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Deep Integration of Technological and Industrial Innovation as a Driver of Future Industry Cultivation: A Case Study of University–Industry Collaboration at the University of Electronic Science and Technology of China

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Abstract: Future industries are driven by frontier technologies and are characterized by high disruptiveness, long development cycles, and pronounced uncertainty; competition in these fields is, in essence, a systemic contest among science and technology innovation (STI) ecosystems, and conventional innovation models struggle to meet the resulting requirements. Promoting the deep integration of technological and industrial innovation (hereinafter "TII integration") has therefore become an important pathway for developing new quality productive forces and cultivating future industries. Drawing on integrated innovation system theory, this article clarifies the mechanism through which TII integration operates and proposes an analytical framework for future-industry STI ecosystems built on a three-layer community structure, four key actors, and three mechanisms. The framework is applied to the university–industry collaboration practices of the University of Electronic Science and Technology of China (UESTC) in the electronic information sector. The study identifies four barriers to deep integration—misaligned actor coordination, blockages in the technology transfer chain, imbalanced factor allocation, and insufficient institutional adaptation—and distills a collaborative model resting on organized research, organized technology transfer, and organized university–local government collaboration. The findings suggest that a well-structured STI ecosystem is the foundation of TII integration and that universities—and particularly discipline-distinctive universities—act as innovation sources and transfer hubs within it. The article offers theoretical insights and practical lessons for building future-industry STI ecosystems during the 15th Five-Year Plan period.

Keywords: University–industry collaboration; Future industries; Innovation ecosystem; New quality productive forces; Organized research; Deep integration of technological and industrial innovation

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1. Introduction

Scientific and technological innovation and industrial innovation are deeply intertwined, and their integration is a fundamental pathway for developing new quality productive forces. The Report to the 20th National Congress of the Communist Party of China called for "opening up new fields and new tracks for development and shaping new momentum and new advantages for development" [1]. A subsequent speech at the National Science and Technology Conference, the National Conference on Commendation for Science and Technology Awards, and the Academicians' Conference emphasized solidly advancing that integration so as to help develop new quality productive forces [2], and an article in Qiushi identified the development of new quality productive forces as an intrinsic requirement and an important focus of high-quality development [3]. The Central Committee of the Communist Party of China [4] then set out, at its Third Plenary Session, reform arrangements for building institutional mechanisms supporting comprehensive innovation, explicitly requiring integrated development of technological and industrial innovation. In October 2025, the Fourth Plenary Session approved the Recommendations for the 15th Five-Year Plan for National Economic and Social Development, listing "accelerating high-level self-reliance and self-strengthening in science and technology and leading the development of new quality productive forces" as a major strategic task and proposing forward-looking deployment of future industries in quantum technology, biomanufacturing, hydrogen and nuclear fusion energy, embodied intelligence, and brain–computer interfaces [5]. The 2026 Government Work Report further proposed an industrial innovation program and mechanisms for investment growth and risk sharing in future industries [6]. Cultivating future industries through the deep integration of technological and industrial innovation (TII integration) and thereby securing a commanding position in global industrial competition has thus become a core issue for the 15th Five-Year Plan period.

Because future industries are driven by frontier technologies, their cultivation depends on the combined strength of a science and technology innovation (STI) ecosystem rather than on the breakthrough of any single actor [7]. Scholarship has grown steadily, addressing the strategic layout of future industries [8]; their conceptual connotations and evolutionary mechanisms [7]; the characteristics and focal points of new quality productive forces [9]; the evolution from strategic emerging industries to future industries [10]; community-based ecosystem structures for future industries [11]; disruptive-technology-driven cultivation pathways [12]; and "dual-high synergy" between universities and high-tech zones [13]. Overall, however, the generative role of discipline-distinctive universities within STI ecosystems remains under-examined, the symbiotic logic linking TII integration and STI ecosystems has not been explained systematically, and replicable university practice cases remain scarce.

This article therefore takes the electronic information sector as its object of study and the university–industry collaboration practices of the University of Electronic Science and Technology of China (UESTC) as its sample. It pursues three objectives: to construct an analytical framework for future-industry STI ecosystems comprising a three-layer community structure, four key actors, and three mechanisms; to analyze the barriers confronting TII integration; and to distill a collaborative model of organized research, organized technology transfer, and organized university–local government collaboration, together with systematic optimization pathways. By combining theoretical construction with an in-depth single case, the article contributes an ecosystem-level explanation of how universities function as innovation sources and transfer hubs. It proceeds from literature and theory (Section 2) through the framework (Section 3), methodology (Section 4), barriers (Section 5), case findings (Section 6), and discussion (Section 7) to its conclusions (Section 8).

