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China's International Cooperation in Cultural Heritage Conservation: An Actor–Network Analysis of the Ta Keo Temple Restoration Project in Cambodia

Yiming Dou[1], Tianqi Lou[2]*

[1] School of Asian Studies, Beijing Foreign Studies University, Beijing, 100089, China, douyiming2022@bfsu.edu.cn

[2] School of Asian Studies, Beijing Foreign Studies University, Beijing, 100089, China, 202220108115@bfsu.edu.cn

***Corresponding author, E-mail: 202220108115@bfsu.edu.cn**

Abstract

In recent decades, cultural heritage conservation has increasingly become an important field of international cooperation. Within this context, China has gradually expanded its participation in overseas heritage conservation initiatives and has developed a distinctive model of international collaboration. Among these initiatives, China's long-term involvement in the conservation of the Angkor monuments in Cambodia represents one of the most representative cases of international heritage cooperation. Taking the restoration project of Ta Keo Temple at Angkor as a case study, this article employs Actor-Network Theory (ANT) as an analytical framework to examine the formation and evolution of cooperation networks in China's overseas heritage conservation practices. Drawing on field research materials and interview data collected in Cambodia, the study analyzes the interactions among multiple actors-including governments, professional institutions, international organizations, and local communities-during the restoration process. The findings indicate that China's participation in international heritage governance has gradually expanded from the provision of technical assistance to a broader role involving institutional coordination. Through the translation and alignment of interests among different actors, a relatively stable cooperation network has been established. This study contributes to understanding the governance dynamics of transnational heritage conservation and provides empirical insights into the evolving model of China's heritage diplomacy.

Keywords: Cultural Heritage Conservation; International cooperation; Actor-Network Theory; Ta Keo Temple; Foreign Aid Projects; Heritage Diplomacy

1. Introduction

In recent decades, cultural heritage conservation has become an increasingly important field of international cooperation. Many countries participate in transnational heritage protection initiatives to preserve historical monuments, promote cultural exchange, and strengthen global cultural governance. Within this broader context, China has gradually expanded its participation in overseas heritage conservation and has developed a distinctive model of international cooperation.

Since the late twentieth century, Chinese government has implemented a series of heritage conservation projects in countries such as Cambodia, Mongolia, and Uzbekistan by dispatching restoration teams, providing financial and technical support, and participating in multilateral cooperation mechanisms. These initiatives not only focus on the restoration and preservation of historical monuments but also emphasize knowledge exchange and capacity building in areas such as conservation philosophy, technical standards, and professional training. Such cooperation reflects a development-oriented approach that highlights long-term institutional collaboration and local capacity building.

Among these initiatives, China's long-term participation in the conservation of the Angkor monuments in Cambodia represents a particularly significant case. The Angkor monuments were inscribed on the World Heritage List in 1992 and were simultaneously listed as endangered due to their fragile state of preservation. In response to international efforts to safeguard the site, China established China-Cambodia Government Team for Safeguarding Angkor in 1997 and subsequently carried out restoration projects at several important monuments, including Chau Say Tevoda Temple and Ta Keo Temple. Through continuous engagement in restoration work and technical cooperation, China has become one of the earliest participating countries and one with the longest continuous involvement in the conservation of Angkor.

Against this backdrop, understanding how China participates in and shapes international cooperation networks in heritage conservation has become an important research question. To address this issue, this study adopts Actor–Network Theory (ANT) as an analytical framework and examines the restoration project of Ta Keo Temple as a case study. Based on field research and interview data collected in Cambodia, the article analyzes how multiple actors—including governments, international organizations, professional teams, and local communities—interact and negotiate within the cooperation network. By exploring the formation mechanisms and operational logic of this network, the study aims to provide insights into China's evolving role in global heritage governance.

2. Literature Review

In recent decades, cultural heritage conservation has attracted increasing attention in the fields of cultural policy, international relations, and heritage studies. Scholars have explored the role of heritage conservation not only as a technical practice but also as a form of cultural governance embedded in global political and social processes.

2.1 International Cooperation in Heritage Conservation in Angkor

International scholarship generally regards heritage conservation at Angkor as a representative case of coordinated international intervention. Since its inscription on the UNESCO World Heritage List in 1992, studies have emphasized the institutionalization of cooperation through a dual mechanism combining multilateral coordination and bilateral implementation. [1]

The literature highlights the central role of the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor as a multilateral platform that aligns standards, funding, and project evaluation among diverse international actors. At the same time, most conservation activities are carried out through bilateral projects led by individual countries, focusing on restoration, technology transfer, and capacity building. [2] Scholars widely agree that these two mechanisms are not separate but structurally interdependent.

Recent studies further note a shift from monument-centered conservation to broader approaches integrating sustainable development, including tourism management and community engagement. Overall, the literature converges on the view that Angkor represents a layered and evolving model of international cooperation, where multilateral governance and bilateral practice jointly shape conservation outcomes.

2.2 Heritage Diplomacy and Cultural Soft Power

International scholarship increasingly frames heritage conservation at Angkor within the broader context of heritage diplomacy and cultural soft power. Since its inclusion on the UNESCO World Heritage List, Angkor has not only been a site of technical cooperation but also a platform through which states project cultural presence and build international influence.

The literature generally holds that participation in conservation projects enables countries to enhance their cultural visibility and strengthen bilateral relations with Cambodia. Through long-term restoration efforts, archaeological research, and capacity-building programs, external actors embed their technical expertise and cultural narratives within the site. [3] In this sense, heritage cooperation is widely interpreted as a form of "soft power in practice," where cultural engagement complements diplomatic and developmental objectives.

At the same time, scholars emphasize that such diplomacy operates within the multilateral framework coordinated by the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor, which moderates competition and promotes a degree of balance among participating states. Recent studies further note a shift toward more collaborative and development-oriented approaches, where heritage diplomacy is increasingly linked with local capacity building and sustainable development goals.

Overall, the literature suggests that Angkor exemplifies how heritage conservation can function as a key interface between culture and international relations, where soft power is exercised through sustained, project-based cooperation rather than symbolic representation alone

2.3 Actor–Network Theory in Heritage Studies

Existing studies on Angkor rarely apply Actor–Network Theory (ANT), tending instead to focus on institutional frameworks and state-led cooperation, particularly within mechanisms such as the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor. As a result, the relational dynamics among diverse actors remain underexplored.

ANT, developed in the 1980s by scholars including Michel Callon, Bruno Latour, and John Law, conceptualizes knowledge and practice as outcomes of interactions among heterogeneous human and non-human actors. [4] It emphasizes "actors," "networks," and "translation," highlighting how relationships are formed and stabilized through processes of negotiation and alignment. [5]

While widely used in broader heritage studies to analyze networked conservation processes, ANT has not yet been systematically applied to Angkor. However, its relational perspective is particularly suited to this case. Under intertwined bilateral and multilateral mechanisms, conservation at Angkor is inherently networked, involving continuous coordination among states, institutions, technologies, and local actors. ANT thus provides a useful lens to explain how cooperation is constructed, how external approaches are localized, and how core actors organize and stabilize complex international networks.

3. Theoretical Background

3.1 The Actor–Network Theory

Actor–Network Theory (ANT) was developed in the 1980s by scholars such as Michel Callon, Bruno Latour, and John Law to explain how knowledge and practice are constructed through social interactions. [6] It departs from human-centered approaches by adopting the principle of generalized symmetry, treating

both human actors (e.g., governments, institutions, experts) and non-human actors (e.g., technologies, artifacts, policy texts) as equally important in shaping outcomes. These heterogeneous elements together form dynamic "actor networks."

ANT is structured around three core concepts: actors, networks, and translation. "Actors" refer to all entities that participate in and influence the formation of a network. "Networks" denote the evolving relational structures produced through interaction, negotiation, and coordination. "Translation" is the key mechanism through which networks are formed, as core actors align diverse interests and resources through processes such as problematization, interessement, enrollment, and mobilization, ultimately stabilizing the network around an Obligatory Passage Point (OPP).

In the context of heritage conservation at Angkor, ANT provides a relational framework for analyzing international cooperation. Given the coexistence of multilateral coordination and bilateral implementation, conservation involves continuous interaction among states, international organizations, technical experts, material technologies, and local actors. ANT helps explain how cooperation is constructed, how external approaches are translated into local practice, and how core actors organize and stabilize complex networks.

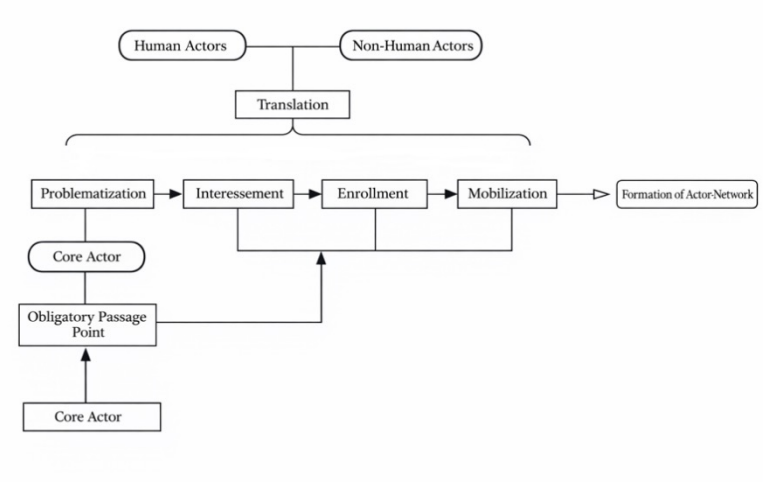

Figure 1. Diagram of Actor–Network Theory

3.2 Cultural Heritage Assistance and International Cooperation in Overseas Heritage Conservation

Scholar Xu Ying points out that cultural heritage assistance refers to China's provision of aid, within bilateral or multilateral frameworks, to help other countries protect specific cultural heritage, particularly those that have been inscribed on the World Heritage List. [7] The forms of assistance include financial support, technology transfer, and professional training, with the aim of promoting the protection and sustainable development of cultural heritage in recipient countries. This practice emphasizes national responsibility and international mutual support, and its fundamental motivation lies in political mutual trust and mutual learning among civilizations rather than the simple expansion of soft power. In fact, the history of China's cultural heritage assistance can be traced back to the period immediately before the founding of the People's Republic of China. In recent years, with the growth of China's comprehensive national strength and the deepening of the "going global" strategy in the cultural field, its diplomatic functions have become increasingly visible, prompting renewed academic attention to its nature as "heritage diplomacy."

On this basis, cultural heritage assistance has gradually evolved into a more collaborative form of "international cooperation in overseas heritage conservation," emphasizing consultative mechanisms and the principle of joint participation. This development represents a phased transition from "cultural heritage assistance" to "international cooperation in overseas heritage conservation." Such a transition indicates not

only a transformation in practice—from one-way assistance to two-way interaction—but also a shift in research paradigms from project-based aid to a broader field of development studies focusing on knowledge co-production, the dissemination of norms, and engagement with international institutional frameworks. At present, this cooperative model not only advances specific restoration projects but also extends to institutional collaboration among international organizations, alignment of technical systems, and joint training of cultural heritage professionals, thereby constructing a more systematic and diversified transnational cooperation network. Compared with traditional "cultural heritage assistance," this form of cooperation places greater emphasis on knowledge production, the dissemination of conservation concepts, and the co-construction of institutional mechanisms. Its connotations are increasingly aligned with the broader international understanding of "heritage diplomacy," and it also reflects China's evolving role in the global cultural governance system—from a participant to a core actor and provider of norms.

4. Case Analysis

As the Australian scholar Tim Winter notes, heritage assistance not only carries the symbolic significance of cultural exchange but is also deeply embedded in national strategic arrangements, becoming an important means for donor countries to expand influence, shape diplomatic relations, and construct regional orders. [8] At the same time, from the perspective of the Cambodian government, the restoration of the Angkor monuments symbolizes not only the process of cultural continuity and national revival but also holds profound political and economic significance. Therefore, cooperation in the conservation of the Angkor monuments is not merely a technical practice of cultural heritage protection but also a complex process of international cooperation involving multiple actors, intricate power interactions, and strategic implications. [9] In order to analyze the diverse actors and their interactions within this process, this study introduces Actor–Network Theory to reveal how technology, institutions, states, organizations, and individuals collectively form dynamic network relationships in China's international cooperation in overseas heritage conservation assistance in Cambodia.

To more effectively analyze and respond to these challenges, this paper adopts Actor–Network Theory as an analytical tool. The theory emphasizes the relational construction and dynamic coordination among multiple actors, enabling heterogeneous elements involved in China's overseas heritage conservation practices—such as government institutions, implementation teams, international organizations, and technical standards—to be incorporated into a unified network perspective. This approach helps reveal how different parties achieve cooperation through negotiation and translation. In particular, when addressing key issues such as difficulties in "translation," Actor–Network Theory can help analyze cognitive differences and coordination obstacles encountered by Chinese approaches within international mechanisms, thereby providing both theoretical support and practical insights for improving cooperative effectiveness and optimizing governance structures.

Within the framework of Actor–Network Theory, China's assistance in the conservation of the Angkor monuments can be understood as a network composed of multiple actors, including the Chinese government, the Cambodian government, international organizations, scholars and experts, and local communities. Taking the Ta Keo Temple restoration project—part of China's second phase of assistance in the conservation of the Angkor monuments—as the main case study, the analytical framework of the actor-network for China's international cooperation in heritage conservation assistance in Cambodia is outlined as follows.

4.1 Problematization — Core Actors and the Obligatory Passage Point of the Project

Problematization constitutes the initial stage in the creation of an actor network. Core actors must identify the problems faced by each actor in achieving their respective objectives, thereby making the solutions they propose the obligatory passage point through which other actors must pass to achieve their goals.

thereby establishing the proposed conservation schemes as the Obligatory Passage Point (OPP). In the Ta

Keo project, this OPP functioned as a nexus where China's Belt and Road diplomatic objectives converged with Cambodia's needs for sovereign cultural revival and UNESCO's multilateral preservation standards."

Therefore, the first step in the problematization stage is to determine who will serve as the core actor. Subsequently, the core actor needs to present the problems and objectives faced by other actors and propose an obligatory passage point through which a shared goal can be achieved.

Taking the Ta Keo Temple restoration project as an example, the creation of the cooperation network involves actors such as the Chinese government, the APSARA National Authority, China-Cambodia Government Team for Safeguarding Angkor, Cambodian artisans, the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor (ICC-Angkor). Cambodian artisans played an important role in the restoration process by carrying out traditional craftsmanship and practical implementation; however, due to their lack of modern restoration techniques and independent operational capacity, they were unable to assume the leading role in the project. UNESCO, as a key international institution responsible for setting heritage protection norms and providing a global platform for discourse, primarily promotes value systems, principles, standards, and international cooperation agendas related to heritage protection. Its influence mainly operates at the macro-policy level and does not directly coordinate project implementation; therefore, it is not suitable to serve as the core actor of the project. ICC-Angkor, established under UNESCO's initiative, functions as a governance organization responsible for reviewing project proposals, coordinating resources, and facilitating multilateral communication, thus providing an institutional platform for the operation of the project mechanism. However, its organizational nature is primarily coordinative, lacking direct control over financial and technical resources and the capacity to independently implement restoration projects.

China-Cambodia Government Team for Safeguarding Angkor serves as the primary provider of restoration technologies and possesses strong professional expertise, playing a leading role in project implementation. Nevertheless, during the early stage of restoration, the team relied on financial support and policy guidance from the Chinese government and could not independently determine the overall direction of the project, making it unsuitable as the core actor. The APSARA National Authority, representing the Cambodian government, plays a significant role in administrative approval and policy support; however, due to limited technical capacity and restoration resources, its ability to lead the project is constrained.

As the initiator and principal funder of the project, the Chinese government possesses sufficient financial resources, technical support, and political influence to coordinate the relationships among different actors and facilitate the smooth implementation of the project. In addition, as an advocate of cultural diplomacy, the Chinese government occupies a proactive position in communication with the Cambodian government and UNESCO, ensuring the effective advancement of restoration activities. Therefore, at the initial stage of the cooperation network's formation for the Ta Keo Temple restoration project, the Chinese government can be regarded as the core actor. As the core actor, the Chinese government must identify and present the problems and objectives faced by other actors, thereby linking its own objective—high-quality cooperation under the Belt and Road Initiative—with the objectives of other actors. In doing so, it persuades other actors that only by joining the cooperation network and passing through the obligatory passage point established by the core actor can their respective goals be achieved. As the project progressed, China gradually strengthened its discourse power within multilateral governance mechanisms, including ICC-Angkor. In particular, during the restoration of Ta Keo Temple, Chinese experts not only engaged in technical exchanges related to heritage conservation but also actively contributed to discussions on heritage management systems and restoration standards, promoting the integration of Chinese experience—such as the principle of "repairing the old as the old"—into international norms. This development demonstrates China's transition from a "technical assistance provider" toward a "provider of cultural norms."

Different actors pursue different objectives and therefore face distinct challenges in achieving them. As the core actor, the Chinese government proposed an obligatory passage point capable of addressing the

problems faced by all actors—the implementation and promotion of the Ta Keo Temple restoration project with the participation of all parties. By providing financial support, technical guidance, and professional training, the Chinese government not only assisted Cambodia in restoring cultural heritage but also promoted international cooperation in the field of heritage conservation and strengthened its influence in cultural diplomacy.

4.2 Interessement — Presentation of Interests among Participants in the Ta Keo Temple Restoration

Each actor entering the cooperation network of the Ta Keo Temple restoration project encounters certain obstacles. At this stage, the core actor—the Chinese government—must demonstrate to other actors that these obstacles can be addressed through coordination and that participation in the cooperation network, by passing through the obligatory passage point established by the core actor, will enable them to obtain expected benefits.

In the case of the Ta Keo Temple restoration project, all participating actors achieved multiple benefits through cooperation. For the Cambodian government, the project effectively alleviated the shortage of restoration resources and enhanced both heritage conservation capacity and national cultural soft power. For the Chinese restoration team, the project provided financial support, opportunities for technical exchange, enhanced international influence, and a practical platform for cultural cooperation under the Belt and Road Initiative. For local artisans, the project created employment opportunities and professional training, promoting the transmission and development of traditional craftsmanship. For UNESCO, the project advanced the standardization of world heritage conservation and strengthened multilateral cooperation. ICC-Angkor ensured the scientific validity and legitimacy of restoration through institutional mechanisms. As the core actor, the Chinese government consolidated its influence in international cultural governance through the implementation of the project, deepened China–Cambodia friendship, demonstrated the cultural diplomacy achievements of the Belt and Road Initiative, and gradually shifted from a technical assistance provider to a cultural norm provider. The realization of these interests strengthened the motivation and commitment of actors to join the cooperation network, laying the foundation for the subsequent stage of enrollment.

4.3 Enrollment — The Inclusion of Actors

During the enrollment stage, the Chinese government, acting as the recruiting actor, negotiated with other actors and attracted them to join the cooperation network of the Ta Keo Temple restoration project according to the design proposed by the core actor. In doing so, it linked its own interests with those of other actors and assigned specific tasks to each participant, positioning them within appropriate roles in the network.

In the Ta Keo Temple restoration project, the Chinese government promoted project implementation and ensured sustainable development through policy support, technical assistance, talent training, and financial investment. Within the cooperation network, the Chinese government acted as the organizer coordinating multiple parties and ensuring alignment with international standards; the Cambodian government served as the regulator and coordinator, guaranteeing compliance and facilitating the participation of local artisans; the Chinese restoration team functioned both as a provider of technical expertise and as a trainer, cultivating local professional capacity and ensuring knowledge transfer; Cambodian artisans acted as implementers and inheritors, acquiring restoration skills through practice and continuing traditional craftsmanship; UNESCO served as an international supervisor, ensuring compliance with global standards and promoting technical exchange; and ICC-Angkor acted as an institutional coordinator and reviewer, providing evaluation guidance and supervisory support. Through such multi-party collaboration, a transparent, efficient, and sustainable cooperation network for cultural heritage conservation was established.

Through the enrollment process, the Chinese government, as the core actor, clarified the roles and task allocation of the various actors within the cooperation network. The positions and functions of each partic-

ipant gradually became clear, forming a stable cooperative structure that enabled the Ta Keo Temple restoration project to proceed smoothly and achieve positive outcomes in heritage conservation, international cooperation, and talent cultivation.

