International Journal of Business and Management Invention (IJBMI)
ISSN (Online): 2319 – 8028, ISSN (Print): 2319 – 801X
www.ijbmi.org || Volume 14 Issue 6 || June, 2025 || PP—193-207

Redesigning University–Industry Collaboration: A Theoretical Framework for Innovation-Oriented Partnerships

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ABSTRACT:*In an era where regional economic competitiveness hinges on innovation, effective models of university–industry collaboration are crucial. This paper develops a theoretical framework for aligning academic research and development (R&D) outputs with industrial technology demand in regional economies. Grounded in an extensive literature review and informed by insights from a university–industrial zone partnership in China, the study proposes an innovative two-way matching model that facilitates dynamic, bidirectional knowledge flow between academia and industry. A virtual platform is conceptualized to intelligently match university technology supply with firm-level demand, coupled with feedback mechanisms that inform academic research directions. This is complemented by an organizational collaboration structure combining physical co-innovation centers and digital networks, a risk assessment and management system for technology transfer, and joint talent development initiatives. Results suggest that such an integrated model can significantly improve technology commercialization efficiency and regional innovation capacity by bridging knowledge asymmetries and fostering co-created solutions. The discussion situates the model in the context of existing theories – including the Triple Helix paradigm and open innovation – highlighting its contributions to the international literature on university–industry collaboration. The paper concludes with implications for policymakers and university leaders on implementing sustainable academia–industry partnership models to drive regional economic development.*

KEY WORD:*University–industry collaboration, Regional innovation, Technology transfer, Knowledge matching, Triple Helix, Demand-driven R&D*

Date of Submission: 15-06-2025 Date of acceptance: 30-06-2025

I. INTRODUCTION

Regional economies increasingly depend on the efficient conversion of scientific knowledge into innovation and industrial growth. Universities, as generators of cutting-edge research, have become pivotal players in innovation ecosystems by producing new technologies, patents, and startup companies. For example, in the United States, academic technology transfer spurred by the Bayh-Dole Act has yielded over 140,000 patents and 18,000 startups from 1996 to 2020, contributing nearly $2 trillion in industrial output. However, realizing the full economic potential of university research requires effective collaboration models that link academic R&D output with the technological needs of industry. In many regions, a persistent gap exists between the knowledge “supply” from universities and the “demand” from local industries, often due to information asymmetries, misaligned incentives, and institutional barriers. Bridging this gap is crucial for fostering innovation-driven growth and has become a strategic priority in both advanced and emerging economies.

Conventional modes of industry–academia interaction, such as linear knowledge transfer or ad-hoc consulting, often fail to ensure a strategic alignment between what universities produce and what industries require. As a result, many scientific breakthroughs remain underutilized while companies struggle to find solutions for technical challenges. This misalignment not only impedes technology commercialization but also represents a lost opportunity for regional development. Successful innovation clusters suggest that closer alignment is possible: for instance, Stanford University’s close ties with local entrepreneurs helped seed Silicon Valley’s high-tech ecosystem, illustrating how academic know-how can fuel regional industries. Similarly, Cambridge’s science parks in the UK leveraged university research excellence to attract R&D-intensive firms, creating a seamless link between new knowledge and industry application. These examples underscore the potential of well-designed collaboration models in generating mutual benefits: universities gain pathways for real-world impact, and industries gain access to cutting-edge innovations, skilled talent, and problem-solving partnerships.

Research aim: The aim of this study is to design a theoretical model of university–industry collaboration that overcomes traditional disjunctions by actively matching academic R&D outputs with industrial technology needs in a regional context. We focus on how universities and firms can co-develop a sustainable collaboration platform and processes that ensure a continuous two-way exchange: not only the "push" of university inventions to industry, but also the "pull" of industry's demand shaping academic research agendas. By emphasizing this bidirectional alignment, the model seeks to enhance innovation efficiency and regional economic relevance of academic research. The context motivating this study is the collaboration between Harbin Institute of Technology, Weihai and the Jiangyin National High-Tech Zone in China, a recent initiative aiming to achieve "seamless connection" between university achievements and local industrial needs. While insights are drawn from that case, this paper generalizes the findings to propose a conceptual framework applicable to university–industry partnerships globally.

Significance: This work contributes to the theoretical discourse by integrating perspectives from innovation theory, knowledge transfer, and regional development into a holistic collaboration model. Unlike case-specific analyses, our approach emphasizes generalizable design principles and mechanisms that can inform policy and practice in various contexts. The study engages with the Triple Helix theory of university–industry–government relations and the literature on innovation systems to position its contributions. It also responds to calls in the literature for more demand-driven innovation strategies that marry the "curiosity-driven" nature of academic research with the practical needs of industry and society. The remainder of the paper is structured as follows. The next section reviews relevant literature on university–industry collaboration models, technology transfer mechanisms, and alignment strategies. We then outline the methodology, followed by the results: a detailed exposition of the proposed collaboration model and its components. A discussion section situates our findings in the context of existing theories and highlights implications and limitations. The final section concludes with a summary of contributions and recommendations for future research and practice.

II. LITERATURE REVIEW

2.1 Evolution of University–Industry Collaboration Models

Formal collaboration between universities and industry has evolved from a linear model of innovation to more complex networked models over the past decades. In the linear model (often attributed to Vannevar Bush's post-WWII framework), knowledge flows in one direction: universities perform basic research, which is then handed off to industry for development and commercialization, with government providing funding and an enabling environment. This model has limitations in today's fast-paced, knowledge-intensive economy because it neglects feedback loops and interactions. In contrast, contemporary innovation theory emphasizes non-linear, interactive models of knowledge production and use.

One influential framework is the Triple Helix model proposed by Etzkowitz and Leydesdorff, which conceptualizes innovation as an outcome of dynamic interactions among universities, industry, and government. In the Triple Helix, each actor overlaps roles to some extent (for example, universities engage in economic development, firms in knowledge creation, governments in venture funding), creating a spiral of intertwined relationships that drive innovation. This model highlights that innovation is not produced in isolated silos but through networks and partnerships; a healthy innovation ecosystem requires universities, industries, and governments to co-evolve and co-create. Empirical studies have shown that regions embracing Triple Helix principles often exhibit stronger innovation performance. For instance, the model has been consciously adopted in regional development strategies in Sweden and the Netherlands to foster closer links between knowledge institutions and industries. The Triple Helix's emphasis on institutional collaboration has informed numerous policy initiatives worldwide.

