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Blockade and Breakthrough: China-U.S. Artificial Intelligence Technology Competition Under Chip Control Policies

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Abstract. In recent years, the rapid development of generative artificial intelligence technology has driven global industrial transformation and emerged as a central domain of strategic competition among major nations. By implementing multi-stage and multi-level chip export control policies against China, the United States has endeavored to restrict the development of China's artificial intelligence technology. This study systematically reviews the three-stage evolution of U.S. chip control policies toward China since 2018, analyzes its two main characteristics, and evaluates the actual effects of these policies in terms of short-term suppression and long-term backlash. It also points out that although U.S. controls have hindered China's high-end chip imports and AI R&D progress in the short term, they have objectively stimulated China's efforts to achieve breakthroughs in various areas, including independent chip innovation, computing power efficiency optimization, supply chain restructuring, and the construction of international rule-making power. Through pathways such as software-hardware collaborative innovation, policy-industry synergy, and international ecosystem co-construction, China has gradually weakened the impact of U.S. technological blockade. This study not only reveals the dynamic game mechanism between technological control and independent innovation, but also provides theoretical frameworks and practical insights for China's strategic approach to artificial intelligence.

Keywords: China-U.S. competition, chip control policies, artificial intelligence, technological breakthrough, supply chain restructuring

1. Introduction

In recent years, generative artificial intelligence models represented by ChatGPT, DeepSeek, and Doubao have emerged in large numbers. As a core driving force leading global technological and industrial transformation under the Fourth Industrial Revolution, generative AI models are bringing huge economic benefits to global industrial development [1]. These tools are progressively assimilating into individuals' daily lives, work, and studies, and also play important roles in national military and technological fields. Artificial intelligence technology has gradually become one of the key national strategic technologies and an important object of competition among major powers.

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The United States regards AI technology as a key object of China-U.S. competition. The policy of imposing restrictions on China's chip technology has evolved through different stages. However, China has still made breakthroughs in AI technology research and development under such severe international conditions. For example, models like DeepSeek have exhibited exceptional performance in natural language processing and code generation, with some capabilities close to or even surpassing top international closed-source models. Through reinforcement learning and knowledge distillation targeted at this model, its team successfully transferred the reasoning capabilities of the 660B-parameter R1 model to a smaller model, enabling it to approach the level of OpenAI o1 in tasks such as mathematics, code, and reasoning [2]. Meanwhile, the DeepSeek-R1 API price is only 1 yuan or 4 yuan per million input tokens, and 16 yuan for output tokens [3], making its cost about 1/17 that of OpenAI GPT-4 [4].

The study topic is "Has the U.S. chip control policy failed in its goal of curbing China's artificial intelligence technology development?" and "How does China break through hardware limitations to achieve advances in artificial intelligence technology?" are significant. On one hand, exploring the dynamic game between U.S. technological embargo and China's independent innovation in the international community at a theoretical level; on the other hand, providing policy recommendations for the development of China's AI industry chain at a practical level.

2. Literature review

Academic discussions on artificial intelligence are intensifying globally. A scholar analyzes U.S. semiconductor export controls against China through the lenses of international trade policy, geopolitical competition, and industrial technology [5]. She employs historical analysis to trace the evolution of U.S. semiconductor trade policy from the "Trump 1.0" to the Biden administration, projecting possible directions for a "Trump 2.0" era. Through case studies of sanctions on firms like Huawei and ZTE, and quantitative trade data, the study concludes that while U.S. restrictions suppress China's trade and technology acquisition in the short term, they also accelerate China’s independent innovation and industrial upgrading in the long run. The author suggests that China should adopt a strategy of "disruptive innovation + open ecosystem" to advance in the global semiconductor chain [5].