2. Literature review and theoretical foundation

2.1. Integrated innovation systems and the mechanism of TII integration

Integrated innovation theory holds that innovation is not a unidirectional linear process but the outcome of the synergistic interaction of multiple actors, factors, and mechanisms [8]. Applied to technological and industrial innovation, this implies that the two form an organic whole characterized by bidirectional empowerment and mutual reinforcement. The essence of TII integration lies in precisely matching technological supply with industrial demand, generating a closed loop of "technological breakthrough–scenario validation–industrial landing–iterative innovation." Original innovation and breakthroughs in critical core technologies are the precondition for future industries to emerge, since they can create new tracks and reconfigure existing production paradigms [12], while industrial innovation is the vehicle through which technological innovation realizes value, with market returns feeding back into further investment. Real demand and industrial bottlenecks orient research, avoiding "research for research's sake." Given multiple uncertainties in technological routes, market demand, and business models, only deep integration can achieve bidirectional validation between technology and market.

2.2. Future industries: Conceptual connotations and evolutionary mechanisms

Future industries are driven by frontier and disruptive technologies and typically stand at an early stage of industrialization; they are distinguished by high disruptiveness, long development cycles, and pronounced uncertainty [7]. Their evolution is not a simple extension of existing industrial trajectories: Pan *et al.* [10] argued that the transition from strategic emerging industries to future industries involves new directions, problems, and approaches, and Zhang *et al.* [12] showed that disruptive technologies shape not only the technological content of future industries but also the modes and pathways of their cultivation. The concept is closely connected to new quality productive forces, whose development depends on the deep coupling of technological and industrial innovation [9], while Chen and Zhu [8] argued that the strategic layout of future industries requires a systemic perspective because the relevant technologies involve long maturation cycles and weak short-term market signals. Cultivating future industries is therefore a systemic endeavor, and the appropriate unit of analysis is the ecosystem rather than the individual project.

2.3. Innovation ecosystems and community-based structures

Innovation ecosystem research treats the innovation system as a dynamic and complex system of multiple actors, factors, and mechanisms, and Li *et al.* [11] proposed a community-structure framework oriented toward future industries, organized around frontier knowledge creation, application scenario transformation, and industrial value realization. A central concern of this literature is the discontinuity between knowledge production and industrial application: the "valley of death" in technology commercialization—where promising research fails to attract the validation, funding, and industrial engagement needed for scale-up—is widely identified as the critical bottleneck, and intermediate functions such as proof of concept, pilot-scale testing and maturation, and specialized technology transfer capacity are accordingly regarded as essential connective tissue.

2.4. Research gaps

Three gaps emerge. First, the generative role of discipline-distinctive universities within STI ecosystems has not been examined deeply enough, even though such universities combine concentrated disciplinary strength with strong industry embeddedness. Second, the symbiotic logic linking TII integration to STI ecosystems

has not been explained systematically, so the two concepts are often treated in parallel rather than as mutually constitutive. Third, replicable accounts of university practice remain scarce, which limits empirical examination of the mechanisms of ecosystem construction. This article responds to these gaps by developing a framework that links ecosystem structure to the mechanism of TII integration and applying it to a single, theory-relevant case.

3. Analytical framework: Three-layer community, four actors, three mechanisms

3.1. The bidirectional empowerment mechanism

The framework rests on the premise that TII integration operates through bidirectional empowerment. Technological breakthroughs supply the raw material of future industries, while industrial scenarios supply the validation and returns that sustain further technological development. Neither direction alone suffices: without industrial validation, technological advances remain unanchored, and without sustained technological advance, industrial upgrading loses its source. Building an ecosystem capable of absorbing and distributing uncertainty, rather than reducing uncertainty at any single point, is therefore the appropriate response.

3.2. Three functional communities as the ecological skeleton

The first layer, the frontier knowledge creation community, is anchored by universities, research institutes, and national key laboratories; it works in unexplored domains on basic research aimed at overcoming bottleneck ("chokepoint") technologies, making it the source of innovation. The second layer, the scenario transformation and service community, is anchored by university science parks, technology transfer institutions, and pilot-scale testing and maturation facilities; it performs technology screening, maturation, and validation, serving as the bridge that spans the "valley of death" in technology commercialization. The third layer, the industrial value realization community, is anchored by chain-leading enterprises, small and medium-sized enterprises, and financial institutions, and drives the large-scale application of technology and the formation of industrial clusters. Sequentially connected and linked through cyclical feedback, the three layers form the ecological skeleton [11].

