

The Geoeconomics of Chips: Policy, Retaliation, and the AI-Driven Reshoring Phenomenon

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Article

Keywords: Global value chains, Semiconductor industry, Artificial intelligence, Supply chain resilience, Reshoring, Geopolitics, US CHIPS Act, Industrial policy, Moore's law, Technological sovereignty

Posted Date: September 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10873896/v1>

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Additional Declarations: No competing interests reported.

Abstract

Over the past two decades, global production strategies have undergone a structural paradigm shift, transitioning from a cost-centric focus toward supply chain resilience and national security. In the early 2000s, deep offshoring and hyper-lean, just-in-time supply chains maximized cost efficiency and economies of scale across global value chains (GVCs). However, compounding shocks—including the U.S.–China trade war, the COVID-19 pandemic, geopolitical conflicts in Eastern Europe, and the rapid rise of Artificial Intelligence (AI)—have exposed the systemic vulnerabilities of hyper-globalized production networks. These disruptions have compelled states and multinational enterprises to reassess their strategic priorities, particularly in the semiconductor sector, where the rise of AI has elevated advanced chips to a critical pillar of technological sovereignty. In this emerging era of resilience, firms and state actors are strategically reconfiguring sourcing networks, strengthening domestic production capabilities, and embracing more regionalized supply-chain frameworks. This study demonstrates that, rather than triggering full-scale deglobalization, these forces are transforming global value chains into policy-driven, security-oriented regional production blocs, while substantial cross-border interdependencies and international economic linkages continue to persist.

1. Introduction

What began as a general push for supply chain resilience has now matured into targeted state intervention within the semiconductor sector. Led by initiatives like the U.S. CHIPS and Science Act of 2022, governments are actively funding the reshoring and "friendshoring" of chip manufacturing and advanced packaging (US CHIPS and Science Act, 2022; Clark et al., 2025). Driven by geopolitical instability and the slowing of Moore's Law, this policy push seeks to secure access to critical technologies through heightened R&D investment and architectural innovation (Peters, 2023). Recent research highlights how these measures forge a new "economy-security nexus" (Farrand, 2025), compelling firms to balance cost efficiency against national security through supply-base diversification and domestic capacity expansion (Dadush, 2023). Ultimately, this shift marks the culmination of earlier supply chain trends: abstract concerns about resilience have transformed into concrete state interventions that are actively restructuring the logic of global production to achieve technological sovereignty (Peters, 2023).

The semiconductor industry faces a fundamental dual challenge. First, escalating geopolitical friction—from trade disputes and sanctions to protectionist mandates and shifting alliances—has eroded the predictability of cross-border production, driving up costs, lead times, and compliance risks across global supply networks. Second, approaching the physical and economic limits of semiconductor scaling has heightened concerns over technological bottlenecks and national sovereignty. As Moore's law decelerates and traditional miniaturization encounters severe technical and capital barriers, sustaining innovation increasingly hinges on novel materials, advanced architectures, and collaborative R&D frameworks. Consequently, both firms and state actors are being forced to forge new organizational and governance models that reconcile economic efficiency with resilience, security, and long-term technological competitiveness.

In this study, reshoring is defined as the strategic relocation of previously offshored manufacturing operations to the home country, supported by domestic firms and institutional mechanisms (Fratocchi et al., 2014; Stentoft et al., 2016). Rather than being driven solely by cost reduction, contemporary reshoring is increasingly motivated by risk hedging, public policy incentives, and the pursuit of supply chain resilience. Recent literature emphasizes that reshoring is a complex, multi-faceted decision-making process conditioned by both external pressures—such as geopolitical instability, inflationary costs, and supply shocks—and internal firm capabilities, including technological readiness and digitalization (Fratocchi et al., 2014; Stentoft et al., 2016). The COVID-19 pandemic accelerated this shift by laying bare the structural vulnerabilities of globally dispersed production networks, prompting lead firms to deploy resilience-oriented strategies that pair localized manufacturing with Industry 4.0 tools and advanced data analytics (Al-Banna et al., 2024; Dubey et al., 2021; Gereffi, 2020).

Within the semiconductor sector, reshoring transcends traditional corporate location theory to become a policy-driven, techno-nationalist imperative (Luo & Van Assche, 2023; Peters, 2023). Catalyzed by the U.S. CHIPS and Science Act and similar global initiatives, semiconductor reshoring entails rebuilding end-to-end domestic ecosystems across fabrication, advanced packaging, and R&D (Boston Consulting Group & Semiconductor Industry Association, 2020; Clark et al., 2025). Furthermore, this paper demonstrates that semiconductor reshoring is dual-structured: it is catalytically driven by the physical limits of Moore's Law and "More-than-Moore" heterogeneous integration (Chen et al., 2024; Thompson & Parthasarathy, 2006), while being operationally enabled by AI-driven smart manufacturing to offset structural domestic cost disadvantages (Dubey et al., 2021; Hofmann et al., 2019).

This study seeks to address research gaps in the following ways. First, a testable hypothesis is that the confluence of technical limits, namely, the decelerating pace of Moore's Law (Thompson & Parthasarathy, 2006; Mack, 2011)—and high geopolitical stakes renders the semiconductor industry uniquely responsive to policy-driven reshoring. Second, while existing literature thoroughly examines reshoring and "friendshoring" as mechanisms for supply chain resilience, few studies systematically evaluate the trade-offs between resilience gains and the potential innovation losses caused by fragmenting highly specialized, globalized production networks (Fratocchi et al., 2014; Stentoft et al., 2015; Freund et al., 2024).

The U.S. CHIPS and Science Act of 2022 represents a landmark industrial policy designed to onshore semiconductor manufacturing, secure critical supply chains, and bolster domestic R&D. Despite its significance, the long-term implications of the U.S. CHIPS and Science Act for global supply chain reconfiguration and rate of technological innovation remain under-explored. Therefore, this paper seeks to address the restructuring of semiconductor supply chains within a broader geoeconomic shift from cost-driven globalization toward security- and resilience-oriented production models. Drawing on insights from global value chain (GVC) analysis and international economics, we examine how external shocks—specifically geopolitical friction, systemic disruptions, and targeted state interventions—reshape firm-level location decisions and governance structures (Freund et al., 2024).

To address the research gaps, this study analyzes the geoeconomic reconfiguration of the semiconductor industry at the intersection of state policy, corporate strategy, and technological transformation. This paper examines how the interplay between geopolitical friction, the deceleration of Moore's Law,

and the surge in AI-driven chip demand forces multinational firms and state actors to restructure global production networks.

Drawing on insights from global value chain analysis and international economics, this paper makes three key contributions: First, it maps historical shifts in global chip capacity shares to demonstrate how efficiency-driven offshoring created systemic strategic vulnerabilities. Second, it evaluates the trade-offs of techno-nationalist policies—such as the U.S. CHIPS Act and retaliatory mineral export bans—highlighting the dual operational pressures faced by semiconductor lead firms. And third, it introduces a novel conceptual framework illustrating how artificial intelligence acts both as a demand catalyst for advanced packaging and as an operational enabler that offsets high domestic production costs.

