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Supply Chain Reconfiguration by Cross-Border E-Commerce Platforms Under Economic Security Shocks: Partial De-Risking Versus Decoupling from the Original Supply Chain

Junting Liu ¹, Songqi Liu ¹ , Zanliang Meng ² and Lingui Qin ^{3,*}

¹ School of Finance and Trade, Liaoning University, Shenyang 110036, China; juntung_liu@126.com (J.L.); liusongqi0205@163.com (S.L.)

² Department of Agricultural Economics, Purdue University, West Lafayette, IN 47907, USA; meng183@purdue.edu

³ College of Economics and Management, Shenyang Agricultural University, Shenyang 110866, China

* Correspondence: qinlingui@syau.edu.cn

Abstract

Cross-border e-commerce platforms increasingly operate under economic-security measures that raise sourcing costs and impair order fulfillment, turning supplier reconfiguration into a joint pricing-and-sourcing problem. We develop a joint pricing-and-sourcing model applied to cross-border platform operations, with a low-cost, high-exposure original supplier and a higher-cost, more reliable alternative supplier. A per-unit tariff-equivalent cost t represents the policy-cost channel, an expected order-level fulfillment-loss rate q represents the fulfillment channel, and convex supply-chain switching costs determine the depth of reconfiguration. The model identifies the trigger for the transition from global sourcing (GS) to partial de-risking (DR) and the boundary between DR and decoupling from the original supply chain (DC). These analytical results are evaluated using a case-informed calibration to SHEIN's low-value U.S. direct-shipping apparel setting. The results show that, under the baseline calibration, the GS-to-DR trigger is $t = 5$ when only the tariff-equivalent cost shock is present and $q \approx 0.282$ when only the fulfillment shock is present. Across the case-informed t - q domain, DR accounts for 82.11% of evaluated combinations and DC for 0.023%; lower switching-cost intensity and a smaller alternative-supplier cost premium expand the DC region. Robustness analyses examine alternative demand specifications, sourcing granularity, capacity constraints, switching-cost forms, supplier risk, failed-order cost incidence, and supply-chain structures. By distinguishing the trigger for diversification from the depth and boundary of subsequent reconfiguration, the study clarifies why partial de-risking can emerge as a distinct strategy between global sourcing and decoupling from the original supply chain and provides decision benchmarks for supplier diversification, regional fulfillment, and resilience investment.



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Keywords: cross-border e-commerce; economic security shocks; supply-chain reconfiguration; partial de-risking; decoupling from the original supply chain

1. Introduction

Cross-border e-commerce and digital trade are reshaping global goods distribution by linking overseas demand to geographically dispersed supply through digital transactions, cross-border payments, and international logistics. The scale of e-commerce activity has continued to expand rapidly. UN Trade and Development's *Digital Economy Report*

2024 documents sustained growth in business e-commerce through 2022 [1]. More recent UNCTAD statistics place business e-commerce sales across 45 developed and developing economies at approximately USD 28 trillion in 2024 [2]. In China, cross-border e-commerce imports and exports reached CNY 2.63 trillion in 2024, representing a 10.8% increase from the previous year [3]. At the same time, cross-border transactions face longer delivery times, customs procedures, payment frictions, information asymmetry, and trust constraints relative to domestic e-commerce [4–6]. Fulfillment reliability is therefore central to both cost competitiveness and market expansion for cross-border e-commerce platforms.

This dependence on cross-border fulfillment also increases platforms' exposure to economic-security measures that raise landed costs or disrupt established sourcing channels. Export controls, investment screening, tighter rules of origin, low-value parcel reforms, and geopolitical tensions are reshaping operating models built on low-cost manufacturing and direct shipping. The scale of this exposure is substantial. U.S. Customs and Border Protection processed more than 1.36 billion de minimis shipments in the 2024 fiscal year [7], while 4.6 billion e-commerce parcels valued at no more than EUR 150 entered the European Union in the same year, approximately 91% of them from China [8]. Policy changes have also broadened in scope. The United States ended duty-free de minimis treatment for covered goods from mainland China and Hong Kong, China on 2 May 2025 [9], extended the suspension globally to covered low-value shipments from 29 August 2025 [10], and continued the global suspension in February 2026 [11]. These changes affect more than landed costs: policy uncertainty can delay market entry and investment and alter firms' export and innovation decisions [12–15]. Platform sourcing decisions must therefore balance cost efficiency, fulfillment reliability, and policy exposure.

