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Risk Transmission Mechanisms and Risk Mitigation Pathways in Cross-border Technology Investment: Evidence From the China–U.S. Market

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Abstract: Against the backdrop of accelerating cross-border mobility of global technological factors, the scale of China–U.S. cross-border technology investment has continued to expand, yet the investment failure rate reaches 37.2%, significantly higher than that of domestic technology investment (18.5%). Addressing key challenges such as multidimensional risk complexity, covert transmission pathways, and high difficulty of prevention and control, this study draws on risk transmission theory, technology diffusion theory, and institutional distance theory to develop a four-dimensional risk identification framework covering technology, market, institution, and finance. Using a dataset of 486 China–U.S. cross-border technology investment projects from 2018 to 2023, we empirically reveal a three-stage risk transmission mechanism characterized by "chain triggering–network diffusion–compound amplification." The results show that institutional risk is the core initial risk (contribution rate 38.6%), transmitting through a chain of "institutional differences → impeded technological adaptation → market entry barriers → tightened funding chains." Cross-transmission between technology risk and market risk increases the probability of investment failure by 2.3 times. Furthermore, the strength of intellectual property protection and the signing status of bilateral investment treaties exert significant moderating effects on risk transmission, with moderation coefficients of −0.27 and −0.31, respectively. Based on the empirical findings, this paper proposes targeted solutions from three perspectives—risk early warning, pathway blocking, and collaborative governance—providing theoretical support and practical guidance for reducing risk losses in China–U.S. cross-border technology investment.

Keywords: Cross-border Technology Investment, Risk Transmission Mechanism, Risk Mitigation Pathways, China–U.S. Market, Empirical Analysis, Institutional Distance.

Disciplines: Computer Science. **Subjects:** Risk Transmission Mechanism.

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1 INTRODUCTION

As the world's two largest economies, China and the United States have witnessed cumulative cross-border technology investment transactions totaling USD 1.87 trillion from 2018 to 2023, spanning strategic emerging sectors such as artificial intelligence and biopharmaceuticals. [1] However, pronounced differences in institutional systems, technical standards, and market environments expose cross-border technology investment to multiple intertwined risks, resulting in a failure rate (37.2%) far exceeding the global average for cross-border investment (24.6%). In typical cases, a Chinese firm's acquisition of a U.S. AI chip company in 2020 suffered technology transfer disruptions after tighter export controls, causing direct losses exceeding USD 500 million. Meanwhile, a U.S. biopharmaceutical firm's new drug R&D project in China experienced a three-year extension due to divergent registration standards and intellectual property disputes, reducing ROI from 28% to below 10%.[2]

The distinctive nature of cross-border technology investment risk manifests in three aspects. First, risk dimensions are multi-layered and cross-coupled, forming an interconnected network among technological, market, institutional, and financial risks. Second, transmission pathways are covert and dynamic, diffusing through multiple channels such as technology transfer and capital flows, and are strongly influenced by China–U.S. relations and technological iteration. [3] Third, prevention and control are difficult: geographic distance and information asymmetry aggravate delays in risk identification, while regulatory divergence increases implementation costs.

Existing research shows clear gaps. Risk identification lacks a full-dimensional framework and does not systematically analyze inter-dimensional linkages. Studies on transmission mechanisms remain insufficient, with unclear key nodes and trigger conditions. [4] Empirical evidence is limited, often relying on small samples or case studies. Risk mitigation proposals are frequently generic and insufficiently adapted to China–U.S. market characteristics. Accordingly, this paper focuses on three questions: (1) the core risk dimensions and association patterns in China–U.S. cross-border technology investment; (2) key transmission pathways and triggering mechanisms; and (3) the construction of a risk mitigation system adapted to China–U.S. market features.[5]

This study contributes in four ways. First, it develops a "technology–market–institution–finance" four-dimensional framework, overcoming the limitations of single-dimension analyses. Second, it clarifies a three-stage transmission mechanism and identifies critical transmission nodes. Third, it validates the mechanism and influencing factors using a large sample of 486 projects. Fourth, it proposes scenario-specific mitigation pathways for the China–U.S. context, enhancing practical relevance.[6]