4.4 Mobilization — The Formation of an Interest Alliance in the Ta Keo Temple Restoration

During the mobilization stage, the core actor (the Chinese government) must effectively organize all actors within the network to ensure their active participation, ultimately forming a relatively stable alliance of interests. The key to mobilization lies in removing obstacles that prevent actors from participating in the cooperation network to the greatest extent possible, thereby enhancing their motivation and ensuring the successful implementation and sustainable operation of the project.

In the Ta Keo Temple restoration project, during the mobilization phase of the cooperation network, the Chinese government dispatched expert teams to coordinate with Cambodian counterparts, ensuring smooth communication and information exchange. A model combining training, practice, and competition was introduced to enhance artisans' skills, while modern technologies such as three-dimensional scanning were applied to reduce technical barriers in restoration and increase local participation. At the same time, China encouraged the participation of international organizations such as UNESCO, thereby enhancing the international influence and replicability of the project. At the institutional level, communication with ICC-Angkor and alignment with relevant standards strengthened the transparency and legitimacy of cooperative governance, establishing an institutionalized framework for cooperation based on multilateral consensus.

With the gradual completion of the restoration work, Ta Keo Temple also began to transform its restored cultural value into economic value through the development of tourism resources, thereby generating additional revenue for the Cambodian government. In 2024, the Cambodian government constructed cycling greenways around the Angkor Archaeological Park and incorporated Ta Keo Temple into the route, enabling visitors to explore the site through cycling tours and enhancing the visitor experience. [10] While promoting the revitalization of cultural heritage, China's overseas heritage conservation assistance projects have also created new sources of income for local communities in Cambodia through technological demonstration, international dissemination, and tourism revitalization. Although this process remains at an early stage, it has already demonstrated the potential for heritage conservation projects to generate economic benefits, forming an important link between cultural value and sustainable social development. According to available statistics, in 2024 the Angkor Archaeological Park received more than one million foreign visitors, representing a year-on-year increase of 28.27 percent compared with 2023; among them, the number of Chinese visitors exceeded 80,000, marking a year-on-year increase of 48.46 percent.

Through these efforts, the division of roles among actors became clearer, and their interests gradually aligned, ultimately forming a stable cooperation network. The restoration of Ta Keo Temple has not only promoted China–Cambodia cooperation in cultural heritage conservation but has also provided new experience for international collaboration in heritage restoration, while contributing to the improvement of skills among Cambodian artisans and the sustainable development of heritage conservation in Cambodia.

5. Discussion

5.1 Network Governance in International Heritage Conservation

From the perspective of Actor–Network Theory (ANT), the restoration of Ta Keo Temple can be understood as a process of network construction in which multiple actors interact to stabilize a cooperative governance structure. Rather than being driven by a single institution, the conservation project involved the coordination of heterogeneous actors, including national governments, international organizations, conservation experts, and local communities. These actors formed a dynamic network through processes of negotiation,

resource mobilization, and role allocation.

Within this network, the Chinese government functioned as a central actor responsible for mobilizing financial resources, organizing technical teams, and coordinating institutional cooperation. Through diplomatic agreements and project planning, it established the basic framework within which other actors could participate in the restoration process. Meanwhile, the APSARA National Authority of Cambodia played an important role in local coordination, ensuring that conservation activities complied with Cambodian heritage management policies.

International organizations also contributed to the stabilization of the cooperation network. For example, UNESCO and the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor provided technical standards and institutional legitimacy for conservation practices. Their involvement ensured that restoration activities were aligned with internationally recognized conservation principles.

From an ANT perspective, these interactions illustrate the process of "translation," through which the interests of diverse actors are gradually aligned. Through successive stages of problem definition, interest alignment, and role negotiation, the conservation project eventually formed a relatively stable cooperation network that enabled the long-term implementation of restoration work.

5.2 Characteristics of China's Heritage Cooperation Model

The Ta Keo Temple restoration project also reveals several distinctive characteristics of China's approach to international heritage cooperation.

First, China's heritage cooperation projects are typically characterized by strong governmental coordination. In many overseas conservation initiatives, the Chinese government acts as the primary initiator and financial supporter of restoration projects. This state-led model enables the mobilization of large-scale technical resources and facilitates long-term diplomatic coordination with host countries.

Second, China's approach emphasizes long-term technical engagement in on-site restoration work. Unlike many international conservation programs that rely on short-term consultancy or financial grants, Chinese conservation teams often remain stationed at heritage sites for extended periods. This long-term presence allows conservation experts to conduct detailed structural analysis, implement complex restoration techniques, and adjust conservation strategies according to the evolving conditions of the monument.

Third, China's heritage cooperation initiatives often combine technical restoration with broader cultural exchange. Through joint conservation projects, Chinese and Cambodian experts engage in collaborative research, professional training, and knowledge sharing. Such exchanges contribute to capacity building in heritage management while strengthening cultural connections between the participating countries.

Together, these characteristics suggest that China's heritage cooperation model integrates technical expertise, institutional coordination, and cultural diplomacy within a single cooperative framework.

5.3 Comparative Perspectives on International Heritage Assistance

Placing the Ta Keo Temple project within a broader international context helps illuminate the distinctive features of China's approach to heritage cooperation.

Several countries have long been involved in heritage conservation projects in Southeast Asia, each adopting different institutional models. For instance, French heritage cooperation has historically relied on academic institutions and archaeological research networks. Organizations such as École française d'Extrême-Orient have played an important role in archaeological excavation, historical research, and heritage documentation across the region. This model emphasizes scholarly expertise and research-driven conservation practices.

Japan has also actively participated in international heritage assistance programs, many of which are im-

plemented through the Japan International Cooperation Agency. Japanese heritage cooperation projects often focus on technical training, capacity building, and community participation. By supporting local conservation professionals and strengthening institutional capacity, Japan's approach aims to promote sustainable heritage management at the local level.

Compared with these models, China's heritage cooperation approach places greater emphasis on state-led coordination and long-term technical engagement. The presence of permanent conservation teams enables Chinese experts to participate directly in large-scale restoration projects and to maintain long-term collaboration with local institutions. As a result, China's approach can be understood as a hybrid model combining technical restoration, institutional cooperation, and cultural diplomacy.

This comparative perspective highlights the diversity of international heritage cooperation models and suggests that different countries may adopt distinct strategies depending on their institutional structures, cultural traditions, and diplomatic priorities.

Country	Main Actors	Primary Contributions	Project Examples & Focus
China	Government expert teams, China Cultural Heritage Research Institute	Long-term conservation, technical assistance, capacity building	Restoration of Preah Srah, Ta Keo, Chau S Tevoda; ongoing Royal Palace core site pro systematic technology transfer and field tra for Cambodian staff
France	Government and research institutions (EFEO), ICC-Angkor co-chair	Historical conservation leadership, institutional coordination	Early restoration (EFEO), co-chairing ICC-Angkor; technical coordination and UNESCO forum facilitation
Japan	Government (Japanese Funds-in-Trust via UNESCO), academic teams, ICC-Angkor co-chair	Financial support, training, infrastructure stabilization	Bayon Temple conservation and risk mappi technical training with APSARA experts
South Korea	Korea Cultural Heritage Foundation, KOICA	Field research, conservation and restoration	Preah Pithu Temple Group project (2015–2 and ongoing maintenance/restoration activi
India	Government archaeological teams	Early conservation engagement, structural and surface treatment	Restoration work at Angkor Wat (1986–19 prior to ICC framework (existing record)

Figure 2. Comparative Perspectives on International Heritage Assistance in Angkor

5.4 Theoretical Implications for Actor–Network Theory

Applying Actor–Network Theory to the Ta Keo Temple restoration project also contributes to the theoretical understanding of heritage governance.

First, the analysis demonstrates that heritage conservation projects involve not only human actors but also important non-human actors. In the case of Ta Keo Temple, the monument itself functions as a non-human actor within the cooperation network. Its architectural structure, material condition, and historical significance shape the decisions made by conservation experts and influence the allocation of technical resources. In this sense, the heritage site actively participates in the formation of the conservation network.

Second, the case highlights the role of international organizations as stabilizing actors within transnational governance networks. By providing technical standards and institutional oversight, organizations such as UNESCO help ensure that conservation practices remain consistent with global heritage management norms. Their participation also enhances the legitimacy of international conservation projects.

Third, the concept of translation provides a useful analytical tool for understanding how diverse actors with different interests are integrated into a common cooperation framework. Through negotiation and coordination, actors gradually align their goals and establish an obligatory passage point that structures the operation of the network. In the Ta Keo Temple project, the restoration plan itself served as such a passage point, guiding the participation of various actors.

These observations suggest that ANT offers a productive framework for analyzing the governance mechanisms underlying international heritage cooperation.

5.5 Challenges and Sustainability of Heritage Cooperation

Despite the achievements of the Ta Keo Temple restoration project, the case also reveals several challenges that affect the long-term sustainability of international heritage cooperation.

One important issue concerns the imbalance of resources among different actors within the cooperation network. International conservation projects often rely heavily on external financial and technical support. While such support is essential for large-scale restoration efforts, excessive dependence on external actors may limit the long-term autonomy of local heritage management institutions.

Another challenge relates to the participation of local communities. Although local artisans and workers are often involved in restoration activities, their role in decision-making processes may remain limited. Strengthening community participation is therefore essential for ensuring that conservation projects are socially sustainable and culturally meaningful.

Finally, differences in conservation philosophies may create tensions among participating actors. International conservation standards sometimes emphasize strict preservation principles, whereas local communities may prioritize economic development and tourism. Balancing these different priorities remains an ongoing challenge in global heritage governance.

Addressing these challenges requires stronger institutional cooperation, expanded local capacity building, and more inclusive governance mechanisms. By integrating local knowledge, international expertise, and long-term institutional support, international heritage cooperation projects can achieve more sustainable outcomes.

6. Conclusion

This study has analyzed China's engagement in international cultural heritage conservation through a case study of the Ta Keo Temple restoration project in Cambodia. By employing Actor–Network Theory (ANT) as an analytical lens, the research elucidates how diverse actors—including national governments, international organizations, conservation teams, and local communities—interact to establish and maintain cooperative networks in the process of heritage restoration.

The findings reveal several salient features of China's approach to international heritage cooperation. First, China's projects are predominantly organized within a state-led coordination framework, wherein governmental institutions assume a central role in mobilizing financial resources, technical expertise, and diplomatic support. [11] This governance arrangement facilitates the implementation of large-scale restoration initiatives through sustained institutional collaboration.

Second, the Ta Keo case underscores the significance of long-term technical engagement in international conservation efforts. In contrast to short-term heritage assistance programs, China's continuous presence at the Angkor site has enabled conservation teams to conduct systematic restoration work while maintaining stable partnerships with local heritage authorities. Such sustained involvement enhances both the continuity and effectiveness of conservation practices.

Third, the study demonstrates that international heritage conservation operates as a complex governance network encompassing both human and non-human actors. Through the process of translation described in ANT, the interests of different stakeholders—including governments, international organizations, technical experts, and heritage sites—are gradually aligned within a shared conservation framework. This network-oriented perspective provides a robust analytical tool for understanding the governance mechanisms underlying transnational heritage cooperation.

From a broader standpoint, these findings contribute to discussions on heritage diplomacy and international cultural engagement. Heritage conservation projects increasingly function as platforms for long-term cultural exchange and diplomatic interaction, enabling participating countries to strengthen cultural ties, promote mutual understanding, and advance the protection of shared human heritage.

Nevertheless, the study identifies several challenges that may influence the sustainability of international heritage cooperation. These include asymmetries in resources among participating actors, limited involvement of local communities in decision-making processes, and potential conflicts between international conservation standards and local development priorities. Addressing these issues necessitates enhanced institutional coordination, greater emphasis on local capacity building, and more inclusive governance mechanisms.

This study has certain limitations. It primarily focuses on a single case study and relies predominantly on qualitative data derived from field investigations and interviews. Future research could adopt a comparative perspective by examining additional heritage conservation projects across different regions or by analyzing cooperation models implemented by other countries.

In sum, the Ta Keo Temple restoration project exemplifies how international heritage conservation can be conceptualized as a process of network governance involving multiple actors and institutional arrangements. By illuminating the dynamics of cooperation networks and China's evolving role in global heritage governance, this study advances a nuanced understanding of transnational heritage conservation practices and offers insights for the development of more sustainable mechanisms of international cooperation.

Conflicts of Interest

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

Author Contributions

Conceptualization: Tianqi Lou; Methodology: Yiming Dou; Writing: Tianqi Lou; Supervision: Yiming Dou; Project administration: Tianqi Lou.

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The Impact of Techno-nationalism on International Innovation Investment

Mingyu Liu[1]*

1 Country and Area Studies Academy, Beijing Foreign Studies University, Beijing, China, 20lmy@bfsu.edu.cn

***Correspondence: 20lmy@bfsu.edu.cn**

Abstract

Against the backdrop of profound shifts in the global geopolitical landscape, techno-nationalism has emerged as a pivotal variable reshaping the international economic order. This paper explores how the rise of techno-nationalism has fundamentally altered the underlying paradigm of international innovation investment. The research identifies a paradigmatic shift in investment rationales, moving from "efficiency-driven" globalization to a "security-centric" logic, where geopolitical compatibility has superseded cost and market access as the primary determinant of capital flows. By analyzing the policy toolkits of major economies—including the U.S., the E.U., and Japan—this study demonstrates that techno-nationalism, through defensive investment screenings and offensive industrial subsidies, is driving a fragmentation and "Balkanization" of global innovation landscapes. Notably, in strategic sectors such as semiconductors and artificial intelligence, cross-border capital flows have experienced a "deep freeze," while "friend-shoring" and "onshoring" are becoming the dominant investment modalities. While this trend may stimulate domestic R&D in the short term, the long-term consequences include diminished global innovation efficiency and the bifurcation of technical standards. Finally, the paper proposes a "multi-local" strategy for multinational corporations and suggests that sovereign states must seek a dynamic equilibrium between security imperatives and innovation vitality.

Keywords: Techno-nationalism, International Investment, Geopolitics, Supply Chain Security, Investment Strategy

1. Introduction

During the first two decades of the 21st century, the global political and economic landscape was primarily shaped by the logic of neoliberal globalization. The defining feature of this era was "techno-globalism"—the belief that technological innovation should transcend national borders, with capital, talent, and knowledge flowing freely across the globe to maximize efficiency. However, in recent years, with the resurgence of great power geopolitical competition, the exposure of vulnerabilities in global supply chains, and the reshaping of national security definitions by emerging technologies, a trend known as "techno-nationalism" has reclaimed center stage in international relations and international political economy.

The resurgence of techno-nationalism is not a simple repetition of history, but rather a profound reflection of the qualitative shift in the relationship between technology and state power. Unlike traditional trade protectionism, modern techno-nationalism no longer focuses solely on tariffs and market access. Instead, it regards cutting-edge technologies such as semiconductors, artificial intelligence (AI), quantum computing, and biotechnology as core pillars of national survival, security, and competitiveness. Under this logic, the state is no longer a market night watchman but an active intervener, investor, and regulator. This paradigm shift is fundamentally reshaping the logic, flows, and structure of international science and technology innovation investment. This study aims to explore the multidimensional impacts of techno-nationalism on international science and technology investment. By systematically examining the theoretical underpinnings, policy instruments, and practical implementations of techno-nationalism across major global powers, this paper seeks to reveal the multifaceted effects of this trend on international investment in science and technology innovation. It further proposes corresponding strategies for multinational corporations and nations to navigate these challenges.

2. The Rise of Techno-nationalism

2.1 Core Concepts and Policy Instruments

2.1.1 Core Concepts of Techno-nationalism

Academic definitions of techno-nationalism have undergone an evolutionary process. Early definitions, such as Robert Reich's 1987 formulation [1], primarily referred to an ideology linking technological advancement to national security and economic prosperity. However, within the current international relations context, the scope of techno-nationalism has significantly expanded. According to recent research by scholars like Alex Capri [2], modern techno-nationalism can be understood as a strategic worldview that deeply binds technological capability and autonomy to national security, economic prosperity, and social stability. It is not merely a defensive posture but rather a set of principles and policies that actively intervene in markets and shape technological trajectories through state power.

The core of this concept lies in the generalization of the logic of "securitization." Traditional national security focuses on military defense and territorial integrity, whereas techno-nationalism expands the boundaries of security to encompass economic security, cybersecurity, data security, and even supply chain security. As Samuels observes [3], technology is viewed as a source of national security and even a symbol of national identity. Under this lens, technological innovation ceases to be a purely commercial endeavor and instead becomes a zero-sum game in great power rivalry. Competition between nations has shifted from traditional arms races to contests over control of critical technologies—what is termed the "innovation war."

The rise of techno-nationalism represents a rethinking and revision of the theory of "interdependence" in the era of globalization. While liberal institutionalism posits that interdependence fosters peace, the theory of "weaponized interdependence" argues that global economic networks—such as finance, the internet, and supply chains—exhibit asymmetrical center-periphery structures. Nations occupying pivotal hub positions can exploit this asymmetry, transforming interdependence into a coercive instrument of power against ad-

versaries [4]. This theoretical shift provides the legitimacy for technonationalist policies—namely, that nations must reduce reliance on external critical technologies to avoid being "choked off" by rivals.

2.1.2 Policy Instruments

To achieve technological autonomy and security, governments worldwide have deployed a complex suite of policy tools. These encompass both defensive measures aimed at blocking adversaries from acquiring critical technologies—such as foreign investment security reviews, export controls, and technology sanctions—and offensive strategies designed to bolster domestic industries, including large-scale industrial subsidies, localization substitution programs, and the promotion of domestic technical standards.

Foreign investment security reviews serve as the most direct defensive tool against techno-nationalism. Their core logic is to prevent foreign capital from acquiring domestic critical technologies or sensitive data through mergers, acquisitions, or equity investments. Take the U.S. Committee on Foreign Investment in the United States (CFIUS) as an example: its authority underwent historic expansion following the passage of the Foreign Investment Risk Review Modernization Act (FIRRMA) in 2018. FIRRMA expanded the scope of review beyond traditional controlling transactions to include non-controlling investments involving "Critical Technologies," "Critical Infrastructure," and "Sensitive Personal Data"—collectively termed "TID" businesses [5]. This implies that even a minority investment by a foreign venture capital firm in a U.S. startup could trigger national security scrutiny if it involves board observer seats or access to non-public technical information. The latest 2024 data shows a significant increase in CFIUS reviews involving the financial, information, and services sectors, with heightened scrutiny of Chinese investors persisting at elevated levels. Additionally, the EU has established a foreign investment screening framework, while Japan revised its Foreign Exchange and Foreign Trade Act (FEFTA), both significantly lowering review thresholds (e.g., Japan reduced the reporting threshold for equity holdings from 10% to 1%) and expanding the list of regulated industries [6].

Export controls have evolved from traditional non-proliferation mechanisms into a powerful tool for major powers to impose technological blockades. The trend toward weaponizing entity lists is evident, with the U.S. Department of Commerce's Bureau of Industry and Security (BIS) managing the "Entity List" to restrict U.S. companies from exporting technology to specific foreign entities. In recent years, this list has expanded rapidly, adding numerous Chinese companies involved in semiconductors, artificial intelligence, and supercomputing [7]. Additionally, the U.S. has implemented long-arm jurisdiction controls by amending the Foreign Direct Product Rule (FDPR). This rule mandates that any foreign-manufactured product incorporating U.S. technology or software—even in minimal proportions—falls under U.S. export controls. This regulation has been used to sever companies like Huawei from global foundry chip supply channels, profoundly reshaping the global semiconductor supply chain ecosystem [8]. Furthermore, export bans on equipment targeting specific technology nodes—such as logic chips at 14nm and below, and NAND flash memory with 128 layers or more—aim to precisely target competitors' technological iteration capabilities, locking them into mature process nodes [9]. This reflects the trend toward precision in technological sanctions.