The remainder of this paper is organized as follows: Section 2 traces the historical evolution of semiconductor manufacturing capacity from 2000 to 2025 and analyzes projected global shifts through 2032. Section 3 examines trade protectionism, techno-nationalist industrial policies, China's retaliatory responses, and the strategic dilemmas of multinational chipmakers. Section 4 evaluates the technical and strategic transition from traditional Moore's Law scaling to "More-than-Moore" advanced packaging. Section 5 synthesizes the role of AI in driving demand and enabling reshoring, presenting an integrated conceptual model of contemporary semiconductor supply chain restructuring. Finally, we present our conclusions, limitations and future studies in Section 6.

2. Historical Evolution of the Semiconductor Industry (2000–2025)

2.1. The Era of Globalization (2000–2016)

In the semiconductor industry, the early 21st century was defined by the pursuit of cost efficiency and vertical disintegration. During this period, the fabless–foundry model became more dominant, with Western firms specializing in design, while manufacturing activities shifted to Asian hubs to exploit economies of scale and modular production networks (Gereffi et al., 2005; Dedrick et al., 2010; Sturgeon & Kawakami, 2011).

2.2. The Turning Point of the Semiconductor Industry (2017–2025)

The turning point of the semiconductor industry arose from 2017 to 2025. Cracks in the semiconductor efficiency-driven model began to emerge during the late 2010s, particularly with the escalation of the U.S.–China trade war. This exposed the geopolitical risks associated with deep global integration (Baldwin, 2016). When the COVID-19 pandemic hit around 2020, the semiconductor industry revealed rather clearly the structural fragility of a globally dispersed semiconductor production networks. Such disruptions during COVID-19 highlighted the vulnerability of the Just-In-Time (JIT) systems of the global supply chain of the semiconductor industry. The exponential demand during this time for semiconductor chips revealed great vulnerability in terms of not only global supply chain, but also cross-border restrictions, and surging digital requirements. This prompted a huge dynamic shift in terms of both corporate strategy and public policy towards resilience, security, and strategic autonomy (Gereffi, 2020).

2.3. Shifting Global Production Shares

Figure 1 illustrates the global distribution of semiconductor manufacturing capacity, comparing historical shares in 1990 with estimates for 2025 and projections for 2032. Figure 1 shows that the geographic distribution of global semiconductor manufacturing capacity has undergone a profound structural shift over the past three decades, transitioning from Western and Japanese dominance toward heavy concentration in East Asia. In 1990, Japan and the United States held a combined 88% of global production share (51% and 37%, respectively), reflecting their early leadership during the peak of transistor scaling. However, driven by the rise of the fabless–foundry business model and deep offshoring to exploit spatial economies of scale, production in both regions declined drastically by 2025—falling to 10% in Japan and 13% in the United States. Meanwhile, Europe's manufacturing share remained stagnant, hovering around 9% to 10% across the entire period. The empirical baseline tracking these shifts—specifically global fab capacity, wafer starts, and regional manufacturing distributions—draws on historical and projected industry tracking compiled by the Semiconductor Industry Association (SIA 2021, 2024, 2025) and Boston Consulting Group (BCG, 2020, 2024), which aggregate underlying fab-level microdata from SEMI (2024) and TechInsights (2024).

Conversely, East Asian economies captured most of the global capacity expansion. Between 1990 and 2025, Taiwan's global production share expanded from a negligible 2% to 26%, while South Korea's share grew from 2% to 20%, establishing the region as the indispensable hub for logic and memory fabrication. Supported by extensive public investment and state-directed industrial policy, China similarly built up its manufacturing base, capturing 17% of global capacity by 2025.

Projections through 2032 highlight the structural impact of contemporary policy interventions. Spurred by the U.S. CHIPS and Science Act, the United States is projected to nearly double its manufacturing share to 24%, reversing decades of industrial decline. Nevertheless, geographic concentration in East Asia remains high; Taiwan is expected to expand its dominant position to 32% of global capacity, while South Korea and China are projected to hold 18% and 17%, respectively. Taken together, these empirical trends illustrate why general concerns over supply chain resilience have solidified into targeted, state-led reshoring mandates aimed at rebalancing the global geography of semiconductor production.

2.4. Global Production Shifts and Strategic Vulnerabilities

The historical trajectory of semiconductor production reveals a dramatic redistribution of manufacturing capacity. In 1990, Japan dominated with over 50% of the global share, while the United States held approximately 37%, reflecting their leadership in memory and logic chips during the peak of Moore's Law scaling. However, by 2025, both nations had ceded significant ground to East Asian hubs. Taiwan and South Korea collectively account for nearly 45% of global output, while China has emerged with roughly a 15% to 17% share.

According to projections by Boston Consulting Group (BCG, 2024) and the Semiconductor Industry Association (SIA, 2020, 2021, 2024), Taiwan's share of global semiconductor manufacturing is expected to reach 32% by 2032, further reinforcing systemic risk in global supply chains.

These trends underscore the growing fragility of U.S. technological sovereignty. As recent studies argue, semiconductor chokepoints are not merely economic; instead, they are strategic assets that shape AI competitiveness, military defense capabilities, and industrial resilience (Farrell & Newman, 2019). The COVID-19 pandemic and U.S.–China tech tensions exposed the cascading vulnerabilities of offshore dependency, prompting a recalibration of industrial policy toward reshoring and diversification to mitigate these strategic risks (Wang, 2024).

Figure 2 demonstrates the substantial acceleration of U.S. semiconductor investment and manufacturing capacity following the introduction of the CHIPS and Science Act. While the United States experienced relatively limited capacity growth during 2012–2022, projected growth for 2022–2032 indicates a marked expansion of domestic fabrication capacity. This development reflects a broader policy-driven effort to strengthen semiconductor supply-chain resilience, attract private investment, and reduce dependence on overseas production (SIA, 2025).

This investment perspective is complemented by projected structural changes in semiconductor manufacturing capacity. Prior to recent federal interventions, U.S. fabrication capacity grew modestly — expanding by approximately 11% between 2012 and 2022, compared to a global average growth rate of 81% over the same period (SIA, 2025). This widening gap, mirrored in Fig. 1's historic decline of the U.S. production share from 37% in 1990 to 13% in 2025, underscores the degree to which fabrication had become geographically concentrated in East Asia. However, projections for 2022–2032 signal a decisive trend reversal: U.S. capacity is expected to surge by roughly 203%, significantly outpacing the projected global expansion rate of 108% (Boston Consulting Group & Semiconductor Industry Association, 2024; SIA, 2025).

However, projections for 2022–2032 signal a decisive trend reversal: U.S. capacity is expected to surge by roughly 203%, significantly outpacing the projected global expansion rate of 108% (SIA, 2024, 2025). As reflected in Fig. 1's projected rebound to a 24% U.S. global share by 2032, these figures provide strong empirical evidence of an impending structural rebalancing in global semiconductor production, subject to successful project execution and sustained policy support.

