Proceedings of ICFTBA 2025 Symposium: Data-Driven Decision Making in Business and Economics
DOI: 10.54254/2754-1169/2025.BL28461

Consumer Electronics Companies' Choices Between Vertical and Virtual Integration and Outsourcing Strategies under Mass Customization

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Abstract. With rapid socio-economic development and a substantial rise in living standards, demand for large-scale customization from enterprises has grown. To cope with an increasingly complex and competitive environment, this study examines how consumer electronics firms dynamically develop an 'integration–outsourcing' adaptation model under the constraints of technological capabilities and external factors, using Apple, Xiaomi, and Huawei as case studies. It analyses their supply chain management strategies, discusses how and why firms choose integration–outsource approaches, and explores the triggers and responses involved in restructuring supply chain integration. The study concludes that the principles for choosing integration–outsource strategies are based on distinguishing between core and non-core activities and applying a dynamic matching mechanism. Through comparative analysis of the three companies' balance between vertical integration and virtual integration, it details each firm's choices at every outsourcing link, examines differences in outsourcing decisions and the decision frameworks for reconstruction paths, and identifies constraints on restructuring effectiveness in terms of a three-dimensional model of firm capabilities and the development of dynamic capabilities.

Keywords: Mass customization, Vertical integration, Virtual integration, Outsourcing, Supply chain strategy.

1. Introduction

The consumer electronics industry is shifting from standardized, high-volume production to ultra-large-scale customization, as consumers' demand for personalized devices reshapes the entire value chain. Mass customization brings new challenges for companies: the core dilemma is preserving large-scale manufacturing efficiency while meeting rising consumer demand for individualized products. As economic globalization deepens, competition across international supply chains has intensified, product lifecycles have shortened, and consumer markets have become noticeably more complex and diverse, exacerbating mismatches and imbalances between supply and demand. This shift in market demand is pushing upstream manufacturers to move from a factor-driven to an innovation-driven model. Large-scale customization as an emerging production approach is

DOI: 10.54254/2754-1169/2025.BL28461

becoming increasingly important [1]. Traditional mass-production models emphasize cost control and steady output, while customization requires flexibility and rapid response. Mass customization (MC) refers to providing products and services tailored to consumers' specific needs at costs and lead times comparable to those of mass production [2]. Mass customization combines the economies of scale of mass production with the economies of scope of customised production. By merging the cost advantages of large-scale manufacturing with the differentiation advantages of customization, it meets the demand for flexible, intensive production characterized by small batches, many product varieties, and low costs [3]. In response to these challenges, companies typically adopt two supply-chain integration strategies. Vertical integration strengthens control by building or acquiring upstream and downstream operations, while “virtual integration” was introduced in the late 1990s. In 1998, Michael Dell, founder of Dell Computer, told Joan Magretta of the Harvard Business Review that he attributed Dell's success to virtual integration with suppliers and customers, and observed that ‘the Internet has fundamentally changed the traditional model of market integration, virtual integration centred on information assets is gradually replacing vertical integration based on physical assets' [4]. Traditional mass-production models prioritize cost control and steady output, while customized demand requires flexibility and rapid response. This dilemma is summed up by the supply chain “trilemma”, companies find it difficult to achieve optimal cost efficiency (Economy) simultaneously, responsiveness (Agility), and depth of customization (Customization) [5]. Different consumer electronics firms exhibit significant divergence in their supply-chain integration strategies. This divergence reveals a gap in the research: under the same mass-customization goals and similar market conditions, how do firms, based on their technological capabilities and external constraints, dynamically construct an “integration–out–sourcing” adaptation model?

Specifically, the following two sub-questions need to be explored in depth:

1. How should a company formulate its integration and outsourcing strategy?
2. What is the redesign/restructuring mechanism for an integrated outsourcing strategy?

This study selects Apple, Xiaomi, and Huawei as case samples. As prominent representatives of the global smartphone and technology sectors, they each exemplify three distinct and highly representative supply-chain integration models: Apple pursues a high degree of integration and balance between different supply chain strategies. Xiaomi practices a user-oriented ecosystem, based on virtual integration, and Huawei follows a highly vertical integration approach. By analysing their practices in the consumer electronics field, the study aims to reveal pathways for building dynamic capabilities in supply chain management in the era of mass customization.