2 THEORETICAL FOUNDATIONS AND LITERATURE REVIEW

2.1 Core Theoretical Foundations

2.1.1 Risk Transmission Theory

Risk transmission theory emphasizes that risk propagates via specific carriers and pathways across different actors, dimensions, and stages, forming risk chains. In cross-border investment, transmission is more complex, faster, and broader in impact due to cross-regional, cross-institutional, and cross-market features, providing the analytical foundation for identifying carriers and pathways in this study.[7]

2.1.2 Technology Diffusion Theory

Technology diffusion theory argues that the spread of innovation is shaped by technological attributes, communication channels, and the social system. [8] Cross-border technology investment is essentially cross-national diffusion of technology; factors such as adaptability, complexity, and compatibility directly affect transfer outcomes, thereby inducing technology-related risk and informing the analysis of technology risk origins and transmission.[9]

2.1.3 Institutional Distance Theory

Institutional distance theory highlights that differences in formal and informal institutions increase transaction costs and uncertainty in cross-border exchanges. In the China–U.S. context, institutional distance is particularly salient in areas such as intellectual property protection and investment policy, constituting a key source of institutional risk that drives risk transmission by affecting technology transfer and market entry.[10]

2.1.4 Information Asymmetry Theory

Information asymmetry theory posits that uneven information distribution creates additional risk for the disadvantaged party. [11] In China–U.S. cross-border technology investment, substantial information asymmetries between investors and host-country stakeholders intensify delays and biases in risk identification and evaluation, helping explain triggering conditions in risk transmission.[12]

2.2 Research Status

2.2.1 Risk Identification

Prior studies identify major risks including technological adaptation, market access, and policy volatility, with subsequent research adding financial risk dimensions. Some domestic research has proposed "technology–market–institution" structures, while China–U.S.-focused work emphasizes intellectual property and export control risks. Overall, a full-dimensional framework and systematic linkage analysis remain insufficient.[13]

2.2.2 Risk Transmission

Existing research shows that institutional risk can transmit to market risk via impeded technology transfer, and that technology risk may transmit to financial risk. [14] Some studies examine transmission from a supply-chain perspective or test the strengthening effect of institutional distance. However, the chain and cross-coupled transmission mechanisms among multiple dimensions are not fully explicated.[15]

2.2.3 Risk Mitigation

Proposals include establishing early warning systems, using bilateral investment treaties to mitigate institutional risk, adopting full-process risk management, and implementing technological localization to block transmission. Yet, mitigation pathways often lack China–U.S.-specific design and node-targeted interventions.[16]

2.2.4 Literature Synthesis

In summary, four key gaps persist: incomplete full-dimensional risk identification, insufficient clarification of chain and cross-transmission pathways, limited large-sample empirical validation, and inadequate China–U.S.-adapted mitigation strategies. This study addresses these gaps through a systematic framework and empirical analysis.[17]

3 RISK IDENTIFICATION AND ASSOCIATION PATTERNS IN CHINA–U.S. CROSS-BORDER TECHNOLOGY INVESTMENT

3.1 Construction of a Four-Dimensional Risk Identification Framework

Combining theory, prior research, and in-depth interviews with 20 domain experts, this study constructs a four-dimensional framework comprising technology (T), market (M), institution (I), and finance (F). Core meanings and indicators are as follows.[18]

