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Strategic Resilience and Reshoring: Reconfiguring Semiconductor Supply Chains in an Era of Global Disruptions

Sergiu Metgher

Institute for Global Supply Chain Studies, Global University, New Delhi

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Abstract: In recent years, the global semiconductor supply chain has been subject to multiple, interwoven shocks—ranging from pandemic-induced disruptions, macroeconomic upheavals, geopolitical tensions, to climate-related risks. This paper offers a comprehensive, theory-driven examination of systemic vulnerabilities in semiconductor supply networks and explores the strategic role of reshoring and resilience metrics in reconfiguring these networks for greater stability and autonomy. Drawing on a multidisciplinary synthesis of supply chain resilience theory, macroeconomic analyses, industry reports, and policy research, we construct a detailed conceptual framework that integrates resilience measurement, disruption impact channels, and strategic adaptations such as reshoring and diversification. The analysis reveals that while traditional supply-chain resilience metrics (e.g., recovery time, robustness, flexibility) remain essential (Behzadi et al., 2020; Campuzano & Mula, 2011), they are insufficient alone in the semiconductor context: the long lead times, high capital intensity, and geopolitical concentration necessitate additional dimensions—sovereign autonomy, climate-risk exposure, and macroeconomic elasticity. We show how reshoring initiatives, especially in high-value segments like GPU manufacturing, can enhance strategic autonomy and buffer macroeconomic vulnerabilities (Lulla, 2025; PwC, 2025). However, reshoring presents trade-offs: elevated costs, potential innovation slowdowns, and environmental externalities. The paper concludes by offering a set of refined resilience metrics tailored for the semiconductor industry, and a policy-oriented roadmap for firms and governments to promote a more

resilient, adaptive, and autonomous semiconductor supply ecosystem.

Keywords: Semiconductor supply chain, Supply chain resilience, Reshoring, Strategic autonomy, Macroeconomic disruptions, Climate risk

Introduction

As The semiconductor industry lies at the heart of global technology infrastructure, underpinning everything from consumer electronics to cloud computing, automotive systems, and defense hardware. Its strategic importance has become starkly visible in recent years, especially against the backdrop of global disruptions. The COVID-19 pandemic, combined with geopolitical tensions, rapid adoption of remote work technologies, and rising climate-related risks, has exposed profound fragilities in semiconductor supply chains. Supply-chain disruptions are not just operational headaches—they generate macroeconomic stress, inflationary pressures, and strategic vulnerabilities for nations and firms dependent on steady chip supply.

Traditional supply-chain resilience theory — developed largely in the context of commodity goods, retail, or manufacturing supply chains — emphasizes metrics such as recovery time, flexibility, redundancy, and robustness (Campuzano & Mula, 2011; Behzadi et al., 2020). However, semiconductor supply chains differ qualitatively: production is concentrated in a handful of specialized foundries, tooling timelines span years, and barriers to entry are high due to capital and technical complexity. These characteristics amplify systemic risk and challenge the effectiveness of conventional resilience strategies.

Simultaneously, rising climate change risks, as flagged by leading industry stakeholders, threaten to destabilize supply continuity even further — with the potential risk to a third of global semiconductor supply within a decade unless adaptation occurs (PwC, 2025). On top of this, macroeconomic analyses show that supply-chain disruptions propagate across sectors and can materially affect GDP, employment, and investment cycles (Acemoglu & Tahbaz-Salehi, 2020; Bai et al., 2024).

In response, firms and policymakers have begun exploring more radical structural adaptations, such as reshoring and strategic diversification (Lulla, 2025; Burkacky et al., 2022). These strategies aim not merely to make current supply chains more "resilient," but to transform the underlying architecture to align with strategic autonomy and risk mitigation objectives.

Nevertheless, the literature remains fragmented. While individual studies examine supply-chain resilience metrics, macroeconomic impacts of disruptions, or reshoring case studies, there is a lack of integrative research tailored to the semiconductor sector that combines metrics, macroeconomic theory, climate risk, and strategic supply-chain redesign. This paper addresses this gap. Through an exhaustive, theory-driven literature synthesis, we (1) critique existing resilience frameworks in light of semiconductor industry characteristics, (2) propose an enriched conceptual framework for assessing resilience and strategic autonomy, (3) analyze the trade-offs and implications of reshoring semiconductor production, and (4) provide policy-oriented recommendations for firms and governments aiming to navigate the deep uncertainties of the next decade.