Technical sanctions differ from conventional trade restrictions, often combining financial sanctions with comprehensive blockades in specific technological domains. Their aim is to deprive adversaries of the ability to profit from or advance through technology. The U.S. "Non-SDN Chinese Military-Industrial Complex Entities List" (NS-CMIC List) prohibits Americans from investing in technology companies deemed to assist China's military modernization. This not only cuts off these entities' access to dollar financing but also effectively "delegitimizes" them in capital markets. Sanctions imposed by the United States on Russia and Iran explicitly include "technology sanctions" provisions, prohibiting the transfer of refining technologies, quantum computing technologies, and advanced materials technologies. These measures are designed to weaken the long-term industrial foundations of these nations. Such sanctions are typically combined with financial decoupling, employing "Smart Sanctions" mechanisms to precisely target critical technological

nodes without imposing comprehensive trade embargoes.

Large-scale industrial subsidies represent one of the primary offensive tools. To reverse the trend of manufacturing outflows and establish technological dominance, governments worldwide have rolled out massive fiscal subsidy programs to guide the reshoring of manufacturing. The U.S. CHIPS and Science Act provides approximately $52.7 billion in direct subsidies and tax credits aimed at incentivizing the return of semiconductor manufacturing to America [10]. However, this legislation is not purely economic stimulus; it includes stringent "guardrails" prohibiting recipient companies from expanding advanced process manufacturing capacity in "countries of concern" over the next decade [11]. This effectively forces multinational corporations to strategically "choose sides." The offensive nature of the U.S. CHIPS Act extends beyond containing China, triggering a global "subsidy race" that compels allies to follow suit to prevent industrial hollowing-out. Examples include the EU's EU Chips Act and South Korea's K-Chips Act. These geopolitically driven subsidy policies are profoundly reshaping the competitive landscape of the global semiconductor industry.

Faced with external blockades, establishing autonomous and controllable supply chains has become a core strategy for nations. Over the past three decades, global supply chains were built around the principles of "efficiency first" and "just-in-time" production, minimizing costs through intricate international division of labor. However, supply chain disruptions triggered by the COVID-19 pandemic, energy shocks stemming from the Russia-Ukraine conflict, and intensifying strategic competition between China and the United States have compelled governments worldwide to shift the focus of supply chain policies toward "security" and "resilience." Establishing "autonomous and controllable" supply chains has become a cornerstone of national security strategies, with core measures including reshoring, friend-shoring, and de-risking. . This shift marks a transition in global economic governance from pursuing Pareto-optimal economic logic to pursuing strategic logic centered on geopolitical security. For instance, the EU's Critical Raw Materials Act (CRMA) sets highly ambitious 2030 quantitative benchmarks for the EU's supply of 34 critical raw materials, including lithium, cobalt, and rare earths [12].

The battle for control over technology standard-setting is pivotal to securing future industrial dominance. In the digital economy era, technical standards are no longer merely technical documents ensuring device interoperability; they have become strategic high ground determining industrial allocation rights, market access privileges, and national security boundaries. Whoever sets the standards holds the power to define the next-generation technology ecosystem and reap "patent royalties" at the apex of the industrial chain. Today, the battle for standard-setting authority has escalated from corporate commercial rivalry to strategic confrontation between nations. Mobile communication standards represent the most fiercely contested arena in geopolitical competition. Within the 3GPP (Third Generation Partnership Project) standard-setting process, Chinese enterprises like Huawei and ZTE have demonstrated formidable influence, triggering deep anxiety among Western nations. In response, the United States has vigorously promoted the Open RAN architecture. By decoupling hardware and software and opening interfaces, it aims to break the integrated hardware-software monopoly held by traditional telecom equipment providers like Huawei, Ericsson, and Nokia. This strategy seeks to allow more American software and chip manufacturers to enter the base station market, thereby circumventing Huawei in the supply chain. In the early stages of 6G research and development, the U.S. government formed exclusive alliances like the "Next G Alliance" with Japan, South Korea, and Europe. These efforts aim to exclude China from the "inner circle" of standard-setting for next-generation core technologies like terahertz communications and integrated air-ground-space systems, striving to reclaim dominance in the 6G era.

2.2 Shifting International Landscape

Under the influence of techno-nationalism, the international political and economic environment has undergone profound structural changes, with global industrial chains, supply chains, and value chains undergoing restructuring. Globalization is no longer a smooth linear process but exhibits distinct characteristics

of regional blocs and alignment. Major economies are adjusting their grand strategies to adapt to this new geo-economic reality.

The Biden administration's National Security Strategy explicitly articulates the "Small Yard, High Fence" concept [13]. Systematically articulated by National Security Advisor Jake Sullivan, its core logic is this: For critical core technologies involving national security—such as advanced logic chips, quantum computing, and biotechnology—a limited-scope ("small yard") yet strictly controlled ("high fence") protected zone must be established. Through the most stringent export controls and investment restrictions, the United States must secure absolute leadership in these domains. Meanwhile, normal international economic and trade relations are maintained across the vast commercial landscape beyond the "yard." In practice, however, the boundaries of the 'yard' are continually expanding. Due to the dual-use nature of many emerging technologies and the pervasive penetration of digital transformation across all economic sectors, the "high fence" is creating far greater barriers to commercial investment than anticipated. Simultaneously, the U.S. vigorously promotes "reindustrialization" and "friend-shoring," seeking to shift critical supply chains from geopolitical rivals to allies or friendly nations. This strategy not only reshapes America's industrial structure but also forces global capital to recalibrate between 'efficiency' and "compliance."

In response to the intensifying Sino-American strategic competition, the European Union has proposed a strategy of "de-risking" rather than "decoupling." This approach was explicitly outlined by European Commission President Ursula von der Leyen in the 2023 European Economic Security Strategy, aiming to reduce reliance on critical raw materials and technologies from any single country while avoiding a complete severance of economic and trade ties. The EU's strategy rests on three pillars: Promote, Protect, and Partner. First, promote competitiveness by strengthening Europe's industrial base and innovation capacity through legislation like the Net-Zero Industry Act and Critical Raw Materials Act. Second, protect critical assets using anti-coercion instruments, foreign investment screening, and export controls to defend against economic security risks. Third, it strengthens partnerships by establishing raw materials clubs and digital partnerships with "like-minded" nations. Although internal European disagreements persist over the precise scope of "de-risking"—such as German business circles favoring maintaining market share in China—the overall policy direction has clearly shifted toward defensiveness [14]. This has resulted in stricter compliance reviews for two-way science and technology investment between China and Europe.

Japan was among the first nations to institutionalize economic security. The passage of the Economic Security Promotion Act (ESPA) in 2022 marked Japan's formal establishment of a comprehensive legal framework for economic security [15]. The Act establishes four pillars: strengthening supply chain resilience by designating semiconductors, batteries, rare earths, and other materials as "specified important materials" and providing financial support to diversify sourcing; ensuring critical infrastructure security through a pre-screening system for key equipment imports across 14 sectors including power, communications, and finance to prevent backdoor implantation; fostering public-private technological collaboration by establishing dedicated funds to support R&D in critical technologies like AI and quantum computing while enhancing industry-academia-government cooperation; and implementing a patent non-disclosure system to classify patent applications involving sensitive technologies like nuclear energy and advanced weaponry, thereby preventing technology leakage. Japan's legislation not only impacts the global operations of its domestic companies but also provides a model for institutionalizing techno-nationalism for other nations. It requires businesses to factor geopolitical risks and supply chain disruption risks into their cost considerations when making international investments.

Against the backdrop of competing national strategies being implemented, the organizational logic of international industrial chains is undergoing a paradigm shift from efficiency-driven "Just-in-Time" to security-driven "Just-in-Case." This structural shift is first manifested in the "forking" and "fracturing" of global high-tech value chains, particularly in the semiconductor and telecommunications equipment sectors. These chains are progressively diverging into two parallel and relatively independent ecosystems: one centered on the United States and its allies, and another anchored by China. Simultaneously, capital allocation exhibits

pronounced regional clustering, no longer solely pursuing global cost advantages based on comparative advantage principles. Instead, it is shifting toward regional hubs like North America (leveraging the USMCA framework), Europe, Southeast Asia, and India. This aims to hedge geopolitical uncertainties by shortening the physical radius of supply chains. However, this restructuring of industrial chains—where political logic overrides economic logic—while enhancing supply chain resilience, inevitably increases the costs of global factor allocation and innovation collaboration. The International Monetary Fund (IMF) defines this [16] as the price of "geoeconomic fragmentation."

3. The Multidimensional Impact of Techno-nationalism on International Sci-Tech Investment

Global economic data from late 2024 to early 2025 reveals that international investment patterns are undergoing the most profound structural rupture since the end of the Cold War. The long-dominant "efficiency-first" logic—where capital seeks globally the lowest-cost, largest-market allocation points—is being supplanted by a new "security-driven" paradigm. This shift is not a mere cyclical fluctuation but a long-term trend driven by geopolitical rivalry, the rise of techno-nationalism, and supply chain security anxieties. Under this new paradigm, global foreign direct investment (FDI) flows exhibit pronounced characteristics of bloc formation, regionalization, and inward-looking cycles. Beyond traditional variables like markets, costs, and talent, "geopolitical compatibility" has emerged as a critical factor, resulting in both physical and logical fragmentation of global capital markets.

3.1 Reconfiguration of Investment Patterns

3.1.1 Geographical "Bloc Formation" in International Sci-Tech Investment Flows

International capital and technology are concentrating within geopolitical alliances, forming distinct technological ecosystems centered on China and the United States. A defining characteristic of this trend is the significant shortening of "geopolitical distance." Research by the McKinsey Global Institute reveals that since the global financial crisis, the "geopolitical distance" of global greenfield FDI (new investments) has shortened by over 20%. This distance is measured by analyzing the alignment of positions between the investing country and the host country on international affairs, such as UN voting. This indicates that companies increasingly prefer to invest between nations with similar political stances. Approximately 35% of large multinational corporations have reduced the geopolitical distance of their investments, with Japanese, South Korean, and European companies showing the most pronounced shift. They are reallocating investments in advanced manufacturing—particularly in automotive and semiconductors—from geographically or politically distant locations to closer allied markets like Europe and the United States.

The core competitiveness of the U.S.-centered technology ecosystem lies in the deep integration of its "alliance system" and "market ecosystem." The United States maintains significant advantages in foundational technologies such as artificial intelligence, semiconductor design tools, and operating systems. It leverages long-arm jurisdiction tools like export controls to influence the technological systems of its allies. Simultaneously, the U.S. is systematically integrating allies' technological expertise—such as Japan and South Korea's semiconductor manufacturing capabilities and Europe's fundamental research strengths—into its supply chain through strategies like "friend-shoring." This forms a transatlantic and Indo-Pacific technological alliance. According to the latest statistics released by the U.S. Bureau of Economic Analysis (BEA) [17], by the end of 2024, the stock of U.S. foreign direct investment increased by $206.3 billion, reaching a total of $6.83 trillion. This growth was highly concentrated in Europe (primarily Luxembourg and Germany) and a few Asia-Pacific ally nations. This reflects a significant strengthening of capital flows among developed economies, forming a relatively closed and self-reinforcing "internal circulation" system. The intensification of this internal cycle and capital concentration exhibits pronounced policy-driven

characteristics. In 2024, greenfield investment projects in the U.S. were dominated by investments in semiconductors, artificial intelligence (AI), and related infrastructure, directly benefiting from massive subsidies and tax incentives provided by the CHIPS and Science Act and the Inflation Reduction Act (IRA) [18]. The ecosystem's innovative vitality relies heavily on its decentralized, venture-capital-intensive market-driven structure. Networks comprising the private sector, top universities, and startups rapidly commercialize ideas. Its technical standards and rules—such as AI governance frameworks and semiconductor alliance agreements—are often disseminated externally through a combination of market dominance and political coordination with allies, forming formidable "soft power."

China's technology ecosystem, centered around the nation, exhibits a distinctive feature of deep integration between "state-led strategy" and "massive-scale market application." To overcome critical bottleneck technologies, China is deepening its "new national system," directing resources toward strategic fields through major national science and technology projects. In practice, this manifests as organizational models like "innovation consortia"—led by anchor enterprises that collaborate with universities and research institutes for systematic breakthroughs. Simultaneously, China aims to dismantle internal barriers by cultivating a unified national technology market, optimizing the allocation of innovation factors to build a self-reliant and controllable industrial chain through concerted national efforts. Furthermore, China possesses the world's largest unified digital market, manufacturing system, and user base, providing "scenario traction" for rapid technological iteration and commercialization [19]. From 5G and new energy vehicles to AI applications, this vast domestic market nurtures and validates local technological solutions, fostering relatively self-contained internal technical standards and application ecosystems. The rise of open-source large-model ecosystems like DeepSeek demonstrates China's approach to leveraging market scale and open-source strategies to build technological influence.

Nations situated in the "intermediate zone" between the two major core spheres—China and the United States—are diverging in their strategic choices. Some countries attempt to maintain equilibrium between the two camps to reap dual benefits. Others, particularly medium powers with specific resource or market advantages, proactively form alliances to establish "mini-multilateral" technology coalitions. This approach aims to consolidate their technological sovereignty and pursue becoming "secondary hubs" in specific sectors. The Australia-Canada-India Technology and Innovation Partnership, established in 2025, exemplifies this trend. It aims to combine Australia and Canada's critical mineral resources with India's manufacturing and talent advantages to create an innovation ecosystem bypassing traditional supply chain hubs. Such alliances represent a key manifestation of multipolarity within the technological ecosystem, further refining and solidifying the boundaries of global technological cooperation blocs.

3.1.2 Sectoral Differentiation in International Sci-Tech Investment

The impact of techno-nationalism on investment sectors exhibits distinct dual-track characteristics. In strategic high-tech fields deemed critical to national security and future competitiveness, investments are undergoing deep decoupling and bloc-based alignment. Meanwhile, uncertainty is rising in non-sensitive sectors, though global capital flows in areas like public welfare and clean energy maintain relative resilience and connectivity—albeit facing potential regulatory risks and supply chain disruptions.

In "chokepoint" sectors deemed critical to national security—such as semiconductors, artificial intelligence (AI), quantum computing, and biotechnology—international investment is undergoing sharp contraction and bloc formation. Capital flows no longer follow the principle of comparative advantage but instead align with national security imperatives. In 2024, global semiconductor FDI exhibited "stable volume but falling prices." While project numbers declined by only 2.8%, total capital investment plummeted by 50% to $55.2 billion [20]. This sharp fluctuation reveals a fundamental shift in semiconductor investment logic: massive capital is shifting from cross-border M&A and global expansion to domestic capacity building driven by government subsidies. The U.S. CHIPS Act and the EU CHIPS Act attracted giants like TSMC, Intel, and Samsung to build advanced process fabs in their respective regions, diverting cross-border capital

that might otherwise have flowed to Asia—particularly China. Furthermore, the U.S. Foreign Investment Review Final Rule, effective early 2025, explicitly prohibits or restricts American capital from investing in China's semiconductor, quantum information, and AI sectors [21]. This move further severs the capital ties between these two global innovation hubs in core technologies. The impact extends beyond capital flows, blocking the accompanying technology transfers and management expertise exports.

Investment in the AI sector exhibits extreme polarization and regional fragmentation. On one hand, global AI-related venture capital (VC) reached a record high in 2024, surpassing $100 billion and accounting for one-third of total global VC funding. On the other hand, this boom is concentrated primarily in the United States (e.g., massive funding rounds for OpenAI, Anthropic, and xAI) and within China (e.g., Moonshot AI, DeepSeek), while cross-border AI investments have significantly declined [22]. Particularly, stringent scrutiny of U.S. investments in Chinese AI has led USD funds to largely withdraw from financing rounds for early-stage Chinese AI startups. China's AI industry has been forced to rely entirely on RMB funds and government-guided funds, creating two parallel and incompatible capital-technology ecosystems. This fragmentation extends beyond capital to computational infrastructure (e.g., the Nvidia chip embargo) and the isolation of model training data.

In contrast, clean energy and certain traditional industries demonstrated strong resilience. In 2024, renewable energy maintained its position as the top global FDI recipient, attracting $270.1 billion in investments—accounting for 27% of the total investment in the world's top ten industries [23]. Despite escalating trade barriers—such as anti-subsidy investigations by Europe and the U.S. targeting Chinese photovoltaic modules and electric vehicles—shared global decarbonization goals maintained cross-border capital flows in this sector. Notably, this resilience stemmed from companies proactively adjusting investment strategies. Chinese new energy enterprises like CATL and BYD adopted a "detour strategy" by establishing factories in Hungary, Mexico, and Southeast Asia to circumvent direct trade barriers in Europe and the US. While this investment model maintained capital flow continuity, it also made global supply chains more circuitous and costly.

3.2 Evolution of Investment Models and Risk Paradigms

Under the influence of techno-nationalism, the operational model of international science and technology investment has undergone a fundamental shift. Investors no longer focus solely on financial returns (IRR) and total addressable market (TAM), but have incorporated "geopolitical risk" into their core decision-making models—even as a veto-power screening criterion. Investment patterns have transitioned from global integration toward "friend-shoring" and "onshore production," with geopolitical due diligence becoming standard practice for venture capital (VC).

In recent years, "friend-shoring" has evolved from a political slogan into concrete operational guidelines and institutionalized arrangements for corporate investment. By 2024, many multinational corporations explicitly prioritize "political alignment" as a key criterion in location decisions. Research from the University of Michigan indicates that [24] U.S. corporate supply chain "decoupling" is not occurring across the board, but is concentrated in sectors capable of shifting to politically allied nations. Decoupling only materializes when alternative suppliers are located in economically viable countries aligned with U.S. geopolitical interests. This pattern is particularly pronounced in the semiconductor industry. Through bilateral agreements, the U.S. and Japan have strengthened "friend-shoring" cooperation in semiconductor and electronic component supply chains. The Japanese government offers substantial incentives to encourage companies to relocate manufacturing bases from China to allied nations like Southeast Asia, reducing reliance on any single country. This strategy effectively builds an exclusive technological investment alliance, raising barriers for non-allied nations to enter high-tech supply chains and shifting the global supply chain network from "flattening" toward "grouping."

Traditional commercial due diligence (financial, legal, business) is no longer sufficient to navigate today's complex landscape. Since 2024, "Geopolitical Due Diligence" has become standard practice in cross-bor-

der mergers and acquisitions (M&A) and venture capital (VC) investments, reaching unprecedented depth and breadth. Investment institutions have begun systematically examining whether target companies are involved in military, surveillance, human rights, or dual-use technology issues related to "countries of concern." For instance, the U.S. House of Representatives' investigation into Sequoia Capital's spin-off and its Chinese arm (Sequoia China/HongShan) portfolio has compelled the entire VC industry to incorporate national security screening mechanisms into investment decisions [25]. This scrutiny extends not only to direct investment targets but also penetrates their supply chains and end-users. While the EU's Corporate Sustainability Due Diligence Directive (CSDDD) focuses on human rights and environmental issues, its implementation often deems operations in geopolitically conflicted regions (e.g., Ukraine, Middle East) as high-risk, compelling stricter compliance reviews. For M&A involving sensitive technologies, buyers must not only assess financial risks but also simulate business continuity under extreme geopolitical scenarios (e.g., escalating sanctions, asset freezes) [26]. Consequently, investors now design exit mechanisms triggered by geopolitical conditions from the initial investment stage. Examples include incorporating expanded "force majeure" clauses or dedicated "sanctions clauses" into investment agreements, stipulating that investors may demand mandatory buybacks or asset divestitures if the target company's country faces specific sanctions or export controls. This defensive investment structuring reflects heightened market anxiety over geopolitical uncertainties.

Against this backdrop, the risk paradigm for international technology investment has evolved, with political risk supplanting commercial risk as the primary consideration. Corporate compliance costs have surged, and global innovation networks have fractured. Historically, multinational corporations based investment decisions primarily on commercial metrics such as return on investment (ROI), market size, and labor costs. However, in the era of techno-nationalism, political license has become a preemptive veto factor. In extreme cases, companies may be forced to withdraw even when market demand exists due to deteriorating political conditions. A prime example is Chinese battery manufacturer SVOLT Energy Technology's decision in 2024-2025 to terminate its European operations and cancel plans for a German factory. Despite Europe's substantial demand for electric vehicle batteries, geopolitical uncertainties, threats of EU anti-subsidy investigations, and the political risks stemming from protracted approval processes exceeded the company's tolerance threshold. Moreover, squeezed by both geopolitical pressures and techno-nationalism, compliance costs for companies are no longer marginal operational expenses. Instead, they have evolved into substantial burdens that devour profits and stifle innovation. This surge in costs is comprehensive, encompassing data compliance, supply chain traceability, export control licensing applications, and legal fees incurred when navigating conflicting regulations across multiple jurisdictions.