National experiences illustrate diverse collaboration mechanisms under the Triple Helix umbrella. The United States, for example, transformed its university–industry linkages through the Bayh-Dole Act of 1980, which allowed universities to claim ownership of inventions from federally funded research. This policy change incentivized universities to establish Technology Transfer Offices (TTOs) and actively pursue patenting and licensing of academic inventions. The result was a surge in academic entrepreneurship and closer ties to industry: by providing a clear path for intellectual property commercialization, Bayh-Dole spurred universities to seek industry partners for licensing or startups. Many credit this framework for turning U.S. universities into engines of innovation and regional growth. In Germany, rather than focusing on patent ownership, a notable model is the Fraunhofer Society, a network of applied research institutes dedicated to bridging university science and industry needs. Each Fraunhofer Institute conducts mission-oriented R&D in partnership with companies, especially small and medium enterprises, to translate academic findings into commercial technologies. Backed by public co-funding, Fraunhofer institutes work closely with university researchers (often co-located or affiliated with universities) and serve as intermediaries that reduce the risk for companies adopting new technologies. This model has been widely credited with supporting Germany's competitive strength in manufacturing and engineering by facilitating incremental innovation and knowledge diffusion across industry.

Japan's approach adds another variation: the creation of university–industry–government co-innovation centers. Japanese policy in recent decades encouraged the formation of collaborative research centers, often on campus or in special zones, where university scientists and industry engineers work side by side on applied R&D projects. This "joint creation" (kyōsō) concept emphasizes solving practical problems together and sharing resources on a common platform. Such centers often involve local or national government support and target strategic industries (e.g. electronics, automotive, materials). The idea is that physical proximity and organizational integration foster trust and tacit knowledge exchange, leading to faster innovation cycles. As Kondo (2009) notes, universities can contribute to industrial innovation not only by transferring existing knowledge, but also through joint knowledge creation with firms and by spinning off new enterprises. These international examples illustrate that while the principle of collaboration is universal, the models can differ – ranging from legal/technology-transfer mechanisms (US), to intermediary institutes (Germany), to integrated co-research centers (Japan), among others. A common thread is the move toward systematic, institutionalized partnerships rather than relying solely on informal ties or the linear hand-off of research results.

2.2 Aligning Academic R&D Supply with Industrial Demand

A recurring challenge identified in the literature is the misalignment between academic research output and industry needs, often described as a supply–demand mismatch in the market for knowledge. Universities, driven by academic priorities, may focus on research that has little immediate applicability to local industries, while firms may have pressing technical problems that academia is not addressing. This gap is exacerbated by information asymmetry: firms may not be aware of relevant research breakthroughs in their region, and universities may lack insight into the specific innovation needs or market trends in industry. As a result, potentially valuable technologies can remain on the shelf, and companies might under-invest in R&D or source solutions externally even when local expertise exists.

Strategies to better align research "supply" with industry "demand" feature prominently in recent policy and scholarly discussions. One approach is demand-driven research agenda setting, where industry stakeholders or government articulate priority areas that guide academic research funding. For example, the European Union's Smart Specialisation concept urges regions to identify niche areas of competitive advantage and align public R&D investments with those domains, thereby marrying university expertise with regional industry strategies. A key question is designing mechanisms that respect academic freedom and curiosity-driven inquiry while ensuring relevance to societal and economic needs. Workshop findings from EU regions highlight the need for a "common language" between universities and regional authorities to achieve this alignment, as well as incentives that encourage researchers to pursue use-inspired projects without stifling fundamental discovery.

Another line of research and practice focuses on knowledge intermediaries and platforms to connect the two sides of innovation. Traditional intermediaries include technology transfer offices, industry liaison offices, and research parks which physically bring companies and labs together. Today, digital platforms and innovation marketplaces are emerging as tools to facilitate matches between problems and solutions on a larger scale. According to an OECD report (2019), online expert communities, open innovation calls, and crowdsourcing competitions are increasingly used to bridge knowledge supply and demand. Platforms like InnoCentive or IdeaConnection, for instance, allow firms to broadcast specific R&D challenges and solicit solutions from researchers worldwide, effectively crowdsourcing innovation. These digital matchmaking systems can algorithmically connect firms with relevant academic expertise or technologies, overcoming geographical and informational barriers. They exemplify the application of data-driven methods to knowledge transfer: by analyzing research outputs (patents, publications) and industry needs, such platforms can recommend potential collaborations that might not arise through traditional networks. While still a developing trend, early evidence suggests that virtual matchmaking can spur new collaborations and augment the innovation capacity of both parties by exposing them to a wider pool of opportunities.

Crucially, effective alignment is not a one-time matchmaking exercise but a continuous, bidirectional process. Literature on interactive innovation highlights the importance of feedback loops: when firms adopt a new technology from a university, their experiences (successes, failures, new needs) should feed back to the researchers, potentially guiding further research or refinement of the technology. This resonates with Donald Stokes' concept of Pasteur's Quadrant, where research is inspired by both scientific curiosity and practical use, leading to breakthroughs like Pasteur's microbiology work that were fundamental science yet directly useful for industry and society. By creating channels for industry feedback – via joint advisory boards, regular forums, or data-sharing – universities can avoid "ivory tower" projects and focus on innovations with clear pathways to impact. Similarly, firms that engage with universities in early-stage research can better anticipate technological changes and shape research trajectories to align with future market needs. A culture of co-creation emerges, blurring the line between producer and user of knowledge.

2.3 Benefits and Challenges of Collaborative Innovation

The theoretical and empirical literature generally agrees that robust university–industry collaboration yields substantial benefits for all stakeholders and for regional development. For universities, engagement with industry can provide additional research funding, real-world validation of theories, and enhanced teaching through industry case studies and internships for students. Students involved in industry-partnered projects gain practical skills and often improved employment prospects, addressing the perennial issue of graduate employability. Firms, on the other hand, benefit from access to new knowledge and technical expertise that can drive innovation in products and processes. Such partnerships can shorten the time between discovery and commercial application by leveraging academic research as an external R&D arm for companies. At the regional level, numerous studies link university–industry collaboration to economic development outcomes such as higher productivity, the formation of high-tech clusters, and job creation. A recent analysis noted that startups originating from university inventions often stay in the vicinity of the university, boosting local employment and innovation ecosystems. Indeed, over two-thirds of life-sciences startups from U.S. universities were found to remain within 60 miles of the university, illustrating how academic entrepreneurship contributes to regional clusters. Strong academic–industry ties can also attract external investment to a region, as venture capitalists and large firms are drawn to locales where knowledge flows freely and talent is abundant.

Despite these benefits, realizing them is not straightforward. The literature identifies several challenges and risk factors inherent in university–industry collaboration. One major challenge is the cultural and incentive misalignment between academia and industry. Universities value open dissemination of knowledge (e.g. publishing papers), long-term research agendas, and often pursue knowledge for its own sake, whereas companies prioritize intellectual property protection, short-to-medium term product development, and research with clear commercial value. These differing values can lead to conflicts over publication rights, timelines, and goals in collaborative projects. Establishing clear agreements and mutual understanding is therefore critical. Joint governance structures such as steering committees can help align objectives and manage conflicts by giving both sides a say in project decisions.

