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MANAGING INTELLECTUAL PROPERTY IN COLLABORATIVE RESEARCH: THE ROLE OF GOVERNMENT SUPPORT AND DYNAMIC INTERACTIONS

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Abstract. This study explores key factors influencing intellectual property (IP) disputes in Industry-Academia-Research Collaboration (IARC) using a process management approach. Through system dynamics analysis, IARC is categorized into two subsystems: Government Support and Enterprise-Institute Collaboration. The findings reveal that financial and policy support, alongside robust IP protection, shape the external framework for mitigating disputes. Major dispute drivers include ambiguous contracts, technical disagreements, profit distribution conflicts, and unauthorized use of research outcomes. These factors interact dynamically, with government intervention playing a pivotal role in resolution. The study underscores the necessity of clear agreements, effective communication, and trust-building to prevent disputes. Insights from this research guide policymakers, industries, and academia in optimizing IP management strategies to enhance collaboration and address global challenges.

1. Introduction

Industry-Academia-Research Collaboration (IARC) is a key driver of innovation, fostering knowledge exchange and economic growth. China has actively promoted IARC, facilitating the integration of enterprises, universities, and research institutions. However, intellectual property (IP) disputes frequently arise due to contractual ambiguities, profit distribution conflicts, and technical disagreements, threatening collaboration stability. IP disputes not only impact innovation efficiency but also introduce legal and reputational risks.

Recent statistics indicate a 30% rise in IARC-related IP disputes over five years, with 75% involving patent infringement and 20% linked to copyright and trademarks. Despite these challenges, existing studies primarily focus on the legal dimensions of IP disputes, overlooking their systemic and dynamic nature. This research bridges the gap by applying system dynamics to model IP disputes in IARC, identifying causal relationships, and assessing their impact on innovation efficiency.

The study aims to: (1) develop a system dynamics model of IP disputes in IARC, (2) analyze their effects on collaboration, and (3) identify key influencing factors such as communication breakdowns and policy interventions. By providing a theoretical foundation and policy recommendations, this study seeks to optimize IARC frameworks and enhance sustainable cooperation.

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2. Literature review and theoretical basis

2.1. **Literature Review.** Industry-Academia-Research Collaboration (IARC) plays a crucial role in technological innovation and knowledge transfer, yet intellectual property (IP) disputes remain a persistent challenge. Research on these disputes can be broadly categorized into three areas: (1) Pre-dispute strategic interactions, which analyze cooperation structures and incentive mechanisms to mitigate conflicts before they arise [20]. (2) Post-dispute legal resolutions, which focus on legal frameworks and enforcement strategies for addressing IP conflicts [21]. (3) Risk factors in IP cooperation, examining factors such as profit-sharing conflicts, contract ambiguities, and opportunistic behaviors.

Cooperative game theory has been widely used to model strategic interactions among governments, enterprises, and academic institutions in IARC. It highlights key risks such as patent infringement, asymmetric information, and opportunistic behavior, emphasizing the role of incentive alignment in mitigating disputes [30]. Meanwhile, system dynamics and process management theories offer alternative perspectives by analyzing the feedback loops and structural inefficiencies that lead to disputes [27]. Despite extensive research on legal and regulatory aspects, many studies overlook the systemic and process-driven causes of IP disputes. This gap necessitates an integrated approach to understanding the causal relationships between dispute factors and overall innovation efficiency [21, 23].

2.2. **Theoretical basis.**

(i) System Dynamics. System dynamics provides a framework for modeling the behavior of complex systems over time, making it useful for analyzing dynamic interactions in IARC [9]. By constructing causal feedback loops, system dynamics helps identify critical variables that influence the emergence and resolution of IP disputes. Previous studies have focused on how changes in IP protection policies impact innovation activities or how technological advancements affect infringement risks [7]. However, its application to IP disputes remains underexplored. Some research suggests that stronger IP enforcement can create unintended negative feedback loops, increasing transaction costs and reducing collaborative incentives [31].

(ii) Process Management Theory. Process management theory emphasizes optimizing organizational processes to improve efficiency and mitigate risks [17]. In IARC, key processes include contract negotiation, research collaboration, and IP commercialization. Disputes often stem from undefined ownership rights, uneven benefit distribution, and ineffective enforcement mechanisms [32]. Using system dynamics modeling, this study maps out feedback loops within these processes to understand how disputes evolve over time. By identifying critical intervention points, process management strategies can be refined to enhance dispute prevention and resolution [18].