2. Principles for choosing between integration and outsourcing strategies

In the context of mass customization, consumer electronics companies show significant differences in their choices of supply chain strategies. Analyzing the cases of Apple, Xiaomi, and Huawei reveals that these decisions are not random but strictly follow the “capability–strategy fit” framework. This theoretical framework emphasizes that a company's supply chain strategy must align closely with its core technological capabilities and strategic positioning [6]. For reasons of management and control, companies often adopt vertical integration, such as building new operations, acquiring controlling stakes, or merging. Under relatively stable market conditions, a vertical integration strategy can be effective. However, with rapid technological advances, intensifying competition, and growing demand for customized products, firms now face a fast-changing, unpredictable buyer's market. Traditionally, all-encompassing vertical integration strategies can no longer respond quickly and flexibly to market needs. This led to the rise of supply

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chain management (SCM), a new approach that leverages external resources to achieve rapid market responsiveness. SCM emphasizes concentrating a company's limited resources on its core activities while entrusting non-core tasks to other firms, i.e., outsourcing. Outsourcing has become one of modern enterprises' most important and widely used business strategies [7].

2.1. Identifying and managing critical steps

When developing a supply chain strategy, companies must determine which links to control to gain a competitive advantage. High technical barriers that affect product competitiveness should be kept in-house. For example, Apple views chip design and operating system development as core activities, allowing it to outperform competitors in the high-end market. Additionally, companies should focus on managing stages that enhance customer loyalty and create ecosystem value. Although Xiaomi may lack advanced research and development capabilities at the chip level, it emphasizes its MIUI system and e-commerce platform as strategic assets. This aligns with its model of “hardware drives traffic; services generate profit.” Xiaomi strengthens its competitive position by controlling user touchpoints and its data platform. Companies must also consider links that are susceptible to external risks. For instance, in response to geopolitical pressures, Huawei retained control over chip design and critical components. This self-reliance, while costly, ensures survival in challenging circumstances. In today's competitive landscape, strategic positioning is essential for long-term success.

2.2. Outsourcing decisions for non-core functions

For non-core business activities, companies can adopt a more flexible outsourcing strategy. For example, highly standardized production stages are natural candidates: all three firms outsourced their manufacturing and assembly because modern electronics manufacturing has become a highly standardized industry. In capital intensive areas, chip fabrication is a typical example. For example, Apple outsources this stage to specialized foundries like TSMC. This approach effectively avoids the enormous investment risk of building a wafer fab. Similarly, highly substitutable support services, such as logistics and after-sales, can be outsourced depending on a company's strategy.

2.3. Implementation of a dynamic matching mechanism

The alignment between capability and strategy is a dynamic process that must continually adapt to internal and external conditions in three key ways. First, the advancement of technical capabilities can transform strategic alignment. For example, Xiaomi's chips and operating systems investments indicate a shift toward a technology-driven model, necessitating adjustments to its supply chain strategy. Second, shifts in strategic goals require corresponding transformations within the supply chain. Huawei's transition from a globalization-focused approach to independent innovation prompted a comprehensive restructuring, including investments in production lines and the development of domestic suppliers. External shocks, such as geopolitical tensions or technology embargoes, can disrupt established balances. Companies must be prepared to reassess their alignment and adapt to new circumstances to maintain a competitive edge.

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3. Case analysis

3.1. Comparing the integration strategies of Apple, Xiaomi, and Huawei

By comparing these three companies' supply-chain strategies in the global consumer electronics industry, we can see three distinctly different, but all highly successful, models (The comparison of these companies is summarized in Table 1).

Apple's supply-chain management is a tightly balanced virtual and vertical integration fusion. It maintains absolute control over its core competencies and concentrates its best resources on strategically critical areas, chip design, the operating system, and ecosystem building. These areas have very high technical barriers and form the foundation of its product differentiation. By developing the A-series and M-series chips in-house, Apple freed itself from reliance on Qualcomm and Intel and secured control of its core technology. At the same time, Apple has forged deeply bound partnerships with its suppliers by imposing strict technical standards, offering large advance payments, and maintaining stable order volumes. Take TSMC as an example: Apple not only secured priority supply of the 3nm process, but through joint investments in equipment and other measures effectively turned the world's largest chip foundry into its “exclusive workshop.” This asymmetric power structure forces suppliers to prioritize Apple's technology roadmap and capacity allocation.

