Education Insights

Review

Exploration and Research on the Path of University Science and Technology Achievement Transformation

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Abstract: This comprehensive review examines the transformation pathways of scientific and technological achievements in Chinese universities, addressing current challenges and potential solutions. The study systematically analyzes the complex barriers in reforming ownership rights of job-related scientific achievements and explores innovative approaches to optimize whole-process management systems. A significant focus is placed on the development of due diligence exemption mechanisms to address the prevalent reluctance in technology transfer processes. The research extensively evaluates the 'organized research' model, drawing from international best practices and experiences. It provides an in-depth analysis of professional technology transfer offices (TTOs) and their crucial role in facilitating successful commercialization of research outcomes. The study presents differentiated strategies tailored for various institutional categories, including research-oriented universities, application-focused institutions, private establishments, and medical schools. Through careful examination of case studies from diverse educational institutions and their affiliated organizations, the research proposes a comprehensive and operationally viable model for transforming university scientific achievements into practical applications. This systematic approach offers valuable theoretical frameworks and practical guidelines for government policymakers, university administrators, and researchers engaged in applied research, ultimately contributing to more effective technology transfer and commercialization processes in the academic sector.

Keywords: technology transfer; research commercialization; academic innovation; university-industry collaboration; scientific achievement transformation; technology transfer offices; institutional governance

1. Introduction

In the current global context, where significant changes are rapidly unfolding, technological innovation has emerged as a central arena in international strategic competition [1]. For China, which is presently focused on high-quality development, advancing the transformation of university research achievements from laboratories to production lines, and from theoretical papers to practical applications, is essential for achieving technological self-reliance and strengthening. This process is also crucial for cultivating new productive forces and establishing a modern industrial system. Universities, as a vital part of the national innovation system, carry the significant responsibility of conducting basic research and fostering original innovation. They undertake a substantial portion of national basic research tasks and natural science projects, producing numerous original and influential outcomes [2]. However, the conversion rate of university research achievements has historically been low, with many high-value scientific and technological accomplishments remaining as papers, certificates, and laboratory samples, without effective transformation into productive forces. This results in a considerable waste of scientific research resources. Although national policies have been introduced to stimulate innovation through institutional reforms, universities still encounter challenges such as unclear ownership definitions and weakened incentive

Received: 04 December 2025
Revised: 16 January 2026
Accepted: 27 January 2026
Published: 31 January 2026

mechanisms. Overcoming the bottlenecks from initial research stages to final application, and establishing an efficient, smooth, and sustainable transformation ecosystem, has become a critical issue for the academic, policy, and industry communities [3, 4].

2. A Multi-Dimensional Analysis of the Transformation of University Research Achievements

Despite the ongoing release of national policy benefits, the low rate of transformation of scientific research achievements in universities remains largely unchanged [5]. Analysis of existing literature and field research reveals that the transformation of university research achievements faces multi-dimensional structural challenges, including institutional mechanisms, management models, organizational forms, and evaluation systems [6].

2.1. Mechanism and system obstacles: The double shackles of ambiguous ownership and the absence of tolerance for errors

Institutional mechanisms are the primary bottleneck restricting the transformation of scientific achievements [7]. The core issue lies in the imbalance between power and responsibility.

The blockage in the reform of ownership rights represents a significant challenge. Although there has been a clear promotion of granting ownership or long-term usage rights of scientific research achievements to researchers, the lack of unified legal interpretations and operational guidelines causes universities to act cautiously when disposing of state-owned assets. This caution leads researchers to have concerns about ownership rights, fearing potential legal disputes or being identified as responsible for the loss of state-owned assets in the future. This uncertainty has caused many achievements to stagnate at the stage of confirming ownership. Additionally, there is a substantive absence of a mechanism for full responsibility exemption. The transformation of scientific achievements is characterized by high risk and uncertainty. Pricing, asset evaluation, and investment decisions are prone to deviations. Without a clear list of full responsibility exemptions and a mechanism for tolerance and error correction, university administrators and researchers often adopt conservative strategies when facing transformation decisions due to the fear of bearing political and disciplinary responsibilities for the loss of state-owned assets [8]. The negative incentive orientation of doing more and making more mistakes, doing less and making fewer mistakes, and doing nothing and achieving success severely inhibits the enthusiasm and initiative of those involved in the transformation. Furthermore, the income distribution mechanism lacks sufficient incentives. Although policy stipulates that transformation income can favor researchers, in practice, internal approval processes within some universities are cumbersome, tax incentives are not fully implemented, and distribution ratios among the school, college, and team are unreasonable [9]. This results in researchers having a weak sense of gain, which diminishes their motivation to participate in the transformation.