Another challenge is managing the risks associated with moving innovations from lab to market. Technological risk is inherent: a promising laboratory result may not scale or perform under real-world conditions. Tools like NASA's Technology Readiness Levels (TRL) provide a gauge of maturity, from concept (TRL 1) to proven system (TRL 9), and are often used to assess how far a technology is from practical implementation. A low TRL indicates high risk and possibly the need for further R&D or prototype development. Market risk is another concern: even if the technology works, there may be insufficient demand or a competitor's solution might dominate, leading to commercial failure. Joseph Schumpeter long ago pointed out the uncertainty in innovation – the fact that market success is never guaranteed even with technical superiority. Engaging industry early can mitigate market risk by ensuring there is a committed user or customer guiding the research. However, economic shifts and changing consumer preferences remain variables outside the control of the research partnership.

Legal and administrative risks also exist. Intellectual property (IP) rights need to be negotiated: without clear IP agreements, disputes may arise over patents or licensing revenue, souring university–industry relations. Likewise, unclear agreements on resource commitments can lead to project delays or cost overruns if one party underperforms. Best practices from successful collaborations include signing detailed research contracts, establishing joint IP ownership or revenue-sharing models, and even creating separate legal entities (such as joint venture labs or spin-off companies) to manage collaborative projects. In the U.S. and Europe, many universities have standard contract templates and dedicated staff (technology managers or legal counsel) to streamline collaboration agreements.

Policymakers play a role in reducing collaboration barriers. Governments can offer incentives and support structures: for example, matching grants for university–industry projects, R&D tax credits that reward industry for partnering with academia, or "innovation vouchers" that SMEs can use to buy expertise from universities. In China, recent policies have introduced the idea of a "no-fault" tolerance mechanism for researchers engaged in technology transfer, to encourage risk-taking by assuring that failures (if due diligence is observed) will not unduly harm their careers. Similarly, initiatives to streamline the administrative process (e.g. simplifying approval for professors to consult or start companies) help create a more collaboration-friendly environment.

Finally, human capital is recognized as both a prerequisite and outcome of effective university–industry collaboration. The concept of "collaborative talent cultivation" has gained traction, wherein universities and companies jointly train students or researchers to operate at the interface of academia and industry. In practice, this can take the form of industrial PhD programs (where doctoral candidates spend time in a company setting working on applied research) or co-op and internship programs for undergraduates and master's students. Europe has seen a rise in industrial doctorate schemes that give candidates dual exposure, resulting in graduates who are adept at both scholarly research and practical problem-solving. Evidence suggests that such programs yield graduates who are more innovative and better match the skill needs of industry. They effectively become knowledge brokers themselves, fluent in both academic and industry languages. From the industry perspective, collaborating in talent development ensures a pipeline of skilled employees who are already familiar with the company's technology and culture. This addresses skill gaps and reduces training costs for firms, while boosting employment outcomes for students – a win–win for regional workforce development.

In summary, the literature paints a comprehensive picture: robust university–industry collaboration models are multi-faceted, combining supportive policy frameworks, intermediary institutions or platforms, alignment of research agendas with industry needs, risk-sharing mechanisms, and joint human capital development. These elements inform the theoretical model we develop in this paper. The next section outlines our methodology for building and validating this model.

III. RESEARCH METHODOLOGY

This research follows a qualitative, design-oriented methodology to develop and refine a theoretical collaboration model, supported by a case study approach. The study can be characterized as conceptual research complemented by exploratory case analysis. We adopted several steps to ensure both rigor in theoretical development and relevance to real-world contexts:

Literature-driven framework building: We began with an extensive literature review (as presented above) covering theories and global practices of university–industry collaboration. This provided the foundational concepts and variables (e.g. collaboration structures, matching mechanisms, risk factors, etc.) that need to be considered in a comprehensive model. By synthesizing insights from prior studies and models (Triple Helix, innovation platforms, technology transfer processes, etc.), we constructed an initial conceptual framework for how an ideal university–industry collaboration system might function to align R&D supply with industrial demand. Key theoretical constructs identified include bidirectional knowledge flows, intermediary platform roles, co-creation processes, and enabling policy/talent factors.

Case study for contextual insight: To ground the theory in practice, we examined an ongoing collaboration between a research-focused university and a high-tech industrial zone in China – specifically, Harbin Institute of Technology, Weihai and the Jiangyin High-Tech Zone. This case was selected as an illustrative example because it explicitly aims to integrate academic outputs with local industry needs, making it a rich source of practical insights on matching mechanisms and institutional innovations. We gathered information from the project's internal reports, public documents, and field interviews (as available) involving stakeholders from both the university and the industrial zone. The data collection emphasized understanding the strategies they employed (e.g. creation of a joint innovation base, establishment of an online matchmaking platform, etc.), the challenges faced, and the solutions devised. While the case context is in China, the lessons drawn were of a generally applicable nature (e.g. how to set up a technology needs database, how to manage cross-organizational teams, etc.).

Model design and iteration: Using an approach akin to design science research, we integrated the findings from literature and the case to formulate a refined collaboration model. In practice, this meant mapping the processes observed in the case onto the theoretical framework and identifying gaps or enhancements. For example, literature emphasized the importance of feedback loops and risk management, which led us to probe whether the case implemented feedback mechanisms or formal risk assessments; indeed, the case study revealed a planned feedback module in their matching platform and the adoption of a Technology Readiness Level scale for evaluating projects, which were incorporated into our model design. The model was iteratively refined by cycling between theory and case evidence to ensure that it is both conceptually sound and practically viable. We also consulted with domain experts (university research managers and industry R&D liaisons) in an informal capacity to validate whether the proposed mechanisms resonated with their experience.

Analytical validation: Rather than a quantitative validation (which was beyond the scope of this conceptual study), we performed an analytical assessment of the model. This involved checking the model against known success factors in literature and against alternative scenarios. For instance, we conducted a thought experiment of how our model would function in a different context (such as a smaller university or a different industry) to test its robustness and generality. Additionally, we compared the model's components with those documented in other successful cases globally (Silicon Valley's university–VC–industry interplay, Germany's Fraunhofer system, etc.) to ensure our design aligns with observed best practices. This comparative analysis builds credibility that the model's elements have analogues in real-world successful collaborations.

Structure and reporting: The final step was structuring the results in line with academic conventions. We organized the presentation of the model into logical components (platform design, collaboration mechanisms, risk management, talent co-development), each substantiated by both theoretical rationale and, where appropriate, reference to the case example. While the case study informs the model, we deliberately minimize context-specific details in the results, in order to focus on broadly applicable principles. The case is used illustratively (e.g., to demonstrate how a particular feature of the model can be implemented), consistent with the goal of theoretical development rather than empirical case study reporting. All supporting information and data are cited from relevant sources to maintain academic rigor.

The methodological approach, being primarily qualitative and design-focused, has inherent limitations. The model has not yet been tested quantitatively or implemented fully in multiple settings, which is an opportunity for future research. Nonetheless, the combination of exhaustive literature grounding and the infusion of real-world insight provides confidence that the proposed framework is both innovative and anchored in existing knowledge. By situating model development in both theory and practice, we aim to contribute a well-rounded perspective to the scholarship on university–industry collaboration.