Another researcher examines U.S.-China computing power competition against the backdrop of AI as a core strategic resource [6]. Through an examination of the computer power industrial chain and analyzing U.S. policy texts, the study finds that the narrowing gap in computing capability triggers U.S. anxiety, leading to a dual strategy of development and containment—focusing on upstream chips and mid-to-downstream integration. Impacts include limited international expansion for the U.S., short-term, pressure but long-term enhanced autonomy for China, and global challenges including tech bloc formation and hindered cooperation [6].

Additionally, a scholar focuses on global AI governance and rule-making, analyzing risks related to data, algorithms, and computing power [1]. Through document analysis of UN, BRICS, and G7 materials, and comparative studies of regulatory approaches in China, the U.S., and Europe, they categorize international coordination mechanisms into four types and identify four regulatory characteristics, outlining challenges in constructing global AI rules [1].

This paper examines the U.S. advanced chip export control system aimed at China, assesses the limitations and practical challenges of its containment efficacy, and explores its multifaceted impact on the global semiconductor supply chain and China's AI development trajectory.

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3. Analysis of U.S. AI chip control policies against China

3.1. The three stages of U.S. chips control policy toward China

Since 2018, U.S. semiconductor control policies toward China have evolved through three distinct phases, each marked by escalating technical restrictions and expanding regulatory mechanisms aimed at curtailing China's advancements in critical technologies.

In the initial phase, the U.S. focused on inhibiting China’s semiconductor manufacturing capabilities. In 2018, the U.S. comprehensively escalated its containment strategy and began controlling the export of lithography machines, notably by coordinating with the Netherlands to block ASML from exporting EUV lithography machines to China, hindering China’s development of sub-7nm process technologies [7]. The March 2019 declaration of a national emergency provided policy support for broader technology restrictions on national security grounds [8]. The addition of Huawei and its numerous subsidiaries to the Entity List restricted these companies’ access to U.S. high-performance chips and obstructed their semiconductor design or manufacturing activities overseas using U.S. technology, significantly impacting China's high-tech chip industry and widening the technological gap.

In the second phase, the Biden administration adhered to a "small yard, high fence" strategy and upgraded AI chip export controls. The CHIPS and Science Act enacted in August 2022 provided over $50 billion in subsidies for the U.S. semiconductor industry while prohibiting recipients from expanding advanced process chip production in China for 10 years and prohibiting joint R&D or technology licensing with entities of concern [9]. In October 2023, the U.S. Department of Commerce issued an interim final rule further strengthening restrictions on exports of advanced computing integrated circuits and semiconductor manufacturing equipment to China, and added several Chinese AI entities to the control list [10]. In January 2025, the Bureau of Industry and Security (BIS) issued the "Interim Final Rule on AI Diffusion," implementing global licensing requirements for advanced AI chips under ECCN 3A090.a and 4A090.a [11] , categorizing China as a Tier 3 country subject to a complete import ban on advanced U.S. AI chips. This rule was later revoked after Trump's second term due to concerns about "stifling innovation" and "excessive regulation" [12].

In the third phase beginning after May 2025, the Trump administration further upgraded AI chip control policies through three guidelines that refined computational thresholds for controlled AI chips, clarified determination methods for model weights, and identified prohibited end-uses including military and weapons of mass destruction applications [13]. The guidelines introduced 11 "red flags" for supply chain due diligence and clarified that General Prohibition Ten applies to all AI chips containing U.S. technology, even if transshipped through third countries. Additionally, BIS issued the interim final rule "Implementing Additional Due Diligence Measures for Advanced Computing Integrated Circuits," which expanded country controls, mandated stricter customer reviews by foundries and packaging plants to prevent circumvention, and established a whitelist mechanism for license exceptions that essentially excluded Chinese chip design companies. These measures indicated a strategic shift from broad containment to precision-targeting of China's chip development capabilities.

3.2. Characteristics of U.S. chips control policy toward China

U.S. AI chip control policy toward China has two main characteristics: stage-based and multi-angle.

