the institutional core of organizational mission. As a concentrated expression of long-term, stable, and fundamental core tasks and responsibilities, mission is essentially a normative definition of organizational functions by specific institutional logics, and directly determines the unique value and functional boundaries of various strategic scientific and technological forces in the national innovation system. From the perspective of multiple institutional logics theory, the mission differences among the three types of entities stem from the unequal weight distribution of four logics, the logic of scientific discovery, the logic of national strategy, the logic of talent cultivation, and the logic of industrial security. This divergence in the weight of logics further shapes their striking differences in task intensity and core focus, and ultimately defines their clear behavioral boundaries.

High-level research universities are guided primarily by the logic of scientific discovery and the logic of talent cultivation. Their core missions are to pursue scientific discovery through free exploration in basic research and to foster high-quality innovative talents, thereby providing intellectual reserves and talent support for the national innovation system via cutting-edge scientific discoveries (Li, 2022). Under the guidance of such logics, their research outputs are academically oriented, with weak direct relevance to market demands, and they do not directly undertake the institutional imperative of serving national strategies and safeguarding industrial security.

National research institutions are guided primarily by the logic of national strategy. Their mission is to address major scientific and technological issues that constrain the overall national development and long-term interests (Cheng, 2000), serving as a direct embodiment of the national strategic will in the science and technology domain. Driven by the logic of national strategy, their core mission aligns with the strategic needs of the country across multiple technological fields for overall development. Their research projects span basic research, applied research, and technological development, with the core orientation of producing high-quality scientific and technological outcomes to serve the country's layout needs in key sci-tech fields. It is important to note, however, that the institutional design of national research institutions lacks robust support from the logic of industrial security. Their achievement transformation links rely heavily on external collaboration; they do not focus on deep cultivation in specific industrial fields, nor do they assume the mission and responsibility for the core industrialization closed loop.

National laboratories take the logic of national strategy as the core and integrate the logic of industrial security, forming a composite mission positioning characterized by strategic guidance and industrial closed loop. Driven by the synergy of these two logics, national laboratories abandon the model of comprehensive layout across multiple fields adopted by national research institutions; instead, relying on their own strengths, they focus on a specific core industrial field and connect the complete chain from basic research to applied research, from technological development to achievement transformation, and from productization to industrialization. They thus feature distinct attributes of specificity in research fields, full-process coverage of scientific and technological innovation, and orientation toward strategic goals. Therefore, the primary mission of national laboratories is to practice the logic of national strategy, in line with the requirements of the Four Orientations, they pursue breakthroughs in original achievements and tackle key core technologies throughout the entire process of scientific and technological innovation, lead the frontiers of science and technology, serve major national strategies (Li and Zhao, 2009). The other core mission reflects the requirements of the logic of industrial security, namely safeguarding industrial security and independent controllability. By promoting the smooth transformation of scientific and technological achievements in specific fields, national laboratories realize the circulation and appreciation of scientific, technological, economic, social and cultural values, support the cultivation and development of new productive forces, provide a strong driving force for economic and social development, and complete the institutional closed loop from scientific and technological breakthroughs to industrial empowerment.

2.2. Comparative analysis of IP management of mission-driven national strategic scientific and technological strength

National laboratories, national research institutions, and high-level research universities are all important components of the national strategic scientific and technological forces. Although all emphasize

intellectual property management, their actual IP management contents and priorities differ from one another to some extent due to their distinct mission positioning. At present, the intellectual property management system of China's national laboratories has not been precisely aligned with this mission orientation. The primary problem is the lack of a systematic understanding of what intellectual property should be managed in mission-driven national laboratories. Although national laboratories, national research institutions, and high-level research universities all require the strengthening of IP management, which basically covers the initiation, implementation and acceptance, as well as the commercialization of scientific research projects with similar management content in some links, there are certain differences in their IP management processes, requirements, and organizational implementation paths due to their different missions.

Overall, the positive and negative latent mechanisms lead to an inverted U-shaped relationship between centrality in the municipal leadership transfer network and the performance of environmental policy diffusion.

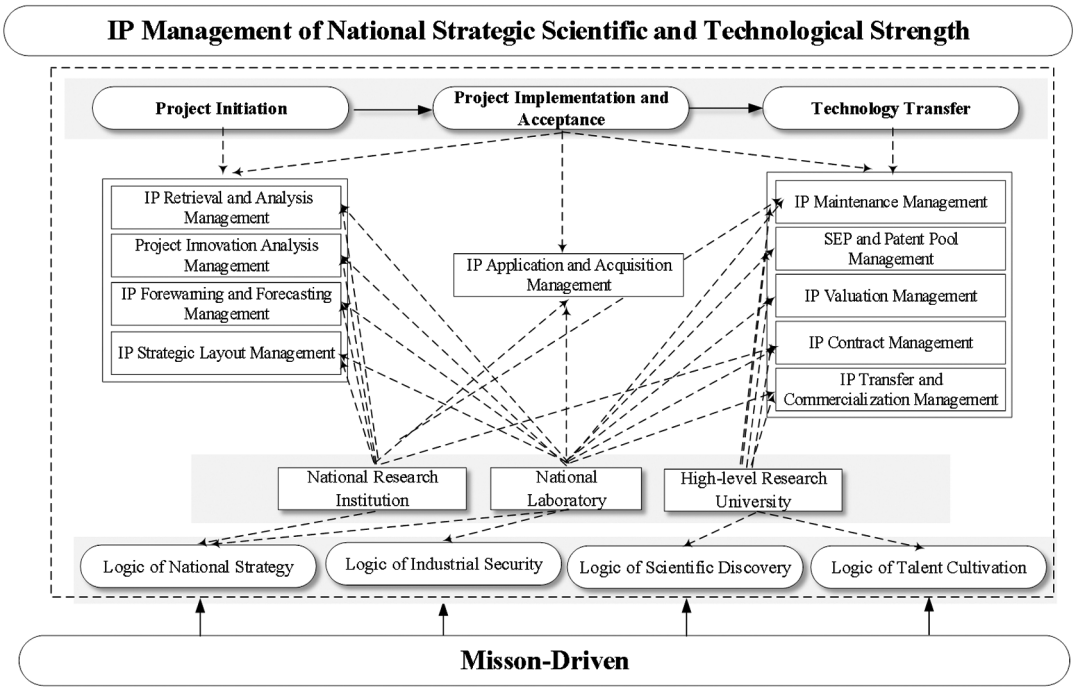

Fig. 1. Mission-driven IP management of the national strategic scientific and technological strength.