IV. RESEARCH METHODOLOGY

We present a novel framework for university–industry collaboration aimed at achieving strategic alignment between academic R&D output and industrial technology demand. The framework is composed of four interlocking components: (1) a two-way matching platform that connects university research supply with industry needs, (2) an integrated collaboration mechanism combining physical and virtual interfaces (the "base + platform" model), (3) a risk assessment and management system embedded in the collaboration process, and (4) a coordinated talent development scheme to sustain long-term innovation synergy. Figure 1 provides a conceptual overview of the core of this framework – the two-way knowledge flow facilitated by the matching platform. Each component is detailed in the subsections below.

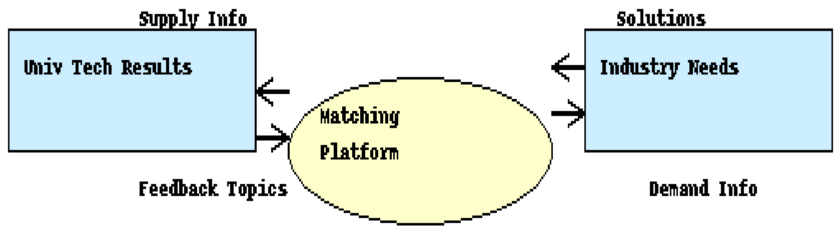

Figure 1:Schematic of the two-way matching model connecting university R&D outputs (supply) and industry technology needs (demand)

In figure 1,the central matching platform enables supply-push of academic innovations to industry (rightward arrow) and demand-pull of industry problem statements to academia (leftward arrow). Feedback loops ensure that information on technology adoption and evolving needs is continually communicated back to the university, allowing research directions to adjust in response to industry input (bottom arrow). Simultaneously, tailored solutions and new technologies are transferred to firms to meet identified needs (top arrow), creating a continuous cycle of co-innovation.

4.1 Two-Way Matching Platform for Knowledge Alignment

At the heart of the proposed model is a two-way matching platform that serves as the interface between university knowledge creators and industry knowledge users. This platform is essentially an information system and process that performs three key functions: collection of supply and demand information, intelligent matching of relevant pairs, and feedback to both parties for continuous improvement.

Supply and demand repositories: On the supply side, the university (or multiple universities in a region) establishes a comprehensive research output repository. This is more than a publication list; it is a curated database of technologies, patents, prototypes, and expertises available for transfer or collaboration. Each entry is catalogued with meta-data such as technical area, maturity level (e.g. TRL stage), and potential application domains. On the demand side, local industries contribute to a technology needs repository, where firms (especially those in the region's key sectors) regularly submit their unmet technical challenges, product improvement targets, and innovation goals. In practice, a regional development agency or industry association can coordinate collecting these needs to ensure completeness and clarity. The platform thus begins by making explicit the often-tacit knowledge on both sides: what universities have to offer and what firms are looking for. This tackles the information asymmetry head-on by creating a shared space of knowledge supply and demand.

Intelligent matching process: The platform employs a combination of automated algorithms and expert evaluation to pair relevant university outputs with industry needs. Initially, a coarse matching can be done using keyword matching and classification: for example, matching a company's need for "high-strength lightweight alloy for automotive frames" with any materials science technologies in the university repository tagged under alloys or composites. However, recognizing that textual matching is insufficient, the model incorporates a refined matching step. This involves forming a joint review team of technical experts from both academia and industry (e.g., professors, engineers) to assess the preliminary matches. They evaluate the technical feasibility and applicability of each potential match, scoring or ranking them based on how well a research result could solve the industry problem. In parallel, advanced data-driven techniques are suggested: for instance, using machine learning to analyze research abstracts and patent filings in combination with the text of industry problem statements. Such analysis can reveal non-obvious connections (for example, a technique developed for aerospace might be repurposed in biomedical devices). Recommender system algorithms or knowledge graph approaches can assist in uncovering these hidden matches by looking at semantic similarities or past successful linkages. The outcome of this phase is a priority list of matched pairs: a set of university technologies that appear promising for each industry need, or conversely, a set of industry needs that each available technology could address, ranked by potential impact and fit.

Facilitating collaboration and feedback: For the top-ranked matches, the platform's role transitions into an active facilitator. It notifies the relevant company and research team of the match and often arranges an initial meeting or technology showcase. This can be done through "brokered" introduction events – essentially, curated matchmaking sessions or tech fairs where university inventors present their work to companies in need. If interest is confirmed, the platform (likely administered by a dedicated team or office) assists in formalizing collaboration – whether it be a licensing deal, a co-development R&D project, or a pilot application at the company. Crucially, the platform does not cease function at deal initiation; it establishes a feedback loop mechanism. As projects progress, the platform collects data on outcomes: which matches led to successful technology adoption, which failed and why. If a match did not succeed, the reasons (e.g. "technology not mature enough for scale-up" or "requirements changed") are fed back into the system. This feedback is provided both to the university side – informing researchers of gaps to address or adjustments needed – and to the matching algorithm itself, enabling machine learning components to improve their future recommendations. Over time, this learning loop makes the matching smarter and more context-aware. The feedback to universities is especially important to ensure demand-driven innovation: researchers get insight into real industry pain points and can refine their research questions or even initiate new lines of applied research that target those needs. Likewise, companies learn more about emerging technologies on the horizon and can adjust their innovation strategies proactively. In effect, the platform creates a living, evolving marketplace of ideas, where supply and demand of knowledge continuously adjust to each other in a dynamic equilibrium.

Collectively, this two-way matching model is expected to yield several outcomes. First, it greatly increases information symmetry between academia and industry – each side has near-real-time visibility into what the other is doing or seeking. The days of a firm being unaware of a local lab's breakthrough, or a lab not knowing the region's industrial priorities, are minimized. Second, it improves matching efficiency: by using intelligent sorting and expert vetting, valuable connections can be identified much faster than by chance or informal networking. Third, it likely raises the success rate of collaborations: because compatibility (in terms of technical feasibility and need relevance) is assessed up front, the ensuing projects have a higher likelihood of delivering results, and obvious misalignments are filtered out early. Lastly, the feedback loop spurs continuous innovation: companies' evolving needs drive academia to explore new solutions, while new academic discoveries create possibilities for novel products, establishing a virtuous cycle of joint advancement. Over time, this can lead to what one might call a coevolution of university and industry – each adapts and progresses in tandem, guided by the signals from the other, which is a hallmark of a resilient regional innovation system.

