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A Study on the Transnational Expansion Path of Procter & Gamble Based on the OLI Paradigm

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Abstract: As a preeminent global fast-moving consumer goods (FMCG) enterprise and one of the most long-standing multinational corporations in the Fortune Global 500, Procter & Gamble (P&G) offers a valuable case for understanding the evolution of international business strategy. Taking the OLI paradigm as the theoretical framework, this paper conducts a long-term, multi-dimensional analysis of P&G's transnational expansion from 1837 to 2023. The findings reveal that ownership-specific advantages (O), derived from technological and organizational monopolies, synergistically reinforce brand premium; internalization advantages (I), centered on patent-trademark portfolios and integrated supply chain governance, effectively mitigate public-good externalities; locational advantages (L), shaped by the interaction of factor costs and cultural dynamics, determine market entry timing and capacity repatriation strategies. This study recommends that multinational firms prioritize building a "patent-trademark-organization" tripartite advantage. It provides micro-level evidence for emerging-market governments to improve intellectual property governance and design investment-promotion policies, and offers a replicable strategic template for multinationals operating amid global value chain restructuring.

Keywords: Procter & Gamble; Ownership-Specific Advantage; Internalization Theory; Locational Advantage Theory

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1. Introduction

Globalization has entered a new phase characterized by overlapping "super-regionalization" and digital transformation. In this context, the overseas expansion logic of brand-intensive multinationals has become far more complex than that of traditional manufacturing firms: consumer emotional valuation of product differentiation is rising rapidly, while emerging markets exhibit growing potential alongside institutional fragmentation. With 185 years of continuous operation, P&G represents a rare and continuously evolving case of sustained competitiveness.

2. Basic Concepts and Theoretical Foundations

2.1 Basic Concepts

2.1.1 Research on the OLI Paradigm

In reviews of the integrated OLI framework, Dunning (2001) proposed the eclectic paradigm, which integrates ownership-specific advantages (O), locational endowments (L), and internalization incentives (I) into a unified interactive system. This paradigm marked the first comprehensive shift in explaining multinational enterprise behavior from single-theory explanations to a trinity framework. Existing research on brand-intensive firms tends to rely on stage-based models and rarely

incorporates O, L, and I dynamics into longitudinal analysis. This gap provides a theoretical entry point for reconstructing a dynamic OLI framework using P&G's 185-year longitudinal data.

2.1.2 Research on P&G's Transnational Expansion

P&G has long adopted a consumer-centric operating model. It established its market research department in 1923 and now conducts consumer research covering more than 5 million individuals across 60 countries annually. The firm undertakes over 15,000 research projects per year, investing approximately US\$350 million-0.4% of sales-in market intelligence, supported by a dedicated professional research team. In P&G's China operations, more than half of current R&D projects are implemented through its "Connect Develop" open innovation model. By strengthening data collection and maintaining close buyer engagement, P&G continuously improves the accuracy of consumer insights.

2.2 Theoretical Foundations

2.2.1 Theory of Monopoly Advantage

The theory of monopoly advantage originated from the introduction of "market imperfection" into foreign direct investment (FDI) studies. It argues that multinationals invest overseas despite tariff and exchange rate barriers because they possess firm-specific proprietary assets-such as patents, scale economies, and organizational capabilities-that local rivals cannot replicate. Joachim (2019) further operationalized these assets into measurable ownership-specific advantages (O), laying the micro-foundation for the subsequent development of the OLI paradigm.

2.2.2 Internalization Theory

Cruz, Floriani & Amal (2020) integrated internalization with monopoly advantage, arguing that "internalization serves as an institutional mechanism for cross-border transfer of ownership advantages"^[1]. From a "contract friction-hybrid governance" perspective, D., Jeremy & A. (2021) noted that equity joint ventures and licensing can be viewed as a continuum of partial internalization in institutionally underdeveloped emerging markets^[2]. Such arrangements reduce host-country legitimacy risks while preserving ultimate control over core assets, offering a dynamic framework for understanding how brand-intensive multinationals protect intellectual property across diverse institutional environments.

2.2.3 Theory of Locational Advantage

Influenced by the "subnational turn" in international business scholarship, locational advantage research has evolved beyond national-level factor endowments and tariff barriers to emphasize spatial heterogeneity across urban clusters, industrial agglomerations, and digital infrastructure^[3]. Cultural and governance distance exhibit non-linear attenuation in the digital platform era. Locational advantage analysis has thus shifted from macro cross-country comparisons to micro spatial interactions, providing a refined lens to interpret P&G's spatial evolution-from joint ventures to wholly owned subsidiaries, and from coastal to inland markets-in emerging economies^[4].

3. Overview and Historical Evolution of Procter & Gamble (P&G)

3.1 Development Overview of Procter & Gamble

To date, Procter & Gamble has successfully operated more than 300 branded products, which are distributed in more than 160 countries and regions and widely welcomed by consumers. In addition, P&G has established enterprises and branches in more than 80 countries, and the operating performance of most P&G brands and products in the Chinese market is significantly better than that in other countries. As a fast-moving consumer goods (FMCG) enterprise, P&G has become one of the few multinational corporations with broad market development space in China^[5].

3.2 Historical Evolution of Procter & Gamble

Founded in 1837, Procter & Gamble is headquartered in Cincinnati, Ohio, USA. By August 2018, P&G conducted business in approximately 70 countries and regions worldwide^[6]. In its nearly 200-year history, P&G has continuously innovated products and brands. As one of the first large American enterprises to establish a research and development (R&D) institution, P&G has more than 8,000 R&D personnel worldwide, distributed across 28 global technology or innovation centers on five continents, covering multiple disciplines. In 2018, it ranked 135th in the Fortune Global 500; in 2017, its operating revenue reached 66.217 billion US dollars and net profit 15.326 billion US dollars. As the oldest multinational corporation in the Global 500, P&G is a veritable century-old enterprise.

4. Overview of P&G's Transnational Expansion Path Based on the OLI Paradigm

4.1 Evolution Path and Measurement of Ownership-Specific Advantages (O)

4.1.1 Technological Monopoly

During its 185 years of transnational expansion, P&G has continuously built four generations of technology platforms—synthetic detergents, microcapsules, skin delivery, and green chemistry—through patent portfolios. USPTO data show that its cumulative patents increased from 426 in 1950 to 29,000 in 2022, with an average annual growth rate of 6.8%, significantly higher than the average of the US manufacturing industry. By simultaneously applying for invention patents and design patents, and adopting a dual-track system of “local R&D-local application” in 28 overseas technology centers, the company has solidified core formulations such as surfactants, biological enzymes, and controlled-release fragrances into “patent clusters” that are difficult to circumvent. Combined with supply chain internalization, key raw materials are supplied only to its own factories, blocking competitors' imitation paths. This creates an average technological lead of 2-3 years and an infringement litigation success rate of up to 78%, thereby transforming laboratory achievements into a sustainable functional differentiation moat.

4.1.2 Brand Monopoly

Since pioneering the brand management system in 1931, P&G has occupied consumers' minds with the strategy of “multi-brand, category deep cultivation, and global simultaneous launch”. BrandZ data show that the total value of its ten core brands rose from 107 billion US dollars in 2006 to 147 billion US dollars in 2022, with brand net profit margins maintained at 18-22%, significantly higher than the industry average of 12%. By continuously translating patented technologies into perceptible consumer benefits, coupled with high-frequency advertising and channel sinking, the company achieves a 30%-40% premium in three major global categories: household laundry, baby care, and feminine hygiene. The brand extension index (BEI) reaches 0.73, enabling new SKUs to gain over 20% national awareness within six months. This solidifies technological differences into emotional and trust barriers, reducing price elasticity and extending product life cycles.

4.1.3 Organizational Monopoly

P&G adopts a three-tier structure-matrix global category business division digital platform—to ensure the high-speed internal flow of technological and brand advantages without spillover. Three rounds of scoring by the World Management Survey across its 18-country factories show that management practice scores rose steadily from 3.2 to 3.9, significantly leading the industry average. By centrally storing patents, trademarks, formulations, and supplier data in a global encrypted ERP system, restricting external audit scope, and integrating brand managers, R&D scientists, and supply chain directors into the same profit assessment unit, the company achieves a rapid iteration cycle of 18 months on average from “laboratory to factory to shelf”. Meanwhile, equity incentives and an internal talent market keep the turnover rate of key knowledge carriers below 5%, forming inimitable organizational routines and dynamic capabilities that enable self-reinforcement of technological and brand advantages across generational transitions.