First, the length of the whole-process IP management process for scientific research projects differs. The whole-process IP management of scientific research projects generally covers ten major management components. Compared with national research institutions and high-level research universities, national laboratories need to address the independent and controllable development of specific core industries in response to national strategic needs. In particular, they must support the entire chain of scientific and technological innovation, produce high-value scientific and technological achievements, lay out high-quality patents, and produce new, creative products and industries, thereby supporting breakthroughs in original achievements and the safety and controllability of the industrial chain in specific fields.

Therefore, their IP management process is longer and more comprehensive, with greater emphasis on the forward-looking nature, backward extension and connectivity of IP management for scientific research projects, requiring coherent and interconnected links throughout the process. IP management in national laboratories must intervene before the initiation of scientific research projects to conduct forward-looking retrieval and analysis and make forward-looking arrangements for IP strategic layout; strengthen high-level IP management in all aspects during project implementation; enhance the management of scientific and technological achievement transformation and IP utilization after project completion to develop independent innovative products with intellectual property rights and realize their industrialization. In addition, post-evaluation and feedback of IP management must be carried out, and the proceeds from commercialization should be fed back into new scientific research project investments. In contrast, national research institutions and high-level research universities do not need to emphasize these requirements. National research institutions generally only need to produce scientific and technological achievements and intellectual property rights and realize industrialization by licensing them to enterprises. High-level research universities usually complete a certain link of the scientific research project or produce scientific and technological achievements and hold part of the intellectual property rights, with their IP management mainly focusing on external licensing.

Second, the requirements for the whole-process IP management of scientific research projects vary in intensity in line with different components of the system. National laboratories must produce products with independent intellectual property rights and realize industrial independent controllability through scientific and technological innovation. Therefore, their IP management requirements are inevitably high and practical, and IP retrieval and analysis must be forward-looking and targeted. Their IP management teams must work closely with scientific research teams to build comprehensive databases of patents, technical standards and standard essential patents (SEPs) in the key core technology fields involved in their industries. They should use the tech-effect matrix to identify technical gaps and risk points in the industry, propose strategic layout strategies for original patents, patent portfolios and improved patents, as well as strategies to prevent patent infringement risks, and adopt the technology lifecycle approach to lay out basic patents, patent portfolios and standard essential patents to support the realization of industrial independent controllability. The generated intellectual property rights must be transformable and utilizable, and IP commercialization should protect and support the innovative development of strategic emerging industries and future industries. In contrast, since national research institutions do not focus on specific industrial fields, they generally do not require IP management departments to establish patent or technical standard databases for specific industries. The forward-looking IP retrieval and analysis conducted before project initiation does not need to be highly targeted; it only needs to prevent low-level repetitive research through necessary IP retrieval and analysis at the time of project initiation. They do not emphasize IP monopoly control but should play a public welfare role, mainly carrying out IP licensing or even low-cost or free licensing. The implementation and acceptance of projects do not overemphasize the production of products with independent intellectual property rights; it is sufficient to produce scientific and technological achievements and intellectual property rights that meet the acceptance requirements, and there is little emphasis on the formation of high-value IP and its support for industrialization. The requirements of high-level research universities for the initiation, implementation and acceptance, as well as achievement transformation of scientific research projects are lower and more flexible.

Third, the organizational structure and talent team for IP management of scientific research

projects differ among different components. Compared with national research institutions and high-level research universities, national laboratories attach more importance to the systematization and institutionalization of IP management. In addition to establishing institutions for technology licensing, IP management, seed investment and startup enterprise management, as well as corresponding talent teams, they also need to build an exclusive IP commissioner team dedicated to serving the periods before and after the initiation and during the implementation of scientific research projects, tailored to the laboratory's own core industries and various technical fields. IP commissioners in national laboratories must be proficient in the core technologies of their respective industries, be able to cooperate with scientific research teams to carry out high-level IP retrieval and analysis management, conduct innovation management of scientific research projects through patent infringement comparison, perform predictive and early warning analysis and management of intellectual property rights for initiated projects, and propose IP strategic layout strategies. At present, due to the fact that scientific and technological innovation in universities and research institutions does not focus on a specific industry or technical field, they generally do not have an IP commissioner team specializing in specific industrial field technologies within their IP management offices. Besides, national laboratories shoulder the mission of safeguarding industrial security and independent controllability. Accordingly, their technology transfer and seed investment departments should actively participate in proof of concept (POC), laboratory scale tests and pilot scale tests. When carrying out invention disclosure evaluation, patent quality evaluation and market analysis using the instruments and equipment of national laboratories, the teams should conduct POC from the dimensions of market feasibility, cost-benefit feasibility and investment feasibility. Furthermore, they must form a reasonable equity structure through intellectual property rights, seed investment and social capital. This approach could support innovation and entrepreneurship based on scientific and technological achievements and intellectual property rights, and promote the establishment of more spin-off enterprises to achieve industrialization in specific fields. Therefore, national laboratories should pay more attention to the construction of internal professional seed-stage investment funds to support the industrialization of their scientific and technological achievements and intellectual property rights. They should establish close cooperative relations with venture capital institutions through equity ties, and build a professional venture capital talent team that can provide financing support for startup enterprises incubated by the laboratories. This approach could help the startups to achieve large-scale industrialization, and thus support the supplementing and strengthening of the industrial chain.