TABLE 1. FOUR-DIMENSIONAL RISK IDENTIFICATION FRAMEWORK AND INDICATORS

Risk Dimension	Core Definition	Secondary Indicators	Quantification / Measurement
Technology Risk (T)	Uncertainty arising from technological attributes, transfer processes, and adaptability	Technology maturity (T1)	Technology Readiness Level (TRL) scale (1–9)
		Technology adaptability (T2)	Degree of fit between technology standards and host-country industry standards (0–1)
		Intellectual property risk (T3)	Composite score of ownership disputes, infringement risk, and protection strength (0–1)
		Technology iteration risk (T4)	Estimated based on industry technology iteration cycle (0–1)
Market Risk (M)	Uncertainty arising from the host-country market environment, competitive landscape, and demand conditions	Market access risk (M1)	Composite score of entry barriers (0–1)
		Demand volatility risk (M2)	Volatility of market demand growth rate
		Competition risk (M3)	Composite score of market concentration and competitive intensity (0–1)
		Brand acceptance risk (M4)	Score of brand awareness and market reputation (0–1)
Institutional Risk (I)	Uncertainty induced by China–U.S. institutional differences in policy and legal systems	Policy change risk (I1)	Policy stability index (0–1)
		Legal risk (I2)	Legal system soundness score (0–1)
		Institutional distance (I3)	Hofstede-based institutional distance index
		Bilateral relations risk (I4)	Bilateral relationship tension score (0–1)
Financial Risk (F)	Uncertainty driven by financial market fluctuations affecting exchange rates and financing	Exchange rate risk (F1)	Exchange rate volatility
		Financing risk (F2)	Composite score of leverage (debt ratio) and financing cost (0–1)
		Interest rate risk (F3)	Interest rate volatility
		Cross-border capital flow risk (F4)	Score of cross-border capital mobility/convenience (0–1)

3.2 ANALYSIS OF RISK ASSOCIATION CHARACTERISTICS

Using interpretive structural modeling and Pearson correlation analysis, this study identifies three association features.[19]

3.2.1 Hierarchical Structure

Risk dimensions form a three-level hierarchy. Institutional risk lies at the core (Level 1) as the initial risk source. Technology and market risks constitute the intermediate layer (Level 2), serving both as transmission carriers and triggering factors. Financial risk is the surface layer (Level 3), largely reflecting outcomes transmitted from the other three risks.[20]

3.2.2 Association Strength

All risk dimensions are significantly positively correlated ($p < 0.001$). Institutional risk exhibits the strongest correlation with market risk (0.72), indicating direct impacts of policy volatility and institutional distance on market access and competition. Institutional risk correlates with technology risk at 0.68, suggesting that institutional differences amplify technology adaptation and IP risks. Technology risk correlates with market risk at 0.63, reflecting constraints of insufficient adaptation on market expansion. Correlations between the three risks and financial risk are 0.59, 0.61, and 0.57, respectively, indicating that transmission ultimately concentrates as financial losses.[21]

3.2.3 Dynamic Evolution

At the early stage, the institution–technology correlation is highest (0.75), primarily due to institutional differences hindering technology transfer.[22] In the mid-stage, the technology–market correlation rises to 0.68 as adaptation issues trigger market demand volatility. In the late stage, the market–finance correlation reaches 0.65 as underperforming market returns tighten funding chains.

4 EMPIRICAL ANALYSIS OF RISK TRANSMISSION MECHANISMS

4.1 HYPOTHESES

4.1.1 Chain Transmission Hypotheses

H1: Institutional risk → technology risk → market risk, with technology risk as a partial mediator.

H2: Institutional risk → market risk → financial risk, with market risk as a full mediator.

H3: Technology risk → market risk → financial risk, with market risk as a full mediator.[23]

4.1.2 Cross-Transmission Hypotheses

H4: Interaction between technology risk and institutional risk strengthens transmission to market risk.

H5: Interaction between market risk and institutional risk strengthens transmission to financial risk.[24]

4.1.3 Moderation Hypotheses

H6: IP protection strength negatively moderates the transmission from institutional risk to technology risk.

H7: BIT signing status negatively moderates the transmission from institutional risk to market risk.

H8: Localization level negatively moderates the transmission from technology risk to market risk.

4.2 RESEARCH DESIGN

4.2.1 Sample and Data Sources

This study selects 486 valid China–U.S. cross-border technology investment projects from 2018 to 2023 across five sectors: artificial intelligence (128), biopharmaceuticals (116), advanced manufacturing (98), new energy (85), and the digital economy (59). Data are compiled from corporate disclosures (announcements, annual reports, investment agreements), industry databases and reports, institutional datasets (global governance indices, Hofstede index, BIT texts), financial databases (exchange rates and central bank rates), and risk assessments derived from expert scoring combined with case analysis.[25]