4.2 "Base + Platform" Collaborative Mechanism

Implementing the above matching model requires supportive organizational mechanisms. We propose a "Base + Platform" dual mechanism, where physical co-location ("base") and virtual integration ("platform") reinforce each other. The platform aspect has been described (the digital/organizational interface for matching). The base refers to a physical collaborative space or entity that anchors the partnership. This could take the form of a jointly established Innovation Center or Research Base located either on the university campus, in the industrial park, or both (in which case a dual-base arrangement exists). For example, in our reference case, a "Future Technology Innovation Base" was set up in the high-tech zone, providing on-site offices and labs for university teams working on local industry projects. Simultaneously, liaison offices were maintained back at the university to coordinate with the main campus. This physical presence in the industrial community serves multiple purposes:

It acts as a technology embassy of the university within the industrial cluster, signalling commitment and facilitating daily interaction. University researchers stationed at the base can work closely with company engineers, use local facilities, and better understand the manufacturing or business context of their work. Conversely, companies gain direct access to academic experts who are just next door, making collaboration more fluid and trustful.

The base provides a venue for regular engagements like workshops, networking events, and demonstration days. The model envisions periodic matchmaking events (as noted earlier) being held physically at the base, complementing the online platform. Face-to-face discussions in these events often lead to deeper understanding and new ideas that pure digital matching might miss. For instance, an industry problem pitched in person might trigger a researcher to propose an unexpected solution on the spot, or vice versa, leading to a new collaboration idea.

A joint base also facilitates co-creation projects through what we term the "joint problem-solving mechanism." In this mechanism, once a match is made, the university and company may set up a joint project team that operates at the base to develop the solution. We encourage an approach whereby the industry partner essentially co-defines the research question ("setting the exam question") and the university partner works on solving it. This is analogous to industry acting as a client with a problem, and the university as a R&D contractor, but with the spirit of partnership rather than a mere transaction. The base provides the needed infrastructure (lab space, pilot production facilities, etc.) for the team to work together. Such co-location and joint task forces can significantly accelerate problem-solving, as communication is constant and iterative adjustments can be made in real time. A concrete example arose in the case study: over the past year, the base hosted more than a dozen joint R&D projects between the university and local enterprises, ranging from new materials testing to AI algorithm integration in manufacturing equipment, all of which benefited from having team members collocated and focused.

Besides the base and platform themselves, the collaboration mechanism includes institutional innovations in governance and incentives. A recurring issue in partnerships is ensuring fair rewards and sustained commitment from all sides. The model proposes a joint governance structure for major collaboration initiatives: for instance, a steering committee including university representatives, company executives, and local government officials (if public funding is involved) to oversee the collaboration portfolio. This ensures transparency and that no party's interests dominate unfairly. In terms of incentives, implementing a benefit-sharing system is vital. The model suggests that intellectual property resulting from joint projects can be co-owned or licensed in a way that both university and industry have a stake in success – e.g., companies might get preferential licensing rights while the university (and researchers) receive royalty streams or equity in spin-off ventures. Some collaborations include provisions for researchers to have a financial stake or for companies to sponsor endowed research positions, aligning incentives towards a common goal. By structuring projects so that "everyone wins" if the project succeeds, motivation remains high. Additionally, the model recommends the use of technology brokers or liaison officers ("technology managers") who act as bridges between cultures. These are professionals skilled in both technical and business aspects, tasked with scouting for collaboration opportunities, managing contracts, and ensuring smooth communication. Their presence can mitigate misunderstandings and keep projects on track, essentially greasing the wheels of the partnership.

The combined "base + platform" mechanism thus creates an ecosystem that is simultaneously high-tech and high-touch: high-tech through the digital platform leveraging data and AI for matching, and high-touch through the personal relationships and trust built at the physical base. One without the other may be less effective – a purely online matching system might lack the depth of engagement to see projects through, while a base without an intelligent system might become insular or miss opportunities beyond immediate contacts. Together, they embody a modern collaborative model fitting the needs of a digital yet interpersonal innovation age.

4.3 Risk Assessment and Management System

Recognizing that innovation collaborations carry significant uncertainties, our framework embeds a risk assessment and management system to identify, evaluate, and mitigate risks throughout the process of technology transfer and co-development. Rather than treating risk management as an afterthought, the model integrates it from the initial matching stage through project execution and commercialization.

Risk identification: Early in the matching process, once a potential university–industry project is formulated, a structured risk analysis is conducted. We classify risks into categories commonly cited in literature: technical risk (will the technology actually work as intended in practical application?), market risk (will the solution have a viable market or meet economic expectations?), organizational risk (can the partners work together effectively and are adequate resources committed?), and IP/legal risk (are there any intellectual property issues or regulatory hurdles?). Each identified project goes through a checklist in these categories. For example, if a project involves scaling a lab prototype, the technical risk might include unknowns in scaling; if it involves a new product, market risk assessment considers competition and customer adoption rates.

Technology readiness evaluation: As noted, the concept of Technology Readiness Levels (TRLs) is utilized as a common language between university and industry to gauge how far a technology is from implementation. For each proposed collaboration, the university researchers estimate the current TRL of the technology. If it's low (basic research stage), all parties acknowledge that significant development is needed, and risk is inherently higher. If it's mid-level (validated in lab or prototype), then specific steps to reach higher TRLs (like pilot tests) are planned. Many companies find this framework useful for decision-making – for instance, a firm might only engage in projects beyond a certain TRL threshold, or if earlier, then only with government subsidy due to risk.

Risk mitigation strategies: For each risk category, the collaboration agreement includes mitigation measures. To handle technical risk, the project plan might include staged milestones with "go/no-go" decision points, proof-of-concept studies, or involvement of additional experts to troubleshoot. To manage market risk, the partnership might involve the company's marketing team from early on or even involve an end-user perspective (e.g., a customer focus group) to ensure the solution being developed has a market fit. Flexibility is key – the model advocates a "pivot allowance" in projects, meaning if initial assumptions prove invalid, the project can pivot to a new approach rather than be terminated outright. This is analogous to the lean startup methodology but applied within a research partnership. Organizational risk is mitigated by careful project management and oversight (as mentioned in the governance structure) – regular meetings, clear delineation of tasks, and committed budget/resources from both sides. If one partner fails to deliver, an escalation process is in place via the steering committee to address issues. IP risks are managed proactively by having clear contracts on ownership of outcomes, licensing terms decided in advance (e.g., company gets commercial rights, university can use for research and publications), and confidentiality agreements to protect sensitive information.

Risk monitoring and "Fail-Fast" mechanisms: During project execution, the risk management system continuously monitors key risk indicators. For example, if a technical milestone is missed or results are below expectation, that's flagged. The model supports a fail-fast approach in the sense that if a project is clearly not meeting technical criteria or market assumptions change drastically, it is better to halt or redirect the effort sooner rather than later, to save time and resources. Importantly, to encourage open communication about problems, the culture of the collaboration – supported by policy in some contexts – should not penalize failure that comes from genuine exploration (the "safe fail" or "no-fault" mechanism earlier noted from Chinese policy). Instead, learning from the failure is fed back into the platform knowledge base. For instance, if a particular technology repeatedly fails at scaling, the system records this as a lesson that perhaps more fundamental research is needed or that particular approach is not viable in current conditions. This institutional memory helps prevent repeating mistakes.