3. Framework of Mission-Driven for IP Management in National Laboratories

National laboratories assume more comprehensive and stringent responsibilities on IP management than national research institutions and high-level research universities. IP management is not only an indispensable core component of the national laboratory management system, but also a fundamental prerequisite for them to achieve strategic objectives and fulfill core missions. To fulfill the core mission of national laboratories, three core requirements must be implemented: first, IP management must be fully integrated into the entire process of scientific and technological innovation; second, an organized, high-quality, and efficient scientific and technological innovation and IP management system must be established; third, IP management must be taken as a breakthrough to promote the deep integration of the innovation chain, industrial chain, capital chain, and talent chain.

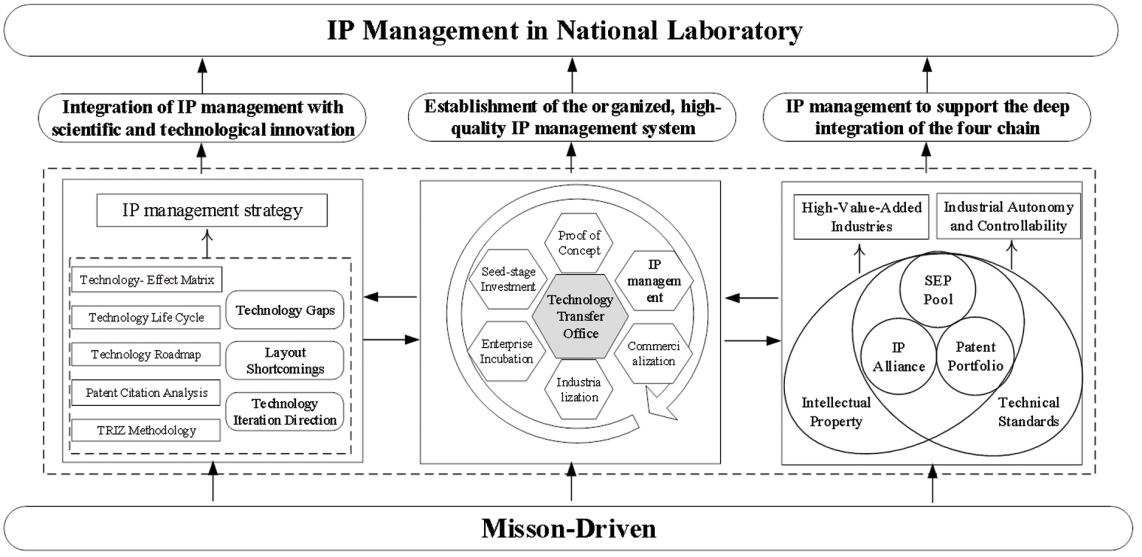

Fig. 2. Framework of mission-driven IP management in national laboratory.

First, the mission of national laboratories mandates the deep integration of IP management with scientific and technological innovation. To drive breakthroughs in original achievements and tackle key core technologies, it is imperative to implement whole-process IP management for scientific research projects and establish IP commissioner teams (Song, 2014). Prior to the initiation of scientific research projects, forward-looking and in-depth IP retrieval and analysis shall be conducted, IP prediction and early warning shall be carried out, and the direction and focus of future IP strategic layout shall be clarified. During the project implementation phase, tracking IP retrieval and analysis shall be performed, along with IP quality management, IP maintenance management, and integrated management of IP and technical standards. At the project acceptance phase, arrangements shall be made for IP maintenance management after project completion. In IP retrieval and analysis, methods such as tech-effect matrix, technology roadmap, patent map, TRIZ, and technology foresight shall be fully utilized to clarify the direction, methods, and focus of R&D and IP strategic layout through patent navigation, thereby optimizing resource allocation, realizing deep integration with scientific and technological innovation management, and enhancing the leading role of IP in scientific and technological innovation (Lyu *et al*., 2020). At the commercialization phase of scientific and technological achievements, continuous layout of high-quality patents shall be maintained, the integration of IP with technical standards shall be realized, and high-level IP contract management and IP transfer and commercialization management shall be conducted.

Second, the mission of national laboratories requires the establishment of an organized, high-quality, and efficient scientific and technological innovation and IP management system that incorporates IP management. Fulfilling the mission of national laboratories also necessitates organized commercialization of scientific and technological achievements. To achieve their missions and strategic objectives, national laboratories must generate high-quality scientific and technological achievements and commercialize them efficiently. The commercialization of scientific and technological achievements and IP rights must comply with the laws of scientific and technological innovation and address the problems of information asymmetry and risk asymmetry in the technology transfer process. This requires national

laboratories to establish a specialized internal institution for the commercialization of scientific and technological achievements and IP management, which integrates technology transfer, IP management, seed fund, and startup enterprise management and forms a mechanism of "mutual cooperation and mutual restraint". From the perspective of technology transfer, the invention disclosure and evaluation system is used to assess whether an invention is worthy of patent application; from the perspective of IP evaluation and layout evaluation, the quality of IP applications is improved; from the perspective of seed investment, POC, pilot testing, productization, as well as equity design and financing are carried out; from the perspective of startup enterprise management, enterprise establishment, equity reduction, and share revenue management are conducted. The proceeds from the commercialization of scientific and technological achievements shall be fed back into R&D investment and seed funds, and the industrial chain shall be supplemented and strengthened through venture capital, thereby forming an ecological system for scientific and technological innovation and IP management in national laboratories.

