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Study on Collaborative Path of Transformation of Scientific and Technological Achievements in Universities-Taking Chengdu as an Example

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Abstract: Guided by the innovation-driven development strategy, universities play a crucial role in advancing scientific and technological achievements yet face persistent obstacles in their commercialization. Focusing on four types of universities in Chengdu, this study identifies four distinct pathways of technology commercialization and analyzes their differentiated strategies. A comparative examination further reveals the shared features of cross-level university collaboration, from which a four-dimensional framework is constructed, covering collaborative entities, organizational structures, resource allocation, and institutional mechanisms. The study argues for the establishment of cross-level collaborative platforms to optimize resources, integrate industry–academia–research–application linkages, improve technology transfer efficiency, and foster the high-quality development of regional innovation ecosystems.

1. Introduction

Technological innovation serves as the pivotal force for enhancing national competitiveness and driving high-quality development. As primary sources of scientific advancement, universities play a vital role in translating research outcomes into socioeconomic progress. To this end, China has implemented policies such as the "Action Plan for Promoting Technology Transfer and Commercialization," which clearly define universities' crucial role in socio-economic innovation. Local governments and academic institutions have actively responded by developing tailored measures and pilot programs that align with regional characteristics and institutional strengths, achieving initial success [1]. However, practical challenges persist, particularly the disconnect between investment and commercialization efforts. For instance, university patent conversion rates remain significantly lower than those of enterprises and research institutes. In addition, the academic community has discussed the transformation of scientific and technological achievements in universities from aspects such as scientific research management [2], evaluation system [3], policy guidance [4], technology-driven development [5] and multi-stakeholder cooperation [6]. It focuses on innovation capacity, social benefits and economic contributions, and emphasizes policy support, institutional reform, incentive design and innovation ecosystem construction. To this end, this paper

constructs a multidimensional analytical framework of "subject-mechanism-organization-resource" based on the triple helix model. Through case studies of four universities at different levels in Chengdu, we analyze their transformation paths and differences from a collaborative perspective, identify commonalities, and propose cross-level strategies for collaborative transformation of scientific achievements among higher education institutions.

2. Theoretical framework

Synergy theory, originating from physicist Haken's concept of co-evolution, emphasizes how multiple elements and entities within a system achieve coordinated processes from disorder to order through mutual interactions [7]. Although the theory itself is complex, its multi-stakeholder collaboration philosophy has been widely applied across various fields. For instance, in public administration, collaborative governance integrates resources from governments, markets, social organizations, and citizens to achieve common goals. In the complex system of university technology commercialization, this synergy concept also holds significant guiding value. While universities serve as core entities, their success in technology transfer ultimately depends on collaboration with governments, enterprises, and other stakeholders. The three-dimensional spiral model is the concrete embodiment of the idea of multi-subject interaction and element integration in the theory of synergy [8]. The Triple Helix model, widely applied in healthcare, industrial sectors, and civil-military integration, emphasizes multidimensional collaboration among governments, universities, and enterprises [9], driving the development of complex organizations and innovative mechanisms. This framework has evolved from three-core interactions into a multi-dimensional coupling system encompassing diversified resource allocation, exemplified by the quadruple helix model in innovation education. Building on this collaborative philosophy, this study establishes an "Actor-mechanism-organization-resource" analytical framework to systematically analyze the intricate processes of university technology commercialization. As shown in Figure 1.

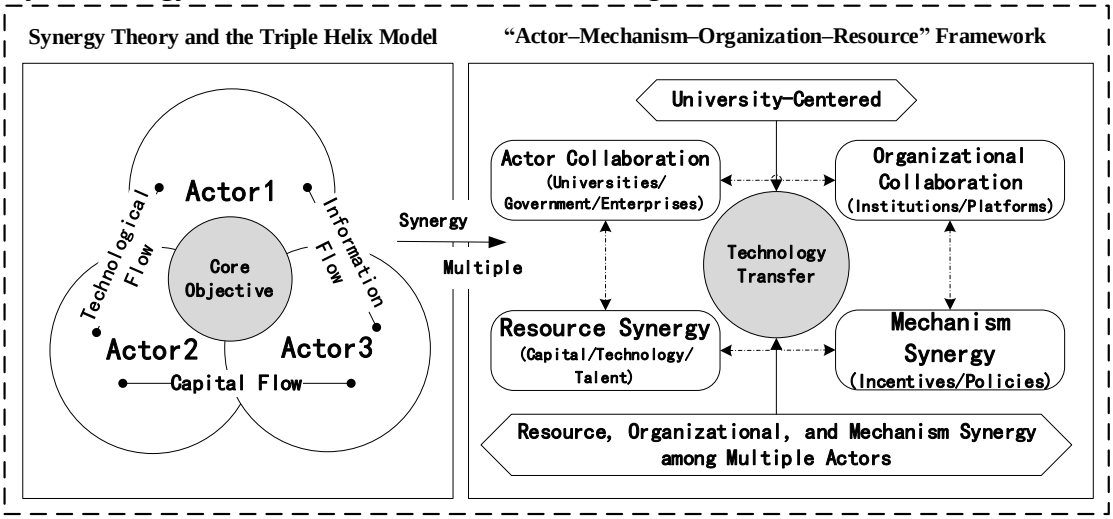

Figure 1: Multidimensional analysis framework

3. Case Analysis

3.1 Methodology

This study employs a multi-case approach, focusing on four universities of different tiers in Chengdu--: University of Electronic Science and Technology of China (A), Southwest Jiaotong