Risk sharing and support: Finally, effective risk management often involves sharing the risk. The model envisions that in high-risk, high-reward projects (like very novel technologies), a third party such as government might chip in via a grant or an innovation fund to absorb some risk (e.g., covering costs if project fails to meet targets). Some regions have created technology transfer venture funds or proof-of-concept funding precisely for this reason – our framework incorporates those as complementary tools. If available, the matching platform could tag projects that qualify for such funding and help the partners apply. By lowering the financial risk, partners are more willing to engage in ambitious collaborations that could yield breakthrough innovations.

In summary, the risk management system in our model is proactive and pervasive: it acknowledges uncertainty, uses formal techniques like TRL assessment to communicate it, implements safeguards and flexibility, and fosters an environment where identifying risks early is rewarded (not punished). This reduces the likelihood of catastrophic failures and increases trust among partners, as companies feel their concerns are addressed and researchers see that potential failure is understood and accommodated. A robust risk management approach ultimately contributes to a higher conversion rate of research to successful innovation, as noted by studies that link supportive risk policies to improved technology commercialization outcomes.

4.4 Talent Co-development and Knowledge Exchange

A critical enabler of sustainable university–industry collaboration is the development of human capital that can operate at the interface of academia and industry. Our model incorporates a comprehensive talent co-development program to ensure a continuous supply of skilled, innovation-savvy personnel for both university labs and industry R&D departments. This addresses the often-cited skills gap and fosters a culture of collaboration from the ground up.

Key initiatives in this research include:

Joint internship and co-op programs: Undergraduate and graduate students from the university are placed as interns or co-op students in partner companies within the region. Ideally, these placements are not generic but aligned with the collaboration projects or the industry sectors of focus. For example, if one pillar industry is advanced manufacturing, mechanical engineering and computer science students might intern at local automation firms, working on projects related to their field of study. The case we studied saw over a hundred students take part in such structured internships in the high-tech zone's companies, with many students subsequently choosing to join those companies full-time after graduation. The benefits are mutual: students gain practical skills and insight into industry needs, while companies inject fresh knowledge and often identify future hires. Moreover, returning interns often become "ambassadors" of industry needs when they go back to academia, sometimes even helping their professors understand real-world constraints better.

Industry-focused graduate programs: The model encourages the establishment of collaborative graduate degrees or "industrial PhDs." In such programs, a PhD student might have dual supervisors – one academic, one from industry – and spend part of their research time at the company. Their dissertation work typically tackles a problem of practical significance to the company, while contributing to scientific knowledge. Countries like Denmark, the UK, and China have launched variants of these industrial PhD schemes, yielding promising results in producing doctorates who are both academically proficient and industry-ready. We propose formalizing similar programs in the regional context: for instance, a cohort of "Innovation Fellows" whose projects are all co-sponsored by local industry. This not only produces solutions for the companies but also trains the next generation of R&D managers who are bilingual in the languages of academia and business. Evaluations of industrial doctorate initiatives show they enhance the employability of PhDs and increase the likelihood of technology transfer from university to industry during the course of research, not just after graduation.

Curriculum co-design and lifelong learning: On a broader level, universities in the region might adapt curricula in relevant departments in consultation with industry advisory boards. This ensures that the skills being taught keep pace with technological trends and industry requirements (for example, adding courses on regulatory standards if the local biotech industry needs that, or on certain software tools prevalent in local firms). Companies can contribute by sending experts as adjunct professors or guest lecturers, as highlighted by the University of Minnesota's collaboration programs. Conversely, academics can offer specialized training to upskill current industry employees (short courses or certificate programs), promoting lifelong learning. This reciprocal educational exchange cements the partnership and directly strengthens the regional workforce's capabilities.

Talent retention initiatives: A known challenge in many regions is retaining top talent (especially if bigger cities or global companies lure them away). University–industry collaboration can help address this by creating local opportunities that are intellectually and financially rewarding. Our model includes efforts like jointly organized job fairs, startup incubation support (for students or researchers who spin off companies, perhaps with industry and university as stakeholders), and highlighting success stories of those who built careers in the region's innovation ecosystem. The underlying idea is to create a sense of community and momentum – where students see a future in the local industries and companies see value in investing in local universities, completing the virtuous cycle. The earlier example of interns returning to work full-time is a direct mechanism for talent retention. Additionally, entrepreneurs emerging from the university are encouraged and supported, potentially contributing to new industry growth and further employment locally.

By embedding these talent-focused measures, the collaboration model extends beyond individual projects – it builds the human foundation for an enduring partnership. Over time, as more graduates with collaborative experience enter the workforce, the cultural gap between academia and industry narrows. A pool of "boundary spanners" (people comfortable in both settings) develops, making future collaborations smoother. Indeed, some of those individuals eventually take leadership roles: a former joint PhD might become R&D head in a company or a professor who deeply values applied work, thereby institutionalizing the partnership ethos. Empirical studies on regional innovation have found that such human capital linkages are often the strongest predictor of sustained university–industry interaction. After all, organizations collaborate through people; thus, nurturing people who can collaborate effectively is the most sustainable strategy of all.

4.5 Summary of the Integrated Model

Bringing together the components described: the two-way matching platform (with its data-driven, feedback-rich processes), the base + platform mechanism (blending physical and digital collaboration spaces), the risk management framework, and the talent co-development system, we arrive at an integrated model of university–industry collaboration for regional innovation. The model's novelty lies in how these pieces reinforce one another. For instance, the matching platform identifies opportunities and channels participants into joint projects at the base; those projects are guided by risk management and likely involve jointly trained students, whose presence facilitates communication; successful outcomes from projects (and even failures) are fed back into the platform and also inform educational adjustments, and so forth. It creates an adaptive, self-improving collaboration ecosystem.

Notably, this model is scalable and generalizable. While inspired by a specific case, its elements can be adapted. A smaller region might start with a lighter-weight digital platform and fewer focus sectors. A larger innovation hub could network multiple universities and dozens of firms on the platform, with several physical bases for different industries. The core principles – information sharing, co-location, co-management, risk-sharing, and co-learning – remain applicable. As a policy recommendation emerging from this, regions should evaluate their current university–industry interface and consider building such integrated structures to boost their innovation performance. Initial evidence from the pilot case is encouraging: within two years of implementing parts of this model, the collaboration yielded numerous joint projects, new IP, and talent attraction to the region, aligning with international experiences that emphasize collaborative innovation as key to economic resilience.

V. DISCUSSION

In framing the above results within the context of existing international literature, we find that our proposed model both aligns with and extends current theoretical paradigms of university–industry collaboration. Here, we discuss the theoretical implications and novel contributions of the model, compare it with established frameworks, and consider its practical significance and limitations.