Taken together, the investment commitments and capacity projections reveal a clear temporal sequence connecting state intervention to industrial expansion. The U.S. CHIPS and Science Act operated as an exogenous policy shock that catalyzed massive private capital commitments, which are subsequently converting into domestic fab construction. This sequence marks a fundamental paradigm shift away from the traditional, market-driven logic of cost-optimized globalization toward a policy-led, security-oriented industrial framework.

Crucially, this capacity surge extends beyond leading-edge logic fabrication to encompass multiple nodes and activities across the semiconductor value chain. This diversification aligns with "More-than-Moore" technological pathways, where performance gains increasingly rely on heterogeneous integration, system-level architecture, and advanced packaging rather than traditional geometric scaling alone (Thompson & Parthasarathy, 2006). Consequently, state-backed capital mobilization fosters not only raw capacity growth, but also the development of a technologically resilient domestic ecosystem.

Ultimately, these empirical trends confirm that contemporary semiconductor reshoring is driven by the dynamic interaction of three mutually reinforcing forces: state industrial policy, geopolitical risk, and structural technological transformation. Rather than signaling a complete dismantling of global trade, the data points toward a reconfigured production landscape in which state intervention actively reshapes the geographic footprint and technological direction of semiconductor manufacturing.

3. Trade Tariffs and Techno-Nationalism

3.1. The Economic and Political Consequences of Tariff Protection

Historically, tariff policies have followed cyclical patterns as governments adjust trade openness in response to prevailing economic conditions. Protectionist policies are not consistently beneficial to the business environment or national interests. Most economists concur that the economic and political gains of blanket protectionism are often outweighed by partner retaliations, thereby reducing overall global welfare (Humphrey, 1987). Tariffs can generate a wide range of negative consequences, encompassing heightened political risk, exposure to retaliatory measures, and supply chain uncertainty.

Aharoni et al. (1981) challenged the classic "infant industry" argument by demonstrating that domestic sectors protected by state subsidies often remain uncompetitive and technologically stagnant. This dynamic is evident in the electric vehicle (EV) sector: Ford Motor Company postponed production of its F-150 Lightning model following a sharp decline in consumer demand driven by its high retail price (approximately USD\$63,000). By contrast, Chinese EV manufacturer BYD produces models priced between USD\$12,000 and USD\$16,000—roughly four to five times cheaper than their American counterparts. Trade analysts observe that heavily subsidized and tariff-protected domestic markets risk turning into "captive protected markets" that shield inefficiencies rather than foster true innovation (Contractor, 2025).

Similarly, in the 1990s, the United States subsidized R&D in the semiconductor industry expecting to foster private-sector innovation and strengthen global competitiveness. Irwin and Klenow (1996) found that the SEMATECH consortium enabled U.S. semiconductor firms to reduce individual R&D spending by approximately \$300 million annually, suggesting that joint research efforts decreased duplicative work rather than simply increasing overall technological investment. This evidence supports the "sharing hypothesis," where pooled resources allowed for increased R&D efficiency within the industry.

3.2. The US CHIPS Act and Techno-Nationalist Industrial Policy

The mixed outcomes of protectionism become increasingly apparent when viewed through the lens of the U.S. CHIPS and Science Act. As geopolitical tension between the world's two largest economies escalates, the U.S. CHIPS Act represents a pivotal national security mechanism designed to repatriate and secure strategic supply chains within domestic borders (Lynn & Salzman, 2023). By prioritizing market-distorting subsidies, it departs from free-trade norms and the traditional open, rules-based multilateral order (Luo & Van Assche, 2023). Additionally, the Act weaponizes global value chains for techno-nationalism, requiring multinational enterprises (MNEs) to carefully weigh geopolitical partnerships when arranging cross-border operations.

Driven by security concerns and rivalry with China, the U.S. has adopted measures beyond the Act itself, tightening inspection of inbound and outbound investment flows. For example, \$52 billion was allocated to finance subsidies and tax incentives within the U.S., while American nationals were barred from supporting advanced chip manufacturing at Chinese facilities. In addition, any semiconductor company receiving federal financial assistance may not choose to undertake significant transactions involving the expansion of semiconductor production capacity in China for 10 years without authorization from the U.S. Department of Commerce. The Act also empowers the government to designate "foreign countries of concern" and restrict access to critical technologies.

Notwithstanding geopolitical gains, several political risks and market uncertainties have been highlighted. As noted by Hamdani and Belfencha (2024), the United States encounters backlash from both its domestic technology sector and allied partners owing to the pivotal role of Chinese manufacturing and rare earth materials. Lin and Chang (2009) emphasized that government subsidies are primarily justified when correcting market failures or funding non-excludable R&D. Calhoun (2023) and Luo and Van Assche (2023) noted that leading global firms—including TSMC, Intel, and Samsung—had already committed to building U.S. capacity prior to the distribution of federal subsidies, raising questions about deadweight loss and market distortion.

3.3. China's Retaliatory and Strategic Responses

In China, ties between government bodies and enterprises are structured through state-capitalist frameworks that allow close alignment during geoeconomic conflicts (Gertz & Evers, 2020). By contrast, distant firm-government relations in the U.S. mean private entities do not always comply with state directives when commercial interests diverge (The White House, 2019).

China has retaliated against U.S. sanctions by establishing a legal framework to counter foreign sanctions. This includes banning U.S. chipmaker Micron Technologies from critical infrastructure and enacting export embargoes on strategic rare earth elements and critical minerals, including antimony, germanium, and gallium (Dowling, 2024; Hamdani & Belfencha, 2024). The impact of these retaliations is substantial:

1. Essential rare earth materials for semiconductor manufacturing remain heavily processed in China (Hamdani & Belfencha, 2024).
2. Antimony, germanium, and gallium are essential for infrared technologies, fiber optics, solar cells, and advanced compound semiconductors, with China controlling 60% to 80% of global output (Dowling, 2024; Liu & Bradshaw, 2023; McGeady & Baskaran, 2025).
3. Approximately 75% of the back-end manufacturing process for U.S.-designed semiconductors is physically situated in East Asia (Boston Consulting Group & Semiconductor Industry Association, 2021).

As reported by Swanson (2023), roughly one-eighth of Micron's worldwide revenue was affected by the Chinese ban, creating spillover effects as domestic Chinese customers shifted toward local memory alternatives. China has also leveraged multilateral organizations (such as the ITU and WTO) and formed strategic alignments with isolated non-Western nations to counter U.S. dominance (Heldt et al., 2025; Qiu, 2023). However, secondary U.S. sanctions continue to impose heavy costs on Chinese tech leaders; for example, Huawei suffered a 30% revenue drop after sanctions restricted its HiSilicon division from accessing TSMC's foundries and U.S. Electronic Design Automation (EDA) software (Horwitz, 2022; Malkin & He, 2023).

3.4. Semiconductor Firms at the Crossroads of Geopolitical Instability

Multinational chipmakers are caught between competing sovereign mandates. Both the U.S. and China are expanding extraterritorial controls over critical software, equipment, and materials. The U.S. Department of Commerce has repeatedly restricted export licenses for EDA design software and advanced lithography tools (Palmer, 2023). Consequently, cross-border enterprises face complex operational hurdles (Meyer et al., 2023; Panibratov et al., 2022).