University (B), Chengdu University of Technology (C), and Chengdu Institute of Technology (D). It systematically reveals the diverse pathways and underlying mechanisms of technology commercialization among these institutions. The selected universities exhibit significant differences in disciplinary structures, resource foundations, and transformation practices, making them highly representative and valuable for comparative analysis. Case materials were obtained through policy documents, meeting minutes published on official university websites and WeChat accounts, as well as authoritative media reports, industry analyses, and academic literature.

3.2 Data analysis

Table 1. Transformation pathways in different types of universities

colleges and universities	Path	Dimensional extraction	Core coding
A	Innovation-driven path	Application-oriented school-local-enterprise collaborative cooperation; professional platform support; industry-education integration-oriented resource integration mechanism; clear ownership + incentive-driven	University-enterprise collaboration initiatives, university-local partnerships, overseas talent hubs, government-enterprise-research team meetings, North America/Europe talent recruitment centers... Technology commercialization task forces, research institutes, Shaheyuan Science Park, four-tier technology transfer platforms (incubators), patent centers... High-tech zones, university-technology innovation clusters, investment institutions, research platforms, overseas talent resources... Three-rights reform, tiered approval systems, profit distribution mechanisms, state-owned equity exit mechanisms...
B	Regional integration path	Building a multi-dimensional collaborative ecosystem (universities, local governments, enterprises, research institutions, and associations); deepening organizational collaboration through national platforms and technology parks; precise resource coordination; and institutional collaboration ensuring support through system reforms and incentive mechanisms.	Government-led collaborative platforms (district/municipal/educational level); Rail transit industry chain integration (associations, enterprises, research institutes)... Preparatory work for the State Key Laboratory of Traction Power and National Rail Transit Laboratory; Southwest Jiaotong University Science Park... Open sharing of scientific facilities (State Key Laboratory equipment); Rail transit talent base development... Institutional innovations such as "mixed-ownership reform" and "prioritize rights confirmation before conversion"...
C	Industry closed-loop path	Precision alignment across three dimensions: discipline-industry-region integration; collaborative framework combining specialized organizations and multi-tiered platforms; four-dimensional resource synergy (human resources × capital + technology × platforms); institutional empowerment through high incentives and strong delegation mechanisms.	Leveraging strengths in materials science, geology, and related disciplines, we collaborate with enterprises and government agencies to achieve industrialization (e.g., geological disaster early warning systems). We establish technology transfer offices and centers, develop on-campus and off-campus industry-academia-research bases, and co-build platforms with local governments. The university-enterprise joint innovation fund supports incubation programs, key technology R&D, and practical implementation of academic applications. Clear ownership of commercialization rights is defined, with proceeds distributed after commercialization and high profit-sharing incentives. A dedicated technology transfer fund is also established...
D	Application-driven path	Application-oriented school-local-enterprise collaborative cooperation; professional platform support; industry-education integration-oriented resource integration mechanism; clear ownership + incentive-driven	Collaborating with Yibin and Pidu District to establish research institutes; supporting the Chengdu-Chongqing Economic Circle; establishing technology transfer centers, science parks, and industry-academia-research collaboration offices with standardized process management. Integrating contract administration, achievement matching, and service window functions... Facilitating enterprise incubation platforms; implementing eco-friendly materials and robotics innovations; allocating pilot-scale R&D funding and promotion funds...

As shown in Table 1, this study organizes and encodes the unstructured data, focusing on dimension extraction (non-theoretical construction) according to the coding steps of rooted analysis

to ensure rigorous analysis.

(1) The technology commercialization pathway at University A is characterized by an innovation-driven pathway. In terms of principal collaboration, the university establishes an open ecosystem through "dual engagement with enterprises" and "local-government partnerships," uniting government agencies, businesses, industrial parks, investment institutions, and overseas talent. Organizational collaboration leverages science parks, research institutes, patent centers, and multi-tiered commercialization platforms to create a multi-layered support network that integrates internal and external resources. Resource collaboration aggregates local policies, high-tech zone resources, and international talent to facilitate regional and global dissemination of achievements. Mechanism collaboration relies on reforms in the "three rights" system, tiered approval processes, and profit distribution mechanisms, covering the entire process from achievement ownership confirmation to benefit allocation to incentivize researchers' active commercialization efforts. Overall, University A has developed a systematic collaborative framework through institutional innovation, achieving multi-stakeholder cooperation and efficient technology transfer.