The combination of cost and fulfillment shocks creates a three-way sourcing choice. The original supply chain may retain a cost advantage as the fulfillment-loss rate rises, whereas alternative sourcing can improve fulfillment reliability at the expense of a higher unit cost and supply-chain switching costs [16–18]. This trade-off gives rise to three possible strategy regions: global sourcing (GS) under low shock intensity, partial de-risking (DR) under intermediate exposure, and decoupling from the original supply chain (DC) when shocks become sufficiently strong relative to the costs of reconfiguration. The key analytical task is therefore to determine how tariff-equivalent cost, fulfillment-loss rate, and switching-cost intensity jointly govern the GS–DR trigger, reconfiguration depth, and the DR–DC boundary.

This three-way sourcing choice is particularly relevant for cross-border e-commerce platforms because they connect front-end digital demand with back-end supplier networks and can adjust retail prices and sourcing shares over relatively short decision cycles. Economic-security shocks affect these decisions through two distinct channels. The first is a tariff-equivalent cost channel: tariffs, compliance requirements, and changes to low-value parcel rules raise the effective unit-sourcing cost of the original supply chain. The second is a fulfillment channel: export controls, customs restrictions, logistics disruptions, and supply interruptions reduce the expected share of assigned orders fulfilled by the original supply chain. The tariff-equivalent cost channel changes the relative sourcing-cost ranking between the original and alternative suppliers, whereas the fulfillment channel reduces realized fulfillment and therefore fulfilled sales and expected platform profit. The two channels can operate independently or reinforce each other.

This decision problem lies at the intersection of the supply disruption and sourcing literatures. Supply-chain research examines how firms balance efficiency, disruption mitigation, and recovery [19–21], while supplier-portfolio models characterize sourcing diversification under demand and supply risk [16,18,22]. These studies provide the theoretical basis for trading off low-cost sourcing against fulfillment reliability. However, for

cross-border e-commerce platforms, this trade-off is further shaped by platform pricing and by economic-security shocks that operate through distinct tariff-equivalent cost and fulfillment channels. Bringing these elements together makes it possible to examine how platforms reconfigure sourcing across global sourcing, partial de-risking, and decoupling from the original supply chain.

Existing research provides several parts of this problem but has not yet brought them together within a unified platform sourcing framework. Trade-policy studies show that policy uncertainty and trade restrictions affect firms' investment, market participation, exports, and innovation [12–15], while related work examines adjustment under tariff threats and broader policy uncertainty [23,24]. Cross-border e-commerce research emphasizes logistics and digital fulfillment [5,6,25,26], and platform studies examine selling modes and channel governance [27–30]. Dual-sourcing and resilience research, in turn, characterizes supplier diversification under disruption [16,18,21,22], with recent studies extending sourcing decisions to multiple sources of volatility [31,32]. Taken together, these literatures leave an important analytical question unresolved: how do the GS–DR–DC boundaries change when a cross-border e-commerce platform jointly determines retail price and sourcing share under a tariff-equivalent cost shock, a fulfillment shock measured by an expected order-level fulfillment-loss rate, and explicit supply-chain switching costs?

Accordingly, this paper develops a joint pricing-and-sourcing model for cross-border e-commerce operations. After observing supplier quotations and the economic-security environment, the focal platform is modeled as a unified decision maker that jointly determines the retail price and the sourcing share allocated to a low-cost, high-exposure original supplier and a higher-cost, more reliable alternative supplier. The model distinguishes a tariff-equivalent cost shock from a fulfillment shock measured by an expected order-level fulfillment-loss rate and incorporates explicit convex supply-chain switching costs. We derive the platform's optimal decisions under the baseline, cost-shock, fulfillment-shock, and compound-shock scenarios, analytically characterize the GS–DR trigger, reconfiguration depth, and DR–DC boundary, and evaluate these results through a case-informed calibration to SHEIN's low-value U.S. direct-shipping apparel setting. Extensions further examine trade-policy uncertainty and resilience investment.