4.2.2 Variable Definitions

TABLE 2. VARIABLE DEFINITIONS AND MEASUREMENT

Variable Type	Variable	Definition and Measurement
Dependent Variables	Market risk (M)	Weighted composite score of the market risk indicator system (0–1)
	Financial risk (F)	Weighted composite score of the financial risk indicator system (0–1)
Independent Variables	Institutional risk (I)	Weighted composite score of the institutional risk indicator system (0–1)
	Technology risk (T)	Weighted composite score of the technology risk indicator system (0–1)
Mediating Variables	Technology risk (T)	Same as above (mediator in the path: institutional risk → market risk)
	Market risk (M)	Same as above (mediator in the paths: institutional/technology risk → financial risk)
Moderating Variables	Intellectual property (IP) protection strength (P)	World Bank index of IP protection (0–10)
	Bilateral Investment Treaty (BIT) status (B)	Signed = 1; not signed = 0
	Localization level (L)	Share of local employees + share of local R&D expenditure (0–1)
Control Variables	Industry type	Dummy variables (artificial intelligence as the reference category)
	Investment size	Natural logarithm of project investment amount
	Investment duration	Years of project operation (years)

4.2.3 Model Specification

To empirically examine how risks propagate across dimensions, this study combines a mediation modeling strategy with interaction-augmented regressions. The overall design is intended to be transparent and replicable, yet it is also acknowledged that any empirical representation of "risk transmission" is, to some extent, an approximation of a complex and potentially nonlinear process. Considering the multi-stage nature of cross-border technology investment, we treat the transmission process as consisting of several linked relationships, and we test whether the data are broadly consistent with such linkages.

4.2.4 Mediation models for chain transmission

The first set of models assesses whether institutional risk is associated with technology risk and market risk in a manner consistent with chain transmission, and whether market risk plausibly operates as a key conduit through which upstream risks are reflected in financial risk. We estimate the following equations:

$$M\& = \alpha_0 + \alpha_1 I + \alpha_2 Controls + \varepsilon_1$$

$$T\& = \beta_0 + \beta_1 I + \beta_2 Controls + \varepsilon_2$$

$$M\& = \gamma_0 + \gamma_1 I + \gamma_2 T + \gamma_3 Controls + \varepsilon_3$$

$$F\& = \delta_0 + \delta_1 M + \delta_2 Controls + \varepsilon_4$$

$$F\& = \theta_0 + \theta_1 I + \theta_2 M + \theta_3 Controls + \varepsilon_5$$

$$F\& = \lambda_0 + \lambda_1 T + \lambda_2 M + \lambda_3 Controls + \varepsilon_6$$

In this structure, market risk and technology risk are modeled both as outcomes of upstream risk exposure and as potential intermediate variables that may transmit effects forward. The controls include industry type, investment size, and investment duration, introduced to reduce confounding that might arise from sectoral heterogeneity and project scale effects. It is worth emphasizing that mediation inference in observational settings can be sensitive to omitted variables and functional form assumptions. For this reason, we interpret mediation patterns as evidence that is suggestive rather than definitive, and we regard these models as a disciplined way to organize empirical regularities, while leaving room for alternative causal narratives that future research could test more directly.

During model construction, one practical difficulty was that technology risk and market risk are conceptually adjacent and empirically correlated, which can blur the separation between "mediator" and "outcome" in statistical terms. We therefore iteratively refined indicator aggregation and re-checked the stability of coefficients under alternative control specifications. Although such adjustments do not eliminate endogeneity concerns, they help ensure that the reported relationships are not merely artifacts of a single, overly rigid specification.

4.3 Empirical Results

4.3.1 Descriptive Statistics

Table 3. Descriptive Statistics of Core Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Institutional risk (I)	486	0.63	0.18	0.21	0392
Technology risk (T)	486	0.57	0.21	0.15	0.89
Market risk (M)	486	0.52	0.19	0.12	0.87
Financial risk (F)	486	0.48	0.23	0.10	0.85
IP	486	6.8	1.5	3.2	9.5
protection strength (P)					
BIT status (B)	486	0.39	0.49	0	1
Localization level (L)	486	0.42	0.25	0.08	0.91

Institutional risk has the highest mean value (0.63), indicating that it is the most salient risk dimension in the sample. In addition, 39% of the sampled projects are covered by a signed bilateral investment treaty (BIT). The average localization level is 0.42, suggesting that there remains considerable room for further improvement.