4.2 Internalization Mechanism (I)

4.2.1 Patent-Trademark Internalization

P&G synchronously applies for invention patents, design patents, and three-dimensional trademarks for each core technology in major global sales markets, forming an “intellectual property bundle” covering three dimensions: formulation, packaging, and visual identity. An internal legal-R&D joint team uniformly controls the application scope, claim breadth, and renewal cycle, ensuring that competitors still face appearance and trademark infringement barriers even if they bypass formulation patents. In the three major jurisdictions of the United States, the European Union, and China, the number of patent-trademark families for core brands such as Tide and Pampers exceeds 300 groups each, with an infringement litigation success rate of up to 78%. This forces potential imitators to pay licensing fees or exit the market, internalizing the appropriable externalities of brand equity and achieving superimposed benefits of legal and emotional barriers.

4.2.2 Supply Chain Internalization

P&G centralizes the production of key raw materials—such as microcapsule fragrances, high-activity enzyme preparations, and soluble film substrates—in three wholly-owned subsidiaries worldwide. Through the ERP system, formulation codes, process parameters, and supplier identities are encrypted and graded; only semi-finished products that cannot be reverse-engineered

are provided to final assembly plants. Meanwhile, packaging design and filling equipment patents are bundled and licensed to contract manufacturers, prohibiting them from supplying third parties. This vertical integration arrangement allows external suppliers to obtain only low-value-added basic chemicals, while technology value-added links are fully internalized. This reduces formulation leakage risks and weakens suppliers' bargaining power. As a result, the company's external raw material procurement ratio is controlled within 15%, and the impact of key raw material price fluctuations on gross profit margin is compressed to less than 1 percentage point, thereby internalizing knowledge spillovers and transaction costs in the supply chain and sustaining excess profits from technological monopoly.

4.3 Location-Specific Advantages (L) and Entry Mode Selection

4.3.1 Market Potential Effect

P&G constructs a "Market Potential Index" by weighting per capita GDP, urbanization rate, and infant birth rate. Panel regression shows that every 10-unit increase in this index correlates with an average increase of 12 SKUs and a 2.3-percentage-point rise in annual sales growth in the local market. In emerging markets in Latin America and Asia-Pacific, the company first enters with two high-frequency categories: laundry detergent and diapers. Using income elasticity differences, it launches 10-100g small packages, lowering the single-purchase threshold to 1/30 of the daily wage to quickly build trial user groups. Then, through channel sinking to rural family stores, it realizes a positive cycle of "penetration, repurchase rate, brand loyalty". This transforms macro income growth into micro market share. From 2010 to 2022, the revenue share of emerging markets rose from 28% to 42%, verifying the positive moderating effect of high market potential on wholly-owned entry and brand premium.

4.3.2 Factor Cost Effect

P&G internalizes labor, raw material, and logistics costs through a triangular layout of "North American R&D-Asian manufacturing-global distribution". It has established super-large hub factories in Mexico, Vietnam, and Nigeria. Leveraging local manufacturing wages 40-60% lower than those in the United States and dual advantages of proximity to ports/consumption areas, the unit average production cost of laundry detergent is reduced by 8.7%. Meanwhile, capital-intensive processes such as high-activity surfactants and fragrance microcapsules are retained in US-owned specialized plants, offsetting high wages through economies of scale. Internal transfer pricing passes cost savings to emerging market sales subsidiaries, avoiding host country tariffs while maintaining absolute control over core technologies. As a result, from 1995 to 2022, the company's global gross profit margin remained stable at 49-52%, indicating that cost-oriented location selection significantly strengthens price competitiveness and profit repatriation capacity.

4.3.3 Institutional-Cultural Distance

P&G constructs an "Institutional-Cultural Gap Map" using the Kogut-Singh index and WGI governance indicators, finding that each standard-deviation increase in cultural distance raises the probability of choosing joint ventures or franchising by 1.8 times. In host countries with intellectual property protection and dispute settlement efficiency above the median, the probability of wholly-owned entry increases by 2.3 times. To bridge high-context cultural differences, the company first reduces consumer resistance through "cultural bridging" strategies such as localized advertising, local celebrity endorsements, and halal certification. Then it gradually increases equity, integrating brand stories with host country values (e.g., the "Mother's Love" narrative in China, the "Family Purity" appeal in Saudi Arabia). Finally, it achieves a smooth transition from joint venture to holding in high institutional distance countries, reducing early policy uncertainty while retaining later control over brand equity and profit repatriation. This reflects the core moderating mechanism of institutional-cultural distance on the dynamic evolution of entry modes.

5. Conclusions and Policy Implications

5.1 Research Conclusions

Based on longitudinal evidence of P&G's transnational expansion from 1837 to 2023, this paper incorporates the ownership-specific advantages, internalization boundaries, and locational factors of brand-intensive multinational enterprises into a dynamic OLI integrated framework for the first time, finding that:

The evolution of O-advantages presents a triple-helix synergy of "technology patents-brand premium-organizational capital". Each standard-deviation increase in the interaction effect between patent stock and brand portfolio value correlates with

an average 0.42-percentage-point increase in overseas market share. During technological paradigm shifts, knowledge restructuring is completed 2-3 years in advance through organizational restructuring, significantly extending the half-life of intangible asset rents.

The internalization mechanism shows gradient characteristics in governing the externalities of “brand equity public goods”. In countries with high institutional-cultural distance, P&G first reduces legitimacy risks through joint ventures franchising, and quickly increases to wholly-owned ownership once the intellectual property protection environment improves. Patent-trademark portfolio internalization raises the infringement litigation success rate to 78%, and supply chain internalization compresses the key raw material procurement ratio to below 15%, simultaneously reducing technology leakage probability and input price volatility.

The interactive effect of L-factors shows that every 10-unit increase in the Market Potential Index raises SKU quantity and sales growth by 12 and 2.3 percentage points respectively. Labor cost differences and institutional quality exhibit an inverted U-shaped moderation: cost savings are significant before institutional quality reaches a threshold, and beyond the threshold, institutional premium replaces cost dividend as the main driver of locational reallocation, providing new evidence for explaining the backflow of emerging market production capacity to developed countries.

5.2 Policy Implications

5.2.1 For Enterprises in Emerging Economies

For enterprises in emerging economies planning to go global, priority should be given to building a trinity O-advantage of “patents-trademarks-organization”. Overseas intellectual property should be deployed in advance during the growth period of the technology life cycle. Functional differences should be transformed into emotional premiums through brand storytelling, and cultural distance reduced through small packages and localized advertising, realizing a positive cycle of “technological leadership, mind occupation, premium locking”.

5.2.2 For Policy Makers

For host governments, improving the transparency of intellectual property enforcement and dispute settlement efficiency can significantly attract FDI in higher equity forms. Meanwhile, reducing cross-border factor flow barriers through mechanisms such as the Regional Comprehensive Economic Partnership (RCEP) helps transform market potential and cost advantages into sustainable tax revenue and industrial chain upgrading, achieving synergistic benefits of “capital introduction-talent introduction-system introduction”.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

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Negotiation Strategies for the China-US Trade War in 2025: A Perspective of Interest Balance and Cross-Cultural Conflict

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Abstract: Since Donald Trump assumed office as U.S. President in 2017, he has enshrined America First as his core governing doctrine, steering U.S. foreign strategy away from globalism toward localism and economic nationalism. Against this backdrop, the U.S. administration launched a series of trade investigations targeting China and unilaterally instigated trade frictions and an all-out trade war, citing the bilateral merchandise trade deficit as its primary justification. Set against the context of the 2025 China-US trade war, this study adopts an analytical framework rooted in international business negotiation theories-including game theory and cultural dimension theory-and incorporates real-world dynamics such as tariff adjustments, technological sanctions, and supply chain reconfiguration. Drawing on historical cases from the 2018-2024 rounds of trade tensions, this paper designs concrete negotiation strategies and conflict resolution solutions. The findings recommend strengthening US trade policy coordination and institutional cooperation, enhancing cross-cultural trade competence for enterprises in both nations, and boosting people-to-people exchanges to foster a constructive trading environment. This research aims to deliver theoretical support and practical guidance for the steady development of US trade relations and advance mutually beneficial outcomes in bilateral economic cooperation.

Keywords: China-US Trade War; Interest Balance; Cross-Cultural Conflict; Game Theory; Cultural Dimension Theory

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1. Introduction

By 2025, the China-US trade war remains intense. Tariff adjustments, intensified technological containment, and accelerated supply chain restructuring have imposed severe strains on bilateral trade relations. Amid deepening global economic integration, the trajectory of US economic ties bears heavily on both national economies and global macroeconomic stability. The successive phases of trade frictions between 2018 and 2024 featured multiple rounds of negotiations and disputes, yielding valuable experience and lessons. These historical episodes provide an empirical foundation for investigating negotiation strategies in the 2025 trade war, enabling a rigorous analysis of the origins, evolution, and countermeasures underlying bilateral trade conflicts.