The analysis yields three main findings. First, the tariff-equivalent cost shock and fulfillment shock generate distinct GS–DR triggers but reinforce each other under compound exposure. A stronger shock through one channel therefore lowers the level of exposure required through the other channel to initiate partial de-risking. Second, once the GS–DR trigger is crossed, switching-cost intensity primarily determines reconfiguration depth and the DR–DC boundary. Under the quadratic switching-cost benchmark, switching-cost intensity does not affect the local GS–DR trigger because the marginal switching cost is zero at the global-sourcing point, but it becomes important once alternative sourcing begins. Third, partial de-risking occupies most of the case-informed parameter domain, whereas deeper reconfiguration becomes more likely as switching-cost intensity declines or the alternative-supplier cost premium narrows.

The main contributions of this paper are reflected in three aspects. First, the model distinguishes a tariff-equivalent cost channel that changes relative supplier costs from a fulfillment channel, measured by an expected order-level fulfillment-loss rate, that changes realized fulfillment and sales. Second, it integrates both channels and explicit supply-chain switching costs within a joint pricing-and-sourcing framework applied to cross-border platform operations, making reconfiguration depth endogenous. Third, it organizes the resulting sourcing decisions through a trigger–depth–boundary framework: closed-form conditions identify the GS–DR trigger, comparative statics and numerical analysis characterize reconfiguration depth, and switching-cost intensity governs the DR–DC boundary.

A case-informed calibration to SHEIN's low-value U.S. direct-shipping apparel setting, together with extensions to trade-policy uncertainty and resilience investment, connects these analytical results to cross-border platform operations.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the model setup, and Section 4 derives the platform's optimal decisions under the baseline, cost-shock, fulfillment-shock, and compound-shock scenarios. Section 5 compares the reconfiguration mechanisms and strategy boundaries across scenarios. Section 6 presents the numerical analysis, Section 7 develops the model extensions, and Section 8 summarizes the main findings, managerial implications, limitations, and directions for future research.

2. Literature Review

Three bodies of research provide the theoretical foundations for the model: economic-security shocks and supply-chain reconfiguration; cross-border e-commerce platforms and digital fulfillment; and supply disruption, resilience, and sourcing diversification. Their intersection motivates the policy-cost channel, the fulfillment channel, switching cost, and the endogenous GS-DR-DC boundaries developed below.

2.1. Economic Security Shocks, Trade Policy Uncertainty, and Supply-Chain Reconfiguration

Research on trade-policy uncertainty establishes that anticipated policy changes affect foreign-market entry, investment, exports, innovation, and welfare [12–15]. Tariff-threat and macro policy-uncertainty studies further document changes in market participation and real activity [23,24,33]. These effects provide the economic basis for representing policy exposure as a tariff-equivalent cost that enters the platform's sourcing decision.

A related stream examines how firms reorganize global supply chains when geopolitical and policy conditions change. Reviews trace geopolitical shocks to reconfiguration across suppliers, regions, and governance arrangements [34,35]. Research on reshoring, relationship stickiness, supplier composition, and viable relocation documents several reconfiguration margins [36–40]. Broader work links these choices to deglobalization and the reshoring decision process [41,42]. This literature motivates a continuous reconfiguration margin spanning supplier substitution, diversification, regional relocation, and organizational redesign. For cross-border platforms, that margin interacts directly with retail pricing and fulfillment decisions.

2.2. Cross-Border E-Commerce Platforms, Digital Fulfillment, and Supply-Chain Configuration

For cross-border e-commerce, supply-chain configuration is inseparable from digital fulfillment. Logistics performance, customs procedures, information transparency, and return arrangements influence the conversion of digital demand into completed cross-border sales [4–6,25,26]. These operational features support modeling the platform as an active decision maker whose sourcing allocation affects realized fulfillment.

Platform models add a governance dimension to this fulfillment problem. Marketplace, reseller, agency, and hybrid structures allocate pricing authority and channel control in different ways [27–30], establishing the platform as an active coordinator of prices and operating terms. The model developed here carries that coordination role into supplier-portfolio reconfiguration, with the sourcing share linking channel decisions to fulfillment exposure.