3. Analysis of the causes of intellectual property disputes in IARC and theoretical framework construction

Intellectual property (IP) disputes in Industry-Academia-Research Collaboration (IARC) arise due to structural inefficiencies in collaboration processes. Using

process management theory, this study categorizes disputes into four key phases: negotiation and planning, research and development, implementation and transformation, and termination [28]. Issues such as unclear agreements, unauthorized use of technology, and profit distribution conflicts persist across these phases, impacting trust and collaboration efficiency.

3.1. **Analysis of the Causes of Intellectual Property Disputes Based on Process Management.** (1)Negotiation and Planning Stage

At the initiation of collaboration, contractual ambiguities often lead to disputes regarding IP ownership, usage rights, and profit-sharing mechanisms [6]. Without clear agreements, conflicts arise over post-collaboration commercialization rights and revenue allocation, undermining cooperation.

(2) Research and Development Stage

Unauthorized use of proprietary knowledge is a significant risk during R&D. Patent infringement, trade secret leaks, and insufficient confidentiality measures exacerbate disputes [5]. Divergent expectations on research contributions further strain partnerships, leading to disagreements over rightful ownership.

(3) Implementation and Transformation Stage

During technology transfer and commercialization, disputes emerge over unfair benefit distribution and unauthorized use of innovations [14]. When commercialization strategies are misaligned or improperly defined, conflicts escalate, damaging future cooperation.

(4) Termination and Dissolution Stage

Post-collaboration disputes primarily involve IP ownership conflicts and failure to fulfill contractual obligations. Discrepancies in final agreements may lead to prolonged legal battles, impacting stakeholder relationships [12, 25].

3.2. **Analysis of Intellectual Property Disputes Based on System Dynamics.**

3.2.1. *Determination of System Boundaries.* A system dynamics approach defines IP disputes in IARC within three key subsystems:

Stakeholder interactions (enterprises, universities, research institutes, government agencies) [16, 28]. Institutional mechanisms (legal frameworks, contracts, dispute resolution) [24]. Market and financial factors (R&D investments, economic incentives, policy support) [33].

Each subsystem interacts dynamically, shaping the frequency and severity of disputes. Contract deficiencies, enforcement gaps, and market-driven incentives directly impact dispute occurrence.

3.2.2. *Analysis of Forces.* IP disputes in IARC are driven by interest conflicts, technological competition, and increasing IP protection awareness, while challenges such as asymmetric information, profit distribution conflicts, and weak institutional enforcement act as barriers [19].

Driving forces include:Interest-driven conflicts, where enterprises seek competitive advantages while universities prioritize research funding. Technology competition, as both parties strive for innovation leadership, leading to conflicts over

ownership and commercialization rights. Growing IP awareness, which encourages stronger protection efforts but also intensifies ownership disputes.

Resistance factors include: Asymmetric information, leading to misunderstandings about IP ownership and value. Profit distribution conflicts, where disagreements arise over revenue allocation from collaborative innovations [2]. Weak institutional enforcement, with unclear regulations exacerbating disputes and complicating resolution efforts [26].

By understanding these forces, system dynamics modeling provides insights into optimizing IP governance, reducing disputes, and enhancing collaboration efficiency in IARC.

3.2.3. *Construction of the System Dynamics Theoretical Framework for IARC Intellectual Property Disputes Based on Process Management.* Based on process management theory, this study develops a system dynamics framework to examine how government-supported enterprises and academic institutions interact in IARC. The model identifies key dispute triggers, process inefficiencies, and resolution pathways to optimize collaboration strategies.

Figure 1 presents a system dynamics model depicting six core stages:

1. Negotiation and Planning – Contract drafting and agreement formation define IP rights and revenue sharing.
2. Research and Development – Stakeholders contribute resources, but weak IP protection raises infringement risks.
3. Implementation and Transformation – Commercialization efforts depend on licensing agreements and regulatory compliance.
4. Ongoing Cooperation – Effective communication and trust-building sustain collaboration.
5. Termination – Project completion requires clear ownership and dispute resolution mechanisms.
6. Dispute Feedback Loops – Profit-sharing conflicts, legal disputes, and policy interventions influence future cooperation outcomes [32].