As long as foreign foundries depend on U.S.-origin intellectual property, they must comply with U.S. export control laws regardless of their corporate headquarters. For instance, TSMC halted deliveries of advanced 7-nanometer AI chips to Chinese designers like Sophgo to comply with U.S. mandates (Freifeld & Potkin, 2024). Similarly, ASML canceled deliveries of Extreme Ultraviolet (EUV) and deep ultraviolet (DUV) lithography systems to Chinese customers under pressure from both U.S. and Dutch authorities (Simpson, 2024).

These enforcement mechanisms rely on key chokepoints held by U.S. and European firms. Upstream equipment manufacturers—such as Lam Research, KLA, Applied Materials, Synopsys, and Cadence—provide tools that cannot be substituted in the short term (Malkin & He, 2023). When U.S. Entity List restrictions were expanded, semiconductor component imports into Mainland China dropped by 7.1% in 2019 and 6.4% in 2020 (Malkin & He, 2023).

In response, chipmakers deploy hedging strategies. Chinese design firms have expanded operational setups across Southeast Asia (Cambodia, Malaysia, Thailand, Vietnam) and the Middle East (Hawkins & Davidson, 2024). Simultaneously, TSMC has diversified geographically by building multi-billion-dollar fabrication facilities in Arizona, Japan, and Europe to mitigate geopolitical exposure (Bu, 2024; Leswing, 2026).

4. From "More than Moore" to National Security

The deceleration of Moore's Law has made it increasingly difficult to rely on geometric transistor scaling for performance gains and cost reductions. Pushing physical scaling toward sub-2nm nodes requires immense capital expenditures—ranging from \$20+ billion fab constructions to soaring mask set costs—while yielding diminishing returns in power and frequency benefits (Cavin et al., 2012; Schaller, 1997).

Faced with this economic and physical bottleneck, the industry has shifted toward "More-than-Moore" technological trajectories (Thompson & Parthasarathy, 2006). Momentum has moved toward advanced packaging techniques, including 2.5D/3D heterogeneous integration, chiplet architectures, silicon interposers, and high-density fan-out methods (Chen et al., 2024; Iyer, 2016).

As conceptualized in Fig. 3 below, semiconductor design is undergoing a paradigm shift from traditional planar scaling to "More-than-Moore" heterogeneous integration. The left panel illustrates the classical Traditional Moore's Law Scaling model, which centers on two-dimensional geometric miniaturization on a

Single Silicon Die (Monolithic Die Shrink). A single-die approach faces severe technical barriers, soaring mask set expenses, and severe capital constraints at sub-2nm nodes, where physical scaling yields diminishing performance returns relative to its exponential cost.

To bypass these physical limits, the right panel depicts the "More-Than-Moore" Heterogeneous Integration framework. Rather than forcing all functional blocks onto a single monolithic substrate, this 3D / Chiplet Architecture disaggregates the system into modular functional units—specifically pairing specialized Logic Chiplets with High-Bandwidth Memory (HBM3). These discrete dies are subsequently integrated at the system level via high-density interconnect structures, such as Silicon Interposers and Hybrid Bonding. This architectural comparison underscores the central argument of Section 4: as geometric die shrinks become economically unviable, innovation hinges on advanced back-end packaging and heterogeneous architectures. By optimizing Power, Performance, Area, and Cost (PPAC) through system-in-package (SiP) design rather than pure transistor density, advanced packaging has transitioned from a routine back-end assembly process into a critical, high-value technological chokepoint essential for national security and AI-driven high-performance computing.

Advanced packaging technologies present significant technical and financial hurdles. Meeting Power, Performance, Area, and Cost (PPAC) targets require complex chiplet interconnect protocols, glass carriers, and hybrid bonding methods. Multi-physics design tools and thermal simulation techniques are required to manage dense thermal profiles. Consequently, 3D chiplet packaging can cost 1.5 to 4 times more than conventional back-end packaging, even though it provides superior system-level performance.

Because advanced packaging capacity has historically been concentrated in East Asia, Western nations face vulnerabilities in back-end assembly, testing, and packaging (OSAT). Scholars increasingly argue that advanced packaging is no longer a low-margin commodity, but a strategic asset critical to national security and AI leadership (Kim & Rho, 2024; Xiong et al., 2025). This perspective underpins public interventions designed to build domestic OSAT capabilities and secure upstream substrates and workforce talent (Xiong et al., 2025).

5. AI, Reshoring, and the Transformation of Semiconductor Production

5.1. AI as a Driver of Semiconductor Demand

The rapid deployment of Generative AI has created an unprecedented demand for High-Performance Computing (HPC) accelerators, GPUs, and High-Bandwidth Memory (HBM). Controlling domestic production of these critical components has shifted from a commercial objective to a primary national security mandate (Scharre, 2023; Stewart et al., 2023).

5.2 AI as an Operational Enabler and Demand Catalyst

While industrial policy provides the requisite capital foundation for reshoring, artificial intelligence (AI) serves as the critical operational enabler that enhances fab productivity and restores cost competitiveness. Modern semiconductor fabrication facilities increasingly deploy advanced Industry 4.0 AI tools—including predictive equipment maintenance, machine-learning-driven yield optimization, real-time dynamic dispatching, and digital-twin thermal simulations—to maximize operational throughput and minimize wafer defect rates (Hofmann et al., 2019). In high-cost domestic environments like the United States and Europe, these smart manufacturing capabilities play a vital structural role: by drastically increasing automation and operational efficiency, AI-driven productivity gains help offset the structural cost handicaps—such as higher labor rates, environmental compliance overhead, and facility construction premiums—that historically incentivized the offshoring of fabrication to Asian hubs (Dubey et al., 2021).

Figure 4 synthesizes this multi-dimensional transition into an integrated conceptual model, detailing how macro-level shocks, state interventions, and micro-level technological enablers converge to restructure global value chains (GVCs). The framework operates through a three-stage, dual-mechanism feedback architecture:

- 1. Exogenous Drivers and Policy Reaction:** The top tier of the model identifies two primary catalysts driving industry restructuring: escalating geopolitical friction and the decelerating pace of Moore's Law. Together, these twin pressures compel state intervention, where industrial policies—most notably the U.S. CHIPS and Science Act—act as exogenous shocks that unlock private capital commitments, funding domestic fab capacity expansion and ecosystem rebuilding.
- 2. The Dual Mechanism of AI Dynamics:** The core innovation of the framework lies in demonstrating that AI influences reshoring through two distinct, reinforcing channels. On the supply side, AI acts as an operational production enabler, deploying smart automation and automated yield management to drive cost competitiveness improvements in high-cost domestic fabs. On the demand side, AI functions as a market catalyst, where the global surge in Generative AI applications drives demand for high-performance computing (HPC) accelerators, GPUs, and advanced packaging architectures, making domestic production a strategic imperative for technological autonomy.
- 3. Reconfigured Global Value Chain Blocs:** The confluence of state capital, AI-enabled operational cost reduction, and strategic AI demand pull results in semiconductor reshoring and reconfigured GVC blocs. Rather than representing a complete reversal of globalization, this structural outcome signals the emergence of policy-led, tech-enabled regional production hubs where state strategy and technological capability jointly determine the spatial distribution of manufacturing.