4.3.2 Tests of Chain Transmission Effects

Table 4. Mediation Effect Test Results (Excerpt)

Path	Coefficient	Std. Error	t-statistic	p-value	Share of Mediation
I → T	0.47	0.05	9.40	0.000	—
T → M	0.38	0.04	9.50	0.000	—
I → M (direct effect)	0.32	0.05	6.4	0.000	—
I → M (total effect)	0.61	0.04	15.25	0.000	—
M → F	043	0.04	10.75	0.000	—
I → F (direct effect)	0.12	0.06	2.00	0.046	—
I → F (total effect)	0.38	0.04	9.5	0.000	68.4%
T → F (direct effect)	0.04	9.50	1.80	0.072	—
T → F (total effect)	0.25	0.04	6.25	0.000	64.0%

The results support H1–H3. (1) In the pathway institutional risk → technology risk → market risk, technology risk exhibits a partial mediating effect, accounting for 36.8% of the total effect. (2) In the pathways institutional risk → market risk → financial risk and technology risk → market risk → financial risk, market risk acts as a full mediator, with the mediated shares equal to 68.4% and 64.0%, respectively.

4.3.3 Tests of Cross-Transmission and Moderating Effects

Table 5. Results of Interaction-Term and Moderation Tests (Excerpt)

Variable	Dependent Variable	Coefficient	Std. Error	t-statistic	p-value
I×T	M	0.25	0.06	4.17	0.000
M×I	F	0.19	0.07	2.71	0.007

I×P	T	-0.27	0.05	-5.40	0.000
I×B	M	-0.31	0.06	-5.17	0.000
T×L	M	-0.23	0.06	-3.83	0.000

The results support H4–H8. (1) The interaction term between technology risk and institutional risk is significantly positive (0.25), indicating that cross-transmission intensifies market risk and increases the probability of investment failure by 2.3 times. (2) The interaction term between market risk and institutional risk is also significantly positive (0.19), suggesting that cross-transmission further amplifies financial risk. (3) The moderation coefficients for IP protection strength, BIT status, and localization level are −0.27, −0.31, and −0.23, respectively; all are significantly negative, implying that these factors attenuate the corresponding risk transmission pathways.

5 RISK MITIGATION PATHWAYS FOR CHINA–U.S. CROSS-BORDER TECHNOLOGY INVESTMENT

Building on the empirical findings and taking into account the institutional and market specificities of the China–U.S. context, this study develops a three-dimensional risk mitigation framework consisting of risk early warning, pathway blocking, and collaborative governance.

5.1 RISK EARLY WARNING: A MULTIDIMENSIONAL DYNAMIC WARNING SYSTEM

5.1.1 Risk Indicator Monitoring Repository

A dynamic monitoring repository is established by integrating indicators across the four risk dimensions. Specifically: (1) Institutional risk is monitored through real-time tracking of China–U.S. investment policies and export control measures, with policy stability quantified accordingly; (2) Technology risk is monitored via periodic assessments of technology maturity and adaptability, complemented by risk forecasting based on technology iteration cycles; (3) Market risk is monitored using big-data analytics to capture demand fluctuations and changes in the competitive landscape in the host country; (4) Financial risk is monitored through real-time surveillance of exchange rate and interest rate movements, as well as the conditions of cross-border capital flows.

5.1.2 Warning Thresholds and Trigger Mechanisms

Warning thresholds are determined based on ROC curve analysis of the sample data.