Third, the mission of national laboratories requires IP management to effectively support the deep integration of the "industrial chain, innovation chain, capital chain, and talent chain" and address systemic resource allocation failures. IP management serves as the binder and catalyst for effectively promoting the deep integration of the four chains, and is also an important starting point and breakthrough for national laboratories to fulfill their missions. National laboratories realize the integration of the innovation chain and industrial chain through IP right transfer and licensing, thereby achieving industrial security and independent controllability; integrate the innovation chain with the scientific research talent chain through IP retrieval and analysis and patent navigation, thereby realizing high-quality scientific and technological innovation; guide social venture capital to invest in early-stage, small-scale, and hard technology projects through seed investment funds, thereby realizing the integration of the capital chain and innovation chain and reversing the current situation of insufficient support from venture capital for the commercialization of scientific and technological achievements; realize the integration of the four chains through the management of startup enterprises by technology transfer managers, and develop high-tech industries, strategic emerging industries, cultivate future industries, and support the development of new quality productive forces through venture capital investment. This requires national laboratories to integrate IP with technical standards, master the dominance of the industrial chain by cultivating SEP and leading or participating in the construction of technical standard patent pools; build an innovation chain encompassing IP retrieval and analysis, patent navigation, IP transfer and licensing, and IP productization; build a capital chain including special funds for IP management, seed-stage investment funds, and venture capital; and build a professional IP talent team consisting of IP commissioners and technology transfer managers.

4. IP Management Experience of National Laboratories from Developed Countries

National laboratories in developed economies such as the United States, Europe and Japan have built IP management systems tailored to their own strategic missions through decades of practice. Their core institutional logic shares commonalities with the compound mission positioning of China's national laboratories, both leverage IP management as a vehicle to address coordination failures, information asymmetry, and imbalance between risks and benefits throughout the entire scientific and technological innovation chain, thereby achieving two-way empowerment between national strategic objectives and industrial development needs. A systematic review of the IP management experiences of these leading

national laboratories therefore provides important reference for the construction of the IP management system of China's national laboratories.

4.1. Core approaches to IP management of national laboratories from developed countries

First, national laboratories in developed countries mostly adopt an integrated centralized management architecture that combines the four core functions of IP management, technology transfer, venture capital, and startup enterprise management. Its core advantage lies in avoiding information asymmetry and operational delays caused by multi-stakeholder coordination failures. This internal centralized IP management architecture has enabled US national laboratories to significantly increase the number of patents while maintaining high patent quality (Jaffe and Lerner, 2001). The *Federal Technology Transfer Act* of the United States mandates that all federal laboratories establish technology transfer offices (TTOs). On this basis, many national laboratories have further set up outreach and partnership offices to assist TTOs in commercialization activities. These offices are primarily responsible for strengthening cooperation and communication between national laboratories, industry, and government departments, and seeking effective pathways for smooth IP commercialization by establishing robust industry-university-research cooperation mechanisms. A large number of national laboratories have thus formed the "integrated centralized IP management + outreach and partnership office" collaborative model, which is adopted by the Office of Intellectual Property and Office of Strategic Partnerships at Lawrence Berkeley National Laboratory, the Polsky Center and Partnerships and Technology Outreach at Argonne National Laboratory, and the Office of Intellectual Property and Office of Industrial Collaboration at the National Institute for Materials Science (NIMS) in Japan.

Second, national laboratories in developed countries are generally equipped with a well-staffed, highly qualified and professionally competent talent team for technology transfer and IP management, to address the challenge of mutual recognition between technical information and market information. The Polsky Center for Entrepreneurship and Innovation at Argonne National Laboratory in the United States currently has approximately 60 staff members, 17 of whom hold doctoral degrees. The team comprises 8 professionals in IP and technology development management, 19 in entrepreneurship program and licensing management, 10 in venture capital, and 9 in the IP risk management team, all consisting of scientists with profound technical expertise and operational professionals[1]. The Knowledge Transfer Group (KT) at the European Organization for Nuclear Research (CERN) employs more than 25 staff across its four internal departments. NIMS has assigned more than 4 patent experts to each research direction of the laboratory. Talent training in North America and Europe is mainly carried out through professional technology transfer organizations such as the Association of University Technology Managers and the Association of European Science and Technology Transfer Professionals. These organizations provide standardized vocational training and certification examinations for technology transfer personnel in universities, research institutions and national laboratories, who then become qualified Registered Technology Transfer Professionals (RTTPs) and serve in technology transfer offices (TTOs) (Jia *et al*., 2022).

Third, national laboratories in major developed countries adopt diversified management models