Advancing the Triple Helix discourse: The model resonates strongly with the Triple Helix theory by operationalizing the concept of university–industry–government synergy in a concrete, process-oriented manner. Triple Helix posits the importance of overlap and interaction among the three spheres; our model provides a blueprint for how, in practice, universities and industries (with government often in a supporting role) can form an interactive knowledge and innovation network. In particular, the creation of an intermediary platform and joint base can be seen as an institutional innovation that provides the "collision space" for the helices to entwine. Prior studies have noted that successful Triple Helix implementations often require new organizational formats (e.g., research consortia, incubators, technology parks) that facilitate cross-sector collaboration. Our contribution is detailing an integrated format that links multiple functions – from matchmaking to risk management to co-training – rather than addressing these in isolation. This moves beyond the traditional linear view of technology transfer (a criticism sometimes levelled at simple Triple Helix applications) to a more systemic, networked Triple Helix approach. In effect, the model can be interpreted as a practical playbook for Triple Helix dynamics in a regional setting, with the platform and base embodying the helix interactions.

Comparison with open innovation models: The principles of open innovation, as articulated by Chesbrough and others, encourage firms to use external ideas and pathways to advance their technology, and likewise for institutions to allow ideas to flow outward. Our model strongly subscribes to open innovation logic: by establishing channels for knowledge to flow in both directions across the university boundary, it breaks down the ivory tower and the closed R&D lab mentality. Companies in the model are essentially practicing open innovation by sourcing solutions from academia, while universities practice it by engaging with external stakeholders to guide research. Notably, the model's emphasis on a global search via digital platforms (e.g., algorithmic matching, crowdsourcing elements) aligns with what many corporations do in open innovation – tapping into a worldwide knowledge base. Where our model extends open innovation theory is in formalizing the role of a regional platform as opposed to purely global or firm-centric approaches. We argue that having a structured regional intermediary can complement firms' own open innovation efforts by focusing on local complementarities and trust, which purely online global platforms might lack. This addresses a gap in the open innovation literature, which often looks at firms in isolation: we provide a regional ecosystem perspective, wherein multiple firms and universities collectively partake in open innovation through shared infrastructure.

Implications for Regional Innovation Systems (RIS): In the context of Regional Innovation Systems theory, universities are key "knowledge nodes" whose effectiveness often determines a region's innovation capacity. Our model suggests a way to greatly enhance the connectivity of that node with industry nodes, thereby strengthening the system's overall network density and knowledge flow. By aligning with Smart Specialisation ideas (aligning research strengths with industrial priorities) and embedding feedback loops, the model directly addresses a common weakness in RIS – the disconnect between R&D activities and local economic needs. The practical implication is that regions seeking to implement RIS or smart specialization strategies should consider investing in such match-making and co-location infrastructures as part of their innovation policy toolkit. The model can be seen as providing the missing middle between broad policy intent and firm-level collaboration: a meso-level institutional arrangement that translates strategy into ongoing collaborative actions.

Risk and failure tolerance – a cultural shift: One theoretical conversation in innovation management revolves around how much tolerance for failure and experimentation an innovation system should have (Schumpeterian creative destruction vs. more controlled innovation). Our model leans towards advocating a culture that is tolerant of smart failure – evidenced by the "fail-fast" and feedback emphasis, and drawing from concepts like the "no blame" innovation policies in some countries. Embedding risk management as we propose inherently acknowledges that some projects will not succeed, but learning from them is invaluable. This approach is in line with modern agile and lean methodologies in product development, but bringing it into university–industry collaborations is relatively novel. Traditional university projects (e.g., grant-funded research) may not always explicitly incorporate such adaptive management; industry projects might, but then collaboration adds complexity. Our framework encourages both sides to adopt an experimental mindset in their joint endeavors. The benefit theoretically is a higher knowledge gain per attempt and a faster cycle of iteration. The potential downside is if not managed well, it could lead to project volatility or loss of confidence if too many failures occur. That's why the risk-sharing element (including possibly government support) is key, as it cushions the impact of failure. The model thus contributes to the discourse on how institutional structures can be designed to reduce the stigma or cost of failure in collaborative innovation – something much needed for truly breakthrough advances, which often come after several failed trials.

Human capital as the locus of innovation: Our heavy focus on talent development echoes and reinforces the growing literature that innovation is ultimately a human-centered process. There is a notion of the "innovative milieu" in regional studies – an environment where skilled, creative people interact freely, leading to innovation. By formalizing joint training and mobility, our model provides a practical mechanism to cultivate such a milieu. It also supports the concept of "absorptive capacity" (Cohen & Levinthal), traditionally referring to a firm's ability to absorb external knowledge. Here, through joint training, both firms and universities raise their absorptive capacities: firms gain employees who can understand academic knowledge, and universities gain researchers/students who appreciate industrial contexts. This two-way increase in absorptive capacity could be a significant theoretical contribution, as most research discusses it mainly on the firm side. Our model suggests that universities, too, need absorptive capacity (to absorb industry feedback and needs), and that joint talent is the vehicle for that. This complements findings in some recent studies that universities with more industry-experienced faculty or joint appointments tend to have higher rates of patenting and collaboration.

Generality vs. specificity – one size fits all? While we tout the generalizability of the model, it's important to acknowledge that one size seldom fits all in university–industry relations. Different disciplines and industries have varying collaboration patterns (e.g., IT vs. biotech vs. social sciences), and regions differ in their institutional thickness (some have multiple universities and a vibrant private sector, others have one dominant player). Our model is perhaps most directly applicable to regions with at least a moderate level of R&D activity on both sides, and where a facilitating organization (like a regional innovation agency or a willing university) can take the lead in establishing the platform. In less developed regions, the concept might need to be scaled down or simplified (e.g., focus first on a couple of sectors, or rely on a national platform if local resources are thin). In very advanced clusters (like Silicon Valley), many elements of the model happen organically through market mechanisms and social networks, so the added value of a formal platform might be less, although even advanced clusters use formal structures like Stanford's Industrial Affiliates Program or incubators. Thus, in discussion with existing literature, we recognize, consistent with studies like those by Gunasekara and others on university roles in different regions, that context matters and the model should be seen as a template to be adapted. No single blueprint will work everywhere, but the components we identified are akin to modules that policy entrepreneurs can configure as needed. This is in line with the literature that calls for flexible, tailored approaches to fostering university–industry links rather than a rigid policy transfer.

Practical impact and examples: Empirical support for the model's efficacy is emerging. Our case study indicated improvements in collaboration outcomes after implementing similar measures (e.g., over a dozen joint projects and dozens of IP filings in the first two years). Other regions show analogous successes: for instance, the Xi'an Jiaotong University and Jiangyin collaboration – mentioned earlier – used a dual-base approach and achieved 19 joint projects and 69 new patents in a short time. This mirrors the effect observed in North America where university-affiliated research parks and consortia accelerated innovation in sectors like semiconductors (SEMATECH consortium) or advanced materials. The consistency of positive outcomes across such varied contexts provides some triangulated validation for our model's components. Still, more systematic evaluation is needed. We suggest future research could quantitatively compare regions that have adopted similar integrated collaboration mechanisms vs. those that have not, on metrics like rate of technology commercialization, new product introductions, and regional GDP growth in high-tech sectors.