3.3 Far-Reaching Consequences for the Global Innovation Ecosystem

The restructuring of investment patterns driven by techno-nationalism has profoundly altered the operational logic of the global innovation ecosystem. The fragmentation of scientific research, rising innovation costs, and opposing technical standards now define the prevailing innovation landscape. While these shifts may temporarily stimulate domestic R&D investment in specific nations, they will ultimately lead to diminished innovation efficiency, fragmented technical standards, and obstructed collaboration in the global public sphere.

The scientific decoupling driven by techno-nationalism hinders knowledge flow and research collaboration, undermining innovation efficiency. For decades, Sino-American scientific cooperation has served as a vital engine for global scientific progress, particularly in life sciences, materials science, and physics. However, multiple authoritative datasets from 2024 indicate this collaboration is rapidly shrinking, resulting in de facto "scientific decoupling." According to the latest data from Clarivate and Nature Index, the number of Sino-American co-authored papers continued to decline significantly in 2024, with drops exceeding 20% in sensitive fields like engineering, physics, and computer science [27]. This "decoupling" severs one of the most critical bilateral connections in the global scientific network, slowing the dissemination of

cutting-edge knowledge. The chilling effect of the U.S. "China Initiative" and increasingly stringent visa reviews have prompted a large number of Chinese scientists to leave the United States and return to China. Data indicates that [28] this talent repatriation has negatively impacted U.S. research output in materials science and AI, while simultaneously accelerating China's self-sufficiency in talent within these fields. Cross-border data restrictions in biomedicine have become the greatest obstacle to collaboration. Influenced by China's Regulations on the Management of Human Genetic Resources and the proposed U.S. Biosecure Act, multinational clinical trials and genomics research face significant compliance risks. This has reduced the synergistic efficiency of global drug development and extended the cycle for new drug research and development[29].

Techno-nationalism compels nations to pursue "autonomy and control" over core technologies, directly leading to redundant resource allocation and diminished innovation efficiency worldwide. Through measures like the U.S. CHIPS Act subsidizing domestic manufacturing, nations are essentially rebuilding industrial chain segments that could previously be efficiently sourced through global trade. This "reinventing the wheel" behavior significantly diverts R&D resources that could otherwise be directed toward exploring new technologies. IMF research estimates that such geo-economic fragmentation could result in up to a 7% loss in global GDP, with the primary long-term cost stemming from the impeded diffusion of knowledge caused by technological decoupling [30]. In highly complex industries like semiconductors, decoupling may force sanctioned parties to adopt suboptimal domestic alternatives, thereby reducing final product yield and performance. IMF models predict that a complete severance of semiconductor trade between the OECD and China could degrade China's input quality by approximately 5%, directly undermining the competitiveness of downstream electronic products [31].

The current global technology governance architecture is undergoing a structural paradigm shift from "interdependence" to "technological apartheid." This geopolitically driven fragmentation is systematically dismantling the unified global technology standards established after World War II [32]. This dualistic technological ecosystem manifests as particularly intense institutional competition at the digital infrastructure level. In the 6G communications domain, the United States and its allies are vigorously promoting the Open RAN architecture. This aims to weaken China's monopoly advantage in traditional integrated hardware by opening interfaces and decoupling software from hardware. This divergence in technological approaches risks a fundamental rupture in global communication networks at both the physical and protocol layers, potentially leading to the emergence of incompatible "split networks." [33] Simultaneously, global AI governance rules are fragmenting into two parallel and competing normative systems: one represented by the U.S. Department of State's Political Declaration on the Responsible Military Use of Artificial Intelligence and Autonomous Technologies, emphasizing military ethics and alliance cooperation grounded in Western liberal values [34]; the other embodied by China's Global Initiative on AI Governance, advocating a UN-centered governance model that prioritizes national sovereignty and representation of developing nations. Moreover, as the boundaries of "data security" become infinitely broadened, intelligent connected vehicles (ICVs) have become the new frontline in trade barriers. The U.S. Department of Commerce's ban on China's Vehicle Connectivity System (VCS) not only effectively erects a "digital iron curtain" blocking technology flows but also extends the fragmentation of industrial chains from the cloud to end devices [35]. Authoritative quantitative research from the International Monetary Fund (IMF) warns that if this deepening "geo-economic fragmentation" evolves into complete technological decoupling, it will sever the cross-border spillover effects of global knowledge and innovation, potentially causing long-term damage to global GDP ranging from 7% to 12% [36]. This would not only mean the evaporation of trillions of dollars in economic welfare but also force countries in the Global South into an "either-or" technological dilemma, exacerbating the permanent entrenchment of the global digital divide.

4. Response Strategies and Future Outlook

As techno-nationalism intensifies and the global innovation landscape undergoes regional realignment,

traditional "borderless" globalization strategies have become unsustainable. Confronted by an era defined by "security first," both multinational corporations and state actors must forge a new dynamic equilibrium between 'connectivity' and "isolation."

4.1 Corporate Strategic Choices

For multinational corporations, geopolitics has evolved from an external environmental variable into a core endogenous factor. To sustain operations in a fractured global market, companies are undergoing profound strategic restructuring. The core logic shifts from pursuing the ultimate efficiency of a single global supply chain to building a "multi-local" architecture capable of isolating geopolitical shocks. This involves establishing relatively independent operational systems in different regions that align with local policies.

The "multi-local" strategy has become the standard paradigm for multinational tech giants navigating geopolitical fractures. This approach requires companies to establish relatively independent operational systems across distinct geopolitical blocs, achieving physical or logical separation of technology stacks, data architectures, and governance structures—effectively forming a "federalized" corporate model. Given increasingly stringent national regulations on data sovereignty and cybersecurity, enterprises must build mutually independent IT infrastructures. For instance, Volkswagen's "In China, for China" strategy established a highly autonomous local R&D center (VCTC), achieving a localized closed-loop from chip design to software development to circumvent cross-border data compliance risks [37]. This isolation is particularly pronounced in finance and investment. Sequoia Capital completely spun off its China operations and restructured them as "Sequoia China," not only to navigate U.S. investment reviews on China but also to achieve risk isolation between dollar and renminbi capital on the fundraising side. This "brand federalism" allows regional entities to maximize retention of the global brand's reputational capital while complying with local regulatory requirements.

In risk management, enterprises should strengthen supply chain resilience by building diversified supply chains and preparing backup chains, while integrating geopolitical risk assessments into core decision-making processes. Against the backdrop of rising tech nationalism and intensifying geopolitical friction, one of the core risks facing international science and technology innovation investments is the vulnerability and susceptibility to disruption of highly globalized and interdependent supply chain systems. A singular, overly concentrated supply chain structure can lead to production disruptions, technology supply cuts, and massive investment losses if key nodes face export controls, entity list sanctions, or political intervention. Therefore, strengthening supply chain resilience must be central to corporate risk management strategies. This serves not only as a buffer against short-term shocks but also as a strategic foundation for ensuring long-term technological competitiveness and investment security. Enterprises must implement multi-dimensional supply chain diversification strategies encompassing geography, suppliers, and technology pathways, moving beyond traditional geographic dispersion. In layout planning, companies should systematically assess geopolitical risk factors across production stages, strategically relocating or backing up high-sensitivity R&D segments and core component manufacturing to allies or neutral regions with strong political trust and stable legal environments. For critical "chokepoint" technologies and components, actively cultivate and certify secondary and tertiary suppliers. Shift away from the cost-first model that prioritized extreme efficiency through single-supplier reliance, accepting a degree of redundancy costs in exchange for supply chain security. Where feasible, pursue parallel R&D and investment in future key technology pathways. Additionally, establish "digital twin" models and dynamic monitoring capabilities for supply chains to visualize risks and enable proactive management. Integrate geopolitical risk assessments into core corporate decision-making processes, embedding them as integral components of strategic planning.

Despite the looming barriers, enterprises still have room to maintain international cooperation in non-sensitive sectors and fundamental research. In basic scientific research, climate change technical standards, and non-dual-use consumer-grade applications, multinational corporations should actively explore "depoliticized" cooperation models. Such collaborations, rooted in shared intellectual pursuits, universal market

needs, or pressing global issues, demonstrate remarkable resilience beyond geopolitical tensions. For instance, in healthcare, despite biosecurity review pressures, cross-border clinical trial data sharing and joint R&D for global health challenges like cancer treatment continue through compliant "firewall" mechanisms, showcasing the humanitarian resilience of innovative partnerships [38]. Transnational research initiatives addressing global challenges like energy transition and climate change—such as collaborations under the Mission Innovation framework—continue to pool the strengths of the world's leading scientific institutions. These partnerships are typically built on shared scientific questions and complementary technical expertise, yielding open and inclusive outcomes that effectively circumvent scrutiny under sensitive techno-nationalism.

4.2 National Policy Balancing

For nations, techno-nationalism is a double-edged sword. While protectionist policies may bolster domestic industries in the short term, prolonged overprotection and decoupling will lead to technological isolation, skyrocketing innovation costs, and the collapse of global public goods provision.

Nations must establish dynamic feedback mechanisms to balance national security safeguards with economic development. Overly broad security framing—elevating all economic issues to national security concerns—not only deters international capital but also severs domestic innovation ecosystems from global cutting-edge knowledge, resulting in wasteful duplication of efforts. Policymakers should define clear security boundaries to prevent restrictions from uncontrollably encroaching on civilian commercial sectors. Therefore, the ultimate goal of national policy is not to make a static, either-or choice between "security" and "development." Instead, it is to construct a policy framework that seeks a dynamic equilibrium between "security" and 'development' under the dual gravitational pull of geopolitics and global markets. The core lies in shifting from the adversarial logic of "comprehensive decoupling" to the risk governance logic of "targeted controls," while actively preserving limited yet essential spaces for global cooperation.

First, the state must establish clear, transparent, and predictable policy boundaries for the concept of "national security" to prevent its unrestricted erosion of commercial and scientific activities. This promotes precise control and avoids broad decoupling and disruption of supply chains. Drawing on the "small courtyard, high walls" strategy, this involves clearly defining a limited number of 'untouchable' core technology domains directly related to national survival and military advantage ("small courtyard") and constructing robust defenses ("high walls") within these areas. For the vast commercial technology domains beyond these "walls," an open approach should prevail. Policy implementation could adopt a "negative list" management model, dynamically updating lists to specify regulated technologies, entities, and activities. This provides stable market expectations and avoids widespread panic caused by the "generalization of security concerns." Control measures should shift from end-use-based restrictions toward those grounded in technical performance metrics and capability thresholds. For instance, regulations on chip manufacturing equipment could be defined by process node and precision parameters rather than blanket bans on enterprises from specific countries. Such objective standards enhance operational feasibility and foster greater international understanding.

Furthermore, while precisely managing risks, nations must adopt more proactive and sophisticated strategies to ensure their industrial and innovation systems remain deeply embedded within and beneficial to the global ecosystem. In response to decoupling pressures from other nations, differentiated opening policies can be implemented across various sectors. For instance, in upstream core technology domains where restrictions are stringent, resources should be concentrated to achieve independent breakthroughs. Conversely, in application layers, market segments, and data resources—areas where competitive advantages exist—proactive expansion of openness should attract global capital and talent. Simultaneously, pursuing "precision recoupling" with third-party nations can build new, diversified technological cooperation networks, preventing isolation from singular technological trajectories. International technical standards form the core of rule hegemony. Nations should encourage enterprises and research institutions to actively participate in—or

even lead—the work of international standards organizations, transforming their technological solutions and industrial practices into globally accepted standards. In areas such as climate change, public health, natural disaster early warning, and fundamental scientific research, countries still share urgent common interests. The nation should effectively leverage multilateral platforms like the United Nations, World Health Organization, and International Telecommunication Union to proactively set cooperative agendas and initiate international large-scale scientific projects in these "low-politics" yet high-value domains. This approach not only maintains essential channels for scientific exchange and eases overall confrontational tensions but also projects a responsible international image while creating opportunities for domestic scientists to integrate into global networks.

Striking a balance between security and development is not a one-time endeavor but a dynamic process requiring continuous monitoring and adjustment. Countries should establish institutionalized policy evaluation mechanisms. Key technology control policies and industrial subsidy policies should undergo regular comprehensive cost-benefit analyses, encompassing dimensions such as the actual impact on domestic innovation speed, the effect on overall industrial chain costs, the influence on international talent attraction, and the implications for alliances and partnerships. When the marginal security gains from protective policies fall significantly below their economic and innovation costs, adjustments should be considered. Concurrently, policy formulation should incorporate broad consultation with diverse stakeholders—including industry, academia, and think tanks—to establish a collaborative mechanism guided by government, led by enterprises, and supported by research. This approach prevents policies from becoming detached from reality.

5. Conclusion

Techno-nationalism has fundamentally and irreversibly reconfigured the underlying logic of international innovation investment, catalyzing its metamorphosis from a purely economic endeavor into a critical frontier of geopolitical rivalry. For decades, international innovation investment operated under a globalization paradigm centered on efficiency and cost optimization, where capital sought the ideal combination of technological factors and market opportunities worldwide. However, the ascendancy of techno-nationalism has forced a paradigmatic shift toward "security-first" and "compliance-centric" rationales. Consequently, geopolitical alignment has ascended from a secondary consideration in investment appraisals to a non-negotiable prerequisite for transactional viability. This transition signifies that international innovation investment is no longer merely a cross-border economic activity but has become an extension of national security statecraft and a primary arena for great-power competition.

In the foreseeable future, international innovation investment will navigate the persistent tension between "security imperatives" and "openness," gravitating toward a "new normal" characterized by fragmentation, regionalization, and deep politicization. Geographically, capital and technology flows are increasingly bifurcated along geopolitical lines, where "friend-shoring" and "onshoring" are supplanting traditional globalized configurations. Sectorally, cross-border M&As and capital mobility in strategic frontiers—such as semiconductors, artificial intelligence, and quantum computing—will face enduring constraints, fostering the emergence of technological enclaves or exclusive ecosystems. The global investment landscape will perpetually oscillate between the pursuit of innovation premiums derived from openness and the demand for containment necessitated by national security.

While techno-nationalism entails significant negative externalities—including diminished global innovation efficiency, redundant construction, and inflated supply chain costs—it has become an inescapable reality for both corporate and state actors. For multinational corporations (MNCs), adopting "multi-local" strategies, fortifying supply chain resilience, and institutionalizing geopolitical risk compliance are imperative for maintaining global competitiveness. For sovereign states, the resilience of governance will be tested by the challenge of maintaining a dynamic equilibrium between defensive securitization and technological vitality. The key to averting a total collapse of the global technological ecosystem lies in precision-targeted regulation rather than indiscriminate decoupling, alongside the preservation of collaborative spaces in

non-sensitive domains. In conclusion, the golden age of unfettered international innovation investment has concluded, giving way to a more fragmented and politicized landscape. In this new era, strategic primacy in the global technological race will belong to those who can most effectively balance security and growth within an increasingly complex geopolitical network.

Conflicts of Interest

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

Author Contributions

The author conducted all research and wrote the manuscript.

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Military Education and Training in University: The Impact of the Russia-Ukraine Conflict on China

Pengcheng Li[1]*, Wangze Ouyang[2]

1 Country and Area Studies Academy, Beijing Foreign Studies University, Beijing 100089, China, Faruk_Li@163.com

2 UCL Institute of Education, University College London, London, WC1H0AL, United Kingdom, ouyang_wangze@163.com

***Corresponding author, E-mail: Faruk_Li@163.com**

Abstract

The Russia–Ukraine conflict reveals transformative shifts in modern warfare across technological, mobilizational, and cognitive domains. The widespread use of drones, loitering munitions, electronic warfare, and open-source intelligence has lowered combat's technological threshold, driving the "civilianization" of military capabilities. Meanwhile, cyber operations, information warfare, and social media have extended battlespace into cognitive domains, making information literacy and psychological resilience vital. Divergent mobilization systems further show that quality reserve personnel are decisive for protracted conflict. These changes challenge China's university-based military education, which remains focused on drills, fitness, and general theory. Traditional training is insufficient for intelligentized, system-of-systems warfare, which requires technical proficiency, specialized skills, and security awareness. As universities concentrate high-quality youth, they are crucial platforms for strengthening defense reserves. Drawing lessons from the Russia–Ukraine war, this paper analyzes modern warfare's demands on military human resources, identifies structural gaps in China's military education, and proposes pathways toward a professionalized, intelligentized, and integrated peacetime-wartime training system. The study aims to offer theoretical and practical guidance for enhancing national defense readiness in the new era.

Keywords: Higher Education Institutions; Military Education; Military Training; The Russia-Ukraine Conflict

1. Introduction

Since its outbreak in 2022, the Russia–Ukraine conflict has rapidly evolved into the largest, longest-lasting, and most technologically intensive high-intensity modern local war in recent years. Beyond its far-reaching geopolitical implications, the conflict offers a highly representative real-world case of military technological innovation, transformations in operational paradigms, and the functioning of national mobilization systems. The large-scale deployment of unmanned aerial vehicles and loitering munitions, the deep integration of informationized command-and-control systems, and the continuous interplay of cyber warfare and public opinion warfare have made the conflict a critical lens through which to observe the evolving character of future wars. The high level of technological density and operational complexity displayed in this war indicates that the demand structure for human resources in modern warfare has undergone a fundamental shift. Rather than relying primarily on physically capable soldiers in the traditional sense, contemporary warfare increasingly depends on multifaceted personnel equipped with technical proficiency, information literacy, psychological resilience, and specialized professional skills.

Within China's current legal framework, the Military Service Law and the National Defense Education Law explicitly designate institutions of higher education as key platforms for implementing nationwide defense education. Universities bear the responsibility of cultivating students' national defense awareness, strengthening their military qualities, and providing talent reserves for the construction of the national defense mobilization system. For a long period, university-level military training has primarily focused on formation drills, physical conditioning, basic skills, and general national defense theory. Characterized by short training durations and relatively fixed content, such programs have centered mainly on discipline education and the enhancement of national defense consciousness. However, the emerging characteristics of modern warfare revealed by the Russia–Ukraine conflict compel a reassessment of whether the existing system remains adequate for the demands of the new era.

From existing research, the Russia-Ukraine conflict is increasingly regarded as a watershed in the transformation of contemporary warfare technology and force structure. In analyses by international scholars and military think tanks, one line of research focuses on how emerging combat capabilities—such as unmanned aerial vehicles, loitering munitions, and electronic warfare—have reshaped the battlefield, noting that both Russia and Ukraine have engaged in competition over spectrum suppression, protection of command-and-control nodes, and integrated air-ground defense systems, with the information and electromagnetic domains becoming decisive factors in determining battlefield outcomes. Another line of research concentrates on cyber offense-defense and cognitive operations, arguing that large-scale cyberattacks, hacker "volunteers", and social-media manipulation during the conflict signal that cyberspace and the information sphere have shifted from peripheral roles to key variables influencing the course of war, further driving militaries to develop new concepts such as "cognitive-domain operations" and "full-spectrum information warfare".

In advancing reforms to national defense education and university military training in response to the demands of modern warfare, China had already taken steps prior to the Russia-Ukraine conflict. The 2019 revised edition of the Military Curriculum Teaching Syllabus for Regular Higher Education Institutions explicitly incorporated modules on "informationized warfare" and "modern warfare and informationized equipment." Domestic academic research also began relatively early and has more recently centered on structural issues such as outdated training content and overly homogeneous instructional methods under conditions of informationized warfare. Scholars generally advocate reconstructing the national defense education system in universities through the integration of modules such as virtual simulation, cyber offense-defense, emergency protection, and information-technology skill training, in order to align university military education with the capability requirements of intelligentized future battlefields and cultivate more versatile national defense talent.

However, existing research, while addressing the general directions for reforming university military

training, remains insufficient regarding the systematic integration of emerging combat elements—such as unmanned systems, intelligent technologies, cyber operations, and cognitive confrontation—into curriculum design and training modules. Therefore, this study addresses the following research question: in the context of modern warfare demands revealed by the Russia-Ukraine conflict, how can China's university-based national defense education and military training be systematically restructured in terms of curriculum content, instructional methods, and competency objectives to cultivate a versatile reserve force capable of operating effectively in intelligentized battlefields.