3.3. Four key actors as core driving forces

The four key actors are government, universities and research institutes, enterprises, and financial institutions. Government acts as the "chief architect of the ecosystem," responsible for institutional supply, scenario opening, and long-term orientation; universities and research institutes serve as the "source of innovation"; enterprises are the "principal agents of integration," translating technological possibilities into industrial value; and financial institutions, operating through patient capital, support cultivation over long time horizons. These actors are functionally complementary, and the degree of their coordination directly determines ecosystem efficiency.

3.4. Three mechanisms guaranteeing ecological evolution

The first mechanism is the technology–scenario–value closed loop, through which technological iteration and value feedback rise together in a spiral. The second, resource–capability–risk matching, dynamically allocates factors and shares risk so as to enhance ecosystem resilience. The third, policy–market–ethics coordination, balances innovation against risk through inclusive and prudential regulation and agile policy responses. **Table 1** summarizes the framework along these three dimensions.

Table 1. Elements of the future-industry STI ecosystem framework

Dimension	Components	Function
Three-layer community structure	Frontier knowledge creation; scenario transformation and service; industrial value realization	Ecological skeleton; layers linked through cyclical feedback
Four key actors	Government; universities and research institutes; enterprises; financial institutions	Core driving forces; coordination determines ecosystem efficiency
Three mechanisms	Technology–scenario–value loop; resource–capability–risk matching; policy–market–ethics coordination	Ecosystem evolution; balances iteration, resilience, and risk

4. Methodology: An exploratory single-case study

4.1. Research design

Because the research question concerns how an STI ecosystem is assembled and how TII integration is achieved, an exploratory single-case design was adopted. This design suits a phenomenon that is contemporary, contextually embedded, and inseparable from its setting, and where the objective is theory development rather than statistical generalization; the study is therefore interpretive and framework-building rather than hypothesis-testing.

4.2. Case selection

The case was selected on three grounds. First, theoretical relevance: UESTC is a discipline-distinctive university whose strengths are concentrated in electronic information, a sector identified for the forward-looking deployment of future industries. Second, practical salience: the university has developed documented arrangements spanning organized research, technology transfer, and collaboration with local governments, making the mechanisms of interest observable. Third, sectoral representativeness: electronic information is technology-intensive, iterates rapidly, and involves long value chains. The unit of analysis is the university's collaboration arrangements rather than an individual project.

4.3. Data sources

The study relies on documentary and archival analysis of publicly available materials: national policy documents on future industries and on TII integration; the university's publicly issued action plans and institutional documents, including its action plan for accelerating the transfer and transformation of scientific and technological achievements; publicly available descriptions of its colleges, national key laboratories, science park, and collaborative innovation platforms; and publicly released news reports concerning its collaboration with local governments. No primary interviews, surveys, internal records, or proprietary data were used.

4.4. Analytical approach

Materials were analyzed using qualitative content analysis. The framework developed in Section 3 provided the initial coding structure, and recurring arrangements associated with the three organized modes were coded as candidate mechanisms. Evidence was then examined for convergent patterns: arrangements reported consistently across multiple public sources were treated as established practices, whereas isolated descriptions were treated as indicative only. This supports analytical generalization against the framework rather than statistical inference.

4.5. Methodological limitations

Four limitations should be noted. First, reliance on public documents captures formalized arrangements better than informal practices and cannot recover participants' perceptions or intentions. Second, the absence of primary data precludes measurement of ecosystem performance, so the study explains mechanisms rather than outcomes. Third, a single case constrains generalizability, and the findings should be read as analytically transferable rather than statistically representative. Fourth, public documents may be shaped by institutional communication considerations, so descriptions of practice were interpreted conservatively.

5. Barriers to deep integration of technological and industrial innovation

When benchmarked against leading international standards, TII integration in China's electronic information sector still confronts four barriers: misaligned actor coordination, blockages in the technology transfer chain, imbalanced factor allocation, and insufficient institutional adaptation.

First, actor coordination is misaligned. Research evaluation in universities continues to weight academic output heavily, so research topics are frequently disconnected from industrial demand. The role of enterprises as innovation actors remains underdeveloped, with a preference for short-term technology acquisition over long-term research and development investment, and university–industry collaboration often remains at the level of short-term project-based cooperation that lacks normalized interfaces and arrangements for sharing both benefits and risks.

Second, the technology transfer chain is blocked. Investment in intermediate stages such as proof of concept and pilot-scale testing and maturation is insufficient, and pilot facilities dedicated to electronic information are scarce. Capacity for specialized technology transfer is weak; there is a serious shortage of technology transfer professionals with combined technical, legal, and commercial competence, and service capacity across the full chain of intellectual property assessment, pricing, transaction, and rights protection is inadequate.