Limitations: In discussing our model's limitations, one point to consider is the resource intensity. Setting up a platform and base, maintaining databases, employing brokers, etc., requires investment. Wealthier regions or those with strong government backing might be able to afford this, but poorer regions or small universities might struggle. We assume that the benefits (more effective innovation) outweigh the costs, but that equation may not hold if the scale of collaboration is small. There is a risk of creating bureaucracy – the platform could become too administratively heavy or slow if not managed well, potentially deterring researchers or firms (who might prefer informal, quick interactions). Therefore, implementation must strive for user-friendliness and agility. Another limitation is ensuring broad participation. If only a few companies or one department of the university engage, the network effects won't materialize. It requires a cultural shift at institutions that may be used to siloed operations. Achieving that is non-trivial and often underplayed in theoretical models. We flagged joint incentives and leadership commitment as ways to encourage participation, but there could still be holdouts or friction.

In conclusion of this discussion, our model stands as a comprehensive, theoretically informed proposal that aligns with many threads of international research on collaborative innovation: it is grounded in Triple Helix and open innovation thinking, responds to calls for better alignment (smart specialization), and incorporates best practices in risk and talent management. Its contribution is knitting these together into an actionable framework. If implemented thoughtfully, it has the potential to significantly enhance the innovation capacity of regions by unlocking the complementary strengths of universities and industries. We view it not as a static solution, but as a starting template that will evolve with further experimentation and feedback – fittingly, just as the model itself incorporates feedback loops, our theoretical construct should be refined by practical trial and scholarly evaluation in the coming years.

VI. CONCLUSION

This study set out to address the challenge of aligning university research endeavors with industrial technological needs in order tocatalyze regional economic development. In doing so, we have proposed a theoretically grounded yet practically oriented model of university–industry collaboration. The model's key innovation is the design of a two-way matching and co-innovation system that facilitates continuous, dynamic interaction between academia and industry – transforming what is often a sporadic or fragmented relationship into a structured partnership geared towards common goals.

Summary of contributions: The article contributes to academic literature in several ways. First, it synthesizes diverse strands of theory – from the Triple Helix to open innovation to regional innovation systems – into a unified framework. We demonstrated how an intermediary platform and joint collaboration base can operationalize these theories, effectively creating a living laboratory of Triple Helix interactions. Second, by emphasizing bidirectional knowledge flows and feedback loops, the model moves beyond the traditional linear paradigms of technology transfer. It provides a mechanism for demand articulation from industry and knowledge push from universities to meet in the middle, thus addressing the perennial supply–demand mismatch in innovation networks. Third, the incorporation of risk management and talent co-development extends the discussion of collaboration from just transactions or projects to the resilience and longevity of the partnership. These elements ensure that the collaboration is not only effective in generating innovations, but also sustainable and adaptable to changing circumstances (e.g., technological shifts or new market conditions). We believe this holistic approach fills a gap in the literature, which often examines pieces of the puzzle in isolation (such as tech transfer offices, or science parks, or curriculum linkages) – our model integrates them into an ecosystem perspective.

Policy and managerial implications: For policymakers at national or regional levels, our findings highlight the importance of creating enabling environments for structured university–industry engagement. This might involve funding the development of collaboration platforms or centers, incentivizing both firms and universities to participate (through grants, awards, or public recognition), and enacting supportive policies (for instance, flexible IP rules or entrepreneurship leaves for faculty). The case evidence and international examples suggest that such investments can yield significant returns in terms of innovation output and economic growth. University administrators and industry R&D managers can also draw lessons: proactively seeking partnerships and investing time in building joint mechanisms can pay off in improved research relevance and faster innovation cycles. Universities might consider reorganizing some of their knowledge transfer functions to align with the two-way platform idea – for example, maintaining an up-to-date portfolio of research assets tailored for industry viewing, or assigning liaisons to key industry clusters. Companies, especially those in high-tech sectors, may benefit from engaging with universities not just episodically but as part of their core innovation strategy, treating the academic sector as a strategic partner in R&D. Our model provides a template for how to structure that engagement systematically rather than leaving it to chance encounters.

Limitations and future research: We acknowledge that our model, while comprehensive, has been formulated based on qualitative analysis and a specific contextual experience. One limitation is the need for empirical validation across different settings. Future research could implement pilot versions of this model in multiple regions or industries and use comparative metrics to assess its impact (e.g., number of collaborations, commercialization success rate, financial outcomes). Quantitative studies could also examine which components of the model contribute most to success – is the platform more critical, or the physical base, or do they require each other? Another area for research is the human aspect: longitudinal studies on students or researchers who participate in joint training programs could shed light on how their careers develop and how that feeds back into the innovation ecosystem. Additionally, while we have considered government mainly as an enabler, deeper analysis of the government's role (the third helix) in our model would be worthwhile – for instance, how local governments can coordinate and mediate between university and industry interests, or how policy can institutionalize some of the feedback processes (perhaps by tying public research funding to demonstrated industry engagement, as some countries do).

It would also be interesting to explore the application of this model in non-technological domains or social innovation contexts, where "industry" might be healthcare providers or government agencies and "technology" could be processes or services. The fundamental idea of matching knowledge supply with societal demand is broadly relevant, but the mechanics might differ.

Concluding thoughts: As regions worldwide strive to become more innovative and resilient, leveraging the full potential of universities in concert with industry is not just desirable but imperative. Our work affirms that this can be achieved not by expecting spontaneous interactions, but by consciously designing collaboration infrastructures that encourage and streamline partnerships. The theoretical insights and practical structures outlined in this paper aim to guide scholars and practitioners alike in reimagining the university–industry nexus – from one of parallel pursuits to one of intertwined endeavors. In the words of an old adage, "Innovation takes a village." By building strong bridges between the ivory tower and the industrial trenches, we ensure that this village – the regional innovation community – thrives through collective effort and shared success. We hope that the model presented here provides a useful stepping stone towards that integrated future, and we invite further dialog and experimentation to refine the art and science of university–industry collaboration for the benefit of regions and societies at large.

ACKNOWLEDGEMENT

Sponsored by Project of Humanities and Social Sciences Research Planning Fund by the Ministry of Education "Research on the Capability Characteristics and Growth Patterns of High-End Talents in 'Double First-Class' Universities" (No.: 22YJA880085); Project of Higher Education Science Research Planning by the Chinese Association of Higher Education "Research on the Cultivation Strategy of Young Scientific and Technological Talents for Organized Scientific Research" (No.: 24RC0302); Project commissioned by Harbin Institute of Technology, Weihai Asset Management Co., Ltd "Research on the Adaptation Strategies between Harbin Institute of Technology, Weihai's Advantageous and Distinctive Technological Achievements and Jiangyin High-Tech Zone's Pillar Industries" (No.: 20241227).

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