2. The Core Characteristics of the Russia-Ukraine Conflict and Their Implications for Military Human Resources

2.1 The Core Characteristics of the Russia-Ukraine Conflict

The Russia-Ukraine conflict highlights a marked trend toward the "civilianization"of contemporary armed confrontation, wherein civilian technologies, societal resources, and nontraditional actors play increasingly prominent roles on the battlefield. Throughout the conflict, large numbers of commercially available quadcopter drones were modified for reconnaissance, fire adjustment, and improvised munition delivery, while Ukrainian civilian teams employed 3D printing and open-source technologies to adapt and upgrade unmanned systems. These developments demonstrate that the operational threshold for high-technology equipment has significantly declined and that their production and employment are no longer exclusively dependent on professional military forces. At the same time, Ukraine's rapid formation of its Territorial Defense Forces in the early phase of the war, mobilizing hundreds of thousands of civilians for urban defense, logistics support, and intelligence gathering, and Russia's partial mobilization both underscore that society-wide mobilization capacity has become a crucial component of national warfighting potential. The informational and cognitive dimensions of warfare have likewise exhibited unprecedented openness and societal participation: Ukrainian cyber units and associated volunteer groups launched cyberattacks against Russian targets; social media platforms emerged as spaces for real-time disclosure of battlefield developments and for contesting international narratives; and incidents such as deepfake videos depicting President Zelensky allegedly announcing surrender circulated widely online. These phenomena point to a fundamental shift wherein information discernment, psychological resilience, and media literacy are no longer competencies reserved for specialized institutions, but essential capabilities for both combatants and civilians engaged, directly or indirectly, in modern conflict.

Simultaneously, both Russia and Ukraine relied extensively on social organizations, volunteer groups, and civilian technical communities in areas such as medical evacuation, vehicle repair, and communications support, resulting in logistics systems characterized by a"military-led, socially integrated"structure. Taken together, the Russia-Ukraine conflict reveals that contemporary warfare is evolving toward greater openness, societal embeddedness, and technological democratization, with the traditional boundaries between military and civilian spheres becoming increasingly blurred.

2.2 Implications for Military Human Resources

The "civilianization" of warfare demonstrated in the Russia–Ukraine conflict has fundamentally reshaped the structural demands placed on military human resources. Throughout the conflict, large numbers of ordinary civilians participated directly in the war effort by operating commercial drones, contributing to community-based defense units, providing logistical support, or engaging in cyber activities. This phenomenon indicates that modern warfare no longer relies solely on professional soldiers or individuals with advanced technical backgrounds; rather, it requires the broad mobilization of societal members who possess diverse disciplinary knowledge and skill sets. The diffusion of civilian technologies, the expansion of operational domains, and the diversification of mission types mean that virtually all young people with formal educa-

tion possess some degree of potential military utility, albeit with substantial variation in the technicality, complexity, and risk associated with the roles they may assume.

In this context, universities, concentrations of highly educated youth, acquire heightened strategic importance. Students in engineering, computer science, and related technical fields naturally align with emerging requirements for unmanned-systems operation, cybersecurity, and data processing. Those in the humanities, social sciences, and management disciplines play equally irreplaceable roles in information operations, psychological support, organizational mobilization, and emergency management. Students in medicine, materials science, and engineering can be directly integrated into critical support functions such as medical care, engineering protection, and equipment maintenance. This shift toward a structure in which "everyone is potentially useful, and each contributes in distinctive ways" transforms university-based national defense education from symbolic patriotic or disciplinary training into a forward-positioned component of national mobilization and emerging force-generation systems.

Accordingly, the lessons of the Russia–Ukraine conflict underscore the urgency of reforming military education in higher-education institutions. On the one hand, a more diverse and stratified training system is required to equip students of different academic backgrounds with foundational military competencies aligned with the roles they may assume in future contingencies. On the other hand, it is necessary to move beyond traditional formation drill and fitness centered training models and integrate technical skills, information literacy, psychological resilience, and comprehensive security awareness into the core curriculum. In essence, the "civilianization of warfare" and the "pluralization of talent value" jointly compel university military education to transition from a uniform, symbolic model to a capability-oriented and task-oriented system designed to generate multidimensional reserve forces for modern conflict.

3. The Current Situation and Challenges of Military Education and Training in Chinese Higher Education Institutions

3.1 The current situation of military education and training in Chinese higher education institutions

The military education and training system in Chinese higher education institutions operates under the strategic guidance of the state and is jointly implemented by university leadership, military training units, and relevant government departments. The National Defense Education Law of the People's Republic of China explicitly stipulates that higher education national defense education serves as a crucial means for the state to enhance citizens' national defense awareness and improve their capability to act in defense of the nation. It constitutes an essential component of national defense development and the overall improvement of public literacy. The primary objectives of university military education are to enable students to acquire fundamental military skills and theoretical knowledge, strengthen their awareness of national defense and state security, and thereby prepare a reserve pool of personnel for the nation's armed forces.

In terms of organizational structure, military training in universities is typically led by university-level administrators, including senior officials responsible for the relevant departments, such as the Director of the University Armed Forces Department, the Director of the Security Office, the Director of the Student Affairs Office, as well as the Party Secretaries of individual faculties. These leaders form a Military Training Work Leadership Group, supported by a Military Training Office and a Military Teaching and Research Office as standing bodies responsible for coordinating daily management and instructional activities. This organizational framework ensures centralized and unified oversight of training, administrative management, and ideological-political education, while facilitating collaboration with local military garrisons, provincial military districts, and people's armed forces departments. Commanding officers and enlisted personnel from the assigned military units are responsible for the direct implementation of training, ideological mobilization, and demonstration guidance, thereby guaranteeing the quality and safety of the programs.

Funding and resource provision for military education in universities are relatively comprehensive. For universities affiliated with central ministries, training funds are allocated by the central government as part of the budget of the supervising department and incorporated into the university's internal budget. For locally administered universities, funding is allocated by local governments within the overall school budget framework and managed at the institutional level. These financial allocations cover training equipment, live ammunition for marksmanship, field facilities, and logistical support. In addition, local people's armed forces departments and stationed military units provide military training equipment and facilities. Universities may also make use of campus grounds or borrow military bases and militia training centers for intensive training, thereby achieving resource sharing and optimizing training conditions.

At present, the military education and training practices in Chinese higher education institutions largely follow the traditional triad of"military theory, military skills, and militarized management."The military theory component primarily encompasses courses on current affairs and policies, national security, national defense education, and military thought. These courses are delivered through classroom lectures, thematic seminars, visits to revolutionary education bases, and the viewing of instructional documentaries. Such modalities aim to convey the fundamental concepts of national defense and state security, foster patriotism, and cultivate students' basic awareness of national defense obligations.

In terms of practical training, military skills instruction centers on formation and drill training, supplemented by military boxing routines, basic operation of light weapons, battlefield first aid, and fire safety exercises. This component emphasizes standardized movements, strict discipline, and foundational combat-related competencies. Training methods typically employ a progressive sequence of "explanation-demonstration-breakdown-practice",with particular attention paid to the acquisition of basic skills and the internalization of disciplinary norms. Some universities incorporate adversarial drill models—such as red blue confrontation in athleticized formats to enhance motivation, build collective morale, and strengthen students' sense of honor.

Meanwhile, militarized management permeates the entire training process. Through uniform dress codes, standardized dormitory arrangements, regimented assembly procedures, and formalized leave protocols, students undergo a short-term immersion in a militarized lifestyle. This experience aims to instill regular routines, discipline, and an awareness of collective cooperation. Such management practices not only reinforce discipline but also cultivate organizational and coordination abilities, enabling students to develop responsibility and a sense of belonging within collective activities. In some institutions, these practices are integrated with campus cultural and athletic events such as performances, military-themed cultural showcases, or"red song"competitions， thereby linking militarized management with everyday campus life and allowing students to experience collective participation alongside exposure to patriotic culture.

3.2 The current challenges faced by military education and training in Chinese higher education institutions

Although China's system of military education and training in higher education institutions has developed a relatively mature framework in terms of organizational structure, institutional support, and pedagogical models, its practical operation still exhibits a series of problems against the backdrop of rapidly evolving forms of modern warfare and a profoundly changing national security environment. The most prominent issue lies in the mismatch between the existing content system and contemporary demands. At present, most universities continue to take traditional skills such as formation drills, basic military physical training, and light-weapons handling as the core of training, while military theory courses are still largely centered on introductory national defense knowledge and classical military thought. This model has its historical rationale, but in the face of the rapid development of informationized and intelligentized warfare, the content of such training has become significantly detached from the new types of combat capabilities that have emerged in recent international conflicts. In particular, in emerging fields such as unmanned systems, information confrontation, and cyber defense, university students' training often remains at the conceptual level,

with little access to hands-on practice or scenario-based exercises. As a result, after completing military training, many students are still unable to truly grasp the nature and underlying logic of new forms of warfare, and they lack a clear understanding of the roles they might effectively play within the national defense system.

Currently, university military training faces the issue of unclear training objectives. Some programs still focus on formations, basic physical fitness, and light weapon handling, supplemented by fundamental national defense theory courses, but there is a lack of systematic clarification regarding the purpose of training: whether it is primarily experiential, aimed at cultivating discipline, or intended to reserve professionally specialized talent for future warfare. This ambiguity manifests in practice as a disconnect between training content, students' professional backgrounds and interests, and national security needs, which may lead students to perceive the training as abstract or formalistic, while universities struggle to strategically leverage talent development. Considering China's national context, with the rapid development of informationized and intelligent military capabilities and the growing emphasis on nationwide defense awareness, universities are expected both to cultivate citizens with basic military literacy and to reserve diverse, applicable talent for modern combat or security operations. In this context, the ambiguity of training objectives not only limits educational effectiveness but also affects students' understanding of their roles within the national defense system, thereby reducing the practical value and strategic significance of military education.

In terms of training organization, Chinese higher education institutions have long adhered to a uniform, closed, centralized training model that emphasizes discipline development and the general mastery of basic military skills. The advantage of this model lies in its ability to significantly enhance students' collective cohesion, obedience, and teamwork capabilities. However, its limitations have become increasingly evident: the training lacks systematic differentiation based on students' professional backgrounds, capability structures, and potential future roles in national defense, resulting in the underutilization of the professional potential of high-quality talent in military education. For instance, students majoring in information technology, computer science, engineering, medicine, or materials science could contribute to critical areas such as cybersecurity, equipment maintenance, or emergency medical response. Yet, the current training system seldom incorporates these professional competencies into practical exercises, preventing students from experiencing the alignment of their skills with national defense needs. While this model strengthens foundational military literacy and collective discipline, it may also diminish students' sense of personal relevance to national defense, fostering a psychological perception of mismatch between their individual abilities and the content of military training, thus limiting the capacity of military education to stimulate professional expertise and cultivate diversified defense talent.

Moreover, due to the brevity and fixed scheduling of military training and the lack of subsequent follow-up mechanisms, current higher education military education struggles to establish a continuous and progressive chain of skill development. Military theory and practical training are often artificially separated in time: theoretical instruction is concentrated in large classrooms and delivered primarily through lectures, making it difficult to deepen understanding in connection with practical exercises; practical training, on the other hand, focuses on short-term, standardized operations, emphasizing procedural correctness and discipline but lacking scenario-based simulations, professional skill extension, and targeted application. This structural discontinuity in timing and content allows students to acquire basic skills and discipline during training but offers limited opportunities to integrate knowledge with their professional expertise, future defense roles, or social practice, making the consolidation of training outcomes difficult. Coupled with the absence of follow-up education and sustained practice mechanisms, organizational discipline, physical fitness, teamwork ability, and defense awareness acquired during training tend to decay over time, leaving military training effects confined to short-term experiences rather than evolving into long-term, sustainable national defense competence.

Building on this, the evaluation system for university military training exhibits a marked tendency toward

formalism, further constraining the deepening of educational outcomes. In most universities, performance assessments still rely heavily on demonstration-based exercises such as military parades or formation displays, with evaluation criteria focusing on observable factors such as movement precision, formation alignment, and command responsiveness. While this approach facilitates management and public display, its overemphasis on "visible results" can lead instructors and students to confine training objectives to superficial performance, neglecting the development of critical competencies in modern defense education such as psychological resilience, emergency response, information literacy, innovation capacity, and teamwork. Formalized assessment encourages training to become uniform and standardized, lacking contextualization, specificity, and interdisciplinary integration, making it difficult for students to connect military theory, practical operations, professional expertise, reserve roles, and future defense needs. Additionally, reliance on demonstration-based evaluations can undermine students' motivation for active learning and independent exploration, weakening both the practical and educational value of training. Over time, this may not only hinder the cultivation of sustained national defense literacy among students but also impair the development of adaptability and comprehensive capabilities in the context of modern warfare and national security.

Overall, military education in Chinese higher education institutions is at a critical stage of transition from a traditional model to a modernized system. The current framework exhibits clear discrepancies with the new requirements for reserve forces in the context of intelligentized warfare, in terms of philosophy, content, methodology, and evaluation. As warfare trends increasingly emphasize "civilian integration" and "technological parity," higher education military training faces challenges that extend beyond content updates, encompassing the need for redefining educational objectives, innovating training models, and repositioning universities within the national defense mobilization system. These trends place heightened strategic demands on future reforms.

4. Reform and Optimization Pathways: Constructing a Layered System for Modern University Military Training

4.1 Optimizing the Objectives of Military Education and Training

Against the backdrop of the overall transformation of the university military education system, redefining military training objectives is not merely a matter of updating concepts; it is a systematic project shaped by multiple interacting variables, including resource allocation, university type, student composition, regional security conditions, and national strategic needs. Significant differences among Chinese universities in terms of financial capacity, faculty structure, disciplinary composition, student interests, and local defense mobilization systems make it impossible for a single model of military education to cover all institutions. Therefore, the reconstruction of military education objectives in the new era should follow the principles of "baseline unification, differentiated training, and tiered talent cultivation", forming an executable and sustainable differentiated objective system under the guidance of the national overall security concept, ultimately enabling students to clarify their roles and responsibilities in national defense, recognize the practical value of their own capabilities within the defense system, and strengthen patriotism and collective discipline.

For comprehensive universities with large student populations, diverse majors, and generally constrained financial resources, optimizing military education hinges on maintaining basic disciplinary training while aligning training content with the evolving trends of modern warfare and finding feasible intersections within the resources available to the school. Lessons from the Russia-Ukraine conflict demonstrate that contemporary warfare exhibits"generalized security" characteristics, including nationwide defense awareness, information security, psychological resilience, and social mobilization. Traditional boundaries between frontlines and rear areas are increasingly blurred, and the safety literacy, emergency response abilities, and information discernment of ordinary citizens have become crucial components of the national security

system. Against this backdrop, university military training can, within existing conditions, prioritize the enhancement of basic security awareness and national defense cognition.

Specifically, while retaining traditional elements such as formation drills, basic military exercises, and light weapon handling, training content can be extended to more practical aspects relevant to modern warfare and security. Emergency evacuation and public incident response can be practiced through campus safety drills, fire evacuations, and simulated emergencies, allowing students to experience crisis response processes in concrete scenarios. Basic battlefield first aid training can be conducted in university clinics or medical rooms, covering injury assessment, simple bandaging, and cardiopulmonary resuscitation, helping students understand the value of their skills in emergency situations. Foundational information security and public opinion awareness training can analyze campus networks and social case studies, teaching students the importance of information protection and individual responsibility in cyberspace. Psychological resilience and team collaboration training can employ stress scenario simulations, emergency decision-making exercises, and crisis psychological adjustment, enabling students to remain calm and work efficiently under uncertainty. Through these practical modules, students not only strengthen discipline and physical fitness but also discover their role in a controlled "simulated combat"environment, understanding how their abilities contribute to national security and social protection, thereby cultivating a tangible sense of responsibility.

Universities with specialized disciplines can further differentiate training objectives according to their professional structure and resources, making military education more aligned with national defense needs. Science, engineering, and information technology universities, equipped with laboratories and computer rooms and with students having strong technical aptitude, can integrate professional courses with defense scenarios. Network technology courses may include modules on basic cybersecurity and attack chain analysis; engineering practice courses can incorporate equipment repair and emergency restoration scenarios; automation and unmanned systems courses can help students understand control logic and system vulnerabilities. Medical universities can focus training objectives on public health security, battlefield first aid, mass casualty management, and bio-risk control, using laboratories and simulation facilities to conduct practical exercises that help students recognize their professional value in emergency contexts. Arts and humanities universities, often with students having lower physical training baselines and limited resources, can emphasize skills in information discernment, psychological resilience, communication ethics, and public crisis response, using case studies, scenario exercises, and group collaboration to enhance students' capabilities in safeguarding national information security within familiar professional contexts. Vocational colleges, with students having strong practical and applied skills, can target training objectives toward grassroots emergency response and support capabilities, integrating basic equipment maintenance and emergency repair in mechanical, automotive, and engineering programs; material allocation and logistics processes in logistics and management programs; as well as low-cost fire, rescue, and civil defense training, thereby forming a skills-oriented reserve force aligned with mobilization needs and promoting integration of learning and practice.

In addition, elective modules such as"Drone Operation and Countermeasures," "Basic Cybersecurity" , "Battlefield First Aid"and "Military English"can be introduced across all types of universities, allowing students to link their professional skills with real defense needs while mastering basic military abilities. Theoretical instruction should also be modernized by incorporating the latest cases, such as the Russia-Ukraine conflict and the Nagorno-Karabakh conflict, to analyze the characteristics of contemporary warfare. More importantly, this enables students to understand modern combat logic and clarify their roles and responsibilities within the national security system, thereby cultivating sustainable national defense literacy and a practical sense of responsibility alongside discipline, physical fitness, and fundamental military skills.

From an institutional perspective, international experience indicates that such reforms can be sustainably embedded within higher education systems. Empirical research on the United Kingdom's University Armed Service Units (UAS) shows that universities can host voluntary and tiered military training programs that

function as long-term reserve force development mechanisms rather than short-term compulsory exercises. By emphasizing leadership development, technical skill acquisition, and familiarization with military norms, UAS integrate military education into everyday university life without undermining academic autonomy. This experience to some extent illustrates the institutional compatibility of modular, capability-oriented military education with modern higher education systems.

At the practical level, recent reforms at Xi'an Jiaotong University demonstrate that the technological and organizational conditions for such transformations already exist within Chinese universities. The university has introduced AI-assisted teaching, digital instructors, and knowledge-graph–based course modules, and has piloted VR-based firearms simulation, UAV reconnaissance training, and tactical confrontation drills. These practices show that information-driven, scenario-oriented, and intelligent training methods can be effectively implemented within university-level military courses, thereby translating institutional reform concepts into concrete teaching practices.

4.2 Optimization of Evaluation Systems and Support Mechanisms

The continuous improvement of military education in universities relies not only on the enhancement of training content but also on the establishment of a scientific evaluation system and a robust support mechanism. Currently, many universities still employ evaluation models centered on performances and drill displays. While these approaches are convenient for management and demonstration purposes, they are limited in their ability to help students genuinely perceive the national security situation and understand their role within the defense system. Without such awareness, students lack a sense of crisis, which in turn makes it difficult to cultivate genuine responsibility for national defense and proactive engagement.

To address this, universities should construct a comprehensive evaluation system based on process performance, competency attainment, and the development of overall literacy. Evaluation should shift focus from mere drill standards and observable outcomes to students' abilities to respond in crisis scenarios, solve problems, collaborate in teams, and apply theoretical knowledge. Methods can include daily performance records, group tasks, practical exercises, theoretical tests, and simulated emergencies or cybersecurity drills. By experiencing potential security threats firsthand, students can clearly understand their role in national defense, develop a genuine sense of crisis, and strengthen their sense of responsibility and patriotic awareness.

In addition, to prevent the benefits of military training from fading after the course concludes, universities should implement follow-up support mechanisms. National defense literacy can be integrated into student clubs, volunteer initiatives, and campus safety education, allowing discipline, emergency response skills, and teamwork to be reinforced in daily campus life. Students with professional potential can engage in elective courses, short-term workshops, or specialized training camps to develop skills aligned with national defense needs. Where feasible, universities can also explore "university-community collaboration," such as participation in local militia or emergency services, combining theoretical knowledge with practical experience and extending the impact of military training beyond campus. Through such dual optimization of evaluation systems and support mechanisms, university military education can not only strengthen discipline and skills but also allow students to directly perceive national security realities, understand their role, and cultivate a sustainable sense of crisis, responsibility, and national defense literacy.