This framework highlights the critical role of clear agreements, dispute resolution efficiency, and trust management in mitigating IP conflicts. Government policies shape dispute dynamics by influencing regulatory frameworks, funding allocation, and enforcement efficiency [18].

Through system modeling, this study identifies leverage points where interventions — such as standardized contracts, arbitration mechanisms, and improved legal frameworks — can enhance collaboration stability and prevent long-term IP conflicts.

4. System dynamics model construction

Intellectual property (IP) disputes pose a persistent challenge in industry-university-research collaboration (IARC), often undermining innovation and cooperation. This section examines the causal pathways leading to such disputes, identifying key contributing factors, feedback loops, and external influences. By constructing a system dynamics model, this study illustrates how government support, institutional mechanisms, and collaboration dynamics interact to either exacerbate

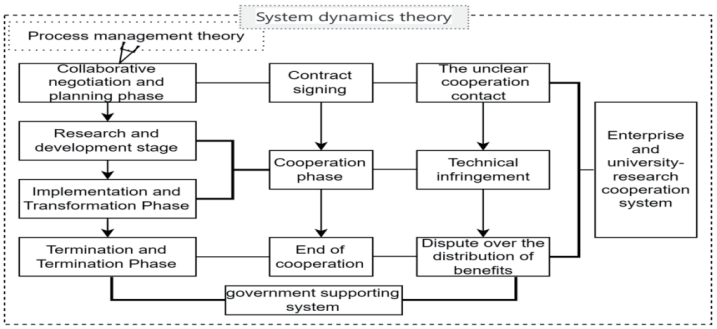

FIGURE 1. Schematic diagram of the theoretical framework of intellectual property disputes in industry-university-research cooperation.

or mitigate IP conflicts. Emphasizing contract clarity, effective communication, and proactive IP protection, this model provides a structured approach to understanding and addressing disputes in IARC.

4.1. **Causal Path Analysis of Intellectual Property Disputes in IARC.** From a process management perspective, IP disputes in IARC stem from multiple interconnected factors that reinforce conflict cycles. The primary causes include unclear agreements, unauthorized use of knowledge, weak IP protection measures, and disputes over benefit distribution. These elements interact dynamically, often escalating disputes rather than resolving them.

One of the fundamental causes of disputes is the lack of clear contractual agreements. Ambiguities in defining ownership rights, commercialization terms, and revenue-sharing mechanisms create uncertainties among stakeholders, increasing the risk of legal conflicts [25]. When contractual terms do not explicitly outline rights and obligations, multiple parties may lay claim to the same IP, leading to prolonged legal battles and inefficiencies in collaboration. The resulting legal actions and counterclaims form a reinforcing feedback loop, further destabilizing cooperation.

Another major factor is unauthorized use of proprietary knowledge, where one party exploits patents, research findings, or trade secrets without proper authorization. This often results in infringement disputes, with the affected party seeking legal recourse or regulatory intervention [12]. However, these enforcement measures can provoke retaliatory actions from the accused party, escalating conflicts instead of resolving them [3].

Weak IP protection mechanisms further exacerbate these disputes. Many IARC stakeholders lack adequate enforcement strategies for safeguarding intellectual property, leaving innovations vulnerable to infringement. In cases where regulatory enforcement is inefficient, infringements go unchecked, compelling organizations to pursue costly legal interventions. This not only strains resources but also damages long-term cooperation prospects.

Disputes over benefit distribution constitute another major source of conflict. When stakeholders perceive that profit-sharing mechanisms are unfair or misaligned with their contributions, disagreements arise over patent ownership, licensing rights,

and commercialization revenues. If unresolved, these disputes lead to contract violations, strained partnerships, and further legal challenges.

Government support plays a dual role in this system. While financial backing, policy incentives, and regulatory frameworks encourage collaboration, they also introduce additional complexity. Increased government funding leads to a higher volume of collaborative projects, which in turn increases the potential for IP disputes [8]. However, effective dispute resolution mechanisms and well-enforced IP policies can mitigate these risks, reinforcing trust and promoting sustained cooperation.