2. Basic Concepts and Theoretical Foundations

2.1 Basic Concepts

2.1.1 Related Research on the China-US Trade War

Domestic scholarship on the China-US trade war has evolved into a multidisciplinary, multi-perspective body of research

covering core themes: the nature of trade conflict, U.S. motivational drivers, legal and normative foundations, differential regional and industrial impacts, and China's strategic responses. Among these, the merchandise trade imbalance is widely recognized as the immediate catalyst of the dispute, a topic long examined in academic literature.

Notably, Jiang (2020) employs the Eaton-Kortum model to examine bilateral trade structure and identifies the "paradox of anti-comparative advantage" in U.S. exports to China: U.S. sales to China are not concentrated in high-value-added sectors where the U.S. holds strong comparative advantage; moreover, sectors with stronger comparative advantage exhibit lower export shares to China relative to global totals. By contrast, China's exports to the U.S. largely align with conventional comparative advantage principles.

Liu and Zhang (2019) use empirical methods to identify a two-way causal relationship between the Sino-US merchandise trade deficit and U.S. manufacturing FDI in China, concluding that deepened international division of labor and U.S. domestic industrial restructuring constitute the fundamental causes of the deficit. Peng (2019b) further enumerates compound drivers: divergent consumption and investment structures, U.S. high-tech export controls, U.S. direct investment, and China's role as a processing-trade hub in global industrial relocation.

2.1.2 Related Research on Cross-Cultural Conflict

US business negotiations are marked by profound cultural divergence. American negotiators typically favor abstract, logic-driven analytical thinking, while Chinese negotiators lean toward holistic, relation-oriented synthetic thinking. Pre-negotiation preparation should include cultural mapping and style analysis, with remote pre-communication used to align strategies with the counterpart's cognitive patterns.

First impressions strongly shape negotiation dynamics. While Chinese negotiators often prioritize relationship-building through social interaction, this approach may clash with American preferences for directness and efficiency. Chinese hosts should therefore adapt by streamlining ceremonial protocols and moving promptly to substantive agenda items.

Cultural differences also shape contractual preferences: American negotiators often favor detailed, rule-based agreements, whereas Chinese counterparts may prefer framework-style, principle-based documents. Negotiators must maintain flexibility on contractual form while upholding fairness and enforceability to bridge such gaps.

2.2 Theoretical Foundations

In the context of the trade war, China and the U.S. function as two strategic players with distinct objectives and choice sets. Game-theoretic models, including the Prisoner's Dilemma and Nash Equilibrium, enable systematic analysis of strategic interactions over tariffs, tech sanctions, and supply chain restructuring, supporting behavioral forecasting and outcome evaluation^[1]. In tariff games, both nations face a binary choice: to impose additional duties or refrain. Mutual tariff escalation raises trade costs and damages welfare on both sides, whereas mutual restraint preserves normal trade flows and generates shared gains. Game-theoretic analysis thus clarifies payoff structures under alternative strategies, furnishing a theoretical basis for balanced negotiation design and incentivizing cooperation over confrontation to achieve joint welfare maximization^[2].

Cross-cultural conflict represents a critical, often under emphasized, variable in US trade negotiations. Cultural dimension theory highlights systematic divergences in values, communication norms, and decision-making patterns that can trigger misunderstanding, deadlock, or negotiation failure. Representing contrasting Eastern and Western systems, the U.S. emphasizes individualism, competition, and direct communication, while China prioritizes collectivism, harmony, and indirect relational dialogue^[3]. Successful negotiation therefore requires deep cultural awareness and adaptive governance. Both sides should strengthen cross-cultural training and exchanges to improve mutual understanding and communicative competence. During formal talks, negotiators should employ culturally congruent rhetoric and tactics to minimize friction, sustain a constructive atmosphere, and improve the likelihood of agreement.

3. Case Analysis

3.1 Review of the China-US Trade War (2018-2024)

In March 2018, the United States launched the China-US trade war by imposing high tariffs on imported steel and aluminum products on the grounds of "national security."^[4] Subsequently, the two sides engaged in a series of games and negotiations

in the trade field. The United States continuously raised tariffs on a wide range of Chinese products, including washing machines, solar products, steel, and aluminum. In response, China took corresponding countermeasures by imposing tariffs on selected US products such as soybeans, pork, and automobiles.

During this period, the two sides held multiple rounds of economic and trade consultations in an attempt to resolve trade disputes through negotiations. In December 2019, China and the United States reached the Phase-One Economic and Trade Agreement, which played a certain role in easing trade tensions. Nevertheless, since 2020, affected by factors such as the COVID-19 pandemic, China-US trade relations have fluctuated again. The United States imposed a series of sanctions on Chinese enterprises in the technology sector, including restricting high-tech firms such as Huawei from accessing US technologies and components, further exacerbating bilateral trade frictions.

From 2021 to 2024, China and the United States maintained a complex game in the trade arena. On the one hand, the two sides adjusted their tariff policies to some extent, reducing tariffs on certain products, yet differences remained in key areas. On the other hand, technology sanctions became increasingly prominent: the United States expanded its crackdown on Chinese high-tech enterprises, while China strengthened the protection of its core technologies and capacity for independent innovation, featuring coexistence of competition and cooperation in the technology sector between the two countries.

3.2 Negotiation Strategies and Lessons from Conflict Resolution in Historical Cases

In the China-US trade war from 2018 to 2024, both sides adopted certain negotiation strategies. China adhered to the principles of equality, mutual benefit, and good faith in negotiations, emphasizing the resolution of trade disputes through dialogue and consultation, while demonstrating firmness in tariff countermeasures to safeguard its legitimate rights and interests. The United States adopted a tough stance in negotiations, attempting to force China into concessions via tariff hikes, yet gradually recognized the negative economic impacts of the trade war on itself and began to seek dialogue and cooperation with China.

This indicates that in China-US trade war negotiations, both sides need to further strengthen communication and cooperation, explore more effective conflict resolution mechanisms, and promote the steady development of trade relations. Lessons from historical cases show that China-US trade war negotiations are a complex process requiring both parties to fully consider respective interests and cultural differences, apply flexible and diverse negotiation strategies, and strike a balance between cooperation and competition. Meanwhile, both sides should enhance dialogue and consultation, establish a long-term and stable communication mechanism, adapt to the evolving trade situation, and prevent the escalation of trade conflicts.

4. Design of Negotiation Strategies for the China-US Trade War in 2025

4.1 Negotiation Strategies Based on Interest Balance

4.1.1 Tariff Policy Negotiation Strategy

In tariff policy negotiations, China and the United States should uphold the principle of mutual benefit and win-win results, and fully recognize the positive impacts of trade liberalization on both economies. China may propose reducing tariffs on selected US products in exchange for corresponding tariff cuts by the United States on Chinese goods, so as to facilitate the normal development of bilateral trade.

In light of different product and industrial characteristics, both sides should adopt flexible tariff adjustment strategies. For high-tech products, manufactured goods, and other sectors, the two sides may negotiate phased and step-by-step tariff adjustment plans to mitigate shocks from tariff policies on their industries. Tariff policies should be adjusted timely in accordance with trade conditions and industrial development to ensure the balance of interests between the two countries.

4.1.2 Technology Sanction Negotiation Strategy

China and the United States should take strengthening intellectual property rights (IPR) protection as an important foundation for technology sanction negotiations. The two sides may reach consensus on IPR protection cooperation through negotiations, establish a joint IPR protection mechanism, and enhance protection for enterprises and innovation achievements of both countries.

On this basis, China may commit to further improving domestic laws and regulations on IPR protection and raising IPR

enforcement standards in exchange for the easing of US technology sanctions against China. In technology sanction negotiations, China may propose enhancing cooperation projects with the United States in high-tech fields, promoting technological progress through joint R&D and technology transfer. The United States may relax partial technology restrictions on Chinese high-tech enterprises, allowing normal technological cooperation and exchanges between enterprises of the two countries to advance the development of the global technology industry.

4.2 Negotiation Strategies Based on Cross-Cultural Conflict Resolution

4.2.1 Cultural Communication and Exchange Strategy

Before negotiations, both sides should organize cross-cultural training and education for relevant personnel to improve the negotiation team's understanding of each others culture. Such training enables negotiators to grasp differences in values, communication styles, and decision-making models between China and the United States, master cross-cultural communication skills, and avoid misunderstandings and conflicts caused by cultural gaps .