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First, stage-oriented. In the initial stage of the semiconductor industry's localization development, the U.S. government significantly constrained the independent innovation process of China's integrated circuit industry by systematically implementing chip technology export control policies. The U.S. adopted such measures aiming to directly intervene in China's R&D capability building across the entire industry chain of chip design, manufacturing, packaging, and testing by cutting off key technology supply chains. It particularly implemented precise blockades against advanced technology nodes like logic chips below 14 nanometers. This structural containment strategy hindered Chinese companies' access to core hardware and basic software, forcing China to reconstruct its semiconductor technology ecosystem lacking international industry collaboration. After China achieved breakthroughs in independent R&D of advanced process chips, the U.S. government turned to adopting structural trade strategies. It partially relaxed restrictions on high-end chip exports, promoting U.S. semiconductor companies to implement systematic commercial dumping in the Chinese market. Specifically manifested as: the U.S. Department of Commerce revised allowed NVIDIA to sell performance-castrated sub-flagship computing chips to China, while simultaneously maintaining continuous blockade of cutting-edge technology.

Second, multi-angle. Overall, the U.S. government's prohibitory policies against China can be mainly divided into three dimensions. First, the U.S. government systematically strengthened the containment of China's semiconductor industry's basic capabilities by constructing a multi-level hardware technology blockade system. For example, it issued the "Export Administration Regulations (EAR)," comprehensively prohibiting the export of key equipment such as semiconductor manufacturing equipment required for advanced processes to Chinese entities [7]. Second, based on the scaling in the semiconductor field, the U.S. government built a systematic containment framework targeting China's computing power development. By blocking computing power hardware, suppressing computing power efficiency, and splitting ecosystem systems, it constrained the iteration cycle of hundred-billion-parameter large models, forming a "computing power chokehold" situation against AI technology leaps. Third, the U.S. led the decoupling of supply chains from China. The U.S. actively joined with allies and partners to build a "chip alliance," attempting to decouple from China technologically on a geopolitical dimension, forming external containment. U.S. containment measures against China covered inter-governmental alliances like the U.S.-Japan "Partnership for Competitiveness and Resilience," also included industry cooperation like the U.S.-EU Trade and Technology Council (TTC), and enterprise-level collaboration like the U.S.-Japan "Commercial and Industrial Partnership." Moreover, the U.S. joined with Japan, South Korea, and Taiwan Region of China to form the "Chip 4 Alliance," aiming to establish a multilateral export control policy to contain China. In Asia, the U.S. established a "Commercial and Industrial Partnership" with Japan and announced the construction of a "Strategic Economic and Technological Partnership" with South Korea, then forming a control "small circle" for semiconductor exports, attempting to exclude China from the chip industry chain and establish an industry system with the U.S. as the core that serves its own interests [5].

3.3. Effectiveness of U.S. AI chip control policy against China

On the one hand, the chip control policies implemented by the U.S. have significantly constrained China's semiconductor industry in the short term. China's considerable reliance on global supply chains for chip manufacturing and R&D meant that restrictions on advanced chips, manufacturing equipment, and key materials—such as EUV lithography machines and EDA software—resulted in a threefold increase in the import cost of high-end chips and delayed AI enterprise R&D by 2–3 years. Chinese semiconductor firms faced barriers in acquiring advanced node manufacturing

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technology, design tools, and core components, hampering innovation and self-sufficiency efforts. Notably, Huawei suffered severe setbacks in high-end smartphones and 5G equipment markets [5]. In a subsequent phase, the U.S. relaxed certain bans—for instance, permitting the export of the intentionally limited H20 GPU—which further suppressed domestic chip adoption in China. With a strategic low price of $12,500 per unit, NVIDIA’s H20 secured a dominant position in the Chinese market, undercutting local competitors like Cambric on. Moreover, because migration costs to domestic platforms were more than three times higher, most Chinese AI firms continued relying heavily on NVIDIA’s CUDA ecosystem, hindering true chip localization.