[1] https, //polsky.uchicago.edu/meet-the-team/

and balanced risk-benefit distribution ratios to address information asymmetry and risk asymmetry in the technology transfer process. The most distinctive business models of national laboratories are establishing spin-off companies through equity contribution, as well as patent portfolio operations and IP alliance models. National laboratories in the United States and Europe attach particular importance to the establishment of spin-off companies, which transform laboratories from mere achievement suppliers into risk-sharing parties. This approach not only guides social capital investment to improve the technology transfer performance of national laboratories (Ni, 2024), but also increases the revenue distribution ratio of national laboratories and their internal technology transfer institutions. The U.S. Department of Energy (DOE) strongly encourages national laboratories to create spin-off companies based on their technologies and provides support through multiple startup investment fund programs, such as the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) seed fund program and the Technology Commercialization Fund (TCF). Internal technology transfer institutions of national laboratories usually also maintain venture capital funds for seed-stage investment in laboratory technologies, including the venture capital fund of the Polsky Center at Argonne National Laboratory and KT Fund at CERN. In addition to financial support, U.S. national laboratories provide talent elements for spin-off companies through various programs. DOE has established the Lab-Embedded Entrepreneurship Program, which allows entrepreneurs to intern at national laboratories for two years and utilize internal laboratory technologies and resources to establish spin-off companies. The CERN KT Group has issued the Spin-off Company Policy to encourage CERN researchers to transform their research results into commercial products and realize technology commercialization by creating spin-off companies. National laboratories also attach great importance to patent portfolio operation and IP alliance models to enhance the commercialization potential and market competitiveness of patents. NIMS in Japan has built strong patent portfolio alliances through patent portfolio cooperation agreements with other research institutions and enterprises, maximizing patent value and forming patent barriers in specific technical fields to restrict the entry of competitors. U.S. national laboratories, by leveraging IP alliance models, actively participate in and even lead the formulation of international technical standards, enhancing the country's voice and influence in global science and technology governance by building "rule-making power" (Lu *et al*., 2014). In major developed countries, service invention rights in national laboratories are primarily vested in the institutions, and researchers cannot directly participate in the commercialization process of technological inventions. Consequently, researchers have a relatively weak negotiating position and low revenue distribution ratio in the commercialization of scientific and technological achievements (Nilsson *et al*., 2010; Link and Siegel, 2005). At Argonne National Laboratory in the United States, the management, commercialization and revenue distribution of intellectual property rights are the responsibility of the Polsky Center for Entrepreneurship and Innovation. Specifically, 55% of commercialization revenue accrues to the Polsky Center, while the research team receives only 25%[2]. The core of this distribution mechanism is to incentivize high-level IP management institutions to operate continuously and efficiently by increasing the risk borne by technology transfer institutions in exchange for a higher proportion of revenue.

Fourth, national laboratories in major countries mitigate the risk of misjudging the value of scientific and technological achievements through institutionalized management processes. Technology transfer

[2] https, //polsky.uchicago.edu/wp-content/uploads/2024/03/revenue_distribution_policy-1.pdf

and IP management in national laboratories typically cover an end-to-end workflow, including invention disclosure and evaluation, IP administration, technology licensing, and innovation and startup enterprise management. U.S. national laboratories mandate the implementation of an invention disclosure and evaluation system. At Argonne National Laboratory, this process commences at the inception of researchers' projects, researchers must first disclose their inventions to the IP team of the Polsky Center for Entrepreneurship and Innovation, followed by the submission of a confidentiality report. This report is reviewed by the Business Development Team to assess commercial potential, including analysis of market demand, technical uniqueness, and profit models. Pre-patent-filing evaluation focuses on two core aspects, whether a service invention merits patent application, and the drafting quality of the patent documents themselves. After confirming the commercial value of a technology, the Polsky Center selects an appropriate IP protection strategy, such as patent filing or trade secret protection. For technologies with no immediate commercialization prospects but significant societal value, the laboratory typically disseminates them through multiple channels, including peer-reviewed publications, academic conferences, technical demonstrations, and software copyright registration, ensuring that knowledge benefits the broader society. Investment-oriented evaluation centers on IP transfer, licensing, and equity contribution. The Polsky Center has established standardized procedures for this stage. If the transformation adopts a transfer or licensing model, its Licensing Team negotiates the terms of IP licensing agreements with commercial partners to safeguard the legitimate rights and interests of the laboratory. If the establishment of a startup enterprise is selected, the Licensing Team grants an exclusive or non-exclusive license of the invention to the startup, while assisting entrepreneurs in compiling business plans and market analysis reports and applying for various financing funds. Its internal venture capital team also provides necessary seed-stage investment.

4.2. Analysis of IP management experiences in national laboratories of developed countries

Based on the framework of mission-driven for IP management in national laboratories, this section conducts a systematic analysis of the IP management experiences of national laboratories in major developed countries. It is evident that these experiences demonstrate three core characteristics. First, IP management in national laboratories effectively underpins scientific and technological innovation. At the scientific research project initiation stage, R&D project planning in national laboratories is closely aligned with market demand, leveraging the close connections established by TTOs and outreach and partnership offices with government and industry. During the R&D process, national laboratories emphasize dynamic control over scientific and technological achievements. Most laboratories implement a mandatory invention disclosure system and improve patent application quality through standardized procedures. Second, national laboratories in major developed countries have generally established an integrated IP management system. Most national laboratories have integrated the four core functions of technology transfer, IP management, seed-stage investment funding, and startup enterprise management into a unified specialized internal institution, staffed with a professional talent team led by technology transfer managers. The management processes are institutionalized and standardized, inventors are required to disclose and assign their inventions to the laboratory, and the specialized institution has established a standardized end-to-end mechanism covering invention disclosure evaluation, patent quality assessment, investment evaluation, patent application, and commercialization implementation, forming an IP management system with clear rights and responsibilities and efficient operation. Third, the mature spin-

off company incubation model and patent portfolio operation in national laboratories effectively promote the deep integration of industry, academia, and research. Most laboratories in developed countries jointly attract social capital investment through the linkage of internal seed-stage investment and government funds, forming a risk-sharing capital pool that deeply binds the risks and benefits of all stakeholders. Meanwhile, patent portfolio operation, IP alliances, and even patent pool management promote the formulation of technical standards, embed core patents into standards, and realize synergy between the innovation chain and industrial chain.