On the integration front, although Apple outsources manufacturing completely, it still exerts tight control over production through real-time data monitoring, an on-site engineer program, and a multi-supplier strategy. Its supply-chain ERP system can track every stage from raw materials to finished products, ensuring that any anomaly is detected and addressed promptly. This approach captures the efficiency benefits of specialized division of labor while avoiding the quality risks of over-outsourcing [8].

Apple's model is a highly integrated mix of selective vertical depth and broad virtual integration: it uses vertical integration to set the game's rules in key technology areas. It uses virtual integration to scale operations at the execution level. The former secures a unique and continuous product experience, providing cost advantages and operational flexibility. The success of this hybrid model rests on Apple's deep technological base, substantial financial resources, and irreplaceable brand influence, factors that are difficult for ordinary companies to replicate.

Xiaomi's supply-chain strategy is an asset-light, collaborative model with limited vertical integration. Its core is positioning the MIUI operating system as a super entry point that connects users and hardware. It uses system-level integration to accumulate user behaviour data that guides precise product iteration. Xiaomi Mall and the Youpin e-commerce platform make up its direct-to-consumer channels, shortening the transaction chain and giving Xiaomi control over user touchpoints. This asset-light operating model reflects an internet-native mindset, using data and traffic to replace traditional factory assets and using ecosystem investments to make up for shortcomings in in-house R&D.

Strategically, Xiaomi shows a pragmatic orientation. To pursue extreme cost control and fast market response, the company relies almost entirely on contract manufacturing; to rapidly expand its product range, it has invested in hundreds of ecosystem companies to build a smart-hardware matrix; but in core areas like chips, constrained by capital and technical accumulation, Xiaomi has only pursued gradual vertical extension.

This model has indeed driven impressive commercial achievements. Over the past decade, Xiaomi has become one of the top three smartphone makers globally, building the world's largest consumer IoT ecosystem. However, the downsides of heavy dependence on external supply chains

DOI: 10.54254/2754-1169/2025.BL28461

have emerged in recent years: capacity fluctuations caused by reliance on external key components, uneven quality among ecosystem products that create brand risk, and a technology ceiling in the high-end market. Intensifying industry competition has forced Xiaomi to adjust its strategy,self-development efforts like Surge OS and the Xuanjie O1, bionic-robotics technology reserves, and a foray into electric vehicles all indicate that Xiaomi is being pushed toward a gradual, deeper move into technology.

Huawei's supply-chain strategy shifted from a global (hybrid) model to a highly autonomous, innovation-driven vertical integration, an evolution that carries both opportunities and challenges. Through full-stack vertical integration, Huawei has built a complete technology system from chip design to the operating system. HiSilicon's Kirin chips, the HarmonyOS, and a nationwide supply-chain footprint have kept the company at the forefront in key areas such as 5G and AI; domestically developed manufacturing equipment and other capabilities have also advanced its self-sufficiency.

However, heavy capital investment drove Huawei's handset business net profit margin down sharply to 5.1%, far below the industry average. In overseas markets, the absence of Google services caused Huawei's global phone share to fall from 18% to 2%. More troublesome are the domestic chip-process limitations that have led to lagging chip performance, rising costs for domestically sourced components, a scarcity of native HarmonyOS apps, and shortfalls in phone production capacity, among other issues.

Apple concentrates 18% of its R&D resources on chip design and the iOS ecosystem while virtualizing and outsourcing manufacturing. By setting strict technical standards and building a strong developer ecosystem, it achieves a balance of “light assets, control of core technology.” Xiaomi's supply chain emphasizes channel integration and data operations; through ecosystem investments and global price-comparative sourcing, it builds an industry chain based on a global supply network. Huawei's vertical integration spans from Kirin chips to HarmonyOS to SMIC's foundry lines, and it has poured roughly 25% of revenue into cutting-edge areas such as semiconductor equipment and basic materials. That full-chain self-reliance drove its localization rate to an astonishing 90%, but it also exposed the risk of lagging domestic technological iteration.