5.3 Synthesis: Reconfiguring Global Value Chains

The structural transformation modeled in Fig. 4 confirms that contemporary semiconductor reshoring is driven by the dynamic interaction of three mutually reinforcing forces: state industrial policy, geopolitical risk, and structural technological transformation. Rather than signaling a complete dismantling of global trade, these empirical and conceptual trends point toward a reconfigured production landscape in which state intervention actively reshapes the geographic footprint and technological direction of semiconductor manufacturing. By pairing public capital deployment with AI-driven operational

productivity, lead firms and sovereign states are building regionalized production ecosystems capable of sustaining high-performance computing needs while hedging against systemic geopolitical vulnerabilities.

5.4. Integrating Policy, Geopolitics, and Technological Transformation

The reconfiguration of semiconductor value chains cannot be understood through any single theoretical lens. Instead, it stems from the interaction of three mutually reinforcing forces: state industrial policy, geopolitical realignment, and structural technological transformation.

Contemporary industrial policies, such as the U.S. CHIPS Act, represent systemic responses to both the fragmentation of global trade networks and the technological inflection of the post-Moore era. In this context, "More-than-Moore" transitions from a technical trajectory into a strategic amplifier that elevates the national security value of semiconductor packaging and fabrication.

This structural realignment carries economic trade-offs. Duplicate fab construction across multiple jurisdictions, incentivized by competing state subsidies, increases the industry's aggregate capital footprint and operational cost structure (Freund et al., 2024). Firms encounter higher capital expenditures and potential coordination friction relative to the era of hyper-globalized scale. However, these higher costs are increasingly accepted by states and lead firms prioritizing supply chain sovereignty over marginal cost efficiencies.

Concurrently, surging demand for AI chips reinforces the imperative for domestically anchored ecosystems. Heavy workloads depend on cutting-edge packaging and heterogeneous integration that require co-located R&D and fabrication assets. Continued reliance on distant offshore foundries is increasingly viewed as an unacceptable security risk (Cai & Maquieira-Alonzo, 2025; Kim & Rho, 2024).

Taken together, these developments indicate that semiconductor supply chains are entering a new structural phase where hyper-globalized production gives way to regionalized blocs and strategically aligned partnerships. While regionalization may introduce economic friction compared to the fully integrated model, it also creates new opportunities for technologically specialized regional ecosystems (Baldwin, 2016). A key task for future research is determining whether the long-term gains of strategic autonomy and supply resilience offset the economic costs of capital duplication and market fragmentation.

6. Conclusion

This study examined the changing geography and governance of semiconductor production through the interaction of industrial policy, geopolitical tensions, technological transformation, and the rapid expansion of artificial intelligence (AI). Rather than interpreting recent developments as evidence of a complete reversal of globalization, the analysis suggests a more differentiated process of strategic production reconfiguration, in which governments and firms increasingly balance efficiency against resilience, technological security, and strategic autonomy. This interpretation is consistent with the broader literature showing that semiconductor production has progressively shifted toward East Asia while remaining embedded in highly interconnected global value chains (Yeung, 2022; Gereffi et al., 2005; Sturgeon & Kawakami, 2011).

Three observations emerge from our analysis. First, the geography of semiconductor manufacturing remains highly concentrated in East Asia, particularly Taiwan and South Korea, despite substantial policy efforts to expand production capacity in the United States and elsewhere. The historical capacity evidence therefore does not support the interpretation that reshoring has simply reversed the previous geographic concentration of semiconductor production. Instead, the evidence is more consistent with *partial* diversification and regionalization of production capacity.

Recent research similarly identifies reshoring in the semiconductor industry as a politically and strategically conditioned process rather than a simple return of manufacturing to its country of origin (Clark et al., 2025). The policy objective is, therefore, not necessarily to eliminate international dependence, but to reduce exposure to sources of geopolitical and supply-chain risk. This reflects a longstanding strategic-autonomy dilemma in which greater autonomy can provide resilience benefits while simultaneously generating additional costs and trade-offs (Aharoni et al., 1981). The contemporary semiconductor context further illustrates how economic interdependence itself can become a source of geopolitical leverage (Farrell & Newman, 2019; Luo & Van Assche, 2023).

Second, the analysis indicates that semiconductor restructuring cannot be understood solely through conventional measures of transistor scaling. The deceleration of traditional Moore's Law scaling has increased the strategic importance of complementary approaches, including advanced packaging, heterogeneous integration, and chiplet-based architectures (Cavin et al., 2012; Iyer, 2016). Advanced packaging is consequently becoming an increasingly important component of semiconductor technological competitiveness, although the present study does not establish that the deceleration of Moore's Law independently causes reshoring or geographic relocation. Rather, technological change appears to interact with industrial policy, investment incentives, and geopolitical considerations in shaping where new semiconductor capabilities are developed. The growing importance of advanced packaging also suggests that future assessments of semiconductor resilience should consider not only front-end fabrication capacity but also the geographically distributed capabilities required to integrate increasingly heterogeneous semiconductor components (Chen et al., 2024).

Third, AI operates through at least two interconnected channels in the emerging semiconductor landscape. On the **demand side**, rapid growth in AI applications has increased demand for advanced computing components, including high-performance processors and memory technologies. On the **production side**, AI-enabled analytics, predictive maintenance, process optimization, and digital manufacturing systems may improve operational flexibility and resilience.

Existing research indicates that data analytics capabilities and organizational flexibility can complement supply-chain resilience, while Industry 4.0 investment can strengthen resilience under conditions of disruption (Dubey et al., 2021; Al-Banna et al., 2024). However, this study does not directly estimate the magnitude of AI-enabled productivity improvements at the fab level. Accordingly, our findings support viewing AI as a potential demand catalyst and

operational enabler, rather than as a demonstrated mechanism that necessarily offsets the higher costs associated with geographically diversified or domestically located semiconductor production.

Taken together, our findings suggest that the semiconductor industry is moving toward a form of strategically managed inter-dependence rather than complete de-globalization. Governments increasingly seek greater control over critical semiconductor capabilities, while firms continue to operate within internationally interconnected production networks. This tension reflects the emerging economy–security nexus in which efficiency, resilience, national security, and strategic autonomy are no longer separable considerations in semiconductor policy (Bu, 2024; Farrand, 2025). The resulting configuration is, therefore, better characterized as policy-led diversification and regionalization within continuing global interdependence than as a wholesale abandonment of globalization.

This study contributes to existing studies by bringing together three dimensions that are frequently examined separately: the changing geographic distribution of semiconductor manufacturing, the growing role of techno-geopolitical policy, and the technological and market effects associated with AI. The proposed framework provides an integrative interpretation of how geopolitical shocks and policy responses may interact with technological transformation and AI-driven demand to encourage changes in global semiconductor value chains. In this respect, the analysis complements research emphasizing the resilience implications of semiconductor disruption (Xiong et al., 2025) and the increasing significance of geopolitical uncertainty for international business and global production networks (Luo & Van Assche, 2023).