2.2. Management model lagging behind: Breakdown of the entire process management and dormancy of archival value

There is a significant mismatch between patent quality and market demand. Influenced by the current evaluation system, many researchers apply for patents merely to meet assessment indicators or requirements for professional title evaluation, lacking in-depth research on market application prospects. This results in a large accumulation of low-value patents and dormant patents. The absence of a comprehensive process management mechanism from project initiation to the end of transformation has led to a disconnect between research direction and industrial demands, with high patent maintenance costs but low conversion rates [10]. The value of scientific research archives has not been fully exploited. In the era of the digital economy, scientific research archives are not only historical records but also valuable data assets [11]. However, current

university scientific research archive management remains at the traditional level of paper-based storage or simple electronic storage, failing to effectively mine technical parameters, experimental data, and failure records in the archives to facilitate technological transformation [12]. A large number of historical achievements remain dormant in the archives, and enterprises cannot obtain complete technical information, resulting in information asymmetry between the supply and demand sides and missing opportunities for transformation.

2.3. The organizational structure is loose, with a lack of organized research and specialized services

Working alone makes achieving synergy difficult [1]. Research teams in universities are often scattered across various departments, lacking a cross-disciplinary and cross-college collaborative mechanism. This results in fragmented and isolated scientific research achievements, making it challenging to form systematic solutions and meet enterprises' demands for complete technologies. The construction of specialized technology transfer institutions lags behind. Most universities' technology transfer centers have a single function and only serve as information platforms, lacking a professional team of technology managers to provide full-chain services such as patent layout, value assessment, business negotiations, and legal risk control.

2.4. The evaluation system is overly simplistic, emphasizing dogma while overlooking the value of transformation

The current scientific research evaluation system still heavily relies on the number of papers, impact factors, and project levels, while neglecting the actual contributions and social benefits of scientific work. The evaluation system for the scientific research of graduate students is still lacking, resulting in students favoring theoretical verification and paper publication when choosing topics, while neglecting application value and market demand. Similarly, teachers face similar difficulties in the professional title evaluation process. The transformation results often cannot be equated with high-level papers, leading to a lack of motivation among researchers to engage in applied research [2]. The absence of a sustainable evaluation incentive mechanism is a significant factor restricting the long-term development of transformation work [4, 7].

Scientific research often has a long-term nature and is difficult to show results in the short term [8, 12]. The existing annual assessment system forces researchers to pursue short-term outputs, making it challenging for them to focus on long-term fundamental transformation work [1].

3. The core path of technological transformation

3.1. Deepen the reform of the institutional mechanisms and stimulate the internal driving force

3.1.1. Comprehensively promote the reform of the ownership of scientific and technological achievements related to positions

Implement the "granting rights first, then transformation" model: Universities should draw on advanced pilot experiences, formulate detailed implementation rules, and clearly grant the ownership or long-term usage rights of scientific research achievements to researchers [7]. By simplifying the approval process and standardizing the confirmation procedures, researchers can truly become the owners of the achievements and enjoy the disposal and income rights, thereby greatly stimulating their motivation to actively connect with the market and promote transformation. Establish a list-based exemption from liability mechanism: Clearly stipulate that under the condition that researchers have not engaged in illegal profits and have fulfilled their diligence and responsibility obligations, they will be exempted from responsibility for decision-making errors caused by market risks in achievement pricing, asset evaluation, and investment decision-making [10]. Through the institutionalized error-tolerance mechanism, researchers and management cadres can relieve their burdens and achieve "confident transformation" and

"bold transformation". Optimize the distribution of income and tax incentives: Further rationalize the distribution ratios of income among the university, the college, the team, and individuals to ensure that researchers obtain the majority of the transformation income. At the same time, actively implement tax preferential policies for scientific and technological advancements to reduce transformation costs and improve the actual sense of gain for researchers.

3.1.2. Implementing refined management throughout the entire process of patent implementation

Source control and high-value patent cultivation: Establish a patent navigation mechanism, introducing market analysis and patent intelligence analysis at the project initiation stage to ensure that the research and development direction precisely aligns with industrial demands [2]. It is necessary to strengthen the full life cycle management of patents, implementing dynamic monitoring from pre-application search and quality control during application to maintenance and operation after authorization. Timely abandon patents with no market value and concentrate resources to cultivate high-value patent portfolios, enhancing the value and conversion rate of patents. Digitalization of archives empowers transformation: Digital technologies such as big data and cloud computing should be utilized to deeply develop and utilize university research archives. Establish an intellectual property transformation database to extract implicit knowledge such as technical parameters, experimental data, and process flows from the archives, providing enterprises with more precise and comprehensive technical profiles. Through the open sharing of archive information, breaking information silos, and facilitating efficient matching between supply and demand parties [3].