On the other hand, the U.S. did not fully accomplish its strategic objectives and incurred considerable losses. NVIDIA experienced an estimated $5.5 billion in losses [14] and a $4.5 billion inventory backlog due to the ban [15], This directly led to an evaporation of over $160 billion in market value for companies in that quarter. According to its CEO Jensen Huang, the scale of China's AI chip market is expected to reach $50 billion in the future, while the ban will result in NVIDIA losing $2.5 billion in revenue in the short term [15]. AMD's MI308 series is also facing similar pressure [16]. After the ban was announced, NVIDIA's stock price plummeted by 6.9% in a single day, with a market value loss of approximately $188.1 billion [17]. Semiconductor companies like Micron and Broadcom fell by 2%-4% [18], which undoubtedly reflects a pessimistic forecast by the U.S. capital markets regarding the U.S. stance on chips related to China. The U.S. seems to have struck against China's chip industry, but it also severely impacted the exports of its domestic chip companies; at the same time, it led to massive sell-offs in the stock market, threatening the stability of the U.S. stock market. In addition, companies like NVIDIA are trying to circumvent U.S. policy regulations; they are also concerned about the potential strengthening of the U.S. chip ban against China, losing confidence in their deployments in China and instead planning operations in Southeast Asia and other regions. AMD is also accelerating production at its TSMC facility in India [19], which undoubtedly increases the operating costs for these companies and adversely affects them.

China responded with robust countermeasures. In May 2025, China’s Ministry of Commerce invoked the Anti-Foreign Sanctions Law to place seven U.S. companies on the “Unreliable Entity List,” explicitly rejecting the extraterritorial application of U.S. export controls. Additionally, China imposed export restrictions on critical rare earth materials—including gallium, germanium, and several medium-to-heavy rare earth elements—targeting both military and civilian end-uses to secure its strategic leverage.

Paradoxically, the U.S. restrictions stimulated China’s progress in semiconductor autonomy. According to the Porter hypothesis, moderate environmental regulation can stimulate technological innovation; that is to say, stringent standards can foster innovative behavior and promote technological upgrades [20]. Huawei’s Ascend 910C, developed with dual-chip packaging technology, achieved 60–70% of the inference performance of NVIDIA’s H100 [21]. Huawei also open-sourced its CANN software [22], challenging NVIDIA’s CUDA ecosystem. Globally, the U.S. measures accelerated the “de-Americanization” of chip supply chains: Japan advanced its 2nm trial production with state backing [23], and the EU Chips Act promoted local FD-SOI technology and reduced dependency on U.S. tech giants. Thus, rather than consolidating U.S. hegemony, the controls intensified global competition and reinforced China’s push for technological self-reliance.

4. Breakthrough paths for China's f artificial intelligence technology

Facing the control of unilateral technical bans from the U.S., China's artificial intelligence industry urgently needs to achieve breakthroughs in key technologies through paths such as independent

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innovation, supply chain restructuring, and policy-industry synergy to gain discourse power in the technical ecosystem of the artificial intelligence field in the international community.

4.1. Innovation breakthrough at the software level

Facing a series of U.S. blockades and controls on hardware exports to China, China has adopted a range of means. China compensates for hardware deficiencies through technological paradigm transformation and innovation in software.

In terms of software optimization and algorithm innovation, China can unearth the ultimate efficiency of chips under limited hardware conditions through algorithm innovation at the software level, thereby hedging against the hardware generation gap and achieving a breakthrough. First, utilizing the revolution in VRAM compression of high-parameter models for dynamic sparse training to shorten the gap brought by hardware; second, adopting full-stack collaborative high-availability design to quickly repair faults and reduce losses.

4.2. Substituting hardware to restructure the supply chain

Besides transformation and innovation in the software field, China has also achieved breakthroughs by substituting hardware and restructuring the supply chain. China can promote localized software, thereby promoting its role in the international chip field from a technology follower to a rule maker.