At the same time, the conclusions should be interpreted within the boundaries of the research design. The evidence identifies important structural patterns and relationships, but does not establish that any single policy, geopolitical event, technological development, or AI-related factor independently caused the observed changes in semiconductor production geography. The framework should therefore be understood as a conceptual and interpretive framework rather than a causal model.

6.1. Limitations and Future Research

Several limitations should be acknowledged when interpreting the findings. First, the study is primarily based on secondary and publicly available industry data. While the manufacturing capacity metrics synthesized Semiconductor Industry Association (SIA, 2021, 2024, 2025) and Boston Consulting Group (BCG, 2020, 2024) draw upon authoritative industry registries – namely SEMI's (2024) World Fab Forecast and TechInsights (2024) –the manuscript does not employ independent, proprietary firm-level microdata or original survey evidence. Consequently, the analysis is better suited to identifying broad structural patterns than to establishing firm-level behavioral mechanisms. Publicly available sources may also differ in definitions, measurement methods, reporting periods, and assumptions, which can affect comparisons across countries and over time.

Second, the analysis relies substantially on historical and projected semiconductor manufacturing-capacity shares. Capacity is an important indicator of industrial geography, but it is not equivalent to actual production, technological capability, economic value added, or supply-chain resilience. A country may possess substantial installed capacity without controlling the most technologically advanced nodes or the most strategically important parts of the value chain. Similarly, projected capacity for 2032 represents expectations rather than realized outcomes. These projections depend on assumptions concerning investment execution, policy continuity, market demand, construction schedules, and technological developments. They should therefore not be interpreted as forecasts with certainty.

Third, the study does not employ a causal identification strategy. Although the analysis identifies temporal associations between policy interventions, geopolitical developments, AI demand, and semiconductor investment, the evidence cannot isolate the independent causal effect of the CHIPS and Science Act, geopolitical tensions, Moore's Law constraints, or AI adoption on reshoring. For example, semiconductor firms may have planned overseas investments before subsidies were introduced, while investment decisions may simultaneously reflect market growth, labor costs, infrastructure, customer proximity, energy availability, and geopolitical considerations. Accordingly, the study's conclusions should be interpreted as evidence of structural relationships and plausible mechanisms rather than causal estimates.

Fourth, the concept of reshoring is analytically difficult to distinguish from related strategies such as nearshoring, friendshoring, diversification, and regionalization. Semiconductor firms frequently maintain production across several jurisdictions rather than moving activities completely back to their home countries. The evidence reviewed in this study, therefore, supports a broader interpretation of production reconfiguration, but it does not provide sufficient firm-level evidence to determine the extent to which observed capacity expansion represents genuine reshoring versus incremental diversification or new capacity responding to market growth.

Fifth, the treatment of AI as an operational enabler remains primarily conceptual and literature based. The paper identifies several applications of AI in semiconductor manufacturing, including predictive maintenance, yield optimization, dynamic dispatching, and digital-twin applications. However, this study does not directly measure the productivity, yield, cost, or return-on-investment effects of these technologies at individual fabs. Therefore, the proposition that AI can offset the higher costs of semiconductor production in Western economies should be regarded as a theoretically plausible mechanism rather than an empirically established effect in this study.

Sixth, the analysis of More-than-Moore and advanced packaging is also principally conceptual. Although advanced packaging, heterogeneous integration, and chiplet architecture are increasingly important to semiconductor performance, this paper does not quantify their effects on production costs, innovation outcomes, national competitiveness, or supply-chain resilience. Future studies could address this limitation by combining technology-level indicators with firm and country-level investment data.

Seventh, the geopolitical environment examined in this study is highly dynamic. Semiconductor export controls, subsidy programs, investment decisions, trade restrictions, and strategic alliances continue to evolve. These conclusions, therefore, represent an assessment of an ongoing structural transition rather

than a settled equilibrium. Subsequent policy changes in the United States, China, Taiwan, South Korea, Japan, and Europe could materially alter the production geography described in this paper.

Finally, the study focuses predominantly on the semiconductor manufacturing and technology-security dimensions of global value chains. Other important determinants of resilience—including electricity availability, water consumption, environmental regulation, critical minerals, workforce constraints, logistics infrastructure, and the role of semiconductor design and equipment suppliers—receive comparatively limited empirical treatment. These factors may substantially influence the feasibility and cost of reshoring and regionalization.

Future research should address these limitations through firm-level panel datasets, investment and fab-level information, trade and input-output data, patent and technological indicators, and interviews with industry and policy stakeholders. Econometric approaches such as difference-in-differences, event studies, synthetic-control methods, or other quasi-experimental designs could be used where appropriate to evaluate the effects of specific industrial-policy interventions. Comparative research across the United States, Taiwan, South Korea, Japan, China, and Europe would also help determine whether policy-induced capacity expansion improves resilience and technological competitiveness or instead produces costly duplication.

More broadly, future research should examine whether the benefits of strategic redundancy and technological sovereignty outweigh the costs of fragmented production networks. The central empirical question is therefore not whether globalization is ending, but under what conditions geographically diversified and policy-supported semiconductor networks can improve resilience without substantially weakening the efficiency, specialization, and innovation advantages generated by international production networks.

Declarations

Ethics Approval and Consent to Participate

This article does not contain any studies involving human participants or animals performed by any of the authors. Therefore, ethics approval and consent to participate were not applicable.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

Funding

No funding was received for conducting this study.

Author Contribution

Author Contributions (CRediT Taxonomy): C.T. (Christina Tay): Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration. D.M.T. (Duong Minh Tran): Data curation, Formal analysis, Investigation, Writing – review & editing. T.T.N. (Thanh Thuy Nguyen): Data curation, Investigation, Visualization, Writing – review & editing. All authors read and approved the final manuscript.

Acknowledgement

All authors whose names appear on the submission made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; drafted the work or revised it critically for important intellectual content; approved the version to be published; and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data Availability Statement

Data Availability:

The data supporting the findings of this study were derived from secondary sources in the public domain, including reports published by the Semiconductor Industry Association (SIA; <https://www.semiconductors.org>), Boston Consulting Group (BCG), SEMI (<https://www.semi.org>), TechInsights, and PwC. Full citations for all secondary data sources are provided in the references. A consolidated synthesis table of the capacity indicators and figure inputs has been deposited as Supplementary Information File S1. No proprietary micro-datasets or custom algorithmic scripts were generated.