2.3. Supply Disruption Risk, Resilience, and De-Risking Through Sourcing

The disruption and resilience literature establishes the efficiency–resilience trade-off that underlies de-risking. Classic disruption models show how firms combine mitigation and contingency when supply is disrupted [19,20]. Subsequent reviews extend this logic to recovery and resilience capabilities [21,43–45]. Recent work connects resilience to public

policy and extends sourcing decisions to multiple sources of volatility [32,46]. These mechanisms motivate supplier diversification, switching cost, and resilience investment in the present framework.

Within this broader literature, dual-sourcing models provide the closest analytical foundation for sourcing-share adjustment. Early models formalize procurement from unreliable suppliers and sourcing under joint demand and supply risk [16,22]. Related work adds process improvement, dynamic pricing, and multi-supplier sourcing to the procurement decision [31,47,48]. Responsive-pricing and unreliable-supplier models further connect price adjustment to supply diversification [49–51]. Together, these studies establish the low-cost/high-reliability trade-off and the interior sourcing-share logic on which the economic-security mechanism builds.

2.4. Literature Synthesis and Research Gap

Taken together, these three bodies of literature provide complementary building blocks for the model. Trade-policy research motivates the policy-cost channel [12–15], platform research provides the pricing and channel-governance structure [27–30], and sourcing research establishes the allocation logic under supply risk [16,18,22,31,32]. Integrating these mechanisms yields a joint pricing-and-sourcing framework applied to cross-border platform operations, with two distinct shock channels, explicit supply-chain switching costs, and endogenous GS–DR–DC regions. The resulting analytical sequence focuses on the trigger for diversification, the depth of reconfiguration, and the boundary between partial de-risking and decoupling from the original supply chain. Table 1 positions this integrated structure relative to the closest analytical benchmarks.

Table 1. Positioning of the present framework relative to the closest analytical models.

Study	Price	Source	Multi-Source	Supply Risk	Trade-Policy Cost	Switching Cost	CBEC Context	Interior DR	Complete DC	Analytical Boundary
Handley & Limão (2015) [13]	–	–	–	–	✓	–	–	–	–	–
Hagiu & Wright (2015) [27]	✓	–	–	–	–	–	✓	–	–	–
Feng (2010) [47]	✓	✓	–	✓	–	–	–	–	–	✓
Feng & Shi (2012) [48]	✓	✓	✓	✓	–	–	–	✓	–	✓
Li et al. (2013) [49]	✓	✓	✓	✓	–	–	–	✓	–	✓
Dong et al. (2022) [50]	–	✓	✓	✓	–	–	–	✓	–	✓
Shan et al. (2022) [51]	✓	✓	✓	✓	–	–	–	✓	–	✓
Federgruen et al. (2025) [32]	–	✓	✓	✓	–	–	–	✓	–	✓
This study	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: ✓ indicates that the corresponding feature is incorporated in the cited study, whereas – indicates that it is not. CBEC denotes cross-border e-commerce. The “CBEC context” column identifies whether the model is developed within a cross-border e-commerce empirical and institutional setting.

3. Problem Description and Model Setup

3.1. Supply-Chain Structure and Decision Maker

Consider a cross-border e-commerce supply chain consisting of a platform P , an original supplier S_1 , and an alternative supplier S_2 . The platform sells products to overseas consumers and jointly determines the retail price and sourcing shares in response to economic security shocks, sourcing costs, and market demand. Because its operating performance depends on both front-end transactions and fulfillment activities, including cross-border logistics, payments, customs clearance, returns, and information transparency [4,5], the platform is modeled as the unified decision maker for market sales and supply-chain configuration.

In the present application, the joint pricing-and-sourcing structure is mapped to cross-border e-commerce operations through pricing authority, transaction coordination, cross-border fulfillment, and exposure to low-value parcel and related economic-security measures.

The original supplier S_1 represents the platform's established low-cost but externally exposed source. It offers a lower unit-sourcing cost but faces greater exposure to tariff-equivalent cost shocks and supply disruption risk. The alternative supplier S_2 represents a lower-risk third-country, nearshore, or local source with a higher unit-sourcing cost but greater supply reliability. This cost and reliability structure is consistent with research on sourcing from unreliable suppliers, dual sourcing, and supplier portfolio selection [16,18,22].