Methodology

This study adopts an integrative literature review methodology, aiming to synthesize insights from different but interrelated domains—supply-chain resilience theory, macroeconomic analysis of disruptions, industry-specific reports on semiconductor production, and policy discussions on strategic autonomy and climate risk. The methodology consists of the following steps:

1. Identification and Selection of Core References: We began with a curated list of seminal and contemporary works covering supply-chain resilience (Campuzano & Mula, 2011; Behzadi et al., 2020), macroeconomic impact analyses of supply-chain disruptions (Acemoglu & Tahbaz-Salehi, 2020; Bai et al., 2024), recent industry-level reports on semiconductor production and reshoring trends (Burkacky et al., 2022; Lulla, 2025), and climate-risk assessments (PwC, 2025). We also included policy research on strategic autonomy (Böheim, 2022) and intellectual property dynamics during global disruptions (Budileanu, 2021) to capture governance and regulatory dimensions.

2. Critical Thematic Coding: Each source was read in depth, and relevant themes were coded manually. Thematic categories included: resilience metrics, supply-chain structure, disruption channels, macroeconomic spill-overs, reshoring rationales, climate risk, geopolitical risk, and policy responses.

3. Comparative Analysis and Gap Identification: By juxtaposing themes across the different literatures, we identified where conventional supply-chain resilience theory fails to address semiconductor-specific vulnerabilities, and where macroeconomic models overlook supply-chain architecture nuances.

4. Framework Construction: Based on the comparative analysis, we constructed a conceptual framework integrating resilience metrics, strategic autonomy indicators, risk exposure dimensions, and adaptation strategies such as reshoring, diversification, and policy interventions.

5. Synthesis and Interpretation: Drawing on the framework, we synthesized findings across the literature to identify patterns, trade-offs, risks, and potential future trajectories.

Through this process, we aim not merely to summarize existing work, but to generate novel theoretical synthesis and actionable recommendations for stakeholders in the semiconductor ecosystem.

Results

Our integrative analysis yields several key findings, which we elaborate below.

Resilience Metrics: Strengths and Limitations in Semiconductor Context

The work of Campuzano & Mula (2011), among others, provides an early systems-dynamics perspective on supply-chain simulation, arguing that supply chains must achieve balance between efficiency and adaptability. They highlight key dimensions: inventory buffers, process flexibility, lead-time variability, and supply-demand matching. More recently, Behzadi et al. (2020) expand on this by proposing a structured set of resilience metrics—including robustness, redundancy, recoverability, responsiveness, and flexibility—that can quantitatively capture a supply chain's ability to absorb shocks.

When applying these metrics to semiconductor supply chains, several limitations emerge. First, redundancy—e.g., having multiple suppliers for a given component—relies heavily on the assumption that such suppliers exist and can quickly ramp production. In the semiconductor sector, especially at advanced nodes or GPU manufacturing, there are a limited number of foundries globally. The capacity to add redundant suppliers is severely constrained by capital, know-how, and time. Thus, redundancy becomes less feasible, or only feasible at much higher cost and long lead times.

Second, flexibility and responsiveness are similarly constrained. Process changeovers in semiconductor manufacturing are complex, require lengthy validation cycles, and involve high fixed costs. This contrasts sharply with supply chains for fast-moving consumer goods, where switching between suppliers or shifting production lines can often be done more easily.

Third, recoverability and recovery time assume that once a disruption ends, production can ramp back quickly. For semiconductors, this assumption may not hold — damage to plant infrastructure, delayed equipment shipping, or even talent shortages can prolong recovery for months or years.

Therefore, while conventional resilience metrics remain a useful starting point, they underplay structural constraints inherent in semiconductor supply networks. A key implication is that resilience cannot be treated as a solely operational phenomenon — it must incorporate structural and strategic dimensions, such as capacity planning, geographic diversification, sovereign risk, and political risk.

Macroeconomic Spill-overs of Supply-Chain Disruptions

The macroeconomic consequences of supply-chain disruptions are well demonstrated in the work of Acemoglu & Tahbaz-Salehi (2020), which shows how firm-level failures and disruptions can propagate through production networks, affecting aggregate output, employment, and investment. Their formal modeling establishes that supply dependencies across sectors can lead to amplified fluctuations when key nodes are disrupted.

More recently, empirical and theoretical advances by Bai et al. (2024) quantify the causal effects of global supply-chain disruptions on macroeconomic outcomes. They document that economies heavily reliant on imported intermediate goods—or highly integrated in global value chains—experience greater volatility in GDP growth, inflation, and investment when supply shocks arise.

Applying these findings to semiconductor disruptions: given that semiconductors are key intermediate inputs for multiple sectors (automobile, electronics, industrial equipment), any shock to chip supply can induce broader systemic stress. Indeed, as noted by industry sources, the microchip shortage in 2020–2022 contributed to inflationary pressures and delayed production in multiple downstream sectors (Did the Computer Chip Shortage Affect Inflation?, 2022; Boguslavsky, 2021).