Third, factor allocation is imbalanced. Substantial talent gaps persist in fields such as integrated circuits and artificial intelligence; the supply of patient capital is insufficient, making financing difficult for small and medium-sized technology enterprises; and data silos remain severe, with data held by research, industrial, and governmental actors difficult to integrate.

Fourth, institutional adaptation is insufficient. Policy has emphasized research and development subsidies while providing insufficient support for scenario opening and ecosystem cultivation; performance assessment of state-owned capital still gives disproportionate weight to short-term returns; siloed, sector-by-sector regulation is poorly suited to the cross-sectoral, rapidly iterating characteristics of future industries; and error-tolerance and correction mechanisms are not yet well established, which discourages bold experimentation.

6. Findings: The UESTC collaborative model

Drawing on its disciplinary strengths in electronic information, UESTC has taken organized research, organized technology transfer, and organized university–local government collaboration as its three entry points, exploring a collaborative model through which a discipline-distinctive university serves the cultivation of future industries.

6.1. Organized research: Consolidating the technological source

The university implemented a peak-building program for its electronic information disciplinary cluster and led

the establishment of specialized colleges including the Sichuan College of Artificial Intelligence, the Sichuan College of Quantum Technology, and the Sichuan College of Unmanned Aerial Systems. Relying on the National Key Laboratory of Communication Anti-Jamming and the National Key Laboratory of Electronic Thin Films and Integrated Devices, among others, it undertook major national tasks and achieved breakthroughs in critical core technologies in integrated circuits, 6G, and artificial intelligence. Seizing the opportunities presented by the "AI+" initiative, it advanced artificial intelligence-driven scientific research (AI for Science) to strengthen the source supply oriented toward future industries [14].

6.2. Organized technology transfer: Connecting the innovation chain

The university strengthened its national university science park as a vehicle for transfer and cultivated a specialized team of technology transfer professionals. In implementing the reform granting ownership rights to job-related scientific and technological achievements, it issued an Action Plan for Accelerating the Transfer and Transformation of Scientific and Technological Achievements, raised the share of transformation returns allocated to achievement originators to 90 percent, and incorporated transformation performance into academic title review and appraisal. It built a full-chain system running from achievement screening through proof of concept and pilot-scale testing and maturation to industrial landing, and deepened its integration into the Chengdu–Chongqing economic circle through vehicles such as the Tianfu Collaborative Innovation Center.

6.3. Organized university–local government collaboration: Building a regional ecosystem

Together with local governments, the university established platforms for generic technology research and development, bases for achievement transformation, and centers for talent cultivation. The Tianfu Collaborative Innovation Center built an integrated STI service platform covering research and development, transformation, incubation, and talent, and cultivated innovative enterprises in electronic information and artificial intelligence. The Shenzhen Institute for Advanced Study and the Guangdong Electronic Information Engineering Research Institute, rooted in the Guangdong–Hong Kong–Macao Greater Bay Area, served the transformation and upgrading of industrial clusters and supported forward-looking positioning in future industry tracks. The evidence indicates that, by virtue of its disciplinary advantages and industry embeddedness, a discipline-distinctive university can simultaneously perform three functions within an STI ecosystem—as an innovation source, a transfer hub, and an ecosystem organizer—and is therefore an important fulcrum for opening up the "last mile" of TII integration. This model resonates with the logic of "organized research plus organized technology transfer" revealed by research on dual-high synergy [13] and is, on this basis, replicable and generalizable.

7. Discussion

7.1. Theoretical implications

The case supports theorizing TII integration as an ecosystem property rather than as an outcome of individual organizational effort. The three-layer community structure specifies where the relevant functions reside; the four key actors specify who performs them; and the three mechanisms specify how the ecosystem is maintained over time. Read together, the framework renders the symbiotic relationship between TII integration and the STI ecosystem explicit: integration is not something that happens to an ecosystem but is the mode through which the ecosystem functions. This also reframes the university's role, since the university is not merely an upstream supplier of knowledge but an actor participating simultaneously in knowledge creation, scenario transformation,

and value realization, and in some configurations organizing the interfaces among them.