During negotiations, both sides may hold cultural exchange activities to enhance mutual cultural understanding and recognition. In a relaxed atmosphere, negotiators can learn about each others cultural customs and values, eliminate cultural barriers, and create a favorable cultural environment for negotiations.

4.2.2 Negotiation Style and Skill Adaptation Strategy

During negotiations, both sides should adjust their communication styles in response to each others communication characteristics. US negotiators tend to be direct and forthright, explicitly stating views and demands at the negotiation table. In contrast, Chinese negotiators prefer indirect communication, expressing opinions through hints and euphemisms.

Therefore, US negotiators should appropriately slow down their speech pace when communicating with Chinese counterparts, pay attention to non-verbal cues, and understand implied meanings. Chinese negotiators may increase directness to clearly state positions and demands, improving communication efficiency and avoiding misunderstandings.

5. Countermeasures and Suggestions

5.1 Strengthening the Construction of China-US Trade Policy Coordination and Cooperation Mechanisms

China and the United States should hold regular high-level economic and trade dialogues to conduct candid communication on trade policy adjustments, tariff measures, technology trade, and other issues, resolve trade disputes in a timely manner, and prevent the escalation of trade conflicts. Through regular communication mechanisms, both sides can enhance mutual understanding and trust in each others trade policies, laying a foundation for the steady development of trade relations.

China and the United States should jointly promote the establishment of a multilateral trade cooperation framework to provide a more stable and predictable institutional environment for bilateral trade cooperation. Within the multilateral framework, the two sides may conduct in-depth consultations on market access, trade rules, IPR protection, and other issues, formulate fair and reasonable trade rules, and facilitate the long-term and stable development of China-US trade.

5.2 Enhancing Cross-Cultural Trade Cooperation Capacity of Chinese and US Enterprises

Chinese and US enterprises should strengthen cross-cultural training and exchanges to improve employees' cross-cultural awareness and communication skills. Through internal training, external expert lectures, cultural exchange activities, and other means, employees can understand China-US cultural differences, master cross-cultural communication skills, and strengthen corporate competitiveness in cross-cultural trade environments.

Regular cross-cultural training courses should be organized, with Chinese and US cultural experts invited to deliver lectures and share successful cases of cross-cultural trade, so as to improve employees' cross-cultural literacy. Chinese and US enterprises should actively explore cross-cultural cooperation models, such as joint ventures and strategic alliances, to achieve complementary advantages and jointly explore international markets. In cross-cultural cooperation, enterprises should focus on cultural integration and management innovation, establish effective cross-cultural management mechanisms, reconcile differences in corporate culture, management models, and business philosophies, and ensure smooth cooperation.

5.3 Strengthening China-US People-to-People Exchanges and Cooperation to Foster a Sound Trade Atmosphere

China and the United States should encourage and support extensive exchanges and cooperation among non-governmental cultural groups, academic institutions, social organizations, and other sectors. By holding cultural and art exhibitions, academic seminars, people-to-people friendship activities, and other events, mutual understanding and friendship between the two peoples can be enhanced, fostering a favorable social atmosphere for the development of China-US trade relations.

China and the United States should encourage and support economic cooperation and exchanges among non-governmental enterprises, chambers of commerce, and other entities. Through trade and investment fairs, enterprise matchmaking events, entrepreneurship competitions, and other activities, cooperation opportunities for non-governmental enterprises can be provided, promoting bilateral cooperation and development in trade, investment, innovation, and other fields.

6. Conclusions and Prospects

6.1 Research Conclusions

Based on the China-US trade war in 2025, this paper analyzes negotiation strategies from the perspectives of interest balance and cross-cultural conflict. By applying international business negotiation theories such as game theory and cultural dimension theory, combined with practical issues including tariff policies, technology sanctions, and supply chain restructuring, this study provides strong theoretical support for China-US trade negotiations.

Meanwhile, drawing on lessons from the 2018-2024 China-US trade war, the optimized negotiation strategies help promote the steady development of China-US trade relations. In terms of interest balance, China and the United States should seek win-win solutions on key issues such as tariff policies, technology sanctions, and supply chain restructuring, and maximize mutual interests through flexible negotiation strategies and effective communication and coordination mechanisms.

In terms of cross-cultural conflict resolution, both sides should strengthen cultural communication and exchanges, adapt to each others negotiation styles and skills, create a favorable negotiation cultural atmosphere, and reduce the negative impacts of cultural differences on negotiations. Furthermore, countermeasures are proposed to strengthen China-US trade policy coordination and cooperation mechanisms, cross-cultural trade cooperation capacity of enterprises, and people-to-people exchanges and cooperation. Implementation of these measures will enhance mutual trust and cooperation in the trade field, laying a solid foundation for the long-term and stable development of China-US trade.

6.2 Future Prospects

With the continuous evolution of the global economic landscape and the sustained development of the Chinese and US economies, China-US trade relations will face new opportunities and challenges. In the future, China and the United States should continue to strengthen dialogue and consultation, deepen trade cooperation, jointly address new issues such as global trade protectionism, climate change, and the digital economy, and push China-US trade relations to a higher level.

In terms of trade negotiation strategies, both sides should continuously innovate and improve strategies, fully consider the impacts of emerging technologies and global industrial chain restructuring on trade negotiations, and enhance the scientificity and effectiveness of negotiations. Meanwhile, the two sides should strengthen cooperation and coordination in formulating international economic rules, jointly promote the establishment of a more fair, reasonable, and inclusive global economic governance system, and create a favorable international environment for the steady development of China-US trade relations.

In the long run, as the world's two largest economies, China and the United States should commit to building a new type of major-country relationship, transcend the traditional zero-sum game mindset, and seek cooperation and win-win results in multiple fields including trade, investment, science and technology, and the environment.

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Digital-Intelligent Technology Empowerment and the Integrated Development of Education, Science and Technology, and Talent in Zhejiang Province: A Mechanism-Based Study

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Abstract: With the deepening of the new round of scientific and technological revolution and industrial transformation, digital-intelligent technologies such as artificial intelligence, big data and cloud computing are profoundly reshaping the way the economy and society operate, while continuously advancing the deep integration of education, science and technology, and talent. The Report to the 20th National Congress of the Communist Party of China states that education, science and technology, and talent are foundational and strategic pillars for building a modern socialist country in all respects; coordinated advancement of this “trinity” has therefore become an important strategic requirement of Chinese modernization. At present, Zhejiang still faces problems such as insufficient data sharing, inadequate multi-actor coordination, and weak alignment between the education chain and the industrial chain, which to some extent constrains the deep integration of education, science and technology, and talent. Empowering their integrated development with digital-intelligent technologies is not only an important component of Digital China, but also a practical requirement for promoting high-quality regional development. From the perspective of digital-intelligent technology empowerment, this paper analyzes the integrated development of education, science and technology, and talent in Zhejiang, with a focus on how platform connectivity, data sharing, collaborative innovation and intelligent governance promote coordinated development among the education chain, innovation chain, industrial chain and talent chain.

Keywords: Digital-Intelligent Technologies; Educational Technology Talents; Coordinated Development; Zhejiang Practice

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1. Introduction

In recent years, relying on the construction of “Digital Zhejiang”, Zhejiang has built a strong development foundation in areas such as the digital economy, digital government, smart education and the artificial intelligence industry. The scale of Zhejiang’s core digital-economy industries has continued to expand; major platforms such as the Hangzhou City Brain, Zhejiang Lab and the West Hangzhou Science and Technology Innovation Corridor have continued to advance; and the artificial intelligence industry represented by DeepSeek has developed rapidly. As a result, the integration of digital technologies with educational governance, scientific and technological innovation, and talent cultivation has continued to

deepen^[1]. Meanwhile, Zhejiang has steadily advanced educational digitalization reform and the construction of its science and technology innovation system, gradually fostering closer coordination among the education chain, innovation chain, industrial chain and talent chain. Digital-intelligent technologies have become an important driving force for high-quality regional development.

At the same time, however, the integrated development of education, science and technology, and talent in Zhejiang still faces practical obstacles. On the one hand, education, science and technology, industry, and talent resources are distributed across different departments and platforms, while substantive platform connectivity and data-feedback mechanisms remain insufficient. On the other hand, the alignment between university research outcomes and real industrial demand remains weak, and there is still room to improve the efficiency with which scientific and technological achievements are transformed into talent cultivation and industrial applications. As artificial intelligence, big data and other technologies are being applied at a faster pace, issues such as data security, algorithmic norms and rules for intelligent governance have also become more prominent. How to use digital-intelligent technologies to improve resource integration, strengthen data transformation capacity, deepen multi-actor collaborative innovation and improve risk-governance mechanisms has become an important issue for Zhejiang in promoting the integrated development of education, science and technology, and talent.