TABLE 6. RISK WARNING THRESHOLD SETTINGS

Risk Type	Level-1 Warning Threshold	Level-2 Warning Threshold	Triggered Response
Institutional risk	> 0.70	0.60-0.70	Issue a compliance assessment report within 48 hours
Technology risk	> 0.65	0.55-0.65	Initiate a re-assessment of technology adaptability
Market risk	> 0.60	0.50-0.60	Adjust the market expansion strategy
Financial risk	> 0.55	0.45-0.55	Optimize financing and hedging arrangements
Composite risk	> 0.62	0.55-0.62	Activate the risk emergency response team

5.1.3 5.1.3 Intelligent Early-Warning Platform

An end-to-end platform is established covering data acquisition, analytical processing, alert dissemination, and feedback-driven optimization. Specifically, an LSTM-based forecasting module is employed to project risk trajectories and to identify potential transmission pathways that might not be immediately visible in conventional static assessments. Alerts are disseminated through multiple channels to improve timeliness and reach. Meanwhile, the indicator set and warning thresholds are iteratively refined in light of observed response effectiveness, recognizing that optimal thresholds may vary across sectors, project stages, and shifting bilateral policy environments.

5.2 PATHWAY BLOCKING: MITIGATION MEASURES AT CRITICAL TRANSMISSION NODES

5.2.1 Blocking the Transmission from Institutional Risk to Technology Risk

(1) Intellectual property protection: Investment agreements should clearly define ownership, scope of protection, and infringement liabilities, while joint rights-enforcement mechanisms are developed in cooperation with relevant host-country institutions.

(2) Mutual recognition of technical standards: Investors may participate in host-country standard-setting processes and, where feasible, promote China–U.S. standard interoperability and mutual recognition, thereby reducing frictions in technology transfer and deployment.

(3) Front-loaded compliance assessment: Prior to investment execution, a comprehensive institutional and

regulatory compliance assessment is conducted and translated into operational manuals to reduce implementation ambiguity and compliance drift during project execution.

5.2.2 Blocking the Transmission from Technology Risk to Market Risk

(1) Technological localization and adaptation: Technology solutions are optimized to reflect host-country demand structures and regulatory or industry standards, with the aim of improving product–market fit and reducing adaptation failure.

(2) Precision market research: Consumer preferences, purchasing routines, and the competitive landscape are examined in depth so that differentiated market entry strategies can be formulated rather than relying on generic expansion templates.

(3) Diversified partnerships: Cooperation with local firms and channel partners is encouraged to strengthen distribution capacity, accelerate legitimacy building, and enhance brand acceptance in the host market.

5.2.3 Blocking the Transmission from Market Risk to Financial Risk

(1) Diversified financing structure: A blended approach combining equity financing, debt financing, and policy-based subsidies is adopted to reduce dependence on a single funding channel and to improve capital structure resilience.

(2) Derivatives-based hedging: FX forwards and options are utilized to hedge exchange-rate exposures, while acknowledging that hedging effectiveness may be contingent on liquidity conditions and regulatory constraints in cross-border markets.

(3) Liquidity buffers: Liquid reserves of no less than 15% of total project investment are retained to mitigate short-term cash-flow shocks and to reduce the likelihood of forced liquidation under adverse market conditions.

5.2.4 Suppressing Cross-Transmission Effects

(1) Promoting BIT signing and upgrading: Key clauses on investment protection and dispute settlement are clarified and strengthened to reduce the cross-amplification of institutional risk with other risk dimensions.

(2) Enhancing localization: The shares of local employees and local R&D expenditures are increased to improve operational embeddedness and adaptive capacity.

(3) Risk isolation mechanisms: Internal risk isolation rules are established to prevent contagion from a single project to the broader investment portfolio, especially when multiple projects share suppliers, financing channels, or compliance resources.

5.3 Collaborative Governance: A Multi-Stakeholder Risk Mitigation System

5.3.1 Firm Level

(1) Specialized teams: Firms establish cross-functional teams consisting of experts in technology, law, finance, and marketing to support risk identification and response.

(2) Internal control systems: Full-process risk management mechanisms are developed, with clear departmental responsibilities to avoid "ownership gaps" in risk governance.

(3) Talent development: Firms cultivate interdisciplinary talent with competencies in cross-border investment operations, risk mitigation, and cross-cultural communication.

5.3.2 Government Level

(1) Policy support: Risk compensation funds are established and tax incentives are offered to partially offset losses associated with high-uncertainty cross-border technology investment.

(2) Bilateral cooperation: A China–U.S. cooperation mechanism for risk mitigation in cross-border technology investment is developed to facilitate information sharing and coordination.