The causal relationships governing these disputes can be summarized through two primary feedback loops:

- Collaboration-Stimulation Loop: Increased government support fosters more cooperation, leading to higher IP output. However, as disputes arise, stakeholder trust declines, reducing the effectiveness of future partnerships.
- Dispute-Resolution Loop: Improved legal enforcement and arbitration mechanisms reduce conflicts, strengthening long-term collaboration by enhancing trust among stakeholders.

By analyzing these causal pathways, this study highlights the critical points for intervention, advocating for more precise contractual agreements, stronger enforcement frameworks, and transparent benefit-sharing models to minimize disputes and optimize industry-university-research collaboration.

4.2. **Model Construction of Intellectual Property Disputes in Industry-University-Research Cooperation Based on System Dynamics.** Intellectual property (IP) disputes in industry-university-research collaboration (IARC) arise from complex interactions between government support, cooperation dynamics, and institutional mechanisms. A system dynamics model helps analyze dispute formation, key variables, and intervention strategies, providing insights into mitigation approaches. This section divides the model into two subsystems: government support and enterprise-research cooperation mechanisms, both playing crucial roles in shaping the landscape of IP management.

4.2.1. *Subsystem Division.* (i) Government Support Subsystem

Government support plays a critical role in industry-university-research collaboration (IARC) through financial aid, policy guidance, and intermediary platforms. Financial investment in innovation-intensive regions fosters collaboration, while regulatory policies enhance IP protection [29]. Additionally, the government facilitates platforms for talent and patent exchange, strengthening industry-academia partnerships.

However, inadequate financial support can lead to incomplete projects, causing disputes, while weak IP protection policies create legal loopholes that undermine cooperation trust. Establishing robust regulatory frameworks and dispute resolution mechanisms is essential for fostering a stable innovation ecosystem.

(ii) Cooperation System Between Enterprises and Research Institutions

The collaborative process consists of three key phases: contract negotiation, execution, and post-cooperation. In the negotiation phase, unclear agreements on resource contributions, IP ownership, and profit distribution often lead to future

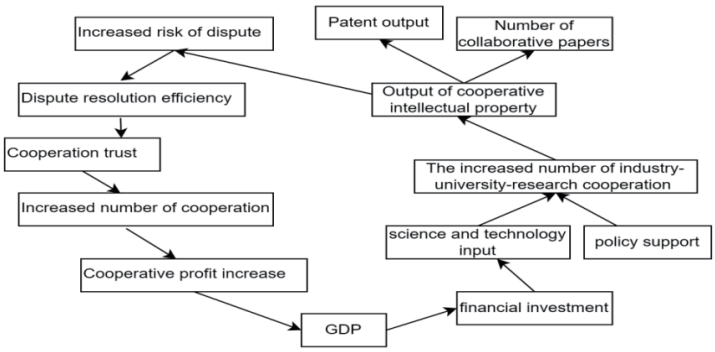

FIGURE 2. Logic diagram of intellectual property disputes in industry-university-research cooperation based on process management.

conflicts. During the execution phase, trust issues may arise due to information leaks, delays, or non-compliance, escalating disputes. The post-cooperation phase frequently sees conflicts over profit allocation and the unauthorized use of co-developed innovations, further straining partnerships.

These phases form an interactive system where unresolved contract ambiguities affect later-stage cooperation, influencing resource distribution and dispute resolution efficiency. If early agreements lack clarity, long-term collaboration sustainability is jeopardized, necessitating stronger legal frameworks and proactive risk management strategies.

By modeling these interactions, the system dynamics framework identifies feedback loops affecting trust, efficiency, and dispute escalation in IARC. Establishing transparent agreements, efficient resource allocation, and structured dispute resolution mechanisms is crucial for fostering sustainable industry-academia cooperation.

4.2.2. *Causality Feedback Analysis.* A causality feedback analysis of intellectual property (IP) disputes in Industry-University-Research Collaboration (IARC) reveals dynamic interactions between key subsystems. Figure 3 illustrates how factors such as unclear contracts, poor communication, and inadequate IP protection contribute to disputes. These elements form a feedback loop, where declining trust exacerbates disagreements, leading to further conflicts. Without clear contractual terms and effective dispute resolution mechanisms, these disputes may escalate, jeopardizing long-term collaboration.