Wholesale prices w_1 and w_2 represent sourcing quotations established through long-term contracts, market quotations, or existing trading relationships. The baseline analysis takes these quotations as given when the platform chooses retail price p and the ex ante sourcing share x assigned to the original supplier, consistent with platform models in which pricing and channel terms are centrally coordinated [27,29]. With strategic supplier pricing, the same trigger logic can be expressed in terms of equilibrium quotations: the cost-only trigger becomes $t^c = w_2 * -w_1 *$, and the fulfillment-only trigger is evaluated at those equilibrium quotations. Section 8.3 identifies supplier pricing and contract coordination as a natural extension. Given the observed quotations, the platform chooses among GS, DR, and DC as tariff-equivalent cost and fulfillment loss intensify. Figure 1 summarizes the supply-chain structure, decision sequence, shock channels, and strategy space.

3.2. Strategy Space and Scenario Classification

The decision variable x is the ex ante share of planned order volume allocated to the original supplier; the remaining share, $1 - x$, is allocated to the alternative supplier. Representing sourcing as a continuous order share follows supplier-portfolio models based on order or capacity allocation [22,31] and permits the model to characterize reconfiguration depth directly. Realized fulfillment from the original supply chain additionally depends on the fulfillment-loss rate q . Section 6.4.5 tests the continuous-share approximation using 5% and 10% sourcing increments and explicit alternative-supplier capacity constraints.

The continuous sourcing-share decision maps into three economically interpretable strategies. Global sourcing corresponds to complete reliance on the original supplier, partial de-risking to an interior sourcing mix, and decoupling from the original supply chain to complete reliance on the alternative supplier. As x decreases, the platform becomes less dependent on the original low-cost cross-border supply chain. Table 2 summarizes these sourcing structures and their economic interpretations.

In this study, "decoupling from the original supply chain" is an operational sourcing boundary: over the modeled decision horizon, the platform assigns no planned orders to the original supplier and relies entirely on the alternative supplier. Accordingly, DC is used here as a platform-level sourcing concept defined over the modeled decision horizon.