Although the IP management experiences of national laboratories in developed countries provide important references for the construction of China's national laboratory IP management system, there are certain limitations in adapting to the core mission of China's national laboratories due to differences in mission orientation. First, there is a deficiency in front-end IP management. Most national laboratories focus their IP management on the technology transfer stage, lacking front-end IP management. Patent navigation in R&D project initiation and implementation is relatively insufficient, and IP support for basic research and key technology research is inadequate. The root cause lies in the fact that the core driving force for R&D in national laboratories mainly comes from industrial demand, with weak binding requirements for tackling key industrial technologies. Therefore, most national laboratories in developed countries lack the motivation to support national industrial security through front-end patent layout. Second, the revenue distribution mechanism is unfavorable to researchers, which will affect the overall efficiency of scientific and technological innovation in the long run. Under the TTO model in developed countries, the majority of technology commercialization revenues are allocated to TTOs. In some laboratories, the income of technology transfer managers far exceeds that of researchers. The insufficient revenue incentives for researchers make it difficult to fully mobilize their enthusiasm, which in turn affects the overall performance of technology transfer and leads to a declining return on investment (Chapple *et al*., 2005). Third, the technology commercialization process completely decouples researchers from the technology, resulting in a lack of sustained scientific research support for technology-acquiring enterprises. The technology commercialization process of national laboratories, mainly in the United States, completely separates researchers from the technology. However, the transformation of scientific and technological achievements is inseparable from researchers. Granting equity to researchers can align the interests of researchers with those of spin-off companies and provide support for the sustainable innovation and development of enterprises.

Taken together, the IP management of China's national laboratories should fully draw on experiences and construct a mission-driven IP management system for national laboratories of developed countries in combination with the mission orientation of China's national laboratories.

5. Mission-Driven Perspectives on IP Management Challenges in China's National Laboratories

The core mission of China's national laboratories is to achieve breakthroughs in original achievements, tackle key core technologies, realize industrial independent controllability. However, the current IP management system has not yet been precisely aligned with this mission orientation. Drawing on the IP management experiences of national laboratories in major developed countries and the mission-driven framework for IP management in national laboratories, there are still many prominent problems in the IP management of China's national laboratories.

First, China's national laboratories have not yet established an IP organizational structure adapted to their end-to-end mission spanning basic research to industrialization. The core shortcoming lies in the failure to integrate the four core functions of technology transfer, IP management, seed investment, and startup enterprise management, resulting in coordination failures across all links. While national laboratories in major developed countries have generally established unified specialized institutions integrating technology transfer, IP management, seed-stage investment funding, and startup enterprise management, most of China's national laboratories established after 2018 lack independent technology transfer and IP management departments. In some national laboratories, IP management is affiliated with the research department, where scientific and technological achievements are merely reported to the department without systematic invention disclosure and evaluation management, IP quality management, or technical standard management. Furthermore, there is a lack of effective cooperation and restraint mechanisms between IP management, technology transfer, and investment funds. Consequently, numerous scientific and technological achievements cannot be commercialized due to insufficient market prospects; low patent quality undermines the patent implementation rate and industrialization rate; and many patents are unrelated to technical standards, failing to generate due monopoly returns and support the mission objective of industrial independent controllability. Some national laboratories have attempted to establish investment funds to promote achievement transformation, but these funds are separated from technology transfer and IP management departments. They do not participate in invention disclosure evaluation, patent quality assessment, POC or pilot testing, failing to address the "information asymmetry and risk asymmetry" in the technology transfer process, let alone solve the problem of investment funds' reluctance to invest in early-stage and small-scale projects. For example, a national laboratory in China collaborated with a central state-owned enterprise to establish a "Science and Technology Innovation Fund" with an investment of 200 million RMB. However, the fund targets technology-based small and medium-sized enterprises across the entire society, and none of the first six enterprises that received investment from the fund were spin-off enterprises of the laboratory[3], failing to effectively promote the industrialization of the laboratory's scientific and technological achievements.

Second, IP management mechanisms, process design and talent allocation of China's national laboratories fail to meet the mission requirements of high-quality IP creation and efficient commercialization, and cannot effectively support the improvement of the laboratories' scientific and technological innovation capabilities. First and foremost, national laboratories lack systematic management mechanisms and processes for invention disclosure and evaluation as well as patent quality assessment. Patent applications filed by researchers and patent documents drafted by patent agencies are generally not evaluated by internal specialized institutions. Some national laboratories even allow researchers to draft patent documents on their own, which inevitably leads to problems such as large patent volume but low quality, and high patent quantity but low commercialization rate. It may even result in the disclosure of scientific and technological achievements that should be protected as trade secrets through patent applications. At present, the patentability assessment of inventions and patent quality assessment in China mainly rely on economic indicator-based evaluation rather than practical management-oriented assessment. Since 2020, China has successively rolled out policies on the high-quality development of intellectual property rights for universities, central state-owned enterprises

[3] https, //caijing.chinadaily.com.cn/a/202410/16/WS670f31f4a310b59111d9e2d5.html

and research institutions, requiring the establishment of a disclosure system for service scientific and technological achievements and a pre-filing patent assessment system. However, these policies are mainly designed to reduce the risks of scientific and technological achievement commercialization, rather than to identify transformable technologies and provide patent protection for them. Furthermore, they lack provisions on seed-stage investment funds, making it impossible to realize a new combination of production factors including technology, capital, labor and management. This inevitably increases the difficulty of technology and IP transfer and commercialization, and also fails to avoid the risk of state-owned asset loss. Most existing proof of concept centers (POCC) conduct validation from the market or even research perspective, rather than the seed investment perspective. POCC policies in some provinces are mainly incentive policies, lacking supportive policies for seed investment-based POC, POC for invention disclosure and patent quality management, and POC leveraging internal laboratory facilities. This is seriously inconsistent with the mission of generating high-value patents to support industrial security. Furthermore, China lacks specialized organizational structures and talent teams for technology transfer and IP management, and existing staff generally lack the requisite professional knowledge, competence and skills. A review of the official recruitment websites of China's national laboratories reveals that most national laboratories have no recruitment openings for IP management-related positions, and some laboratories only recruit 1 to 2 people for such positions, far below the ratio of researchers to technology transfer managers of approximately 25, 1 in European and American countries. There are numerous flaws in the IP management policies of China's national laboratories. Most technology transfer and IP management staff are placed in public institution management posts or support posts with severely limited staffing quotas. In addition, their salary and benefits are low or even fixed, with no linkage to technology transfer performance. While most national laboratories in developed countries are staffed with talent teams dominated by technology transfer managers, the reduction policy for vocational qualification examinations excludes technology transfer managers from the national qualification system in China. The training and professional title evaluation for technology transfer managers are also highly unstandardized, which significantly hampers the development of specialized technology transfer talent teams in national laboratories. It is extremely rare for technology transfer managers in China's national laboratories to serve as managers of spin-off enterprises. In most cases, researchers become the actual managers of enterprises by establishing companies through priority implementation or right allocation of achievements. However, practice has proven that researchers have a low success rate and face high risks in entrepreneurship. This model is also not conducive to researchers focusing on their core research mandates. In the long run, it will weaken the capacity of national laboratories in making breakthroughs in original achievements and tackling key core industrial technologies, and hinder the continuous improvement of their scientific and technological innovation capabilities.