DOI: 10.54254/2754-1169/2025.BL28461

Table 1. Supply chain integration options for three companies

Category	Huawei	Apple	Xiaomi
Integration mode	Comprehensive vertical integration and domestic substitution	Vertical integration of core processes plus virtualized manufacturing	Purely virtual integration and ecosystem investment
Driving factors	Pressure from sanctions is driving a push for autonomy and independent control.	Technology premium and experience control	Cost efficiency and ecosystem expansion
Control the key points.	Fully independent and controllable across the entire chain	Standard-setting and Ecosystem Governance	Channel integration and data operations
Technical depth	Comprehensive in-house development across the full stack, semiconductor chips, operating systems, and manufacturing processes, necessitated by external circumstances	Semiconductor chips/operating system (OS) / active sensors	Limited in-house research and development (a preliminary foray into semiconductor chip development)
Supply chain objectives	Completely eliminate any embellishment.	Globally optimal integration of resources	Global procurement at the lowest feasible cost
critical investments	Semiconductor equipment, materials, and manufacturing	Semiconductor chip design and its ecosystem	Ecosystem investments and user traffic management
Resource allocation	Strong emphasis on research and development, with R&D expenditures amounting to 25% of revenue	Strong emphasis on research and development, with R&D expenditures amounting to 18% of revenue	Limited research and development (constituting 5% of revenue)
Risk	The pace of iteration of domestically developed technologies	Capital-intensive structures constrain innovation	Deficit of bargaining power within the supply chain

3.2. A breakdown across six core links for Apple, Xiaomi, and Huawei

These strategic differences are apparent across the six core links of the supply chain: chip design and fabrication; core component manufacturing and assembly; production and final assembly; software and operating systems; logistics and after-sales service; and retail channels. (The specific outsourcing strategy choices are shown in Table 2).

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Table 2. Supply chain outsourcing decisions of three firms

Category	Huawei	Apple	Xiaomi
Outsourcing strategy	Subsistence-oriented internal research and development (compelled insourcing of previously outsourced activities)	Control-oriented outsourcing (stringent oversight of non-core functions)	Efficiency-driven outsourcing (prioritizing cost minimization across all stages)
Underlying logic	Supply chain security>the efficiency of globalization.	Technological premium > cost	Traffic efficiency > depth of technological capability
Geopolitical strategy	Comprehensive national import substitution.	Globally optimal integration of resources	China's manufacturing and contract manufacturing in emerging markets
Resilience	Comprehensive end-to-end sanctions resilience.	Multi-supplier backup arrangements	Rapid transition between contract manufacturers.
Greatest risk	The generational gap in domestically developed technologies.	Exclusive reliance on high-end components.	Deficit of bargaining power within the supply chain

3.2.1. Chip design and manufacturing

Apple builds technical barriers with in-house chip design while relying entirely on foundries for fabrication. This protects chip performance and hardware–software integration and avoids heavy capital investment, but the reliance on external fabs is a potential bottleneck. Xiaomi follows a "procurement-first with in-house trials" approach: high-end phones use Qualcomm Snapdragon chips while lower- and mid-range models experiment with the in-house Surge series, which has not yet scaled to replace suppliers. Xiaomi's core strategy is to use mature supply chains to reduce R&D risk, but it faces a long-term loss of technological leverage. Following sanctions, Huawei pivoted from "in-house design plus TSMC foundry" to "in-house design plus domestic manufacturing," investing heavily in China's semiconductor supply chain. However, cost and yield challenges remain significant.

3.2.2. Core components manufacturing and procurement

Apple uses a "high-end customization plus multi-supplier balancing" strategy, driving down prices through supplier competition, avoiding supply cutoff risk, and strengthening control via prepayments and co-investment. Xiaomi pursues "global price comparison procurement plus domestic substitution," prioritizing cost-effective components but still relying on international suppliers like Samsung for high-end models; this cost-oriented approach sacrifices some consistency in performance. After sanctions, Huawei has pushed for 'full domestic substitution'. It secures its supply chain but domestic components are more expensive and in some areas still lag international competitors in performance.

3.2.3. Manufacturing and assembly

Apple outsources 100% of manufacturing but exerts tight control by stationing engineers and sharing data systems, an "asset-light with strong intervention" model that balances cost and quality. Xiaomi's control is weaker and relies entirely on contract manufacturers; its "extremely asset-light" strategy enables rapid expansion but leads to frequent quality-control issues. Huawei moved from outsourcing to Foxconn toward building its own production lines for trials. Dongguan Songshan

DOI: 10.54254/2754-1169/2025.BL28461

Lake facility handles Mate 60 series production with monthly capacity far below that of contract manufacturers, but it preserves confidentiality for core technologies.