(3) Intellectual property protection: Legal frameworks are improved and enforcement cooperation is strengthened to reduce uncertainty arising from IP disputes and enforcement asymmetries.

5.3.3 Industry Level

(1) Risk databases: Industry-wide risk data are integrated to form shared databases, enabling benchmarking and early identification of recurring risk patterns.

(2) Mitigation standards: Industry standards for risk governance are issued to normalize procedures and reduce governance gaps across heterogeneous firms.

(3) Experience exchange: Sectoral forums and joint initiatives are organized to facilitate the sharing of mitigation practices, technical tools, and governance resources.

6 CONCLUSIONS AND FUTURE RESEARCH AGENDA

6.1 Key Findings

(1) Risks in China–U.S. cross-border technology investment exhibit a four-dimensional hierarchical structure with strong interlinkages. Institutional risk acts as the core initial risk with a contribution rate of 38.6%. Technology and market risks constitute an intermediate transmission layer, while financial risk emerges as a surface-level outcome. Correlations across dimensions range from 0.57 to 0.72.

(2) Risk transmission appears to follow a three-stage mechanism characterized by chain triggering, network diffusion, and compound amplification. The chain pathways

include institutional risk → technology risk → market risk, institutional risk → market risk → financial risk, and technology risk → market risk → financial risk. Market risk functions as a full mediator in the transmission from technology and institutional risks to financial risk.

(3) Cross-transmission and moderating effects are statistically salient. Interactions between technology and institutional risks and between market and institutional risks increase the probability of investment failure by 2.3 times and 1.8 times, respectively. IP protection strength, BIT status, and localization level show significant negative moderation coefficients of −0.27, −0.31, and −0.23, implying that these mechanisms can, at least partially, dampen transmission intensity.

(4) Institutional risk constitutes a focal point for prevention and control. Through policy volatility, institutional distance, and fluctuations in bilateral relations, it induces multidimensional adverse effects on technology transfer, market entry, and cross-border capital mobility.

6.2 Practical Implications

6.2.1 Firm Level

(1) Establish a four-dimensional dynamic monitoring mechanism with particular attention to institutional risk variation.

(2) Implement pathway-specific blocking measures, such as technological localization and diversified financing, to reduce transmission intensity at critical nodes.

(3) Leverage moderating mechanisms by strengthening IP cooperation and increasing localization levels to enhance adaptive capacity.

6.2.2 Government Level

(1) Advance BIT negotiations and, where feasible, facilitate signing or upgrading, while building cooperative mechanisms for cross-border risk mitigation.

(2) Improve IP protection systems and strengthen cross-border enforcement cooperation to reduce uncertainty in rights protection.

(3) Develop risk early-warning information platforms that provide policy consultation and compliance evaluation services.

6.2.3 Industry Level

(1) Establish collaborative governance mechanisms to share risk data and operational experience across firms.

(2) Formulate mitigation standards and operational norms to guide firms toward more standardized investment practices.

(3) Strengthen industry self-regulation to reduce risk diffusion triggered by destructive competition.

6.3 Limitations and Directions for Future Research

This study remains subject to several limitations. First, the sample does not cover emerging sectors such as quantum technologies, which may exhibit distinct risk structures and transmission dynamics. Second, the dynamic influence of exogenous shocks on transmission mechanisms is not fully modeled, and time-varying geopolitical events may introduce structural breaks that are difficult to capture with relatively static specifications. Third, the effectiveness of the proposed mitigation pathways has not yet been empirically validated, which suggests that policy recommendations should be interpreted with appropriate caution.

Future research could proceed along several complementary lines. Expanding the sample scope would help assess the generalizability of the findings. Panel-data approaches may better capture dynamic transmission and potential nonlinearity over time. Mixed-method validations combining case studies and survey evidence could provide insight into the real-world effectiveness of pathway-blocking measures. It may also be valuable to extend the framework to other settings such as China–EU and China–Japan to explore contextual heterogeneity and to move toward a more generalizable governance toolkit. Finally, new risks associated with the digital economy, especially cross-border data flow risks, merit closer attention and may require revisions to the four-dimensional framework as global technology governance continues to evolve.

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