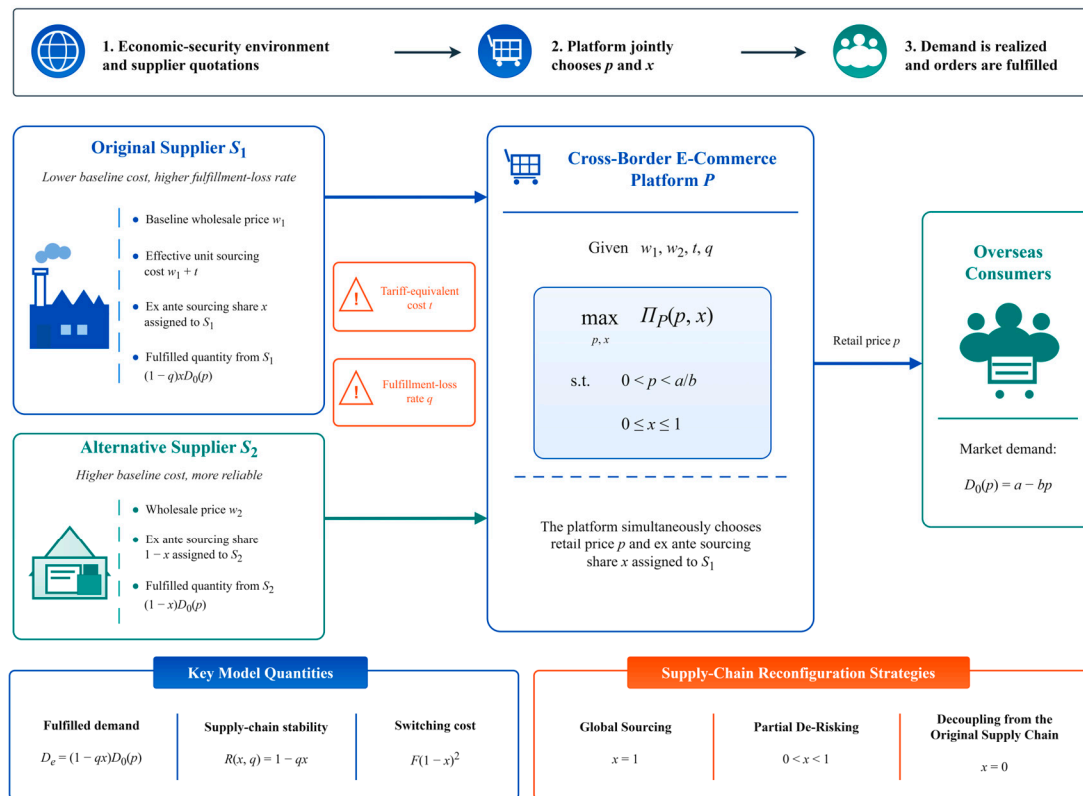


Figure 1. Supply-chain structure and decision sequence under economic security shocks.

Table 2. Supply-chain reconfiguration strategies and sourcing structures.

Strategy	Condition	Sourcing Structure	Economic Interpretation
Global sourcing (GS)	$x = 1$	All orders are assigned to S_1 .	The platform retains the cost advantage of low-cost cross-border sourcing but remains exposed to tariff-equivalent cost shocks and disruption risk in the original supply chain.
Partial de-risking (DR)	$0 < x < 1$	Both S_1 and S_2 are used.	The platform balances cost efficiency against fulfillment reliability by combining the original and alternative suppliers. Under the relevant combinations of shocks and switching costs, dual sourcing constitutes a distinct optimal supply-chain configuration.
Decoupling from the original supply chain (DC)	$x = 0$	All orders are assigned to S_2 .	The platform stops allocating orders to the original supplier but incurs a higher alternative sourcing cost and supply-chain switching cost.

3.3. Demand, Fulfillment, and Supply-Chain Stability

Potential market demand is represented by the linear function $D_0(p) = a - bp$, where a denotes potential market size and b measures price sensitivity; $p < a/b$ ensures positive demand. The linear form provides an analytically tractable benchmark around the case-informed operating point and yields an explicit price response and closed-form sourcing triggers. This choice is consistent with the importance of price and quick response in fast-fashion operations [52]. Section 6.4.5 evaluates an isoelastic specification calibrated to the same no-shock price, demand level, and local elasticity.

The fulfillment-loss rate $q \in [0, 1]$ measures the expected fraction of planned sales assigned to the original supply chain that remains unfulfilled over the relevant operating horizon. It aggregates order-level losses associated with inspections, clearance delays, logistics-time variability, supply interruptions, and related delivery frictions. Sourcing

shares are chosen before fulfillment uncertainty is realized, so failed orders remain unfilled within the operating period represented by the model.

Potential market demand is $D_0(p) = a - bp$. Because only a fraction $1 - q$ of the orders assigned to the original supplier is successfully fulfilled, total fulfilled demand is $D_e(p, x, q) = (1 - qx)D_0(p)$, and supply-chain stability is $R(x, q) = 1 - qx$. The fulfillment-loss rate therefore translates supply-disruption risk into realized fulfillment through the sourcing share x without changing the underlying consumer-demand parameters.

When $q > 0$, global sourcing has the lowest supply-chain stability, decoupling from the original supply chain has the highest, and partial de-risking lies between them. When $q = 0$, all three strategies have the same supply-chain stability. The platform continues to maximize profit, while $R(x, q)$ serves as a supplementary measure for comparing fulfillment performance across strategies. Table 3 summarizes potential demand, supplier-level fulfillment, total fulfilled demand, and supply-chain stability.

Table 3. Demand, realized fulfillment, and supply-chain stability.

Measure	Expression	Interpretation
Potential market demand	$D_0(p) = a - bp$	The potential order volume available to the platform at price p .
Fulfillment by the original supply chain	$Q_1 = (1 - q)xD_0(p)$	The quantity of planned orders actually fulfilled by the original supplier.
Fulfillment by the alternative supply chain	$Q_2 = (1 - x)D_0(p)$	The quantity fulfilled by the alternative supplier.
Total fulfilled demand	$D_e(p, x, q) = (1 - qx)D_0(p)$	Demand that is ultimately delivered and converted into sales.
Supply-chain stability	$R(x, q) = 1 - qx$	The fulfillment success rate; it equals $1 - q$, $1 - qx$, and 1 under GS, DR, and DC, respectively.