2. Literature Review

The rapid development of digital-intelligent technologies, including artificial intelligence, big data and cloud computing, is continuously transforming the modes of resource allocation, organizational coordination and governance operation^[3]. Particularly in the context of Digital China, digital platforms, data governance and artificial intelligence technologies have become deeply embedded in educational governance, scientific and technological innovation and talent-development systems, while the interaction among the education chain, innovation chain, industrial chain and talent chain has been further strengthened.

Existing studies mainly discuss the topic from the perspectives of collaborative innovation, digital transformation and educational digitalization. The Triple Helix theory holds that, in the knowledge-economy era, innovation increasingly depends on dynamic coordination among government, universities and enterprises, and that the traditional linear innovation model is gradually being replaced by a networked innovation structure^[2]. Etzkowitz subsequently further pointed out that universities are no longer merely traditional institutions for talent cultivation, but are increasingly becoming important actors in scientific and technological innovation^[1]. This indicates that education, science and technology, and talent have begun to form a coordinated operating structure. Later studies have found that digital platforms and data governance are changing traditional coordination models. Vial argues that digital transformation does not simply mean technological upgrading; rather, digital technologies drive systemic changes in organizational structures, governance logic and value-creation modes, with resource allocation shifting from traditional administrative allocation toward platform-based and data-driven allocation^[3]. At the same time, artificial intelligence has become further embedded in educational governance and talent-cultivation systems. Relevant studies suggest that AI technologies are changing the allocation of educational resources and the structure of educational governance^[4], and that their application in higher education has expanded from learning support to research collaboration, talent profiling and educational decision-making^[5]. This shows that digital-intelligent technologies are no longer merely educational tools; they have become an important force for advancing the coordinated development of education, science and technology, and talent.

Compared with international research, domestic studies pay greater attention to the practical issues of educational digitalization, digital governance and the coordinated development of education, science and technology, and talent. Zuo Chongliang argues that education, science and technology, and talent have formed a clear interactive relationship, and that universities are gradually becoming important components of the national innovation system^[9]. Hu Hang and Yang Lin also point out that digitalization and intelligentization are driving the coordination model of education, science and technology, and talent to shift from traditional administrative promotion toward intelligent coordination^[8]. In the field of educational digitalization, existing research mainly focuses on smart education, platform governance and data-driven governance^[7]. Studies on digitally empowered governance further indicate that digital platforms and data connectivity are promoting a

transformation in governance structures from traditional departmental governance toward holistic governance^[11].

Overall, existing research has formed a foundation in areas such as collaborative innovation, digital governance and educational digitalization, but certain deficiencies remain. Most current studies focus on a single field, while research on how digital-intelligent technologies promote the integrated development of education, science and technology, and talent through mechanisms such as platform connectivity, data sharing, collaborative innovation and intelligent governance remains relatively insufficient. Mechanism-oriented research that is grounded in Zhejiang's practice of digital reform is also lacking.

3. Coordinated Mechanisms through Which Digital-Intelligent Technologies Empower the Integrated Development of Education, Science and Technology, and Talent in Zhejiang

Using digital-intelligent technologies to promote the integrated development of education, science and technology, and talent is not a matter of simply applying technology to a single field. Rather, it requires strengthening the links among the education chain, innovation chain, industrial chain and talent chain through digital platforms, data sharing, artificial intelligence, algorithmic models and other technological means^[10]. In the past, the education system, the science and technology innovation system and the talent-development system were characterized by dispersed resources, weak information connectivity and low coordination efficiency, making it easy for disjunctions to arise among talent cultivation, scientific and technological innovation and industrial demand. The development of digital-intelligent technologies has changed the modes of interaction among different actors and has also promoted the sharing and integration of education, science and technology, industry and talent resources on a broader scale, thereby improving overall coordination efficiency.

Specifically, digital-intelligent technologies promote the integrated development of education, science and technology, and talent in Zhejiang mainly through four mechanisms: platform connectivity, data-driven coordination, collaborative innovation and intelligent governance. Based on this logic, this paper constructs a mechanism transmission diagram for digital-intelligent technologies empowering the integrated development of education, science and technology, and talent in Zhejiang, as shown in Figure 3-1.

3.1 Platform Connectivity Mechanism

Traditional education, research and industrial systems have long lacked stable information-exchange mechanisms. Universities mainly undertake talent-cultivation tasks, research institutions focus on technology research and development, while enterprises place greater emphasis on industrial application and market demand^[2]. Because information flows inefficiently among different actors, universities find it difficult to grasp industrial technological changes in a timely manner, and enterprises also struggle to participate deeply in research collaboration and talent cultivation. As a result, gaps easily emerge among education and training, scientific and technological innovation and industrial demand, while the efficiency of transforming research outcomes is also constrained to a certain extent.

Platforms serve as information channels that connect education, science and technology, and talent collaboration. The construction of digital platforms promotes interconnection among educational platforms, research platforms and industrial platforms. Enterprises' technological needs can enter university curricula and research processes more quickly, while university research outcomes can enter industrial application scenarios in a more timely manner^[3]. Research institutions can also use platforms to share educational resources and industrial data, significantly shortening the information-transmission chain among different actors and further strengthening the coordinated relationship among education, science and technology, and talent.

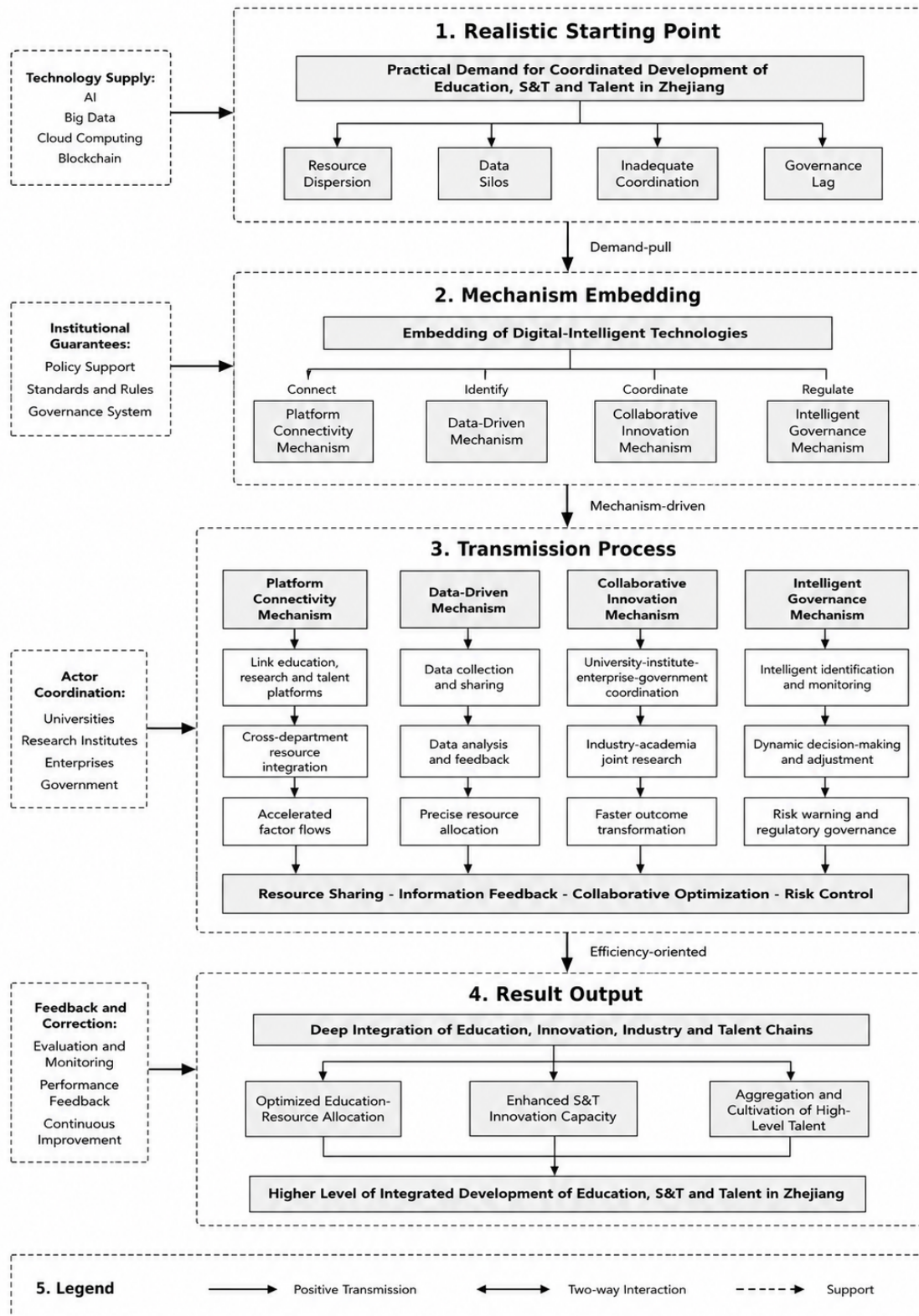
3.2 Data-Driven Mechanism

Traditional educational and scientific governance relies on experiential judgment, and changes in industrial demand are often difficult to feed back promptly into education and research systems^[4]. There is a lack of real-time feedback mechanisms among university program adjustment, research-direction planning and talent-policy formulation. Consequently, the structure of talent cultivation can easily become misaligned with industrial demand, and the efficiency of educational-resource allocation remains relatively limited.