Third, the business models and revenue distribution systems for the commercialization of scientific and technological achievements in China's national laboratories are unable to support the mission objective of deep integration of the industrial chain, innovation chain, capital chain, and talent chain. At present, China's national laboratories generally commercialize scientific and technological achievements through transfer and licensing models. However, the transfer of IP rights for scientific and technological achievements cannot deeply bind multiple stakeholders across the chains through shared interests, and is inconsistent with the public welfare nature and mission positioning of national laboratories. Due to the inaccurate interpretation of the requirement that "universities and research institutions shall no longer establish new enterprises, and shall strengthen the external dissemination of scientific and

technological achievements through licensing in principle" stipulated in the Several Opinions of the Central Committee of CPC and the State Council on *Deepening Institutional and Mechanism Reforms to Accelerate the Implementation of the Innovation-Driven Development Strategy*, China's national laboratories rarely commercialize achievements by establishing spin-off companies through equity contribution based on the IP rights of scientific and technological achievements. In fact, the core purpose of this policy is to enable researchers to focus on their core research mandates, rather than prohibiting national laboratories from holding equity stakes in spin-off enterprises. Domestic and international experiences have proven that establishing spin-off enterprises through equity contribution of scientific and technological achievements is the most effective approach for the commercialization of scientific and technological achievements (Yang and Xiao, 2019). However, most of China's national laboratories have not established seed-stage investment funds integrated with technology transfer and IP management, making it difficult to conduct proof of concept and pilot testing for laboratory achievements through seed-stage investment, which restricts the industrial implementation of research outputs. Furthermore, the current revenue distribution ratios of China's national laboratories are unreasonable. The commercialization of scientific and technological achievements is inseparable from the participation of service inventors, yet researchers only control the technical factor, not other key factors of production such as capital, labor, and management. Empowering researchers to become the main subjects of achievement commercialization through priority implementation or right allocation does not conform to the objective laws of scientific and technological achievement commercialization. It will also give rise to a wide range of risks, including technical risks, market risks, legal risks, management risks, post rights and interest risks, state-owned asset loss risks, capital chain break risks, and personal ethical risks, resulting in a low success rate. To incentivize researchers to participate in the commercialization of scientific and technological achievements, many local governments, universities, research institutions and national laboratories in China have continuously increased the revenue distribution share for researchers. The share allocated to researchers and their teams is usually more than 70%, and in some cases even as high as 100%[4]. While this approach can boost researchers' motivation in the short term, it fails to fully consider the factor allocation costs and risk costs of multiple stakeholders participating in achievement commercialization. Internally, it is also detrimental to the establishment and development of specialized internal technology transfer and IP management institutions. In the long run, it will distract researchers from focusing on basic research and their core mandates, thereby undermining the fulfillment of the mission and strategic objectives of national laboratories

6. Construction of Mission-Driven IP Management System for China's National Laboratories and Corresponding Policy Recommendations

To give full play to the role of IP management in effectively underpinning high-quality development, innovation-driven development, and the development of new quality productive forces, this paper, based on the framework of mission-driven for IP management in national laboratories, puts forward the following policy recommendations for strengthening IP management in China's national laboratories.

First, it is mandatory for national laboratories to establish a specialized internal institution that

[4] https, //www.gz.gov.cn/zwfw/zxfw/ylfw/content/post_9590876.html

integrates the four core functions of technology transfer, IP management, seed-stage investment, and startup enterprise management. The three functional departments of IP management, technology transfer, and seed-stage investment shall form a mechanism of mutual cooperation and mutual restraint. The specialized institution shall regularly liaise directly with the laboratory's strategic planning department to achieve seamless alignment between national strategies and IP indicators. The state shall establish a special fund for the specialized internal technology transfer and IP management institutions of national laboratories to support their development, with continuous funding for 5 years at an annual amount of no less than RMB 500,000. The national venture capital guidance fund and the national fund for technology transfer and commercialization shall support national laboratories in establishing internal seed-stage investment funds through equity investment via fund of funds, guarantees, loan interest discounts, risk subsidies and other means. These seed-stage investment funds shall invest in technologies and IP that have passed investment evaluation, and guide social venture capital to conduct joint investment. They will exit from the management of startup enterprises through gradual equity reduction around the third year of the venture. The long-term investment role of the national venture capital guidance fund shall be given full play to support the sound and stable development of startup enterprises engaged in the commercialization of scientific and technological achievements.