3.2. Innovate organizational models and promote organized research

3.2.1. Drawing on international experience, establish a specialized Technology Transfer Organization (TTO) system

Analysis of practices at certain American universities reveals that specialized technology transfer offices (TTOs) serve as central hubs for technology transfer. Universities should form specialized TTO teams consisting of senior technical experts, intellectual property lawyers, marketing experts, and investment and financing advisors. A professional qualification certification system and salary incentive mechanism for technology managers should be established, positioning them as the bridge between universities and the market [9]. These teams should provide comprehensive professional services, including patent layout, value assessment, legal risk control, and business negotiations. In response to major strategic demands and local industry challenges, it is essential to overcome departmental barriers and form interdisciplinary and cross-institutional research teams [2]. Mechanisms such as targeted research initiatives should be implemented to develop systematic technical solutions and enhance the industrial applicability of the results.

3.2.2. Implement differentiated policies and explore specialized transformation paths [9,

The integration model between private universities and enterprises highlights the flexibility of private universities, which should be fully utilized to deepen cooperative efforts with enterprises. Models such as cooperative establishment of research and development centers, order-based talent cultivation, and integrated university-factory initiatives should be established to achieve shared benefits and risks [1]. Using enterprise technical problems as university research topics can ensure a seamless connection between research and production [3, 12]. In university-affiliated hospitals, a deep connection mechanism between clinical doctors and engineers should be established. This encourages doctors to propose clinical needs and engineers to implement the technology, promoting the integration of medical devices, new drug research and development, and

diagnostic and therapeutic technologies. This approach shortens the cycle from clinical needs to product development, addressing critical issues in the medical field.

3.3. Digital empowerment and diversified collaboration, enhancing conversion efficiency

3.3.1. Intelligent technology facilitates multi-dimensional collaborative mechanisms [3].

A multi-dimensional collaborative mechanism has been proposed for enabling the transformation of university research achievements through intelligent technology, providing a practical model for the cultivation of new productive forces [11]. By leveraging big data and artificial intelligence technologies, an intelligent supply-demand matching platform was constructed [1, 2]. Through analyzing the technical demand profiles of enterprises and the characteristics of research achievements of universities, precise push and intelligent matching were achieved, significantly reducing search costs and transaction costs [8]. Utilizing the immutable and traceable features of blockchain technology, the entire process of achievement transformation, including patent ownership, transaction records, and income distribution, was recorded to solve trust issues in multi-party collaboration and promote collaborative cooperation among multiple entities such as universities, enterprises, and financial institutions. By using digital twin technology, the pilot production process of the achievements was simulated in a virtual environment, reducing pilot production costs and risks, and accelerating the process of transforming research achievements from the laboratory to the production line.

3.3.2. Configuration optimization based on the TOE framework

Research based on the TOE (Technology, Organization, Environment) framework indicates that the efficiency of university technology transfer is the result of the concurrent effect of multiple factors, and there is no single optimal path. Strengthen the construction of digital platforms, enhance the maturity of technology and the level of digitalization, and utilize intelligent technologies to empower the entire process of transfer [2, 9]. Optimize the internal governance structure, establish specialized transfer institutions, improve the incentive mechanism, and enhance the organization's transfer ability and willingness [2, 6]. Seek government policy support, create an innovative culture, improve laws and regulations, and build a favorable external ecological environment [4, 5].

3.3.3. Deep Integration of Industry, Education and Research and Ecological Construction

Research at universities in Guangdong Province has shown that the deep integration of industry, academia, and research is the inevitable path to enhancing the conversion rate [12]. Encourage universities to jointly build physical platforms such as joint laboratories, pilot production bases, and industrial parks with enterprises, achieving the aggregation of physical space and the free flow of innovative elements [1]. Through local-university cooperation and local-enterprise cooperation, embed the intellectual resources of universities directly into the industrial chain. Introduce diversified financial capital such as venture capital, industrial funds, and bank credit to form a positive cycle from technology to industry and then to finance [6].