By analyzing these interactions, this study highlights the importance of well-defined agreements, transparent communication, and structured conflict resolution processes. Strengthening these aspects can mitigate disputes and enhance trust among collaborating entities.

4.2.3. *Constructing the System Flow.* To understand the complex relationships governing IP disputes in IARC, a system flow model (Figure 4) is developed, mapping interactions between government, enterprises, and research institutions. This model highlights critical variables and external influences shaping cooperation dynamics.

(i) Identifying Key Variables

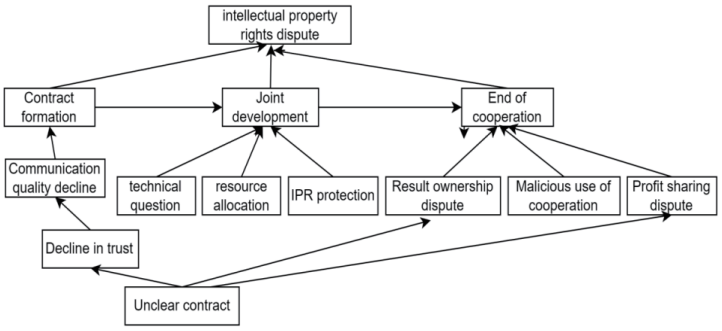

FIGURE 3. Causal feedback graph of intellectual property disputes with subsystem interaction.

Key indicators include the number of cooperation projects, IP output (patents, publications), R&D investment, talent mobility, and policy enforcement. Additionally, the efficiency of dispute resolution mechanisms and legal frameworks significantly impact collaboration sustainability [6].

(ii) External Factors

Technological advancements, policy changes, and economic conditions influence IARC. Government funding stimulates cooperation, while legal reforms affect IP protection and dispute resolution efficiency. Market demand also shapes collaboration intensity, impacting the value and commercialization of research.

(iii) Flowchart Construction

Figure 4 visualizes the cause-and-effect relationships driving IP disputes. Central to the model is the "Dispute" variable, influenced by trust levels, dispute resolution efficiency, and cooperation incentives. Factors such as "Technical Complexity," "Communication Frequency," and "Profit Sharing" shape dispute emergence, while government policies and financial support mediate these dynamics.

By integrating these elements, the model provides a structured framework for managing IP risks in IARC, emphasizing clear agreements, proactive governance, and adaptive policy measures to foster successful industry-academic collaboration.

5. Discussion

This study provides a comprehensive analysis of intellectual property (IP) disputes in university-industry collaborations, emphasizing the importance of clear ownership agreements, trust-building, and effective dispute resolution mechanisms. The findings confirm that IP-related conflicts often arise from divergent expectations among stakeholders, particularly in the negotiation, cooperation, and post-collaboration phases. Prior research has largely focused on contract formulation as the primary risk point, but this study highlights the ongoing influence of trust crises and resource shortages throughout collaboration, which can significantly escalate disputes [15].

Moreover, the study underscores the need for continuous communication, transparency, and adaptive agreements, rather than relying solely on initial contract

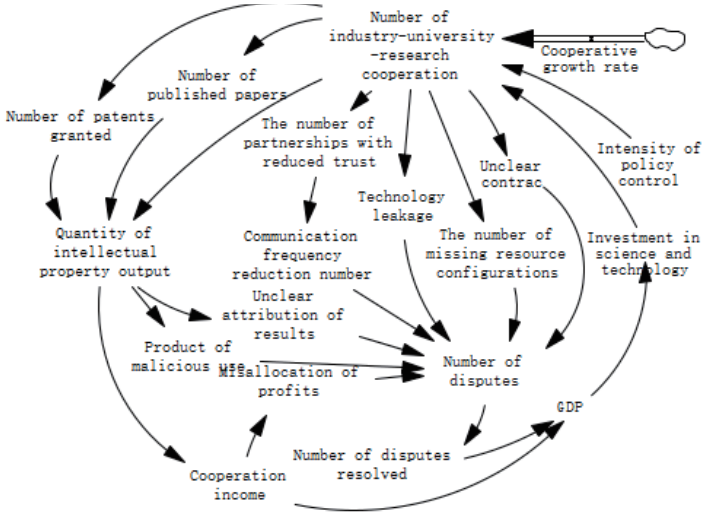

FIGURE 4. Intellectual property dispute system flow diagram.

clarity. These aspects ensure more resilient partnerships, mitigating the risks of unanticipated conflicts and IP misuse [10].