Thus, semiconductor supply-chain disruptions do not remain confined to the technology sector — they ripple across the macroeconomy, affecting investment cycles, inflation, employment, and even trade balances. This macro-link underscores why resilience strategies in this domain carry broader economic significance than most supply-chain resilience interventions in traditional manufacturing.

Emerging Pressures: Climate Risk and Geopolitical Concentration

A key insight from recent industry-level reports is that climate change poses a non-trivial risk to future semiconductor supply reliability. The 2025 report by PwC warns that as much as one-third of projected US$1-trillion global semiconductor supply could be at risk within the next decade unless firms adapt to climate risk (PwC, 2025). These risks may emerge through water scarcity (affecting wafer cleaning processes), energy instability (requiring continuous clean power for fabrication), or extreme weather (damaging infrastructure).

Moreover, the geopolitical concentration of semiconductor manufacturing in a few regions (notably East Asia) magnifies strategic risk. A regional natural disaster, political sanction, or regional conflict could disrupt a disproportionate share of global supply. The concentration issue intersects with climate risk to produce a "systemic single-point-of-failure" scenario — a scenario seldom encountered in traditional supply-chain planning, but increasingly plausible in a warming world with escalating geopolitical tensions.

These emerging pressures challenge the assumption that resilience can be achieved solely via operational flexibility. They demand structural reconfiguration — diversification across geographies, investment in climate-resilient infrastructure, and strategic autonomy mechanisms.

Reshoring and Strategic Autonomy: Industry Trends and Motivations

As a response to these systemic vulnerabilities, there is growing interest in reshoring—or at least partial onshoring—of semiconductor production. The report by Burkacky et al. (2022) highlights that the "semiconductor decade" is already seeing massive new investments in domestic fabrication capacity across different regions, including North America and Europe, as firms and governments seek to reduce geopolitical risk and strengthen supply-chain sovereignty.

In parallel, the study by Lulla (2025) examines reshoring of GPU production to U.S.-based factories, analyzing strategy adaptations by firms to localize high-end semiconductor manufacturing. The motivations are multifaceted: reducing lead times, improving supply assurance, gaining favorable public subsidies, and enhancing sovereign control over critical technology.

These reshoring efforts represent a strategic shift — from optimizing for cost and efficiency to optimizing for stability, sovereignty, and risk mitigation. They reflect a broader industry recognition that the conventional globalized, highly distributed supply-chain architecture may no longer be compatible with a volatile geopolitical and climate environment.

Framework for Evaluating Semiconductor Supply-Chain Resilience and Strategic Autonomy

Based on the synthesis of the literature, we propose an enriched conceptual framework for evaluating semiconductor supply-chain resilience and strategic autonomy. The framework comprises four interlinked dimensions:

1. Operational Resilience — traditional resilience metrics such as robustness, flexibility, responsiveness, redundancy, and recoverability (Behzadi et al., 2020; Campuzano & Mula, 2011).

2. Structural Resilience — supply-chain architecture characteristics:geographic concentration/diversification; number and distribution of manufacturing nodes; degree of vertical integration; capacity buffers; and lead-time elasticity.

3. Strategic Autonomy — the ability of a firm or a nation to produce critical components domestically or in trusted jurisdictions; control over intellectual property; supply-chain governance; and regulatory or policy alignment (Böheim, 2022; Budileanu, 2021).

4. Risk Exposure & Adaptation Capacity — exposure to climate risks, geopolitical risk, regulatory risk, and capacity to adapt (via climate-resilient infrastructure, alternative supply sources, and strategic reserves) (PwC, 2025; Burkacky et al., 2022).

Under this framework, resilience is not a single attribute but a multidimensional quality that must be managed across operational, structural, strategic, and risk-adaptation axes. Each dimension interacts: structural decisions affect operational flexibility; strategic autonomy influences risk exposure; and adaptation capacity shapes long-term sustainability.

Discussion

The enriched framework yields several important theoretical and practical implications.

Rethinking Resilience Beyond Operational Metrics

Traditional supply-chain management literature often defaults to operational-level interventions — e.g., increasing inventory, dual sourcing, buffer stocks, or demand smoothing. While these remain relevant, they are insufficient for semiconductors, where supply dependencies are deep, lead times long, and capacity constraints severe.

Our framework suggests that firms and policymakers must also address structural vulnerabilities — geographic concentration, limited number of foundries, and capacity bottlenecks — through long-term strategic investments. Structural resilience may require trade-offs: higher costs, lower short-term efficiency, and potential overcapacity in calmer times. However, these trade-offs may be justified by the reduction in systemic risk and reduced macroeconomic fragility.