First, in terms of hardware substitution, China has achieved innovation in GPUs and cost reduction. Huawei's Ascend 910C achieved dual breakthroughs in inference performance and energy efficiency. The Ascend 910C uses SMIC's 7nm Chiplet packaging and integrates 53 billion transistors; in terms of selling price, the unit price for the first batch of 70,000 Ascend 910C chips purchased by Alibaba, Tencent, and Baidu is only 20,000 yuan, while the H20 unit price is about 35,000 yuan [24].

Second, China has restructured the supply chain, making layouts domestically to achieve manufacturing autonomy. Utilizing "East Data West Computing," a green regional computing power network is established. In terms of localization of equipment and materials, SMEE's 28nm DUV lithography machine has entered production line verification and is about to achieve mass production in 2026 [25]; simultaneously, the Yangtze River Delta has also formed a full-chain collaborative regional industry cluster, this full chain implements integration from design to manufacturing to packaging and testing [26]; and in the Gui'an Data Center, it utilizes the natural conditions of geological stability without earthquakes, an annual average temperature of 15 degrees Celsius, and 56.7% hydropower geological and energy advantages to achieve green manufacturing.

4.3. Synergy between government policy and industry

The essence of China's AI ecosystem co-construction is to facilitate a transition from laboratory to supply chain through precise policy assistance for industrial vertical integration, and finally to scenario opening and fission, ultimately transforming national institutional advantages into international ecological definition power.

First, the Chinese government must provide precise policy support, building a dual-wheel drive system of finance/taxation and standards. The Chinese government leverages technology tackling key problems with a lever effect, providing financial and tax incentives to related technology enterprises; simultaneously, the Ministry of Finance implements a super additional deduction policy, raising the additional deduction ratio for R&D expenses of technology-based small and medium-

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sized enterprises to 200%, twice that of traditional enterprises, significantly reducing the actual tax burden [27]. The core of China's AI ecosystem co-construction is to facilitate a transition from laboratory to supply chain via targeted policy support for industrial vertical integration, culminating in scenario development and fission, thereby converting national institutional advantages into international ecological influence.; simultaneously, by implementing a model of "equity investment + capacity order binding," requiring invested enterprises to have a localization procurement rate of over 70%, accelerating the supply chain to achieve a closed loop.

Second, China focuses on establishing technical standards, simultaneously promoting international exchange and cooperation in artificial intelligence technology, striving for global rule discourse power. China's chip manufacturing and management standards surpass international standards, with the ultimate goal of exporting its own chip governance framework. In September 2024, the Chinese government released the "Artificial Intelligence Capacity Building Universal Plan." The core goal of this plan is to bridge the global intelligence divide. In February 2025, China, as a signatory of a 61-country joint declaration, participated in the Paris AI Action Summit. At the meeting, China advocated for inclusive and sustainable AI governance, opposing technological monopoly. Even though the signing of this proposal was not successful due to non-cooperation from countries like the U.S., China also demonstrated to the world its determination and efforts to promote the development of international AI governance.

Third, China promotes a new model of industry synergy from single-point breakthrough to system coupling. This model includes three core elements: reconstructing the technology chain through vertical integration and full-stack optimization; building a joint computing power laboratory mechanism to strengthen supply chain resilience; and using diversified layout to hedge risks. Leading cloud manufacturers like Alibaba and Tencent adopt a "three-line parallel corridor" strategy, simultaneously deploying three technical routes: import retention, domestic substitution, and self-developed chips; simultaneously, also took certain measures to isolate international political risks. When the U.S. upgraded its H20 sales restriction order again, Alibaba Cloud's preventive measures could migrate H20 loads to HanGuang 800 through elastic scheduling, keeping business interruption time within 2 hours [28].

But simultaneously, industry synergy faces many problems. Domestically, regional fiscal and tax policies are fragmented, with 26 provincial governments issuing different local versions of subsidies, causing a 15% efficiency loss in cross-regional R&D expense split declaration. Meanwhile, in the international market, the EU boycotted China's AI governance framework on the grounds of "ethical audit," delaying the progress of Ascent’s entry into Europe by 6 months, striking the export sales volume of enterprises.