(2) The technology commercialization pathway at University B reflects a regional integration collaborative model. The institution actively establishes a multi-stakeholder network involving government, industry associations, enterprises, and research institutions, creating an open innovation ecosystem that integrates scientific research, industrial applications, policy support, and service delivery. Leveraging core platforms such as the National Key Laboratory, the Rail Transit National Laboratory preparatory project, and the Technology Transfer Research Institute, it has developed a comprehensive organizational framework. By sharing major scientific facilities, establishing rail transit talent training bases, and collaborating with regional industrial hubs, the university optimizes resource allocation for technology transfer and talent development. Institutionally, it implements a "prioritize rights confirmation before commercialization" approach to manage academic achievements, while innovating profit-sharing mechanisms to boost conversion incentives. Overall, University B aligns with regional industrial demands by building diversified collaborative networks and high-level platforms, driving efficient technology commercialization and industrialization through institutional innovation and incentive-driven strategies.

(3) The technology commercialization pathway at University C is defined by an industry closed-loop model. Leveraging its strengths in materials science and geology, the university actively aligns with regional key industries to implement critical technologies such as geological disaster early warning systems and new material applications, fostering deep integration between academic disciplines and local industries. Through its Technology Transfer Office, Technology Transfer Center, and university-local collaboration bases, the institution has established a "professional organization + multi-tier platform" collaborative system to enhance technology incubation and commercialization efficiency. By integrating resources including technology, talent, funding, and platforms, the university has set up a joint innovation fund to create synergistic momentum. Implementing a "commercialization-first, distribution-later" approach with high-profit-sharing mechanisms, it has established special funds to build a policy closed-loop of "strong empowerment + high incentives", effectively motivating researchers' enthusiasm for technology commercialization. Overall, University C capitalizes on its disciplinary strengths while aligning with industry, enterprise, and regional development strategies. Emphasizing industry-education integration, multi-tiered platform support, and resource coordination, the university drives technological innovation to achieve transformation within specialized industrial chains.

(4) The technology commercialization pathway at University D exhibits a strong application orientation. By strengthening university-local-enterprise collaboration, the institution leverages its research institutes and Electronic Information & Intelligent Manufacturing Base co-established with Yibin and Pidu District. Capitalizing on the Chengdu-Chongqing Economic Circle's advantages, it

facilitates precise implementation of cutting-edge technologies into industrial frontiers. Through specialized platforms including technology transfer centers, science parks, and industry-academia-research cooperation offices, the university institutionalizes achievement matching and contract management systems. Emphasizing industry-education integration, it supports enterprise incubation platforms by establishing pilot-scale trials and dedicated promotion funds to enhance incubation efficiency and commercialization speed. The institution continuously advances ownership reforms and incentive mechanism innovations, clarifying researchers' profit-sharing ratios while incorporating commercialization outcomes into faculty evaluations. Overall, University D utilizes professional platforms and industry-education integration mechanisms to align with industrial demands through close government-enterprise partnerships, forming an application-driven commercialization pathway.

4. Research conclusions and recommendations

This study employs case analysis to systematically examine four practical models and collaborative mechanisms for technology commercialization in higher education institutions, proposing a theoretical framework for cross-level collaborative transformation chains. Different types of universities have developed diverse commercialization pathways—innovation-driven, industry-closed-loop, regionally adapted, and application-oriented—tailored to their resource endowments and external environments. Despite varying approaches, these pathways share common collaborative mechanisms that evolve from internal coordination to multi-stakeholder collaboration, establishing a four-dimensional synergy system encompassing entities, organizations, resources, and mechanisms. This system is embedded within a collaborative network involving governments, enterprises, and industrial parks. Crucially, complementary functional positioning and resource integration among universities form a vertically coupled transformation chain, achieving seamless integration from original innovation to practical application, thereby advancing technology commercialization. To enhance this process, it is recommended to strengthen government guidance by establishing cross-level collaborative platforms. Local governments should lead in creating university technology transfer hubs, integrated platforms, and talent development mechanisms to facilitate open sharing of achievements, projects, and expertise within regions. Furthermore, differentiated support should be implemented: high-level research universities should focus on innovation origins and global resource integration, industry-focused institutions and regional universities should concentrate on technology incubation and local adaptation, while application-oriented universities should emphasize commercialization and enterprise empowerment. Through categorized funding and performance evaluations, the government can guide universities to fulfill their respective responsibilities and collaborate effectively. At the same time, we should promote the deep integration of industry, university and application, open up cooperation channels between universities and enterprises, the government, scientific research institutions and other diverse entities, encourage joint research, build platforms and joint funds, promote two-way flow and in-depth cooperation between university researchers and enterprise technicians, and build a collaborative ecology of multiple symbiosis.

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