5. Conclusion

The Russia-Ukraine conflict and the characteristics of modern warfare it has revealed provide profound insights for reforming military education and training in Chinese higher education institutions. The conflict demonstrates that contemporary warfare is marked by lowered technological thresholds, civilian integration into operational systems, a heightened emphasis on information and cognitive domains, and the central importance of societal mobilization capabilities. This necessitates a shift in university military education from

traditional models focused on formations, physical training, and basic theory toward a capability-generating, task-oriented system that integrates professional specialization and intelligent technologies.

This study contends that reforms in university military education should focus on several key aspects. First, training objectives must be clarified, following the principles of "baseline unity, differentiated training, and tiered talent development," allowing different types of universities to set differentiated goals according to their professional structures and resource conditions. This approach ensures the development of foundational military literacy while promoting the alignment of professional skills with national defense needs, enabling students to clearly understand their roles and responsibilities within the defense system and to recognize the practical application of their abilities. Second, training content should be optimized by combining traditional formation drills, physical training, and basic military skills with modern operational capabilities, information literacy, psychological resilience, and emergency response skills. Elective modules such as drone operation and countermeasures, basic cybersecurity, battlefield first aid, and military English should be added, while theoretical instruction should incorporate recent conflict cases to enhance students' understanding of modern warfare and the national security system. Third, evaluation systems and support mechanisms should be improved. Comprehensive assessments based on process performance, capability achievement, and competency formation can help students clarify their roles through exposure to simulated security threats, cultivating crisis awareness and a sense of national defense responsibility. Follow-up support through student organizations, volunteer activities, elective courses, and school-community collaboration can further extend training effects and ensure continuous skill accumulation.

Overall, reforms in university military education should be guided by national security needs, with the goals of fostering student discipline, capability generation, national defense responsibility, and patriotic spirit. Through the reconstruction of objectives, innovation in training content, and optimization of evaluation and support mechanisms, a diversified and sustainable training system can be established that addresses modern warfare and the comprehensive national defense system. This not only enhances students' defense literacy and patriotic awareness but also provides institutional support for the development of a professional, information-capable, and psychologically resilient reserve force, achieving an organic integration of educational outcomes with national defense strategic requirements.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Author Contributions

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The Impact of Digital Communication on the Language Development of Chinese Adolescents: A Comparative Perspective with the UK

Yang Tongtong[1]*, Han Yixuan[2]

1 School of English and International Studies, Beijing Foreign Studies University, Beijing, China, 2985026172@qq.com

2 Department of Earth Sciences, University College London, London, UK, yx_han@ucl.ac.uk

***Correspondence: 2985026172@qq.com**

Abstract

This study conducted a comprehensive investigation into the impact of digital communication on the language development of Chinese adolescents, and supplemented it with a systematic comparative analysis with the UK. The research employed a rigorous mixed-method design, including a questionnaire survey of 300 participants, a textual analysis of 300 digital chat records, and semi-structured interviews, to meticulously document the widespread use of internet slang, significant grammatical simplification, and language practice differences resulting from platform variations among Chinese adolescents. It further elaborates on the crucial regulatory role played by institutional educational policies and familial communication dynamics. By integrating extensive secondary data from the UK context, including Ofcom's annual media use reports, seminal linguistic works by Crystal and Tagliamonte & Denis, and national digital literacy frameworks, this paper constructs a detailed cross-continental comparison. This analysis reveals the convergent trend in the adaptation of digital language, such as lexical innovation and fragmentation. However, it also emphasizes the significant differences resulting from different cultural norms, educational concepts, and regulatory approaches. These differences are manifested in various outcomes such as the ability to switch codes, the degree of mastery in formal contexts, and the recognition of the legitimacy of digital dialects in academic settings. The study concludes with a set of culturally nuanced, evidence-based recommendations targeting educators, parents, and technology platform designers in both China and the UK. These recommendations aim to foster resilient, adaptable, and critically aware language competencies in an era of ubiquitous digital mediation.

Keywords: Cultural Heritage Conservation; International cooperation; Actor-Network Theory; Ta Keo Temple; Foreign Aid Projects; Heritage Diplomacy

1. Introduction

The emergence and widespread adoption of digital communication technology have triggered the most rapid and profound transformation in human language behavior since the invention of the printing press. For adolescents who are in crucial stages of cognitive, social and identity formation, digital platforms are not merely tools but rather influential environments that shape their communication methods, social norms and language identities. In China, this transformation is particularly notable. Platforms such as WeChat, QQ, Douyin (TikTok) and Bilibili have become the primary venues for adolescents to engage in social interaction, entertainment activities and information consumption. The China Internet Network Information Center (CNNIC, 2024) reported that the internet penetration rate among Chinese adolescents has reached a nearly saturated level of 97.8%, highlighting the comprehensiveness of this digital immersion. This environment has fostered a distinct linguistic ecology characterized by rapid lexical innovation (e.g., "yyds", " 绝绝子 ", " 摆烂 "), syntactic compaction, and pragmatic rules distinct from those governing face-to-face or formal written communication. However, despite the wide recognition of these phenomena, academic research often lacks coherence. As Xu & Zheng (2018) and Zheng & Zhu (2019) pointed out, the existing studies mainly focus on classifying online buzzwords or analyzing the structure of online society, leaving a significant gap in understanding the systematic language features of vocabulary, syntax, and pragmatics, as well as their longitudinal impact on core formal language abilities, which are crucial for academic and professional success.

At the same time, some unique concurrent development trends with distinct backgrounds can also be observed among the youth population in the UK. British adolescents have also deeply integrated into the digital ecosystem. The report of the Ofcom (2023) shows that 96% of adolescents aged 11 to 17 use social media, mainly through smartphones. Platforms such as Instagram, Snapchat, WhatsApp, and TikTok dominate their communication fields. Pioneering and ongoing research by scholars such as David Crystal (2006, 2011) and Sali A. Tagliamonte (Tagliamonte & Denis, 2008) has extensively documented the linguistic creativity and adaptation within these spaces, noting the proliferation of acronyms, initialisms, neologisms, and a distinctive "texting" register. This background in the UK also contains a rich history of sociolinguistic research on language varieties and changes, providing a solid theoretical foundation for exploring the impact of digital technology (Cheshire et al., 2011).

However, there is a crucial flaw in comparative and cross-cultural studies, namely that these studies fail to conduct a comparative analysis of the digital language development of adolescents from completely different social language environments, such as China and the UK. Although both of these groups are active digital participants, their language policies (top-down standardization and descriptive literacy skills), cultural values (the subtle differences between collectivist hierarchy and individualist egalitarianism), and educational systems are all different. Understanding these differences is not merely an academic pursuit; it is a practical necessity for formulating effective teaching strategies, parent guidance frameworks, and responsible platform governance in the context of globalization.

Therefore, this study has three main objectives. Firstly, to conduct a systematic and empirical analysis of the typical language features exhibited by adolescents when communicating on mainstream digital platforms. Secondly, to assess the perceived and potential long-term impacts of these digital activities on their formal language abilities. Thirdly, to explore the regulatory role of domestic cultural norms and institutional policies in China. What sets this research apart is that it also incorporates a fourth comparative element: the findings from China are interpreted within the broader context of British adolescents' digital language usage, drawing on authoritative materials such as reports from the British Communications Office and existing Western academic research findings. This comparative perspective aims to distinguish the universal impact of digital technology from the unique influence shaped by specific cultural and institutional structures, thereby providing a more comprehensive understanding of the overall language development of global adolescents in the 21st century.

2. Literature Review and Theoretical Framework

2.1 Digital Communication and Adolescent Language

2.1.1 The Chinese Landscape

The research on the online language used by Chinese adolescents has progressed from the early stage of merely providing a descriptive vocabulary list of online slang to a more complex level of sociological and linguistic analysis. The Institute of Linguistics, Chinese Academy of Social Sciences (2024) highlights the dynamic, cyclical nature of internet buzzwords, often reflecting broader social sentiments and youth anxieties, such as " 内卷 " (involution) and " 躺平 " (lying flat). Xu & Zheng (2018) expounded on online language use from the perspective of "generalized relationships and differential sequential communication". They argued that digital platforms not only expanded but also complicated the traditional Chinese social networks (guanxi), and language was an important marker of membership. Similarly, Zheng & Zhu (2019) studied the "circular" dissemination phenomenon of online language, that is, specific words and styles become fixed within certain sub-cultural groups on platforms such as Bilibili or Douyin, thereby forming language-based "echo chambers".

However, there is a consistent critical viewpoint in this series of studies, which is that their main focus lies in the innovation of vocabulary. In contrast, detailed corpus-based research on the grammatical and syntactic changes brought about by digital communication is relatively scarce. There are still many issues that have not been fully explored: To what extent does the short phrase style of instant messaging weaken the complex sentence structure? How does the parallel, emoticon-laden speech flow in social media comments affect the narrative coherence? This study aims to fill this gap by conducting a systematic syntactic analysis of digital texts.

2.1.2 The UK Landscape

In contrast, the research on digital languages in the West, especially in the UK and North America, has a longer development history and often employs quantitative linguistic research methods. Crystal's (2006) foundational work positioned "Netspeak" as a new and legitimate language variety, which has its own grammar and conventions. Tagliamonte and Denis (2008) conducted a corpus analysis of instant messages and proved that although adolescents used a large number of abbreviations and non-standard forms, these forms were systematic and followed certain rules, and did not indicate a decline in language. Their research showed that even in very informal digital communication environments, the core grammatical structures were well preserved.

The research also focused on exploring its effects. Wood et al. (2011) conducted a study on the impact of text messages on children's reading ability, and found that there was a complex relationship involved: familiarity with text abbreviations might be positively correlated with certain speech skills, but it was not necessarily related to broader writing abilities. Ofcom's annual reports (e.g., 2023) provides macro-level data on usage patterns, device ownership, and network activities, offering social background information for linguistic research. Furthermore, the UK Council for Internet Safety's framework (UKCIS, 2020) adopts a policy-oriented approach, emphasizing "digital literacy", which includes a critical understanding of online communication methods, in order to bridge the gap between informal digital practices and formal education.

2.2 Key Theoretical Frameworks

This study is informed by two key theoretical frameworks. First, Social Identity Theory (Tajfel & Turner, 1979) provides a lens for understanding the symbolic function of digital language. The adoption of specific buzzwords, acronyms, or communicative styles has become a marker of membership within digital peer

groups, fan circles, or subcultures. For instance, the expression " 家人们 " in China, or specific meme references in the UK, all play a role in either including or excluding members, establishing social boundaries, and strengthening the cohesion of the internal group. This theory helps explain language innovation and the motivations behind following specific platform norms.

Second, the concept of Cultural Capital, particularly in its linguistic form, is crucial for analyzing differential outcomes. The work of Livingstone and Helsper (2007) on the "digital divide" extends beyond access to include gradients in usage, skills, and the benefits derived from digital media. In the context of language, families with higher social educational capital may adopt "mediatization" or "co-learning" approaches, discussing internet slang and its applicable contexts, thereby helping adolescents develop metalinguistic awareness and code-switching abilities. In contrast, families lacking such resources may experience "language silence", where digital language becomes a barrier to intergenerational communication rather than a shared resource. This framework is crucial for explaining the moderating effect of family dynamics observed in both China and the UK.

2.3 Identified Research Gaps and This Study's Position

The relevant literature has revealed different research approaches: Chinese studies have delved deeply into the sociocultural significance of digital vocabulary within specific cultural contexts, while UK/Western studies have provided powerful models for analyzing the systematicity of grammar and its educational impact. However, few studies have conducted direct and structured comparisons. The key gaps addressed by this research include:

1.The lack of integrated analysis connecting platform affordances, concrete linguistic changes (especially syntax), and moderating cultural factors in a single Chinese study.

2.The absence of a sustained comparative perspective that contrasts the Chinese experience with that of a Western, English-speaking nation like the UK, where digital adoption is similarly high but cultural-institutional frameworks differ markedly.

3.The need to move beyond lexicon to a holistic analysis encompassing vocabulary, syntax, and pragmatics in assessing digital language's impact.

These disparities collectively highlight the need for more comprehensive and cross-cultural research methods. By conducting the study of Chinese cases within a global context, this research not only addresses the methodological shortcomings but also enriches the theoretical understanding of the fact that the evolution of digital languages is both a universal phenomenon and culturally distinctive. This research approach enables a more comprehensive assessment of whether digital communication will lead to language convergence or strengthen the existing boundaries of sociolinguistics.

3. Research Methodology

To address these complex, multi-layered questions, a pragmatic mixed-methods research design was employed, following the principles outlined by Creswell and Plano Clark (2017). This approach fully leverages the advantages of both quantitative and qualitative research methods. The former is used to identify universal patterns and correlations in larger samples, while the latter is employed to gain in-depth understanding of motivations, cognition, and actual experiences, which are rich and contextually informed content.

3.1 Research Design and Participant Sampling

3.1.1 Chinese Cohort Study

Quantitative Survey: A structured online questionnaire was developed and disseminated via the widely used Chinese platform "Questionnaire Star." Participants were recruited through school networks and online community channels to ensure diversity. The final sample comprised N=300 Chinese adolescents aged 13-

18, spanning multiple provinces (including Beijing, Guangdong, Sichuan, and Henan) to mitigate regional bias. The questionnaire contained 17 items across four sections: (A) Digital media usage habits (platforms, daily screen time); (B) Awareness and use of specific internet buzzwords; (C) Self-perceived impact of digital communication on formal writing/speaking; (D) Perceived influence of school and family on language use. Qualitative Components:

1. Textual Analysis: A corpus of 300 naturally occurring digital texts was compiled. This included 150 private/group chat logs from WeChat and QQ, and 150 public comments/posts from Douyin (TikTok). Texts were anonymized to protect user privacy.

2. Semi-Structured Interviews: Among the survey participants, 10 individuals were deliberately selected to cover various aspects such as screen usage duration, self-reported academic performance, and family background. These interviews were conducted online and each lasted for 45 to 60 minutes. The interview protocol covered the following topics: the conscious adaptation of language in different contexts (in school and online); the experience of the school's language policy; detailed discussions with parents/classmates about digital language; and the individual's reflection on the role of online communication in one's own language development.

3.1.2 UK Cohort Study

Given scope constraints, the UK analysis is based on a systematic review and synthesis of existing authoritative data and research. Key sources include:

1. Official Statistics: Ofcom's "Children and parents: Media use and attitudes report 2023" provides foundational data on platform penetration, usage time, and device access among UK teens.

2. Academic Research: Seminal and recent studies by Crystal (2006, 2011), Tagliamonte and Denis (2008), Wood et al. (2011), and Cheshire et al. (2011) provide evidence on linguistic features, systematicity, and social variation in digital language use.

3. Policy Documents: The UK Council for Internet Safety's "Education for a Connected World" framework (UKCIS, 2020) outlines the official educational approach to digital literacy, including language and communication.

4. Sociological Studies: Work by Livingstone and Helsper (2007) on digital inclusion and parental mediation informs the analysis of socio-economic and familial moderators.

This secondary data was analyzed thematically to construct a coherent profile of UK teenage digital language use, which served as the point of comparison for the primary Chinese data.

3.2 Data Analysis Procedures

3.2.1 Quantitative Data Analysis

Survey data were analyzed using statistical software (SPSS). Analysis included:

1. Descriptive Statistics: Frequencies and percentages for all items.

2. Reliability Analysis: Cronbach's Alpha was calculated for multi-item scales within the questionnaire, showing good internal consistency (Section B: α=.78; Section C: α=.82).

3. Comparative Analysis: Cross-tabulations and chi-square tests were performed to examine relationships between variables, most notably between daily screen time categories (e.g., <2 hrs, 2-4 hrs, ≥4 hrs) and self-reported language fragmentation, and between family discussion frequency and buzzword usage intensity.

3.2.2 Qualitative Data Analysis

A hybrid thematic analysis approach was used, combining deductive codes from the research questions

and inductive codes emerging from the data itself (Fereday & Muir-Cochrane, 2006).

1. Textual Analysis: The 300 digital texts were manually coded for: (1) Presence of specific buzzwords from the survey; (2) Sentence length (in characters); (3) Sentence complexity (use of subordination, conjunction); (4) Punctuation density; (5) Use of emoji/emoticons as syntactic or pragmatic markers. These were compared against baseline metrics derived from standard Chinese middle school textbook passages.

2. Interview Analysis: Interviews were transcribed verbatim. Transcripts were coded iteratively using NVivo software. Major themes that emerged included: "Performance of Identity Online," "School as Linguistic Gatekeeper," "Family as Mediator or Barrier," and "Code-Switching Fatigue."

3.2.3 Comparative Analysis

The preliminary analysis results of China and the secondary review results of the UK were presented side by side in a structured comparison table format and discussed in narrative form. This comparison focused on the common aspects (general numerical effects) and the different aspects (cultural-specific manifestations), and was guided by the research goals related to language features, influences, and regulatory factors.

4. Results and Discussion

4.1 Linguistic Characteristics of Digital Communication

4.1.1 Lexical Innovation and Semantic Nuance

The survey data from China reveals the hierarchical structure of buzzword, and this structure is closely related to emotional expression. " 摆烂 " (bài làn, meaning to openly embrace failure or mediocrity) led at 79.25% usage, powerfully encapsulating a generational sentiment towards pervasive academic and social pressure. This was followed by " 家 人 们 " (jiā rén men, "homies/fam") at 60.38%, which repurposes a kinship term to create digital affinity, and the translingual hybrid "yyds" (forever god) at 58.49%. Platform specialization was clear: " 家人们 " thrived in the quasi-private, group-based dynamics of WeChat, while " 摆烂 " dominated the performative, emotion-driven space of TikTok comments.

In the UK, lexical innovation follows different patterns. While also creating in-group markers (e.g., "simp, " "ghosting, " "cheugy"), the influence of a globalized, American-dominated internet culture is stronger. Acronyms like "LOL," "BRB," and "IMO" have been standardized for over a decade (Tagliamonte & Denis, 2008). The creativity often lies in meme culture, where phrases from videos, shows, or tweets ("That's so meta," "It's giving…", "Ok, boomer") gain rapid currency. Unlike the Chinese phenomenon of compressing whole phrases into character-based neologisms (" 绝绝子 "), UK digital lexicon frequently expands or alters the meaning of existing English words through ironic or contextual reuse.

4.1.2 Syntactic Simplification

The analysis of the Chinese text provides clear quantitative evidence of grammatical changes. The average sentence length in the digital corpus is 12.5 characters, which is only half of the 25.8 characters in textbook prose. The density of punctuation marks has decreased from 0.21 (the number of punctuation marks per character) in textbooks to 0.12 in digital texts. This is reflected in expressions such as " 下课了 食堂 速 " ("Class is over. To the cafeteria. Hurry up.") where the subject, predicate, and conjunction are omitted, relying largely on pragmatic inference.

Research in the UK has confirmed a similar trend, namely that language expression tends to be concise and in parallel structure. Crystal (2011) notes the predominance of simple or compound sentences over complex ones in texting and instant messaging. Tagliamonte and Denis (2008) found frequent omission of subjects (especially "I"), auxiliaries, and determiners in their corpus of Canadian instant messages (e.g., "Going out now. Back later."). The driving factors are similar: speed, convenience, and adaptability to

screen size and interface design. However, the degree of fragmentation may be influenced by the underlying grammar of the language; English relies more on word order and necessary subjects, so even in a concise form, its structure may show a certain degree of clarity that is not as evident in Chinese, as Chinese relies more on context and topic prominence.

4.1.3 Pragmatic Code-Switching and Platform Logic

Chinese adolescents have a keen awareness of context-based language transformation. The interview data show that they consciously "optimize" their language expression when completing school assignments, communicating with elders in family WeChat groups, or interacting with teachers. The platform itself also stipulates practical norms. For WeChat used for multi-purpose communication (family, school, friends), it requires more context-sensitive language expression. While as a short-video dissemination medium, Douyin encourages the use of exaggerated, emotional, and often deliberately non-standard language to attract attention.