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Figures

Global Semiconductor Production Share by Region (1990–2032)

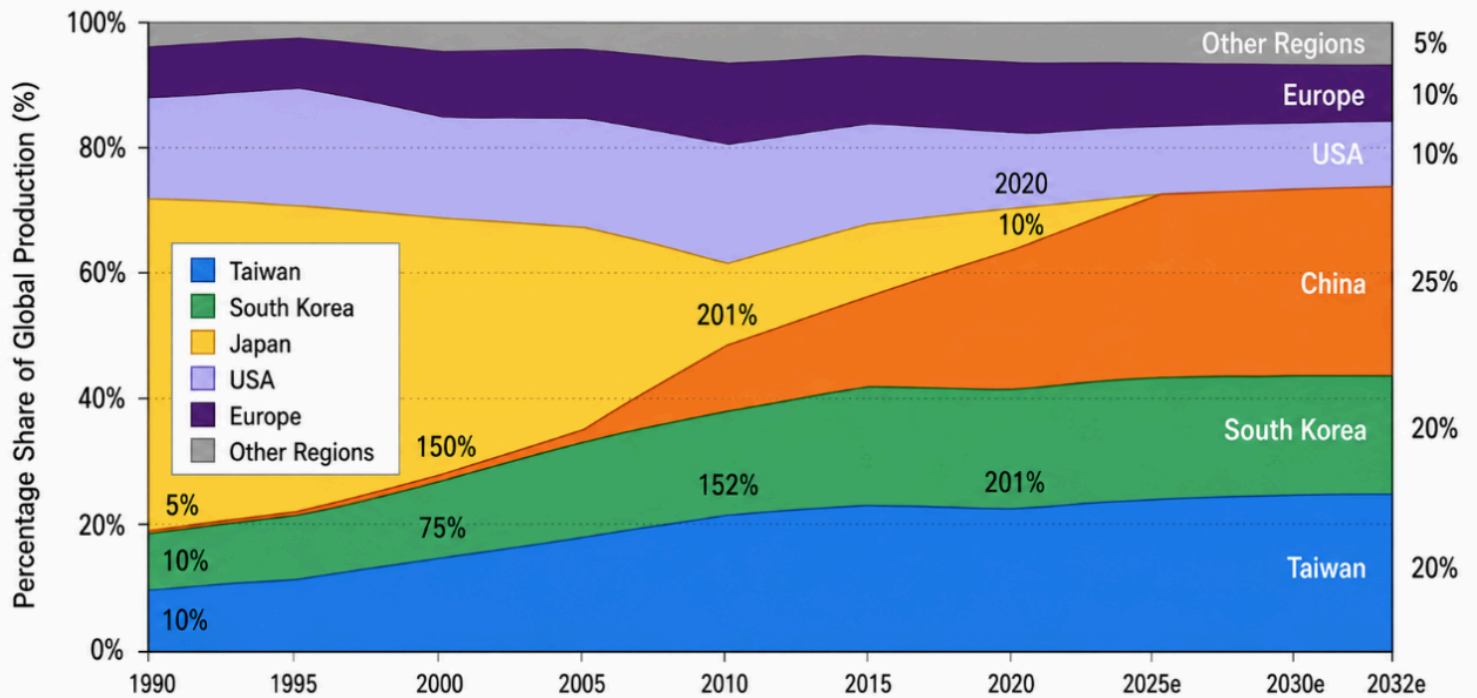


Figure 1

Global Semiconductor Production Share by Region (1990–2032).

Source: Adapted from Semiconductor Industry Association (SIA 2021, 2024, 2025), Boston Consulting Group (BCG, 2020, 2024) based on underlying fab capacity tracking data from SEMI (2024) which provides World Fab Forecast and TechInsights (2024).

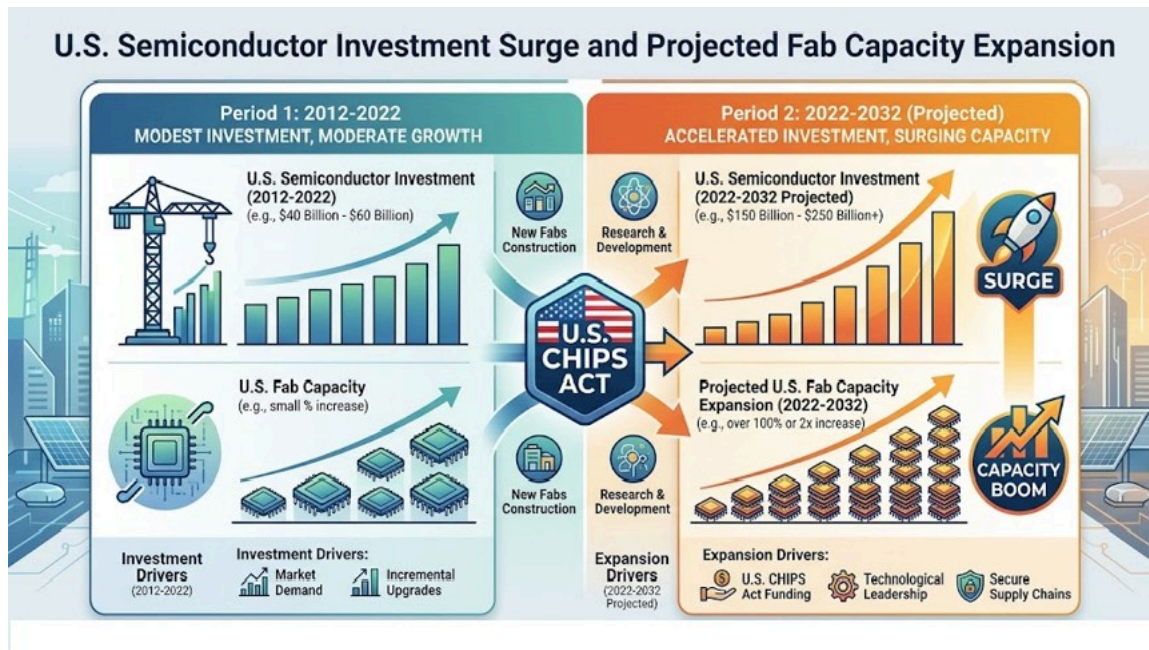


Figure 2

U.S. Semiconductor Investment Surge and Projected Fab Capacity Expansion, 2012-2022; 2022-2032.

Source: Semiconductor Industry Association (2021, 2024, 2025).