(i)Key Findings and Implications

- IP ownership complexity can create significant collaboration barriers, requiring explicit agreements on rights allocation, usage, and profit distribution [11].
- Ongoing trust-building through regular updates, transparent decision-making, and conflict resolution mechanisms is essential for sustaining cooperation.
- Government intervention plays a crucial role by strengthening IP policies, improving dispute resolution frameworks, and offering financial incentives to facilitate collaboration.

(ii)Recommendations for IP Management

- Develop clear agreements – Contracts must explicitly define ownership, rights usage, and benefit-sharing to prevent ambiguities leading to conflicts.
- Enhance communication – Establishing structured reporting mechanisms and transparency protocols can help safeguard long-term collaboration stability.
- Strengthen policy frameworks – Governments should refine IP protection laws, promote arbitration mechanisms, and support research commercialization efforts.

(iii)Limitations and Future Research

This study is based on literature review and does not incorporate primary empirical data, which may limit real-world applicability. Additionally, sector-specific or region-specific variations were not examined. Future research should:

- Investigate sectoral differences in IP disputes.
- Evaluate the effectiveness of policy interventions.

- Examine the role of technology transfer offices and intermediaries in IP management.

By addressing these areas, future research can further refine dispute mitigation strategies, ensuring that university-industry partnerships maximize their innovation potential while minimizing IP conflicts.

6. Conclusion

Intellectual property (IP) disputes in industry-university-research cooperation arise from complex interactions across three stages: contract negotiation, cooperation, and post-collaboration. Unclear agreements, resource shortages, and trust crises can trigger conflicts, undermining collaborative efforts. During cooperation, supervision costs increase due to a lack of trust, while unauthorized disclosures may lead to legal and reputational risks, discouraging future cooperation. Post-collaboration disputes over IP usage and benefit distribution can further escalate tensions, damaging long-term partnerships.

To minimize IP disputes, clear contractual agreements, equitable profit-sharing mechanisms, and robust conflict resolution strategies must be established. Addressing these issues proactively through a supportive policy environment and improved trust mechanisms will foster sustainable industry-university collaboration.

6.1. **Theoretical Implications.** This study integrates System Dynamics Theory, Process Management Theory, and Cooperative Game Theory to analyze the dynamics of IP disputes in Industry-Academia-Research Collaboration (IARC).

- System Dynamics Theory identifies key variables and causal feedback loops, explaining how IP disputes evolve [1].
- Process Management Theory highlights critical cooperation phases and their role in dispute generation [13].
- Cooperative Game Theory examines stakeholder strategies, information asymmetry, and opportunistic behavior, offering insights into fairer benefit distribution.

This framework provides a structured foundation for managing IP conflicts, emphasizing the need for flexible agreements, transparent information-sharing, and efficient dispute resolution mechanisms.

6.2. **Policy Implications.** Effective IP dispute management requires targeted policies to address stakeholder conflicts. Policymakers should:

- Develop standardized agreements – Define IP ownership, information-sharing guidelines, and dispute resolution frameworks to align stakeholder expectations.
- Enhance legal and arbitration mechanisms – Strengthen IP protection laws, ensuring fair benefit distribution and efficient conflict resolution [22].
- Increase transparency and oversight – Implement progress reporting requirements and open communication channels to build trust and accountability.
- Provide financial and institutional support – Governments should incentivize collaboration, reducing financial risks and uncertainties in IARC.

These measures ensure a balanced approach, promoting cooperation while minimizing disputes in IP-intensive collaborations.

6.3. **Future Research Directions.** Further research should examine:

- Sector-specific IP dispute dynamics – Investigate industry-specific variations in IP conflicts to refine management strategies.
- Emerging technologies and IP management – Explore how AI, blockchain, and digital assets influence IP protection and enforcement.
- Effectiveness of existing policies – Conduct empirical studies assessing how legal and financial interventions impact IP disputes.
- Interdisciplinary dispute resolution mechanisms – Study the role of technology transfer offices and IP intermediaries in mitigating IP conflicts.

Addressing these areas will enhance IP governance in industry-university cooperation, ensuring more effective knowledge transfer and commercialization.

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