3.4. Reconstruct the evaluation system and guide the value orientation

3.4.1. Improve the evaluation system

Evaluation serves as a guiding tool. A comprehensive evaluation system that focuses on actual results, is multi-dimensional, and has a long-term perspective must be established to encourage researchers to engage in. A research and development outcome evaluation model for university graduate students has been constructed based on network analysis and fuzzy comprehensive evaluation methods, addressing a gap in this field. Therefore, not only the number and level of paper publications should be examined, but also multi-dimensional indicators such as patent conversion rate, horizontal project funds, technical service income, standard formulation, and research and development cases should be included [3]. Both the final economic and social benefits should be considered,

as well as process indicators such as participation degree, contribution degree, and team collaboration ability during the transformation process.

3.4.2. Improve the teacher's professional title evaluation and performance assessment

Evaluation serves as a guiding tool. A comprehensive evaluation system that focuses on actual results, is multi-dimensional, and has a long-term perspective must be established to encourage researchers to engage in [12]. For teachers engaged in different types of work such as basic research, applied research, and technological development, separate evaluation standards and channels should be established. For teachers engaged in applied research, the weight of technological achievements in the evaluation should be significantly increased, and even a "representative work" system can be implemented, where a major transformation result can be equivalent to multiple high-quality papers. A long-term evaluation and incentive mechanism should be established to avoid short-term behavior. It is allowed for transformation results to continuously generate benefits over a long period and be included in the assessment, and to encourage researchers to focus on doing long-term basic transformation work to ensure the sustainability of the transformation process [8].

4. Discussion and Future Prospects

4.1. Current Challenges and Limitations

Although the path is becoming clearer, numerous entrenched challenges persist in the transformation of university research outcomes [7]. Most universities lack professional pilot production bases and adequate funding, resulting in many achievements remaining at the laboratory sample stage and unable to transition from samples to products [3]. There is a significant shortage of comprehensive technical transfer talents skilled in technology, market, law, and finance, and career advancement channels are not well-established, which restricts the professionalization of transformation services. In the eastern coastal regions, due to strong industrial foundations and innovative concepts, transformation is active. However, in the central and western regions, limited by industrial support, funding, and traditional concepts, transformation is more challenging, and the Malthusian effect is evident. Overcoming the focus on paper-based evaluations involves deep interest adjustments. Some universities and educators still exhibit inertia in thinking, making evaluation reform difficult to implement and slow to yield results.

4.2. Future direction in the research

Future research should focus on utilizing advanced technologies such as AI large models and generative artificial intelligence to achieve automated and intelligent decision-making support for the transformation of achievements, enhancing the accuracy and efficiency of matching [10]. With the expansion of international engagement, promoting the internationalization of university achievements, leveraging global rules for competition and cooperation, and establishing a cross-border transformation mechanism will become significant research areas [10]. Establishing a scientific and reasonable long-term evaluation mechanism, balancing short-term assessments with long-term benefits, avoiding short-sightedness, and ensuring the sustainability of transformation efforts are topics worthy of in-depth exploration [7]. Attention should be given to the unique role of new research institutions in the transformation of achievements, examining their collaborative mechanisms with universities and enterprises, and exploring more flexible and efficient transformation models.

5. Conclusion

The transformation of scientific and technological achievements in universities is a complex project that requires coordinated changes across various dimensions, including systems, mechanisms, organizations, technology, and evaluation. This article identifies key aspects to address current transformation challenges.

First, it is essential to reform the ownership of scientific and technological achievements through a dual approach of granting rights and exemption from liability. This approach aims to resolve the issue of researchers' lack of motivation and transform institutional benefits into innovation vitality. Second, innovating the organizational model of scientific research by implementing organized research and establishing specialized Technology Transfer Organizations (TTOs) can address the fragmented, small, and weak capabilities of scientific research achievements, enhancing the ability to solve complex industrial technical problems. Third, strengthening digital empowerment by leveraging technologies such as big data and artificial intelligence can improve the efficiency of matching supply and demand, reshaping the transformation process. Fourth, restructuring the evaluation system by establishing a focus on the effectiveness of transformation can address the issue of prioritizing publications and guide researchers to engage in the main areas of impact.

In the future, universities should actively integrate into the national innovation system. By considering their unique positioning and regional characteristics, they should explore distinctive and differentiated transformation paths. Through the collaborative efforts of government, universities, enterprises, financial institutions, and all sectors of society, an open, efficient, and sustainable transformation ecosystem should be constructed. This will convert the technological potential of universities into a driving force for economic and social development, providing a solid foundation for cultivating new quality productive forces and achieving high-level self-reliance and self-strengthening in science and technology. This requires continuous policy optimization and profound cultural transformation, fostering a belief among university teachers and students that innovation is valuable and transformation is dignified.

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