Structural Comparison of Traditional Monolithic Scaling versus “More-than-Moore” Heterogeneous Integration

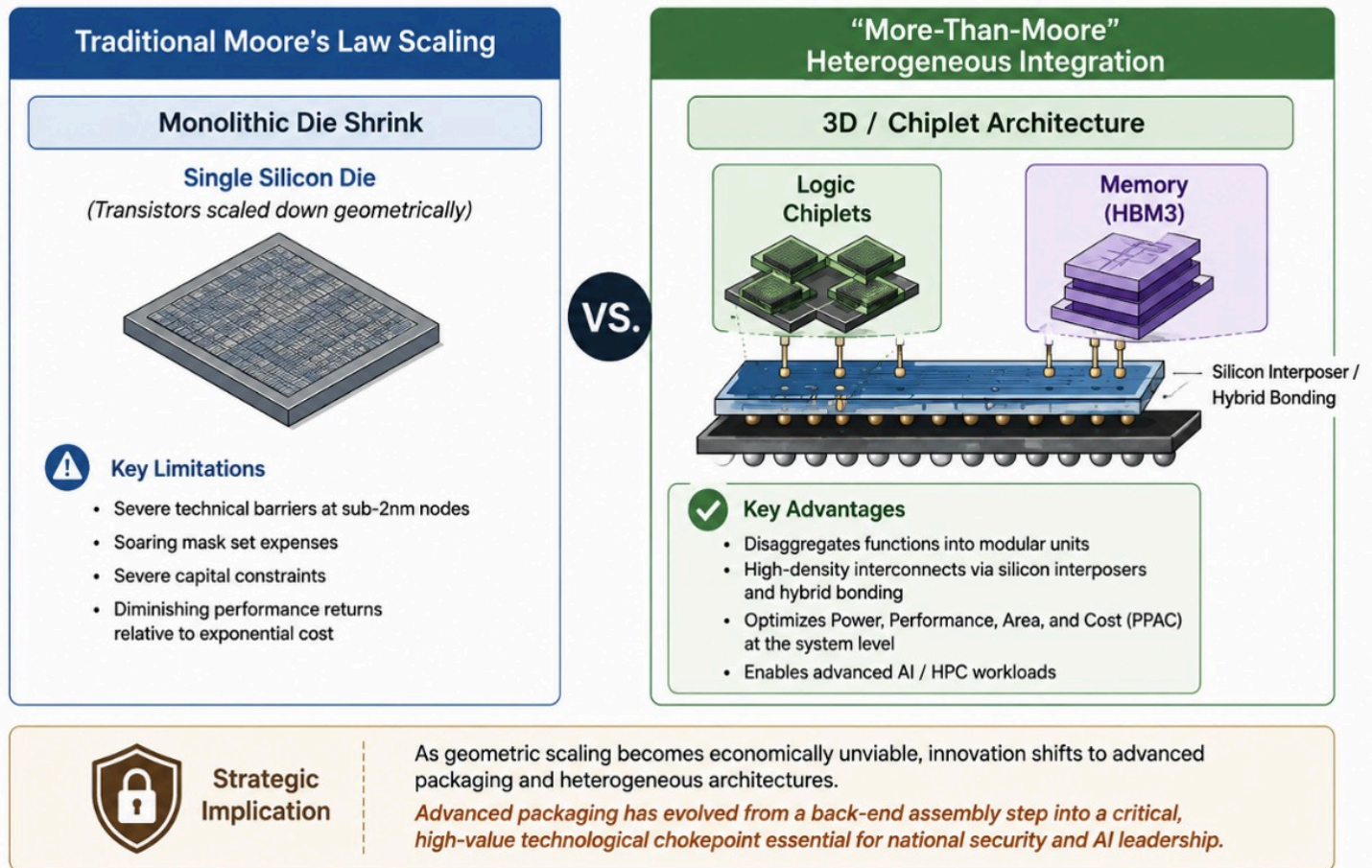


Figure 3

Structural Comparison of Traditional Monolithic Scaling versus "More-than-Moore" Heterogeneous Integration.

Conceptual Framework of AI-Driven Reshoring in the Semiconductor Industry

Multi-dimensional transition to macro-level shocks, state interventions, and micro-level technological enablers to restructure global value chains (GVCs)

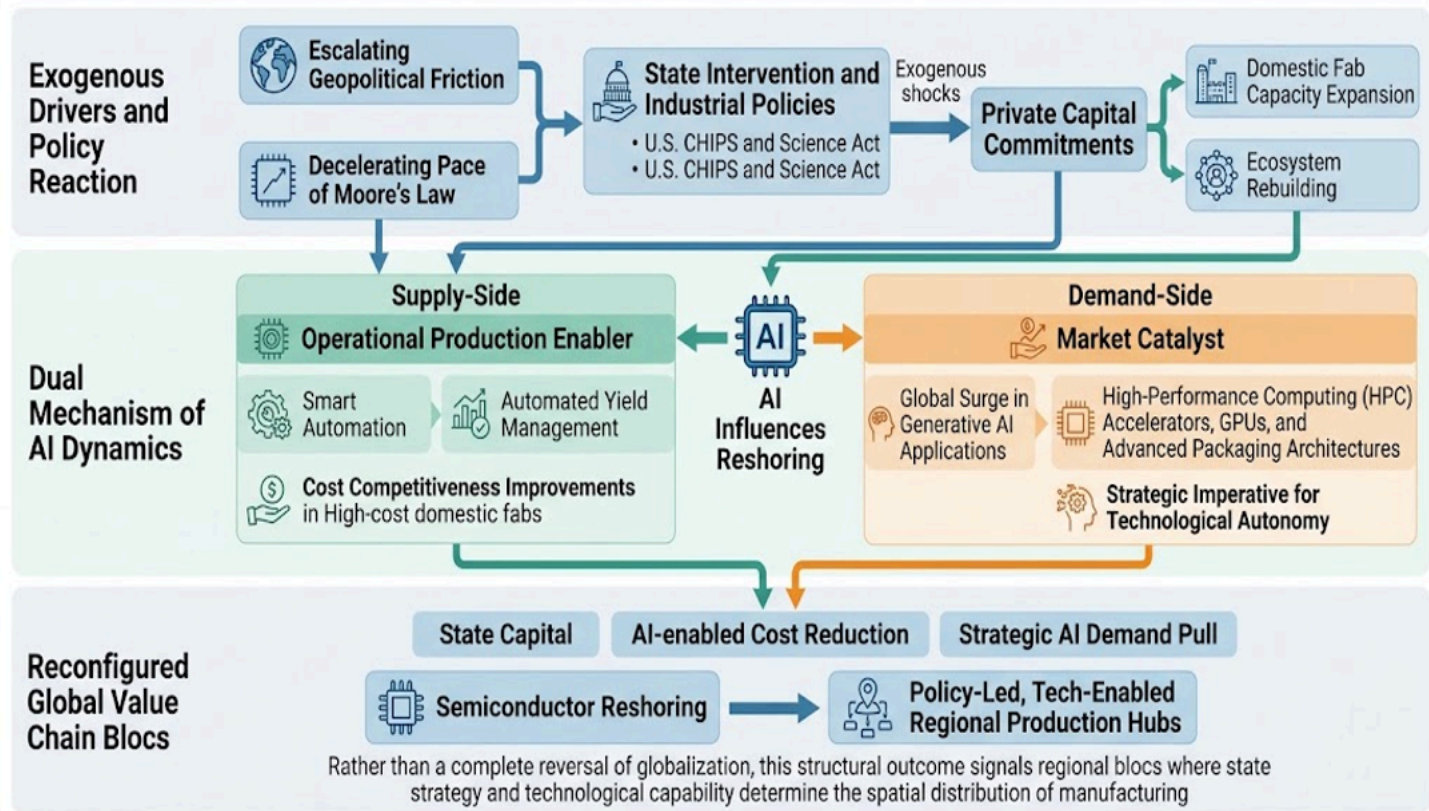


Figure 4

Conceptual Framework of AI-Driven Reshoring in the Semiconductor Industry

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