7.2. Dialogue with existing research

The findings are consistent with, and extend, prior work in three respects. First, they corroborate the community-based account of future-industry ecosystems advanced by Li *et al.* [11], while specifying the mechanisms connecting the three communities and the conditions under which their interfaces operate. Second, they support the argument of Li and Wang [7] and Pan *et al.* [10] that future industries require a policy logic oriented toward long time horizons and uncertain returns, and illustrate how that logic is expressed in institutional arrangements at the level of a single university. Third, they extend the account of dual-high synergy offered by Lu [13] by showing that organized research and organized technology transfer are supplemented by a third function, organized university–local government collaboration, which addresses the regional and spatial dimensions of ecosystem building. In contrast to accounts emphasizing disruptive technology as the primary driver [12], the present case suggests that technological disruptiveness and organizational capability are complementary rather than substitutable, since technological potential is realized only through organizational arrangements able to absorb its uncertainty.

7.3. Practical implications

Four areas of practical action follow. First, actor coordination should be strengthened: leading science and technology enterprises should be supported in forming task-oriented innovation consortia that jointly propose demand, invest, share results, and share risk [5], and a model in which industry poses the question, science and technology answers it, and the market grades the answer should be promoted, supported by a routine mechanism for soliciting technological demand from future industries, alongside deeper reform of research evaluation so that industrial contribution and transformation outcomes become core indicators.

Second, the full-chain transformation system should be completed: national proof-of-concept centers and pilot-scale maturation bases should be laid out under government-guided, enterprise-led, university-participating mechanisms [5]; specialized technology transfer institutions should be strengthened, with professional certification and career development for technology transfer professionals; and the reform granting ownership rights to job-related achievements and the separate management of related assets should be deepened [4], accompanied by an improved error-tolerance mechanism.

Third, the supply of innovation factors should be optimized: education, science and technology, and talent development should advance in an integrated manner [5] through customized training models; the mechanisms for investment growth and risk sharing in future industries should be implemented [6], with government investment funds encouraged to act as patient capital channeling long-term capital toward early-stage, small-scale, long-horizon, and hard-technology investments. Instruments such as intellectual property pledge financing and science and technology insurance should be developed; data barriers should be broken down; and data rights confirmation, pricing, and trading rules should be improved so that data assetization can be advanced steadily.

Fourth, the institutional and governance system should be improved: fiscal support should shift from subsidizing research and development and construction toward subsidizing scenarios, ecosystems, and transformation; performance evaluation of state-owned capital in future-industry investment should adopt long-horizon assessment centered on technological breakthroughs, ecosystem cultivation, and industrial traction; and regulatory sandboxes, cross-departmental agile regulation, full-chain intellectual property protection, and deeper participation in global

science and technology governance should be pursued so as to foster an open innovation ecosystem [5].

7.4. Explaining the triple function

The case indicates that a discipline-distinctive university can perform a triple function consisting of an innovation source, a transfer hub, and an ecosystem organizer. These functions rest on two enabling conditions: disciplinary concentration, which allows the university to accumulate and sustain depth in fields of high frontier uncertainty; and industry embeddedness, which supplies the demand signals and validation opportunities its research requires through repeated contact with real industrial problems. Disciplinary concentration without industry embeddedness tends toward supply-driven research; industry embeddedness without disciplinary concentration tends toward service provision rather than knowledge creation. It is their combination that allows the university to operate across all three layers of the ecosystem and to organize the interfaces among them.

8. Conclusion and limitations

8.1. Conclusions

TII integration is the core logic of future-industry cultivation, and a structurally complete ecosystem with well-functioning mechanisms is the fundamental vehicle through which deep integration is achieved. Discipline-distinctive universities, as innovation sources and transfer hubs, play an irreplaceable role in building future-industry STI ecosystems. The experience of UESTC indicates that organized research, organized technology transfer, and organized university–local government collaboration can effectively open up the full chain from basic research to industrial landing. More broadly, cultivating future industries is better approached through the design of ecosystem interfaces than through the accumulation of isolated programs.

8.2. Policy implications

For the 15th Five-Year Plan period, the analysis points toward three priorities: maintaining systemic thinking and long-termism in policy design; building an STI ecosystem in which source innovation, scenario transformation, and industrial landing are coordinated across the full chain; and, on that basis, advancing TII integration to a higher level while accelerating the development of new quality productive forces and achieving high-level self-reliance and self-strengthening in science and technology.

8.3. Limitations and future research

Because this article is based on a single university case analyzed through publicly available documents, the generality of its conclusions requires further examination through multi-case comparison and empirical testing. Future research could proceed in two directions: the quantitative evaluation of STI ecosystem performance, and analysis of how ecosystem configurations adapt to differences in regional and sectoral context. Comparative designs involving universities with different disciplinary profiles, or regions at different stages of industrial development, would be particularly valuable for establishing the boundary conditions of the model described here.

Disclosure statement

The authors declare no conflict of interest.

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