Through the extensive application of artificial intelligence, big data and algorithmic technologies, the speed of information

transmission among the education system, the science and technology innovation system and the industrial system can be significantly improved. Universities can adjust their program structures according to employment data and changes in industrial demand, while research platforms can identify technological hotspots and innovation directions through data analysis^[5]. At the same time, enterprises' talent-demand information can more rapidly enter university curriculum reform and research collaboration processes.

Figure1: Mechanism Transmission Diagram of Digital-Intelligent Technologies Empowering the Integrated Development of Education, Science and Technology, and Talent in Zhejiang



3.3 Collaborative Innovation Mechanism

In the past, innovation activities were mostly promoted independently by universities, research institutions or enterprises, and the depth of cooperation among different actors was relatively limited^[6]. Universities placed greater emphasis on theoretical research, while enterprises paid more attention to practical application. Therefore, the cycle for transforming research outcomes was relatively long, and talent cultivation was prone to becoming disconnected from industrial demand.

After the rapid development of the digital economy and the artificial intelligence industry, scientific and technological innovation has created an increasing demand for multi-actor coordination. Enterprises have begun to participate more deeply in university research and talent-cultivation processes, while universities can acquire industrial technology needs and market-change information in a timelier manner^[7]. The development of university-enterprise joint laboratories, industrial colleges and collaborative R&D platforms has further strengthened resource linkages among universities, research institutions and enterprises. Industrial demand can directly enter the research and talent-cultivation processes, while university research outcomes can enter industrial application scenarios more quickly.

3.4 Intelligent Governance Mechanism

As the connections among educational governance, science and technology governance and talent governance continue to strengthen, traditional hierarchical governance models have become increasingly unable to meet the operational needs of complex coordination systems^[8]. In the past, information feedback among different governance actors was relatively slow, and resource adjustment relied heavily on manual management, resulting in limited overall coordination efficiency.

With the promotion of digital-intelligent technologies, the information-linkage capacity among educational governance, science and technology governance and talent governance has been significantly enhanced. The government can use digital platforms to coordinate educational, research and talent resources; universities can obtain industrial and policy information in a timelier manner; and enterprises can participate more directly in research collaboration and talent governance^[9]. Coordination among educational-resource allocation, research management and talent services has also continued to improve. Industrial demand can be fed back more quickly into the education system and the science and technology innovation system, and the efficiency of information linkage among different governance actors has accordingly increased.

4. Measurement Design for the Support Level of Digital-Intelligent Technology Empowerment Mechanisms

4.1 Measurement Indicator System

Focusing on the four mechanisms of platform connectivity, data-driven coordination, collaborative innovation and intelligent governance, this paper constructs a measurement system for the mechanism-support level of the integrated development of education, science and technology, and talent in Zhejiang. The purpose is to observe, from a data perspective, the practical foundation and operational intensity of digital-intelligent technology empowerment mechanisms. The system includes four first-level indicators, eight second-level indicators and sixteen third-level indicators. The specific indicators, calculation methods, indicator attributes and data sources are shown in Table 1.

Table 1: Measurement Indicator System for Digital-Intelligent Technology Empowerment Mechanisms in the Integrated Development of Education, Science and Technology, and Talent in Zhejiang

First-level Indicator	Second-level Indicator	Third-level Indicator	Attribute	Data Source
Platform Connectivity Mechanism	Network Access Foundation	Number of fixed broadband Internet access users	Positive	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook
		Mobile Internet access traffic	Positive	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook
	Resource Carrying Pressure	Student-teacher ratio in regular higher education institutions	Negative	Zhejiang Statistical Yearbook
		Urban registered unemployment rate	Negative	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook

First-level Indicator	Second-level Indicator	Third-level Indicator	Attribute	Data Source
Data-Driven Mechanism	Digital Industry Foundation	Added value of core digital-economy industries	Positive	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook; provincial public digital-economy data
		Added value of information transmission, software and information technology services	Positive	Zhejiang Statistical Yearbook
	Digital Application Diffusion	Online retail sales of physical goods	Positive	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook; provincial e-commerce public data
		Express delivery volume	Positive	Zhejiang Statistical Communiques; Zhejiang Statistical Yearbook; postal administration public data
Collaborative Innovation Mechanism	Innovation Input Capacity	R&D expenditure	Positive	National Bureau of Statistics; National Statistical Communique on R&D Expenditure; Zhejiang Statistical Yearbook
		R&D intensity	Positive	National Bureau of Statistics; National Statistical Communique on R&D Expenditure; Zhejiang Statistical Yearbook
	Innovation Transformation Pressure	R&D input per patent authorization	Negative	Zhejiang Statistical Yearbook; CNIPA; Zhejiang Intellectual Property Administration public data
		R&D input per invention patent authorization	Negative	Zhejiang Statistical Yearbook; CNIPA; Zhejiang Intellectual Property Administration public data
Intelligent Governance Mechanism	Governance Actor Carrying Capacity	Cumulative number of valid high-tech enterprises	Positive	Zhejiang Provincial Department of Science and Technology and relevant annual public data
		Asset-liability ratio of industrial enterprises above designated size	Negative	Zhejiang Statistical Yearbook
	Institutional Supply Capacity	Number of national enterprise technology centers	Positive	Zhejiang Provincial Development and Reform Commission, economic and information departments, and national enterprise technology center lists
		Cost per RMB 100 of operating revenue of industrial enterprises above designated size	Negative	Zhejiang Statistical Yearbook

4.2 Measurement Method

After constructing the indicator system, this paper further adopts range standardization, the entropy weight method and the linear weighted method to measure the support level of Zhejiang’s digital-intelligent technology empowerment mechanisms. Through these treatments, indicators of different types and units can be transformed into comparable data results, thereby providing a basis for the subsequent assessment of operational differences and weak links among the four mechanisms.

4.2.1 Data standardization:

(1)Formula for standardizing positive indicators:

$$X'_{ij} = \frac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}} \times 0.99 + 0.01$$

(2)Formula for standardizing negative indicators:

$$X'_{ij} = \frac{X_{\max} - X_{ij}}{X_{\max} - X_{\min}} \times 0.99 + 0.01$$

4.2.2 Determining indicator weights by the entropy weight method:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^m r_{ij}}$$

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij} \ln p_{ij}$$

$$g_j = 1 - e_j$$

$$w_j = \frac{g_j}{\sum_{j=1}^n g_j}$$

4.2.3 Building the comprehensive evaluation model based on the linear weighted method:

$$y_i = \sum_{j=1}^n w_j \cdot r_{ij}$$

4.3 Descriptive Statistics

From 2015 to 2024, the relevant indicators for digital-intelligent technologies empowering the integrated development of education, science and technology, and talent in Zhejiang generally show a sound growth foundation. Zhejiang’s digital infrastructure has reached a certain scale, and its network access and carrying capacity have continued to improve. The average number of fixed broadband Internet access users is 28.202 million, and mobile Internet access traffic increased from 620 million GB to 18.670 billion GB. However, pressure on educational-resource carrying capacity and talent matching still requires attention. According to the data, the average student-teacher ratio in regular higher education institutions is 17.04, and the average urban registered unemployment rate is 2.58%. Meanwhile, Zhejiang’s digital-industry foundation and digital-application scenarios have continued to expand. The average added value of core digital-economy industries is RMB 745.119 billion; the average added value of information transmission, software and information technology services is RMB 345.200 billion; online retail sales of physical goods average RMB 1,531.150 billion; and express delivery volume averages 16.207 billion pieces. Zhejiang has also maintained a relatively high level of investment in scientific and technological innovation. Its average R&D expenditure is RMB 184.996 billion, with a maximum of RMB 290.140 billion, and its average R&D intensity is 2.74%. However, average R&D input per 10,000 patent authorizations is RMB 5.524 billion, and average R&D input per 10,000 invention patent authorizations is RMB 41.347 billion, indicating that pressure remains in transforming innovation input into innovation output. The scale of Zhejiang’s innovation actors is continuing to expand: the average number of valid high-tech enterprises is 23,547.40, the average number of national enterprise technology centers is 125.90, the average asset-liability ratio of industrial enterprises above designated size is 54.45%, and the average cost per RMB 100 of operating revenue is RMB 84.84. Nevertheless, enterprise operating pressure and governance-operation pressure still need to be further alleviated. Overall, Zhejiang already has a strong practical foundation for digital-intelligent technologies to empower the integrated development of education, science and technology, and talent. However, educational-resource carrying capacity, talent matching, innovation-transformation efficiency and industrial operating pressure remain key areas for subsequent mechanism optimization