3.2.4. Software and operating systems

Apple develops an in-house, closed-source ecosystem (iOS/macOS) to achieve deep hardware–software integration. The App Store's 30% commission is a core profit driver, but the closed ecosystem faces antitrust pressure. Xiaomi deeply customizes Android with MIUI and relies on Google Mobile Services (GMS); its open-source strategy lowers R&D costs but limits overseas competitiveness where Google services are restricted (e.g., markets where GMS is banned). After sanctions, Huawei launched its HarmonyOS, which is compatible with Android apps but free from underlying dependencies; however, the lack of mainstream app support makes it hard to build an overseas ecosystem.

3.2.5. Logistics and after-sales

Apple outsources premium logistics but operates its own after-sales to boost brand premium; global cold-chain transport ensures a new-product launch experience but is costly (air freight over 60%). Xiaomi fully outsources logistics to JD Logistics and after-sales to authorized partners to match its low-price strategy; third-party after-sales are efficient but uneven in quality, for example, India shows a 15% complaint rate. Huawei utilizes a hybrid logistics model combining state-owned partners with its service teams. By shipping sensitive components through COSCO, Huawei enhances its domestic operations and offers specialized services to government and enterprise clients. However, the rising costs of international logistics due to sanctions highlight the urgent need for innovative solutions.

3.2.6. Retail channels

Apple mainly uses direct retail, giving it complete control of user experience and pricing, though this model only works well in high-spending urban areas. Xiaomi emphasizes its online Mi Store plus franchised Mi Home offline stores; the franchising model expands rapidly into lower-tier cities. However, weak oversight has led to problems like unauthorized price markups. Huawei combines direct flagship stores with state-linked channels and relies on carrier subsidies to support offline sales, but its overseas retail network has contracted by about 80% because of sanctions.

4. Triggers and response mechanisms for supply chain restructuring

Two kinds of environmental shocks mainly trigger supply-chain restructuring. The first is geopolitical conflict, including systemic risks like technology blockades and trade sanctions. Take the U.S. sanctions on Huawei in 2019 as an example: the measures directly severed key links in its supply chain, such as chip foundry services and operating systems and the impact was at the highest level. The second is technological paradigm shifts, which may not immediately threaten a company's survival but can reshape the industry's competitive landscape. Firms adopt different response strategies depending on their capabilities. Incremental adjustments are appropriate when the shock is of moderate intensity. For example, during U.S.–China trade tensions, Apple pursued regional diversification of production capacity, moving parts of its product lines to places like Vietnam and India while keeping its core supply-chain architecture intact. In contrast, a company may be forced into disruptive restructuring when faced with an existential crisis. Huawei's case shows this: by

DOI: 10.54254/2754-1169/2025.BL28461

pursuing full-stack independent innovation, covering chip design, operating systems, and manufacturing processes, it rebuilt its supply-chain system, a transformation that took more than five years.

4.1. A decision-making framework for reconstruction pathways

First, the path for gradual optimization is to diversify suppliers to reduce concentration risk and optimize the supply-chain network. For example, Apple brought in second-tier suppliers like Luxshare to reduce single dependence on Foxconn; it also adjusted regional layouts to implement a nearshoring strategy. The capacity for products sensitive to high tariffs has moved to areas surrounding target markets. For instance, Apple set up production bases in Mexico to serve North America. Companies also develop alternative solutions with strategic partners to drive technological cooperation and innovation. For example, Xiaomi's jointly customized chips with Qualcomm allow it to achieve differentiated products with limited R&D investment.

Second, the key measures for disruptive transformation include Huawei's vertical integration breakthrough: by building the Songshan Lake production base, Huawei achieved in-house manufacturing of key products. The initial capacity was limited, but these secured core technologies. Another approach is innovating the technology path: combining mature process nodes with advanced packaging to bypass process limitations, a strategy whose feasibility was validated by the successful mass production of the Kirin 9000S chip. Finally, ecosystem reconstruction, using the HarmonyOS compatibility layer to preserve the existing app ecosystem while gradually building an independent technology stack.