5. Future trends of China-U.S. artificial intelligence competition

5.1. Fragmentation of the global AI market

The diverging evolution of Chinese and U.S. open-source and sovereign AI models is leading to architectural splits and technological fragmentation within the global artificial intelligence market. China is restructuring the AI development paradigm through an ultra-low-cost open-source strategy. This engineering philosophy of “adequate is efficient” has allowed Chinese companies to establish a unique advantage in balancing inference efficiency and cost.

The U.S., by contrast, employs a selective open-source approach to build technical barriers while shifting toward sovereign AI models. The White House’s “AI Action Plan” requires federal agencies to only adopt models that align with “American values [29],” compelling vendors like OpenAI and

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Anthropic to incorporate ideological review layers that filter content related to social equity, racial justice, and other issues.

The architectural divergence between China and the U.S. is splitting the global AI market into two directions: universal benefit and ideology-driven development.

5.2. Alliance confrontation and supply chains decoupling

The establishment of rival alliance systems led by China and the U.S. is restructuring the global AI ecosystem, resulting in alliance-based confrontation and supply chain decoupling. In July 2025, China established the "Model-Chip Ecosystem Innovation Alliance," which includes 112 companies such as Huawei, Baidu [30] .The alliance focuses on unifying technical standards, implementing capacity allocation mechanisms, and co-building open-source communities. It adopts the CAPiC chiplet interconnection protocol to break international monopolies and enhance China's influence.

The U.S. promoted the creation of the "AI Global Alliance" to enforce technology bundling, using the "Foreign Direct Product Rule" to compel allies to adopt the "NVIDIA + OpenAI" technology stack. Countries that refuse to comply face secondary tariffs of 25% [31]. For example, the U.S. sanctioned South Korea for exporting HBM equipment to China, resulting in a loss of $2.3 billion in orders.

The competition between these alliances reflects a struggle for ecological dominance between China and the U.S. China is expanding its market share through open architecture, while the U.S. relies on compulsory technology binding—a strategy vulnerable to cracks as allies seek greater strategic autonomy.

5.3. Deep supply chains decoupling and hidden dependencies

The U.S. and China are engaged in an ongoing game of supply chain resilience, leading to deeper decoupling alongside persistent hidden dependencies. China is accelerating the localization of equipment and materials, boosting production of lithography machines, and establishing a full-chain regional cluster in the Yangtze River Delta.

The U.S. is strengthening its global monitoring network to enforce decoupling, placing export control officers in 12 countries including Malaysia and Vietnam to conduct spot checks and prevent chips from reaching China [32]. Supply chains between the two countries are entering a phase of deep separation. China is leveraging mature process equipment to circumvent U.S. restrictions, while the U.S. is constructing a "digital iron curtain" to systematically block technology diffusion.

However, U.S. chip regulations have caused reaction. Companies like NVIDIA faced a $4.5 billion inventory backlog and lost $5.5 billion due to sales restrictions on China [13]. Meanwhile, China is accelerating foreign product substitution—Huawei's Ascend chips are gaining market share in intelligent computing centers. Yet Chinese chip firms still rely on U.S. equipment subsystems and design tools. Interdependence has shifted from visible trade to hidden penetration: the U.S. blocks key subsystems but loosens controls on end products, while China remains dependent on certain foundational components. Full decoupling remains economically unfeasible.

6. Conclusion

Future Sino-U.S. AI competition may evolve along three trajectories: comprehensive decoupling into two tech blocs, selective coexistence with civilian-sector exchanges and military isolation, or competitive interdependence with cooperation on global issues. The author argues selective

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competitive coexistence is most likely—the U.S. allows restricted chip sales to protect commercial interests, while China focuses on applied innovation. Cooperation may continue in areas like quantum computing, demonstrating a dynamic equilibrium of interdependence and comparative advantage.

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