Table2: Descriptive Statistics

Variable	Mean	SD	Min	p25	p50	p75	Max
Fixed broadband Internet access users (10,000 households)	2820.20	731.15	1316.00	2510.75	2860.50	3329.25	3767.00
Mobile Internet access traffic (100 million GB)	94.13	71.14	6.20	30.65	89.05	156.53	186.70

Variable	Mean	SD	Min	p25	p50	p75	Max
Student-teacher ratio in regular HEIs (students/teacher)	17.04	0.53	16.47	16.59	16.91	17.41	17.95
Urban registered unemployment rate (%)	2.58	0.14	2.38	2.48	2.58	2.67	2.82
Added value of core digital-economy industries (RMB 100 million)	7451.19	2081.59	4680.00	5930.00	7094.95	8819.75	11060.00
Added value of information transmission, software and IT services (RMB 100 million)	3452.00	1217.14	1850.00	2470.00	3320.00	4427.50	5320.00
Online retail sales of physical goods (RMB 100 million)	15311.50	3914.82	7611.00	13751.75	16376.50	17742.25	20210.00
Express delivery volume (100 million pieces)	162.07	96.01	38.30	84.50	150.25	228.75	322.00
R&D expenditure (RMB 100 million)	1849.96	658.59	1011.20	1311.15	1764.85	2352.03	2901.40
R&D intensity (%)	2.74	0.35	2.36	2.44	2.62	3.07	3.22
R&D input per patent authorization (RMB 100 million/10,000 patents)	55.24	9.65	43.03	48.27	52.80	59.02	72.35
R&D input per invention patent authorization (RMB 100 million/10,000 patents)	413.47	37.41	371.97	382.96	409.46	435.23	491.12
Cumulative valid high-tech enterprises (enterprises)	23547.40	14154.26	7905.00	12258.75	19237.00	33708.75	47500.00
Asset-liability ratio of industrial enterprises above designated size (%)	54.45	0.84	53.10	53.85	54.35	55.05	55.80
National enterprise technology centers (centers)	125.90	15.49	105.00	113.50	126.00	135.75	152.00
Cost per RMB 100 operating revenue of industrial enterprises above designated size (RMB)	84.84	0.30	84.40	84.62	84.85	85.05	85.30

5. Analysis of the Support Level and Weak Links of Digital-Intelligent Technology Empowerment Mechanisms

5.1 Analysis of Mechanism Weight Results

The weight results show that the intelligent governance mechanism has the highest weight, totaling 0.2702. This indicates that governance-actor carrying capacity, industrial operating pressure and institutional supply capacity have an important impact on digital-intelligent technologies empowering the integrated development of education, science and technology, and talent in Zhejiang. It is followed by the collaborative innovation mechanism, with a total weight of 0.2593. In this mechanism, R&D input per patent authorization and R&D input per invention patent authorization indicate that pressure remains in Zhejiang's innovation transformation. The data-driven mechanism ranks next, with a total weight of 0.2541, showing that the digital-industry foundation and the diffusion of digital applications provide strong support for mechanism operation. The platform connectivity mechanism ranks last, with a total weight of 0.2163. Platform foundations, educational-resource carrying capacity and talent-matching pressure jointly affect resource-connection efficiency. These results indicate that Zhejiang needs to further alleviate pressure on innovation transformation, enterprise operations and talent matching, so that digital-intelligent technologies can better serve the integrated development of education, science and technology, and talent.

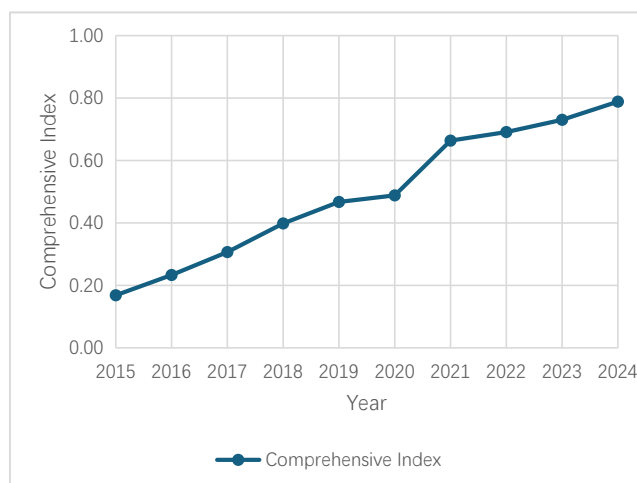
Table3: Indicator Weight Results Based on the Entropy Weight Method

First-level Indicator	Second-level Indicator	Third-level Indicator	Weight
Platform Connectivity Mechanism	Network Access Foundation	Fixed broadband Internet access users (10,000 households)	0.0356
		Mobile Internet access traffic (100 million GB)	0.0847
	Resource Carrying Pressure	Student-teacher ratio in regular HEIs (students/teacher)	0.0499
		Urban registered unemployment rate (%)	0.0461
Data-Driven Mechanism	Digital Industry Foundation	Added value of core digital-economy industries (RMB 100 million)	0.0686
		Added value of information transmission, software and IT services (RMB 100 million)	0.0722
	Digital Application Diffusion	Online retail sales of physical goods (RMB 100 million)	0.0394
		Express delivery volume (100 million pieces)	0.0739
Collaborative Innovation Mechanism	Innovation Input Capacity	R&D expenditure (RMB 100 million)	0.0759
		R&D intensity (%)	0.1008
	Innovation Transformation Pressure	R&D input per patent authorization (RMB 100 million/10,000 patents)	0.0473
		R&D input per invention patent authorization (RMB 100 million/10,000 patents)	0.0353
Intelligent Governance Mechanism	Governance Actor Carrying Capacity	Cumulative valid high-tech enterprises (enterprises)	0.0944
		Asset-liability ratio of industrial enterprises above designated size (%)	0.0518
	Institutional Supply Capacity	National enterprise technology centers (centers)	0.0675
		Cost per RMB 100 operating revenue of industrial enterprises above designated size (RMB)	0.0565

5.2 Analysis of the Comprehensive Index

From 2015 to 2024, the comprehensive index of digital-intelligent technologies empowering the integrated development of education, science and technology, and talent in Zhejiang generally showed a continuous upward trend. From 2015 to 2020, the basic conditions for digital-intelligent technology empowerment in Zhejiang gradually took shape, and the comprehensive index rose steadily from 0.1684 in 2015 to 0.4883 in 2020. After 2021, the index increased at a faster pace, the comprehensive effects of the various mechanisms were further strengthened, and the index reached 0.7886 in 2024, representing a notable overall improvement. The continuous rise of the comprehensive index shows that Zhejiang has moved from the earlier stage of digital infrastructure construction into a stage characterized by mechanism coordination and capacity enhancement.