In the UK, there is also a similar phenomenon of language transformation, but this transformation may not be strictly regulated by formal authorities. Adolescents make content choices based on different "audiences" on various platforms - from carefully planned Instagram posts, to brief Snapchat stories, to chaotic group WhatsApp chats. The work of Cheshire et al. (2011) on Multicultural London English (MLE) shows how digital and face-to-face peer interactions can drive rapid linguistic change that later permeates wider youth culture. These practical rules are equally complex, but they may have a lower degree of association with hierarchical obedience (which is an important value in Chinese Confucian culture) and are more closely linked to the norms of calmness, authenticity, and internal unity within diverse peer networks.

4.2. The Impact of Digital Engagement

4.2.1 Screen Time and Linguistic Fragmentation

A key finding from the Chinese quantitative data was a strong positive correlation between high daily screen time (≥4 hours) and the self-reported perception of one's own language becoming more "fragmented, " "simplified, " or "difficult to switch back" to formal style. This group was 3.5 times more likely to report such perceptions compared to low-frequency users (<2 hours). This aligns with the "cognitive cost" hypothesis discussed later.

The research from the UK provided more detailed analytical results. Wood et al. (2011) found that familiarity with text abbreviations ("textism") does not have an adverse effect on reading ability, and may be associated with a stronger phonological awareness (a crucial reading skill). However, they also cautioned that this does not mean that writing ability will be enhanced as a result. Data from Ofcom (2023) indicates a high level of participation, but it does not directly measure the influence in terms of language. This difference might lie in the different measurement methods: this Chinese study captured the subjective perception of the impact, while studies like those by Wood et al. measured the objective performance in specific tasks. Both types of findings are valid, indicating that there might be a certain gap between adolescents' feelings about language and their actual abilities, which is a very suitable area for future cross-cultural research.

4.2.2 Impact on Formal Writing and Expression

In China, the most direct impact is that, without strict control, a large number of internet terms have flooded into the formal written language. In schools without strict policies, students reported accidentally using words like " 栓 Q" (thank you) or " 破防 " (emotionally overwhelmed) in essays. The interview data revealed a more subtle concern: People tend to rely too much on digital shorthand when expressing their emotions. One respondent said: "When I need to write a reflective diary, sometimes I have difficulty finding the right words to describe my feelings... But online, I would use emojis or say ' 我 emo 了 '."

In the UK, in the past, people's focus was on spelling and grammar issues ("u" for "you," lack of punctu-

ation). However, research by Tagliamonte and Denis (2008) argues that adolescents possess a "digraphic" competence, understanding the difference between informal texting and formal writing. The greater concern voiced by UK educators, as reflected in the UKCIS (2020) framework, is not the degradation of grammar, but rather skills such as constructing coherent arguments, evaluating online information, and understanding tone and audience in the digital space. These skills go beyond the binary opposition of "formal and informal" language.

4.3. The Moderating Role of Cultural and Institutional Factors

4.3.1 The Power of School Policy

The Chinese data demonstrated the powerful influence of top-down policy. In schools with explicit rules banning internet slang in assignments, 79% of students reported "rarely or never" using it academically. One elite Beijing high school's policy of a 5-point deduction per internet word resulted in a mere 7% usage rate in student writing, compared to 35% at a university with no such policy. Schools play a major role in implementing the "standard Mandarin" concept.

The approach in the UK is completely different. Although schools do teach standard English, as emphasized by the UKCIS framework, the policy focus is on developing "digital literacy". This includes the ability to use technology effectively and critically, as well as an understanding of how language operates in different online environments. There are no such strict prohibitions in the UK. Instead, there are more guiding discussions regarding appropriateness, audience, and purpose. This reflects a more descriptive and functional language education model, which contrasts sharply with the more prescriptive and standardized model in China. Both have strengths and weaknesses: The Chinese model may better maintain formal writing standards in the short term, but it might suppress creativity and cause a significant gap between school education and students' actual language environment. The British model aims to achieve integration and critical awareness, but when dealing with the widespread phenomenon of digital informal language, it may struggle to adhere to traditional writing norms.

4.3.2 Family Dynamics

The findings in China strongly support the cultural capital model. Adolescents who frequently have explanatory discussions with their parents about internet slang are 57% less likely to be classified as "high-frequency, uncritical users". One participant (S8) described that explaining "yyds" to his mother made him more consciously aware of his language choices. This kind of "family language co-learning" plays a natural and intrinsic regulatory role.

Livingstone and Helsper's (2007) discovered a similar hierarchical pattern in their research in the UK. They describe "enabling" mediation styles in educated families, where parents discuss online content and practices with their children, fostering critical thinking skills. In contrast, more restrictive or laissez-faire approaches in other families can lead to different outcomes. In the context of a significant social and economic disparity in the UK, the benefits brought by family mediation may show more pronounced differences. The key point is that the family is not merely a passive background factor but an active participant, playing a crucial role in shaping the way adolescents integrate their digital self with their offline self.

4.4 Synthesis and Comparative Discussion

The comparative analysis reveals a core paradox of digital language development in the 21st century: The characteristics of technology have brought about a strong pressure for convergence, while deeply rooted cultural and institutional structures have led to persistent differences in the outcome.

Convergence is seen in the universal adaptation of language to the demands of speed, brevity, and social signaling on digital platforms. Adolescents in both China and the UK are innovative, creating new lexical items and simplifying syntax. They are skilled pragmatists who can flexibly switch their expression meth-

ods in different situations. Both the educators of the two countries are concerned about the possible trade-offs in terms of cognition and expression, such as the reduction of patience for complex grammar, or the reliance on fixed expression methods to convey emotions, etc.

Divergence is rooted in the different "linguistic ecosystems." The language ecosystem of China is characterized by a strong, centralized tradition of language standardization, a collectivist culture with clear hierarchical communication norms, and an educational system that emphasizes mastery of a canonical written form. Digital language here exists in a tense, often adversarial, relationship with this official ecosystem, leading to sharp context-switching and explicit policy battles.

The ecosystems in the UK are more diverse and fluid. Although standard English enjoys a high reputation, people's acceptance of language diversity (e.g., regional accents, multicultural vernaculars) has also increased. This educational philosophy is increasingly inclined to emphasize critical reading skills rather than mere formalism. Here, digital language, though influential, is more readily accepted as a new language form, belonging to one of the various language varieties. This contradiction no longer lies between "standard" and "non-standard", but more between "critical/effective" and "uncritical/limited" communication methods.

This disparity indicates that there is no universal solution applicable to all situations. Therefore, intervention measures must be adjusted according to the cultural context. In China, effective strategies might involve leveraging the respect for institutional authority by having schools lead "critical appreciation" courses on digital language, formally bridging the gap. In the UK, strategies might build on existing digital literacy frameworks, empowering adolescents to analyze the pragmatics and persuasion techniques within their own digital spaces.

5. Conclusions and Recommendations

5.1 Conclusions

This study has confirmed that digital communication plays a transformative role in the language development of adolescents. Its impact is neither entirely positive nor entirely negative; rather, it is fundamentally constrained by social culture and institutional environment. This fundamental research in China reveals a situation where there is a coexistence of the rich creativity of vocabulary and the obvious simplification of grammatical structures, while also placing a high emphasis on pragmatics based on context. The perceived negative impact on formal language is real for heavy users, but it is greatly mitigated by two key forces: explicit school policies that defend the boundaries of formal writing, and engaged family communication that fosters meta-linguistic awareness and code-switching flexibility.

This contrast in the UK reveals another approach to addressing similar challenges. Although the language adaptation methods of British adolescents are similar, the environment they are in is not so strictly dichotomous. Their response is not to reinforce the barriers of standard English, but to attempt to expand the concept of "reading and writing skills" to include the field of digital communication. Both approaches encounter the same core challenge: how to equip young people with flexible and resilient language skills so that they can succeed in various diverse communication fields in the modern world—from a university essay to a TikTok video, from a job interview to a WhatsApp group.

The study ultimately concluded that the "impact" of digital communication cannot be evaluated in isolation. It is the result of the continuous negotiation among individual users, the technical characteristics of the platform, and the entire framework encompassing culture, education, and family. Ignoring any one of these aspects will lead to an incomplete understanding of this impact.

5.2. Recommendations

The following suggestions are derived from a comprehensive analysis of findings in China and an in-depth understanding of the relevant background in the UK. These suggestions are designed to be flexible, as

effective intervention measures must be culturally compatible and institutionally feasible. Our aim is not to propose a one-size-fits-all solution, but to provide some strategic directions so that stakeholders can make adjustments based on their specific circumstances.

5.2.1 For Educational Institutions

1. China: Move beyond simple prohibition. Develop and pilot "Digital Sociolinguistics" modules in junior and senior high schools. These courses would analyze and compare online buzzwords and classic idioms, study the grammatical differences between online posts and classic essays, and explore the pragmatic adaptation in different contexts. This turns digital language from a threat into a legitimate object of study, fostering critical awareness within the authoritative framework of school.

2. UK: Deepen the implementation of existing digital literacy frameworks (UKCIS, 2020). Move from general skills to specific, language-focused analysis. For example, an English course could analyze the rhetorical strategies and audience adaptation in influential Twitter posts or YouTube videos, and link them to traditional concepts of rhetoric and style.

5.2.2 For Families and Communities

For these both contexts, we should advocate the "family language co-learning" model. Community centers, schools and parenting websites should provide relevant resources to help parents understand the basic vocabulary and functions of adolescents' digital culture. This is not to regulate it, but to open up channels for communication. Initiatives like the "Family Language Co-learning Camp" in Shanghai are exemplary.

As for the specific tasks, they are to hold low-intensity "language exchange" activities at home on a regular basis. Parents and adolescents should take turns explaining new words or phrases in their respective fields to enhance mutual understanding and accumulate language capital.

5.2.3 For Technology Platform Designers

1. Platforms like Douyin should explore guidance mechanisms in their models targeted at adolescents. For users whose content always employs extremely fragmented grammar, the algorithm can occasionally intersperse some carefully produced, longer-form video content (e.g., mini-documentaries, storytelling) in the pushed content, so that they can be exposed to different language patterns.

2. Platforms should collaborate with linguists and educators to create optional "language insight" features. For instance, Bilibili or YouTube could offer a "transcript" or "vocabulary highlight" tool for educational videos, explicitly linking spoken informal language to more formal written forms.

3. Develop a secure and privacy-respecting dashboard feature that enables families to view, rather than control, aggregated and anonymized information about communication patterns, which may be related to the school-led digital literacy goals, thereby promoting a tripartite partnership among adolescents, families, and schools.

In conclusion, the language of adolescents in China, the UK, and across the globe is being dynamically rewritten in the digital crucible. The challenge for society is not to resist this change but to guide it with wisdom, equipping the next generation not only with the grammar of the past but with the critical capacity to navigate and shape the communicative landscapes of the future.

Conflicts of Interest

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

Author Contributions

Conceptualization: Yang Tongtong, Han Yixuan; Methodology: Yang Tongtong; Software: Yang Tong-

tong; Formal analysis: Yang Tongtong; Investigation: Yang Tongtong; Resources: Yang Tongtong (Chinese cohort), Han Yixuan (UK data and literature); Data Curation: Yang Tongtong; Writing – Original Draft: Yang Tongtong; Writing – Review & Editing: Yang Tongtong, Han Yixuan; Supervision: Lin Luzhou; Project Administration: Yang Tongtong.

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Mechanisms of Viral Dissemination of Regional Languages Songs on Short-Video Platforms

Manyi Li [1]*

1 Changxin International College of Art, Yunnan University, Kunming, Yunnan, P. R. China, 1669275880@qq.com

***Correspondence: 1669275880@qq.com**

Abstract

Short-video platforms have fundamentally reshaped the landscape of music dissemination. Taking TIKTOK as a case study, this research examines four regional languages songs that have achieved widespread popularity, aiming to uncover the underlying mechanisms driving their rapid spread. The findings indicate that the dissemination of these songs does not depend on listeners' comprehension of the lyrics. Rather, they share a common dissemination logic: firstly, platform algorithms offer these songs an initial chance to be discovered; next, iconic musical snippets then serve as sonic hooks that make them instantly memorable; then easily imitated visual movements become participatory templates that invite user engagement; and, ultimately, these elements work together to evoke emotional resonance that transcends linguistic barriers.

Keywords: Regional languages songs; Short-video platforms; Music dissemination; Algorithmic recommendation; User participation

1. Introduction

1.1 Research Background and Problem Statement

The emergence of short-video platforms has fundamentally reshaped how music is disseminated worldwide. These platforms are no longer mere entertainment outlets but have become leading channels for music promotion. On Douyin, hundreds of millions of users scroll through videos daily and are constantly exposed to musical content, whether through passive background listening or active engagement with music-driven content. A single song can garner hundreds of millions of plays overnight through a 15-second clip-a scale of dissemination unimaginable in the era of traditional media[1].

Prior research has extensively examined music dissemination on Douyin and similar platforms, identifying key drivers such as immersive viewing experiences, algorithmic recommendation, user imitation, and social sharing.[2] These forces have accelerated and broadened the reach of music, turning it from a purely auditory experience into an audio-visual phenomenon and granting unprecedented exposure to original compositions, obscure old songs, and traditional folk music. [3] At the same time, scholars have documented a range of accompanying problems: inadequate copyright protection, the clip-based fragmentation of songs, stylistic homogenization, a tendency to prioritize entertainment over artistic depth, the fleeting popularity of viral hits, and a growing dissociation between widely known songs and their unrecognized creators.[4] Existing studies have largely addressed these issues from the angles of dissemination characteristics, technological affordances, aesthetic influence, and copyright governance. While these concerns remain significant, they do not directly account for the mechanism through which regional languages songs manage to circulate widely, the interplay of audio-visual participation, algorithmic amplification, and emotional bonding in this specific context warrants a focused investigation.[5]

However, the dissemination of regional languages songs remains an under-explored area. Even when listeners cannot understand the lyrics, these songs can still spread widely. This observation raises several questions: why these songs stand out amid the vast amount of short-video content, whether and how the music generates an emotional appeal that transcends language barriers, and what role platform recommendation algorithms play in driving this phenomenon. To address these questions, this study conducts a qualitative analysis of four widely circulated regional languages songs on Douyin, aiming to uncover the shared logic behind their dissemination. In this study, “less commonly spoken languages” is operationally defined as languages that are neither natively spoken nor widely learned among Douyin’s primary user base in China.

1.2 Analytical Framework, Case Selection, and Method

This study examines the rapid dissemination of these songs through four interrelated dimensions: the driving force of platform algorithms.[6] The acoustic appeal of the sound clips, the participatory nature of the visual content.[7] And the emotional resonance that transcends linguistic barriers.[8] Specifically, acoustic appeal focuses on rhythm, melodic fragments, and timbre as immediately graspable sonic properties, while emotional resonance centers on listeners’ subjective affective responses and their discursive expressions in comments and re-creations. [9]

Four representative songs were selected based on three criteria: (1) the song is in a language unfamiliar to the vast majority of Douyin users in China; (2) it has accumulated over 200 million cumulative views under its dedicated hashtag on the platform; and (3) its wide circulation is demonstrably tied to a distinctive dance challenge or visual imitation trend. The selected cases are as follows. The Vietnamese song “See Tình”, performed by Hoàng Thùy Linh and produced by the DTAP team, was released on February 20, 2022, and gained widespread circulation on Douyin accompanied by the highly recognizable “Ear-Covering Dance”. The Russian song “Зая” (also transliterated as “Zaya”) by the group Bambinton, released on February 17, 2017, later swept short-video platforms along with the associated “Zaya Dance”. The Thai song “Whatev-

er" by the girl group PIXXIE, released on September 28, 2022, attracted massive attention in 2024 through its high-energy chorus and the accompanying hand-gesture challenge. The Spanish song "Montagem Nada Tropica" by producer Eternxlkz, released on April 18, 2025, circulated widely via a sped-up version and the accompanying "Sachi Shake" dance.

Spanning a release period from 2017 to 2025, these four pieces are in languages largely unfamiliar to most Chinese Douyin users. Despite their divergent linguistic origins and musical styles, all have accumulated hundreds of millions of views and display remarkably similar patterns of widespread circulation, making them well-suited for the comparative analysis undertaken in this study.

To analyze these cases, the study draws on data collected directly from Douyin. For each of four songs, the author identified the primary dedicated hash tag (e.g., "SeeTinh") and, as of 1 March 2026, retrieved the top 50 user-generated videos ranked by like count under that tag. The associated comment sections were then sampled from the five most-liked videos within each group of 50. A thematic coding approach was applied to the collected sonic, visual, and textual data to identify recurring motifs. Specifically, this involved open coding of user comments to capture recurring expressions of emotional response (e.g., "I feel like crying", "so healing") and participatory intention (e.g., "I want to learn this dance", "here's my version"), followed by an iterative grouping of these codes into broader themes. By examining how sonic features, dance movements, and user engagement data interact, the analysis uncovers the shared dissemination patterns driving the viral spread of these four songs[10].

2. Douyin's Dissemination Ecosystem

2.1 Decentralized Algorithmic Mechanism

Content visibility on Douyin is largely governed by a tiered recommendation algorithm.[11] Initially, an uploaded video is shown to a small, randomly assigned seed pool of users. Its subsequent fate is determined not by the creator's prior fame, but by quantitative engagement metrics generated in this pool-including completion rate, likes, comments, and shares. Videos that surpass certain algorithmic thresholds are then circulated to larger user pools, creating a cascading exposure effect. This feedback-driven, rather than editor-centric, process is commonly referred to as a decentralized recommendation mechanism.[12]

For this study, this logic constitutes the technological precondition for the widespread dissemination of regional languages songs. Since their appeal is embedded not in lyrical meaning but in sonic and visual elements, these songs can accumulate positive engagement signals in seed pools irrespective of listeners' linguistic backgrounds. In this way, the algorithm systematically lowers the barriers of language and national borders, offering these otherwise niche musical pieces a viable path to mass discovery.

2.2 Platform Features that Promote Participation

Douyin's interface is designed to lower the barriers to imitation and derivative creation, offering several built-in functions that turn users from passive listeners into active disseminators.

The editing tool allows users to extract the most infectious snippet of a song-often a brief melodic or rhythmic hook, rather than a lyrical passage-and pair it with their own video.[13] This separates the song's immediate sonic appeal from its verbal meaning, which is especially important for regional languages songs: the snippet can circulate as pure sound, without listeners needing to understand the words. Moreover, recording and template-based reuse functions further turn listening into visible participation.[14] Users can film themselves alongside an existing video or creatively adapt its visual elements, inserting themselves directly into the song's ongoing spread.

Most importantly, topic-based challenges organize this participatory activity on a large scale.[15] A specific dance move or creative format is designated as the template, which significantly reduces the effort needed to come up with an original idea. Users can feel a sense of participation and creativity simply by

replicating and personalizing the given format, while the hashtag mechanism gathers all these replicas into a single, constantly growing space of circulation.

Together, these features transform a song into a compact, easily replicable combination of sound and movement. They lower the creative threshold while keeping the content highly imitable, which is precisely what allows regional languages songs to spread quickly across language barriers.

3. Case Analysis

3.1 “See Tình” (Vietnam)

Released by Vietnamese singer Hoàng Thùy Linh in 2022, “See Tình” blends electronic dance music with traditional Southeast Asian elements. A closer examination of its musical structure reveals why it was peculiarly suited to rapid, large-scale disseminationon short-video platforms. [16]

The track is built on a 4/4 time signature at 140 BPM, driven by a steady four-on-the-floor kick pattern that, together with additional percussive accents, creates a sense of relentless, evenly distributed pulse. This forward-driving energy maps easily onto visual editing: no matter where a clip is cut, the resulting movement tends to land on a strong beat, substantially lowering the barrier to music-choreography synchronization for participatory content.

The chorus hook-the playful, onomatopoeic “ding-ding-dong-dong”-functions as a pure sonic trigger. For non-Vietnamese listeners, any lexical meaning dissolves entirely; what remains is a phonetically memorable pattern. The arrangement reinforces this effect: in the bar leading into the hook, most instruments drop out, leaving only sparse percussion and the vocal line. This sudden textural thinning creates a moment of focused anticipation, which is released when the full instrumentation crashes back in immediately after the hook. The resulting contrast between near-emptiness and saturation heightens the hook’s memorability and likely contributes to sustaining viewer retention, a key metric in Douyin’s algorithmic evaluation cycle.