4.2. Decision-making framework for restructuring pathways

4.2.1. A three-dimensional model of enterprise capabilities

First is the depth of technical reserves: Huawei's ability to quickly launch HarmonyOS owes to its long-term R&D accumulation in embedded systems. The timeliness (patent validity) and breadth (the capacity to integrate technologies across domains) of those technical reserves determine how fast an overhaul can proceed. Second is the level of financial resilience: Apple, with large cash reserves, can carry out supply-chain relocation with ease, while Xiaomi, with a net profit margin of only 5%, is more likely to favour a light-asset approach. Finally, the strength of policy support: China's “Big Fund” investments in firms like Yangtze Memory have significantly lowered the difficulty of implementing Huawei's supply-chain localization.

4.2.2. Building dynamic capabilities

Dynamic capabilities refer to “a firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments.” They are mainly used to explain how firms dynamically align their resources with their environment to obtain and sustain competitive advantage [9,10]. The existing literature divides them into three dimensions: opportunity-sensing capability, opportunity-seizing capability, and strategic-reconfiguration capability [11,12]. First, opportunity-sensing capability refers to a company's ability to detect and identify potential opportunities and threats in a rapidly changing market environment [10]. In a fast-changing market, companies must quickly identify potential opportunities and threats to adjust their strategies in response to internal and external changes and maintain a competitive edge [11]. Second, the ability to seize opportunities refers to a company's capacity to develop, evaluate, and select

DOI: 10.54254/2754-1169/2025.BL28461

strategic options rapidly and to adjust them promptly as the environment changes. When a new opportunity is detected, the company must act quickly to craft practical, feasible strategies to avoid the risk of making poor decisions [13]. Third, strategic reconfiguration capability refers to optimizing resource allocation and adapting to new environments by changing business processes and innovating business models. Firms leverage various resources and mechanisms, coordinate all parties, and create, expand, integrate, reconfigure, and renew strategic resources to achieve sustained competitive advantage [11,14]. Thus, dynamic capability is an integrated process that begins with keen insight into market dynamics, moves through scientific yet flexible strategic decision-making, and achieves efficient reconfiguration of strategic resources. It encompasses sensing, decision-making, and action, ensuring that when faced with market opportunities, a firm can quickly and effectively acquire, allocate, and integrate internal and external resources to achieve optimal resource deployment [15].

Based on the above analysis, successful supply-chain restructuring requires situational awareness to establish a systemic risk early-warning mechanism, for example, Apple's "geopolitical risk dashboard," which quantitatively assesses a business-risk index across regions. It also requires the ability to rapidly secure critical resources, as Huawei did through its Hubble investment program, quickly building strategic positions in more than 60 semiconductor companies. Finally, it needs organizational transformation capability to flexibly realign the business architecture. Xiaomi's shift from a phone maker to an ecosystem centered on smart vehicles and AIoT illustrates this kind of strategic restructuring ability.

5. Conclusion

Choosing a supply-chain strategy for consumer-electronics firms is a complex systems problem that requires balancing multiple factors such as technological capabilities, strategic positioning, and environmental constraints. Establishing a rigorous decision-making framework and practicing dynamic management can help find the best trade-off between efficiency and security.

The above analysis can resolve two issues. When firms decide between vertical integration and outsourcing, identifying core activities requires a systematic evaluation framework: a scientific assessment system should judge each link's strategic importance across technical barriers, commercial value, and risk. In an uncertain business environment, companies must keep their supply-chain strategy flexible and leave room to adjust for potential strategic pivots. Second, outsourcing strategies should be realistic and matched to a company's capabilities. Firms at different development stages and with different resource endowments should choose an appropriate level of control rather than unquestioningly imitating industry leaders. Beyond the make-or-buy dilemma, the second major issue involves responsive restructuring under varying disruption intensities.

On the second question, supply-chain restructuring is not a binary choice but a continuum of strategies: under low shocks, make incremental, efficiency-driven adjustments; under moderate shocks, pursue adaptive hybrid strategies; under severe shocks, undertake systemic restructuring aimed at survival.

This study has limits: it is theoretically idealized, narrowly focused, may have biased empirical results, and is slow to address changing conditions, human-centered issues, and new challenges. As deglobalization intensifies, the supply-chain "resilience premium" may keep rising. Therefore, future research should incorporate more dynamic and human factors to better reflect real-world complexities and evolving global supply chain dynamics.

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