Figure2: Changes in the Comprehensive Index from 2015 to 2024



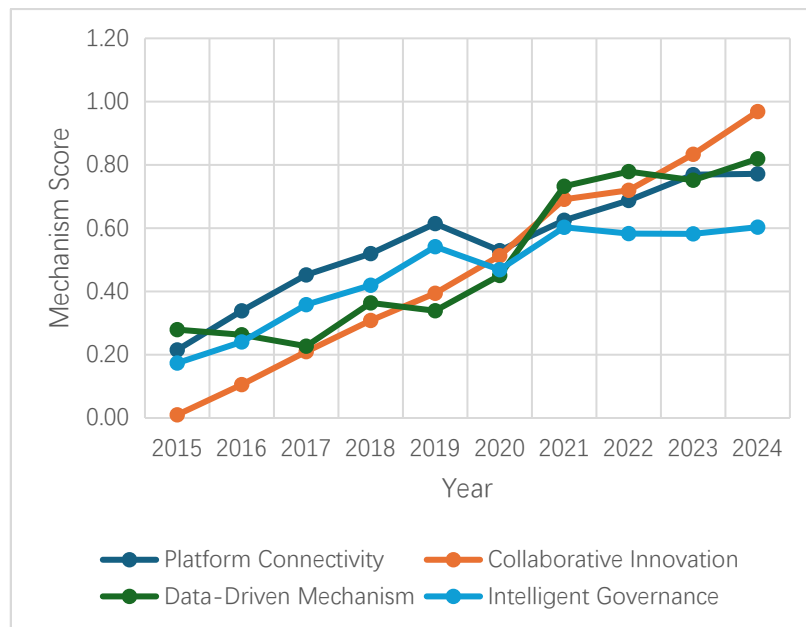
5.3 Analysis of the Support Levels of the Four Mechanisms

As shown in Figure 5-4, the support levels of the four mechanisms have all increased over the past decade, indicating that platform connectivity, data-driven coordination, collaborative innovation and intelligent governance have continuously strengthened their support for integrated development. In 2024, the platform connectivity mechanism scored 0.7717, the data-driven mechanism scored 0.9686, the collaborative innovation mechanism scored 0.8193, and the intelligent governance mechanism scored 0.6032. Overall, the gaps among the four mechanisms have gradually narrowed, and Zhejiang already has a solid comprehensive foundation for the integrated development of education, science and technology, and talent empowered by digital-intelligent technologies.

Specifically, the platform connectivity mechanism improved relatively early, reflecting Zhejiang’s strong foundation in network access and platform carrying capacity. Nevertheless, indicators such as the student-teacher ratio in regular higher education institutions and the urban registered unemployment rate also suggest that educational-resource carrying capacity and talent matching still need to be optimized. The data-driven mechanism maintained an overall upward trend, indicating the continuous expansion of the digital-industry foundation and digital-application scenarios. However, improvement in the data-driven mechanism does not mean that data have been fully utilized; functional departments still need to strengthen data sharing and feedback. The collaborative innovation mechanism also continued to improve, while data on R&D input per patent authorization and per invention patent authorization show that pressure remains in transforming research input into innovation output. The intelligent governance mechanism improved more rapidly in the later period, reflecting the continuous strengthening of actor support from high-tech enterprises and enterprise technology centers. However, enterprise operating pressure and governance-adjustment pressure still require attention.

Therefore, future practical pathways should, on the basis of continuing to enhance collaborative innovation capacity, further improve data sharing, substantive platform connectivity and intelligent-governance rules. At the same time, attention should be paid to educational-resource carrying capacity, talent matching, innovation-transformation efficiency and enterprise operating pressure, so as to promote the four mechanisms to shift from “basic strengthening” toward “coordinated efficiency enhancement”.

Figure3: Changes in the Support Levels of the Four Mechanisms from 2015 to 2024



6. Practical Pathways for Digital-Intelligent Technologies to Empower the Integrated Development of Education, Science and Technology, and Talent in Zhejiang

At present, Zhejiang still faces problems such as insufficient depth of collaborative innovation, inadequate data sharing and feedback, the need to further strengthen substantive platform connectivity, and the need to improve rules for intelligent

governance. In the future, Zhejiang should further leverage digital-intelligent technologies in resource integration, data transformation, collaborative innovation and risk governance. Specifically, it should improve practical pathways in four respects: platform connectivity, data sharing, collaborative innovation and intelligent governance, thereby promoting the deep integration of the education chain, innovation chain, industrial chain and talent chain.

6.1 Improving the Platform Connectivity System to Promote Coordinated Integration of Education, Science and Technology, and Talent Resources

Platform connectivity is the basic prerequisite for digital-intelligent technologies to empower the integrated development of education, science and technology, and talent. Under the traditional governance model, education platforms, research platforms and talent-service platforms often operate independently. The lack of a unified connectivity mechanism among different departments can easily lead to problems such as resource dispersion, information barriers and insufficient coordination efficiency. With the continuous advancement of digital reform, digital platforms have gradually become important carriers of resource integration and collaborative governance^[2].

The key to platform connectivity lies in using a unified platform system to promote the optimization of the governance structure. At present, platforms such as Zheli Ban, Zhejiang Government DingTalk and the Hangzhou City Brain have formed a certain foundation for digital governance. However, education governance, science and technology governance and talent governance still face some degree of platform fragmentation. Zhejiang should continue to improve its unified platform system by unifying data standards, optimizing platform interfaces and improving platform operating mechanisms, thereby continuously strengthening the coordinated allocation capacity among educational, scientific and technological, and talent resources^[3]. At the same time, universities, research institutions, enterprises and the government also need to rely on digital platforms to establish long-term coordination mechanisms that promote the coordinated operation of education, science and technology, and talent.

6.2 Improving the Data-Sharing Mechanism to Enhance the Allocation Efficiency of Education, Science and Technology, and Talent Resources

Data sharing is a core support for promoting the coordinated development of education, science and technology, and talent. Although Zhejiang has already developed strong digital-governance capacity, certain data barriers still exist among different departments and platforms. Some data resources have not yet achieved effective connectivity, making it difficult to form precise matching relationships among education and training, scientific and technological innovation and industrial demand. Improving data-sharing capacity requires promoting a shift in resource allocation from traditional experience-driven approaches toward data-driven approaches. Zhejiang should strengthen public-data openness and data-resource integration, and continuously improve data development and utilization capacity through artificial intelligence, big-data analysis and intelligent algorithms^[5]. Specifically, universities can use industrial data analysis to dynamically adjust program structures and talent-cultivation plans; research institutions can rely on data connectivity to optimize research directions and pathways for achievement transformation; and the government can use data analysis to improve the precision of talent policies and resource allocation. Meanwhile, universities, research institutions and enterprises should strengthen data coordination and resource sharing, so as to achieve coordinated connectivity among educational data, research data and industrial data and improve resource-allocation efficiency as well as collaborative-governance capacity.

6.3 Deepening the Construction of a Collaborative Innovation System to Promote Deep Integration of the Education Chain and the Industrial Chain

Collaborative innovation is a key pathway for promoting the integrated development of education, science and technology, and talent. Zhejiang has already formed a collaborative innovation system represented by Zhejiang Lab, the West Hangzhou Science and Technology Innovation Corridor and artificial intelligence industrial clusters. However, some university-enterprise cooperation still remains at the level of project collaboration, and a stable coordination structure among the education chain, innovation chain and industrial chain has not yet truly taken shape.

The focus of constructing a collaborative innovation system is to create a coordinated linkage mechanism among education and training, scientific and technological innovation and industrial application. Universities need to dynamically optimize

their program structures and curriculum systems in light of the development needs of emerging industries such as the digital economy, artificial intelligence and intelligent manufacturing, and strengthen the cultivation of interdisciplinary digital talent^[6]. At the same time, enterprises need to participate more deeply in talent cultivation and research collaboration, gradually forming a coordinated development model of “education and training - scientific and technological innovation - industrial application”. Through platform connectivity, resource sharing and joint research and development, relevant functional departments can form a stable innovation ecosystem, thereby continuously improving regional innovation capacity and the quality of talent cultivation.

6.4 Improving the Intelligent Governance System to Enhance Coordinated Governance Capacity for Education, Science and Technology, and Talent

Intelligent governance is an important guarantee for digital-intelligent technologies to empower the coordinated development of education, science and technology, and talent. At present, artificial intelligence technologies have been widely applied in areas such as educational evaluation, research management and talent services. However, problems including data security, algorithmic bias and the digital divide have also gradually emerged. Therefore, Zhejiang needs to continue improving systems for data security, privacy protection and algorithmic regulation, and strengthen the construction of digital-governance institutions^[8].

The construction of an intelligent governance system aims to promote a shift in governance models from traditional departmental governance toward holistic governance^[12]. On the one hand, Zhejiang needs to strengthen the security governance of educational data, research data and talent data, improve standards for data collection, storage and use, and prevent data leakage and information-security risks. On the other hand, it also needs to strengthen algorithmic ethics governance, promote the standardized application of artificial intelligence technologies, and avoid algorithmic bias and digital-divide problems^[9]. At the same time, Zhejiang should continue to improve digital-governance capacity and digital literacy, so that educational governance, science and technology governance and talent governance become fairer, more transparent and more intelligent.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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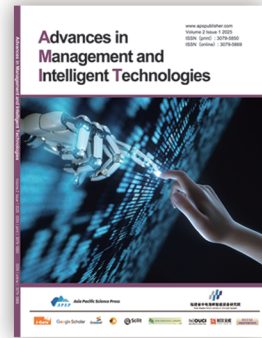
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