Second, build a high-caliber talent team for technology transfer and IP management in national laboratories. In terms of staffing size, the number of personnel in the technology transfer and IP management departments of the specialized in-house institutions of national laboratories shall be no less than 20. In terms of staffing establishment, the person in charge of the specialized in-house institution may be granted a public institution staffing quota, while other personnel shall be recruited through open social recruitment. In terms of performance appraisal, a performance evaluation and promotion mechanism for technology transfer and IP management personnel shall be established, with core focus on work quality, professional competence, job performance and individual contribution. Meanwhile, a policy shall be implemented to link the salaries of technology transfer and IP management personnel to the proceeds from technology transfer and commercialization. Technology transfer managers shall be included in the scope of the national vocational qualification examination. National laboratories shall be supported and encouraged to send personnel to actively participate in the national technology transfer managers qualification examination and professional title promotion. Targeted IP management training shall be organized in light of practical work to continuously improve the professional competence of relevant personnel.

Third, establish an effective system for IP right ownership and commercialization and utilization in national laboratories. National laboratories shall be supported to carry out empowerment reform of delegating ownership or long-term use rights of scientific and technological achievements, and implement separate asset management of scientific and technological achievements. Meanwhile, synergy shall be strengthened between the empowerment reform policy, separate asset management policy, and the policy of establishing specialized in-house technology transfer and IP management institutions in national laboratories. After being empowered, researchers of national laboratories shall disclose and assign their service invention achievements to its employers. The internal technology transfer institution of the laboratory shall be responsible for the external licensing and equity contribution of scientific and technological achievements and IP rights. Researchers shall abide by non-compete obligations, receive reasonable consideration, and focus on their core research mandates by disclosing and assigning their inventions. The specialized in-house institution shall identify high-value patents through invention

disclosure and evaluation and patent quality management. Furthermore, a mechanism of "government guidance fund + internal seed investment + venture capital + risk guarantee" shall be established to address the problem of reluctance to invest in early-stage, small-scale, long-cycle and hard-technology projects as well as financing difficulties. This will promote the deep binding of multiple stakeholders including national laboratories, governments, enterprises, financial institutions and intermediary service institutions, forming a community of interests with risk sharing and benefit sharing, and providing solid support for the efficient transfer and commercialization of scientific and technological achievements and IP rights. Meanwhile, national laboratories shall be encouraged and supported to conduct high-value patent inventory and establish a precise docking mechanism with enterprises. A "co-ownership + pay-after-use" model shall be adopted to promote IP implementation and utilization, the partnering enterprise shall first be added as a co-owner of the national laboratory's patent right, and then the enterprise may use the patent first and pay the fee subsequently through a signed agreement.

Fourth, improve the revenue distribution system for high-quality IP creation and efficient utilization in national laboratories. A reasonable revenue distribution ratio for technology transfer in national laboratories shall be formulated, taking into account the interests of national laboratories, internal specialized technology transfer institutions, research teams, social capital, and the departments where researchers are affiliated. Inventors shall receive a fixed primary share of the revenue, while other stakeholders shall obtain revenue in proportion to their capital contribution. All parties shall bear the costs of commercialization failure in proportion to their shares, establishing a diversified and reasonable revenue distribution mechanism that balances the interests of researchers, IP management and operation institutions, social capital, and innovation entities. On the basis of the *Law of the People's Republic of China* on Promoting the Transformation of Scientific and Technological Achievements, it shall be explicitly stipulated that the licensing income of scientific and technological achievements and IP rights shall not deduct costs such as prior R&D investment, but mainly deduct costs including IP retrieval and analysis, agency fees, and pre-authorization management fees. It is recommended that the revenue share for service inventors be 40%-55% of the net proceeds, and an annual cap system shall be implemented to enable researchers to focus on scientific research work. When scientific and technological achievements and IP rights are commercialized through equity contribution or joint implementation, researchers shall be granted reward equity rather than becoming direct shareholders, to prevent the loss of state-owned assets. Specialized technology transfer and IP management institutions may retain 15%-20% of the technology transfer revenue, which shall be used for technology evaluation, patent application, and employee salaries and benefits, so as to improve patent quality and licensing investment rate through economic leverage. National laboratories and the departments where inventors are affiliated may receive approximately 15% of the technology transfer revenue, which shall be used to support scientific research and graduate student training.

Fifth, support national laboratories in cultivating SEP and leading or participating in the construction of patent pools. Strengthen the capacity building of technical standard and IP management in the specialized in-house technology transfer institutions of national laboratories. All national laboratories shall establish an integrated local database covering patents, technical standards and SEP in the key core technology fields of their respective industries. Strengthen the support for SEP cultivation in national laboratories from the national venture capital guidance fund, the national fund for technology transfer and commercialization, and various industrialization projects. Actively guide national laboratories to formulate national or international technical standards based on high-value patents, and master SEP

through research and development in alignment with national or international technical standards. Establish support program for patent pool construction in national key strategic emerging industries, plan and lay out patent pool construction for future industries, and actively guide national laboratories to lead or participate in patent pool construction in major fields. By mastering SEP, it could reduce the widespread excessive homogeneous competition in China's industries and enhance industrial independent controllability. Through the formulation and revision of technical standards and the updating of patent pools, it could realize industrial empowerment and optimization and upgrading.

In summary, this paper systematically investigates the construction of the national laboratory IP management system from a mission-driven perspective. It breaks through the limitations of previous studies that are overly macro-oriented and overly reliant on foreign experience references, constructs a theoretical framework that couples mission, institutional logics and IP management, clearly identifies four key shortcomings in China's national laboratory IP management and puts forward actionable policy pathways. This study enriches the theory of IP governance for public research organizations within the national innovation system, and also provides operational policy solutions for national laboratories to strengthen original innovation, tackle key core technologies, and support industrial self-reliance and controllability. Future research can further conduct empirical tests based on the operational data of national laboratories, and refine the dynamic adaptation mechanism of IP management across different industrial sectors.

Conflicts of Interest

The authors declare no conflict of interest.

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