Reshoring as a Strategic Response — Not a Panacea

Reshoring high-value semiconductor production — especially GPU and advanced-node chips — offers clear advantages in terms of strategic autonomy, supply-chain sovereignty, and risk mitigation. As Lulla (2025) notes, US-based GPU factories reduce dependence on overseas foundries and shorten supply lead times.

Yet reshoring carries trade-offs that must be carefully weighed. First, cost inflation: labor, energy, and compliance costs tend to be higher in OECD countries compared to low-cost regions. This may translate into more expensive end products, or compressed margins. Second, innovation dynamics: global semiconductor innovation often thrives in ecosystems where multiple firms, foundries, and design houses co-locate — benefiting from knowledge spillovers, shared infrastructure, and competition. Relocating production to isolated domestic sites may reduce these spill-over benefits. Third, environmental and resource constraints: localized manufacturing may strain local energy grids or water supply systems — especially if climate risks are high, or infrastructure is not adapted. Ironically, reshoring for resilience must itself ensure environmental sustainability and climate adaptation (PwC, 2025).

Therefore, reshoring should be seen as a strategic option among a portfolio — not the only solution. In many cases, a hybrid model may be optimal: a combination of domestic production for critical nodes, selective offshore sourcing for non-critical components, strategic inventory buffers, and diversified supplier networks across trusted jurisdictions.

Policy Implications and Governance Considerations

For firms aiming to implement resilience and strategic autonomy strategies, several policy and governance measures become relevant. First, governments can play a catalytic role by providing subsidies, tax incentives, and infrastructure support to lower the cost barrier for reshored semiconductor plants — as is emerging in several jurisdictions. Second, regulatory frameworks around intellectual property and trade must be updated to reflect the changing strategic value of semiconductors: domestic IP protection, tech transfer controls, and licensing regimes (Budileanu, 2021) become more important.

Third, climate adaptation policies must integrate industrial planning: ensuring clean, stable energy supply; water-resource management; and infrastructure resilience — especially for water- and energy-intensive semiconductor fabrication. Fourth, coordinated industrial policy across allied states may support regional resilience: for example, distributing fabrication capacity across multiple countries to avoid concentration risk.

Finally, transparency and reporting standards for supply-chain risk, climate exposure, and resilience investment should be developed — akin to financial disclosures. Firms should regularly assess and disclose their exposure to supply, climate, and geopolitical risks, and document their resilience and adaptation strategies.

Limitations and Future Research Directions

While this study offers a comprehensive conceptual framework, it is subject to several limitations. First, as an integrative literature review, it does not present new empirical data — there is no primary data collection such as firm-level interviews, supply-chain simulation, or macroeconomic modeling. Future research should empirically validate the proposed framework: for example, by collecting firm-level data on reshoring costs, resilience investments, and supply-chain performance post-disruption.

Second, the framework, though tailored for the semiconductor industry, may not fully capture all relevant risk dimensions — for instance, cyber-security risk, supply-chain data vulnerability, or supply-chain labor risk. These dimensions may be especially salient in advanced-node chip manufacturing, where intellectual property and data security are critical.

Third, environmental externalities of reshored manufacturing — energy consumption, water usage, waste management — require more detailed, location-specific analysis. Future work should integrate lifecycle environmental impact assessment with resilience evaluation.

Fourth, macroeconomic spill-overs of reshoring are not fully addressed. If reshoring leads to higher production costs, resulting in higher prices for semiconductors and end products, how will demand, competitiveness, and global trade patterns evolve? Quantitative macro-models integrating cost changes, demand elasticity, and global trade dynamics are needed.

Conclusion

The semiconductor industry stands at a critical inflection point. The combined pressures of global supply-chain fragility, macroeconomic volatility, climate change, and geopolitical risk demand a rethinking of conventional supply-chain resilience strategies. This paper argues that firms and governments must shift from narrow operational resilience interventions toward broader, structural reconfiguration — prioritizing strategic autonomy, capacity diversification, climate-risk adaptation, and long-term industrial policy support.

Our integrative framework—encompassing operational resilience, structural resilience, strategic autonomy, and risk-adaptation capacity—provides a conceptual foundation for evaluating and designing resilient semiconductor supply-chain architectures. Reshoring high-value segments, while not a panacea, emerges as a strategic lever that, when combined with diversification, climate adaptation, and governance reforms, can enhance supply-chain stability and sovereignty.

Moving forward, empirical research and policy experimentation will be needed to test and refine this framework. Governments, industry consortia, and firms must collaborate to develop transparent risk reporting, supportive regulatory regimes, and sustainable infrastructure investments. Only through such coordinated efforts can the global semiconductor industry build a supply-chain architecture that is robust, adaptive, and resilient in the face of mounting global uncertainty.

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