Significantly, the production appears to favor the mid-to-high frequency range (roughly 2 kHz-5 kHz), which suits smartphone speakers’ typical output characteristics and aligns with the human ear’s heightened sensitivity in this band. This helps the track cut through ambient noise and capture attention within the critical first two seconds of autoplay-a technological precondition for surviving the seed-pool screening described in Section 2.1.

Paired with the visually simple, highly imitable “Ear-Covering Dance” and the track’s lighthearted mood, these sonic features coalesced into a package that lent itself to widespread imitation and resharing. By the time of this study, the “See Tình” topic on Douyin had accumulated over 900 million views.

3.2 “Зая” (Russia)

Released in 2017 by the Russian group Bambinton, “Зая” operates at 123 BPM-a medium-to-fast tempo that sits comfortably within the optimal range for dance-driven short-video content. The percussion follows a steady pattern in which the kick drum falls on the first and third beats and the snare and electronic claps on the second and fourth, producing a reliable “thump-clap-thump-clap” pulse. This regularity is functionally significant for user-generated content: every strong beat provides a dependable anchor for physical movement, allowing users to synchronize their actions without needing to edit precisely to an irregular rhythm.

The word “Зая”-a Russian term of endearment roughly equivalent to “sweetheart”-is repeatedly placed on these strong beats. For non-Russian-speaking listeners, its lexical meaning is entirely inaccessible; what registers is its sound: a soft, breathy texture that functions independently of semantics. The vocal delivery reinforces this effect. The singers use a close-miked, conversational tone, while the instrumental backing is pulled back in the mix, keeping the voices forward and unadorned. The result is a whispered proximity-as if the voice is directed not at a crowd but at a single listener holding a phone. This intimacy is highly com-

patible with the solitary, headphone-based mode of short-video consumption, and it directly activates the emotional resonance dimension of this study's analytical framework.

Melodically, the chorus is strikingly constrained: it revolves almost entirely around D4 and spans no more than a perfect fifth. This narrow range makes the vocal line easy to internalize and reproduce after a single hearing. More importantly, the melody's brevity aligns precisely with the loop-based logic of short-video playback, where a 15-second hook is replayed rather than a full song being performed. A melody that can cycle seamlessly within this window is likely to sustain high completion rates-a key signal in Douyin's algorithmic recommendation system.

To accompany the track, users devised a distinct dance pattern characterized by light, alternating footwork timed to the percussion accents. The dance is visually distinctive yet technically undemanding, lowering the threshold for imitation while still offering room for personal variation. Cumulatively, "Зая"-related topics on Douyin have amassed over 280 million views.

3.3 "Whatever"(Thailand)

A fusion of Thai pop and R&B, "Whatever" is built on a simple chord progression in C major-primarily I, IV, V, and VI-which produces a bright, open, and immediately accessible sound. This harmonic straightforwardness means the song demands no effort from the listener to follow its melodic contour, lowering the cognitive threshold for engagement from the very first seconds of exposure.

The instrumental arrangement is clearly layered in three distinct registers. The foundation rests on arpeggiated guitar chords, each note plucked separately so that the texture stays crisp and uncluttered. The middle layer features carefully restrained drum patterns, with the kick and snare processed softly so that the rhythm section supports rather than competes. The top layer introduces luminous electronic textures via synth pads that fill the mid-to-high frequency range, helping the track cut through the limited output of smartphone speakers. The contrast between the bright electronics and the warm acoustic guitar gives the song an immediately recognizable sonic signature-an advantage in a feed where attention must be captured within seconds.

The tempo sits at roughly 70-80 BPM, close to a resting heart rate. Rather than driving forward, this pace creates a gentle, breathing rhythm. The drum pattern reinforces this effect by emphasizing off-beats-placing accents on the second and fourth beats of each bar-producing a subtle swaying sensation rather than an insistent dance pulse. This rhythmic profile is crucial for understanding the song's dissemination pattern on Douyin: the tempo is too slow for full-body choreography, but ideally suited to the hand gestures and upper-body movements that became the song's signature visual template. The music thus directly shaped the form of user participation that followed.

The singer's vocal timbre is highly distinctive. She places her voice far forward in the mix and relies extensively on a breathy delivery, producing the sensation of being whispered to at close range. For listeners who do not understand Thai, the semantic content of the lyrics is entirely opaque. What registers instead is the sheer intimacy of the vocal texture itself-a tender, breathy closeness that requires no translation. This emotional immediacy, conveyed through vocal timbre alone, closely parallels the dynamic observed in "Зая": two different languages, two distinct vocal styles, yet both activate the same mechanism of non-verbal emotional resonance.

Cumulatively, the "Whatever" topic on Douyin has amassed over 2.28 billion views.

3.4 "Montagem Nada Tropica" (Spanish)

As a fusion of funk and electronic music, "Montagem Nada Tropica" circulates on short-video platforms primarily in a sped-up version. The original tempo of around 100 BPM is accelerated to roughly 134 BPM. The slower original offers a fuller, warmer texture, while the sped-up version sharpens the attack of every sonic element-tightening the rhythm, raising the vocal pitch, and intensifying the overall sense of urgen-

cy-making it better suited to the rapid-fire autoplay environment of Douyin's feed.

The track is built almost entirely from electronic synthesis. The low-frequency foundation comes from synth bass and plucked bass, while a steady kick drum anchors the rhythm. This clean frequency separation-deep lows handled by synthesized bass, clear highs occupied by vocals and melodic lines-ensures that the main hook remains distinct even when played through smartphone speakers. The overall texture is lean, precise, and uncluttered, producing a futuristic, cyberspace-like atmosphere that distinguishes it from the warmer, more organic timbres of the other three cases.

The emotional profile of the track derives from its sonic construction: a powerful, driving beat, dense instrumental layering, and a rapidly ascending melodic contour combine to generate a strong sense of forward rush and intensity. Where "See Tình" evokes playfulness and "Зая" and "Whatever" create intimacy, "Montagem Nada Tropica" offers exhilaration. Crucially, this emotional quality is conveyed through sheer sonic energy and does not depend on listeners' understanding of the lyrics, directly activating the emotional resonance dimension of this study's analytical framework.

The visual template that emerged around the track-dubbed the "Sachi Shake" by Douyin creators-is built around rapid, precisely timed movements synchronized to the track's pronounced rhythmic accents. The fast tempo means that the window for executing each movement is compressed, which makes accurate synchronization more visually rewarding: when a creator locks their motion to the beat, the resulting "beat-matching" effect delivers a strong sense of visual satisfaction. This tight coupling of rhythm and movement, amplified by the track's already high-energy sonic profile, further drove imitation and sharing.

Cumulatively, related Douyin topics have amassed over 260 million views.

4. Mechanism of Viral Spread

4.1 Algorithm-Driven Dissemination

The dissemination of all four songs began with Douyin's tiered recommendation algorithm. When users upload short videos containing these songs, the platform evaluates content appeal through quantitative engagement metrics-watch time, likes, comments, saves, and shares. Videos that generate strong initial signals are then pushed to progressively larger user pools, initiating a self-reinforcing cycle in which positive feedback and expanded distribution feed into each other. This is the decentralized mechanism described in Section 2.1, and every case in this study followed this same trajectory.

What is striking across the four cases is that none of them depended on listeners' comprehension of the lyrics to generate the initial engagement that triggered broader distribution.[17] The Vietnamese "ding-ding-dong-dong" registered as playful onomatopoeia, not as meaningful speech. The Russian "Зая" was received as an intimate vocal texture rather than a word with a dictionary definition. The Thai chorus conveyed tenderness through breathy timbre alone. The accelerated track delivered its impact through sheer sonic density. In each instance, the algorithm's evaluation was driven by how users responded to sound, not by what they understood from language.

The musical structures analyzed in Chapter 3 help explain why these responses were consistently strong. Each song contains a hook that appears designed-whether intentionally or through production choices that happened to align with short-video consumption-to capture attention within the critical first seconds of autoplay. The build-and-release arrangement of "See Tình", the whispered vocal proximity of "Зая", the gestural pulse of "Whatever", and the high-energy rush of "Montagem Nada Tropica" all created conditions conducive to high viewer retention. A high completion rate is among the most influential signals in Douyin's recommendation logic. When users additionally replayed the same video, this behavior may have further signaled content quality to the algorithm, amplifying exposure still further.

In this way, the platform's algorithm functioned as the first bridge enabling regional languages songs to cross linguistic barriers. It reduced content competition to a data-driven level where neither promotional re-

sources nor linguistic origins solely determined a song's reach. The algorithm did not recognize these songs as "foreign-language" or "niche"; it recognized them only as content that users watched, liked, and shared. This indifference to language, built into the very architecture of the recommendation system, was the precondition that made all subsequent mechanisms-sonic hooking, template-driven participation, and emotional resonance-possible on a mass scale.

4.2 Sonic Hook Mechanism

If the algorithm provides the channel through which regional languages songs are discovered, the sonic hook determines whether they are remembered. Across all four cases examined in this study, the musical segment that circulated most widely was not a full song, nor a verse chosen for its lyrical meaning, but a brief, self-contained snippet engineered-whether by design or by accident of production-to grab attention within seconds and lodge itself in memory. There are three shared characteristics of these hooks help explain why they functioned so effectively in the short-video environment, each corresponding to a distinct facet of the "acoustic appeal" dimension set out in this study's analytical framework.

The first is semantic detachability. In every case, the hook's communicative power did not depend on the listener understanding what the words meant.[18] The Vietnamese "ding-ding-dong-dong" operated as pure onomatopoeia-its rhythmic, phonetic shape was the message, not any lexical content it may carry for a native speaker. The Russian "Зая", a term of endearment in its original context, registered for non-Russian listeners as a soft, breathy vocal texture rather than a word with a dictionary definition. The Thai chorus, delivered through a close-miked, breathy vocal style, conveyed tenderness through timbre alone, bypassing the semantic layer entirely. "Montagem Nada Tropica", once accelerated, compressed its syllables to the point where they became rhythmic components within a larger sonic rush rather than carriers of discrete meaning. In each of these instances, the language barrier did not weaken the hook; it stripped away the cognitive work of linguistic processing and left behind something more immediate-sound as sensory experience, accessible to any listener regardless of language background.

The second is structural compatibility with the short-video playback loop. Douyin videos are measured in seconds, not minutes. A hook that requires buildup, narrative development, or extended listening to make its impact is structurally unsuited to this environment. The four hooks in this study, by contrast, are all conspicuously short, self-contained, and repeatable. "See Tình" delivers its four-syllable chant within a single bar. "Зая" places its one-word hook squarely on the strong beats of a steady percussion pattern. "Whatever" confines its chorus melody to a narrow interval range-no more than a perfect fifth-making it reproducible almost instantly. "Montagem Nada Tropica", in its sped-up form, packs its entire hook into a dense burst of electronic energy that hits with full force from the first beat. Each of these fragments can play out completely within a fifteen-second window, cycle multiple times, and still feel musically coherent rather than truncated. This structural fit between hook length and video duration contributes to sustained viewer retention: a user who reaches the end of a clip has, by definition, heard the full hook, and the seamless loop invites replay rather than signaling an endpoint.

The third is production-level adaptation to mobile playback conditions. Smartphone speakers, the default listening device for short-video consumption, have well-documented limitations in reproducing low frequencies. The hooks in this study all appear-whether through conscious mastering decisions or stylistic convention-to favor the frequency range where these devices perform best and where the human ear is most sensitive. "See Tình" exhibits a pronounced presence in the 2 kHz-5 kHz band, helping it cut through ambient noise. The three-layer arrangement of "Whatever" places luminous synth pads in the mid-to-high register above a restrained rhythm section, ensuring the hook's textural signature remains clear even on small speakers. "Зая" takes an alternative but equally effective approach: by pulling back the instrumental mix and pushing the vocals far forward, it creates an intimate, close-miked effect that is ideally suited to headphone listening, the other dominant mode of short-video consumption. The accelerated version of "Montagem Nada Tropica" sharpens the attack of every element, raising the overall spectral energy in a way that

translates forcefully even through limited hardware. Across these varied strategies, the result is the same: the hook sounds distinct, legible, and attention-commanding under the actual listening conditions in which short-video users encounter it.

In conclusion, these three characteristics-semantic detachability, structural compatibility with the loop, and mobile-optimized production define the sonic hook as the second link in the dissemination chain identified by this study. The algorithm, as described in Section 4.1, opens the door; the hook determines whether the user stays, finishes the clip, replays it, and remembers it. Without this retention, no further mechanism-no visual template, no participatory challenge, no emotional bonding can be activated.

4.3 Participatory Templates

A song that is merely catchy can be listened to; a song that is paired with a replicable visual action can be participated in. Across all four cases, the transition from passive reception to active engagement occurred through the same mechanism: a core musical hook was extracted and bound to a distinctive, easy-to-imitate movement template. This binding transformed the song from a piece of audio into a participatory package-compact, shareable, and open to variation.

The pattern was remarkably consistent. In "See Tình", the onomatopoeic "ding-ding-dong-dong" hook was matched with the "Ear-Covering Dance," a simple upper-body movement that required no dance training to replicate. In "Зая", the steady "thump-clap-thump-clap" pulse and the repeated endearment were paired with a light, alternating footwork pattern that users could perform in place. In "Whatever", the gentle, off-beat sway of the chorus was linked to a hand-gesture challenge involving fluid upper-body and arm movements. In "Montagem Nada Tropica", the accelerated electronic rush was coupled with the "Sachi Shake", a rapid, precisely timed sequence of motions designed to lock onto the track's pronounced beats. In every instance, the visual template was not an afterthought appended to the music but an integral part of what made the song spread.[19]

What made these templates so effective as vehicles of dissemination can be understood on three levels.

Firstly, the templates drastically reduced the creative threshold for participation. The user did not need to invent a dance, choreograph a sequence, or conceptualize an original visual concept. A ready-made format was provided-a set of movements that anyone could observe, memorize after one or two viewings, and reproduce with a phone camera. The cognitive effort required was minimal, while the sense of achievement upon completing the imitation was immediate. As described in Section 2.2, Douyin's editing tools and topic-based challenge system further supported this process by allowing users to extract the relevant music snippet with a single tap and place their own video alongside countless others under the same hashtag.

Secondly, the templates enabled personal variation within a shared framework. While the basic movements were fixed enough to be recognizable, they were also loose enough to accommodate individual interpretation. Users could perform the "Ear-Covering Dance" with different facial expressions, settings, or costumes. The footwork for "Зая" could be executed with varying levels of energy and style. The hand-gesture challenge for "Whatever" invited subtle differences in how each person moved their arms and fingers. The "Sachi Shake" could be intensified or softened depending on the creator's physicality. This combination of standardization and flexibility meant that participation did not feel like mechanical copying; it allowed for a sense of personal ownership while still contributing to a collective, recognizable trend.

Finally, the templates were inherently social. Each video posted under a song's topic hashtag was simultaneously an act of individual expression and a contribution to a growing collective phenomenon. Users who scrolled through the topic page could see thousands of others performing the same template, which created a dual motivation: the desire to join a visible community and the reassurance that the barrier to entry was low, since so many others had already done it. Analysis of the comment sections under the most widely circulated videos for each song supports this reading. Comments repeatedly expressed the desire to participate, the sense of being part of a collective trend, and the wish to showcase one's own version. These discursive

patterns indicate that participation satisfied multiple needs at once: the need for social validation through engagement with trending topics, the need for entertainment through playful imitation, the need for virtual connection with other users and with the original creators via duet and remake features, and the need for self-expression through creative personalization.

The participatory template was thus the mechanism through which the sonic hook's retention power was converted into sustained, large-scale user engagement. The hook made the song memorable; the template gave users something to do with that memory. Without this step, the song would remain an auditory experience passively consumed. With it, the song became a site of active, visible, and socially rewarding participation-a condition that algorithmically amplified it still further, as each new video fed back into the engagement metrics that drove continued recommendation. In the chain of dissemination, the template was the link that turned listeners into disseminators.

5. Conclusion

Through an analysis of the dissemination pathways of four regional languages songs on Douyin, this paper draws the following conclusions.

In essence, the widespread popularity of these songs embodies a form of decentralized dissemination. In traditional music distribution, understanding the specific meaning of lyrics is often a prerequisite for listener engagement; however, within Douyin's ecosystem, this premise has been fundamentally overturned. The fact that listeners cannot understand the lyrics does not necessarily impede their engagement; on the contrary, under the conditions examined in this study, the suspension of semantic comprehension can redirect attention toward the sonic surface. When the semantic function of linguistic symbols recedes, their timbral properties come to the fore, shifting listeners' focus from "what this song is singing about" to "how this song sounds".

The core dissemination mechanism can be summarized as the synergy of four interrelated elements: algorithm, sonic hook, participatory template, and emotional resonance.

The algorithm provides the channel, determining how songs are discovered. Douyin's decentralized recommendation mechanism grants equal exposure opportunities to any content with potential, evaluating videos purely through engagement metrics rather than by the creator's identity or the language of the lyrics.

The sonic hook serves as the bridge between discovery and retention. Across all four cases, the musical segment that circulated most widely was a brief, self-contained snippet in which semantic content was either absent or irrelevant to non-native listeners. These hooks shared three characteristics-semantic detachability, structural compatibility with the short-video loop, and production-level adaptation to mobile playback-that together ensured they could capture attention within seconds and sustain high completion rates.

The participatory template provides the form, shaping how listeners interact. By binding a core musical snippet to a distinctive, easy-to-imitate visual action, each song was transformed from something merely pleasant to listen to into something people could actively engage with. This binding drastically lowered the creative threshold for participation while still allowing room for personal variation, turning passive recipients into active disseminators.

Emotional resonance forms the deepest layer, explaining why these songs move their listeners.[20] The four songs span distinct emotional registers-playfulness, intimacy, warmth, and exhilaration-yet all four reached their audiences not through the semantic content of the lyrics but through the sonic surface itself: the texture of the voice, the speed of the beat, the density of the arrangement. Listeners who understood not a single word nonetheless described these songs in terms of how they felt, not what they said.

These four elements are indispensable and mutually reinforcing. Without the algorithm, the songs would remain undiscovered. Without the sonic hook, initial exposure would not convert into sustained attention. Without the participatory template, retention would not translate into active engagement. And without emotional resonance, none of the preceding mechanisms could generate the voluntary, sustained, and socially

contagious participation that defines the phenomenon this study set out to explain.

From the perspective of the music industry, this phenomenon offers several practical insights. Music production wishing to optimize for short-video circulation may benefit from deliberate attention to the design of a hook, whether a catchy vocal phrase, a clean instrumental interlude, or a simple, recurring lyric. Its defining traits are brevity, memorability, and imitability: the opening seconds of a song often determine its fate on short-video platforms. During the arrangement stage, composer should consider mobile-speaker playback quality, anticipate which segments users are likely to clip as video soundtracks, and assess whether the music lends itself to simple, replicable movements.

From the perspective of cross-cultural communication, this phenomenon also opens new avenues for reflection.[21] In the short-video era, the universality of emotions and embodied behaviors may matter more than linguistic commonality. Traditional cross-cultural communication often depends on translation and the accurate understanding of meaning, but the dissemination pathways observed on Douyin demonstrate an alternative possibility: conveying emotions directly through sound and movement. As the four cases in this study suggest, when the linguistic barrier suspends semantic processing, listeners' attention can be redirected toward the sonic surface-the grain of the voice, the pulse of the rhythm, the contour of the melody-enabling an unmediated encounter with the emotional substance of the music itself. This mode of communication requires neither translation nor explanation to resonate across cultural boundaries.

Finally, it should be noted that the success of these four songs, while following a shared underlying logic, does not imply any fixed formula for widespread dissemination. Each song possesses its own distinct sonic character, and every visual template originated from a specific creative act within a particular user community. Algorithms can amplify content, but they cannot create it; templates can facilitate participation, but they cannot replace the spontaneous appeal of the music; and emotional resonance, however systematically analyzed, ultimately depends on something that cannot be engineered-the capacity of sound itself, stripped of semantic meaning, to evoke a genuine emotional response.[22]

Conflicts of Interest

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

Author Contributions

The author conducted all research and wrote the manuscript.

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