3.4. Cost Structure, Profit Functions, and Welfare Measures

Let t denote the per-unit tariff-equivalent cost or per-unit compliance cost incurred when the platform sources from the original supplier S_1 . The effective unit-sourcing cost of the original supplier is therefore $w_1 + t$, whereas the alternative supplier's unit-sourcing cost is w_2 . We generally assume $w_1 < w_2$ and define $\Delta w = w_2 - w_1 > 0$, as the alternative supplier's baseline cost disadvantage relative to the original supplier. When $t < \Delta w$, the original supply chain retains an effective cost advantage. When $t \geq \Delta w$, the tariff-equivalent cost eliminates or reverses that advantage.

Reconfiguration also entails switching costs when the platform reduces reliance on the original supplier and expands alternative sourcing. These costs include supplier search and qualification, contract and production adaptation, logistics and warehousing adjustment, information-system integration, and compliance with customs and rules-of-origin requirements. They also include organizational and relational frictions associated with unwinding established links and stabilizing new supplier relationships [17,36,37,42]. The switching-cost intensity introduced below therefore captures implementation, relational, and network frictions separately from the alternative supplier's unit-cost premium and the original supply chain's tariff-equivalent cost.

Let $r = 1 - x \in [0, 1]$ denote the planned sourcing share assigned to the alternative supplier. We represent supply-chain switching costs using the continuous convex switching-cost function $C_S(r) = Fr^2 = F(1 - x)^2$, where $F > 0$ has the same unit of measurement as platform profit and captures the overall intensity of supply-chain switching costs. When

the platform shifts entirely to the alternative supplier, $r = 1$ and the normalized switching cost equals F . The function satisfies

$$C_S(0) = 0, \quad C_S(1) = F, \quad C_S'(r) = 2Fr \geq 0, \quad C_S''(r) = 2F > 0. \quad (1)$$

The benchmark specification $C(r) = Fr^2$ represents the supply-chain switching cost as increasing and convex in the alternative sourcing share. Small trial orders require limited adaptation, whereas deeper shifts involve contracts, capacity, quality control, logistics, inventory, information systems, and trading relationships. The parameter F therefore governs the marginal organizational and network cost of moving sourcing toward the alternative supplier. Section 6.4.5 evaluates the linear-quadratic form $C(r) = \kappa r + Fr^2$ to distinguish an initial switching wedge from subsequent curvature.

The platform pays sourcing costs only for successfully fulfilled orders. Unfulfilled orders from the original supply chain generate neither sales revenue nor the corresponding sourcing expenditure; instead, they affect the model through lower fulfilled demand. Supplier production costs c_1 and c_2 determine supplier profits and system welfare, whereas the platform's optimal price and sourcing share depend on wholesale prices and the remaining model parameters. Consumer surplus and system welfare are used as supplementary performance measures in the numerical analysis. Table 4 summarizes the platform and supplier profit functions and the corresponding welfare measures.

Table 4. Profit functions and supplementary welfare measures.

Measure	Expression	Interpretation
Platform profit	$\Pi_P(p, x) = [p - (w_1 + t)](1 - q)x D_0(p) + [p - w_2](1 - x) D_0(p) - F(1 - x)^2$	The platform's primary optimization objective.
Original supplier profit	$\Pi_{S_1} = (w_1 - c_1)(1 - q)x D_0(p)$	Profit generated by orders actually fulfilled by the original supplier.
Alternative supplier profit	$\Pi_{S_2} = (w_2 - c_2)(1 - x) D_0(p)$	Profit generated by orders fulfilled by the alternative supplier.
Consumer surplus	$CS = \frac{(1-qx)(a-bp)^2}{2b}$	Consumer surplus adjusted for the level of fulfilled demand.
System welfare	$W = \Pi_P + \Pi_{S_1} + \Pi_{S_2} + CS$	A supplementary comparison measure used in the numerical analysis.

Note: c_1 and c_2 are the unit production costs of the original and alternative suppliers, respectively. Wholesale prices w_1 and w_2 are exogenous in the baseline model.

This is the benchmark failed-order cost assumption. Section 6.4.5 and Supplementary Note S4.4 relax it by allowing a fraction $\varphi \in [0, 1]$ of the original-source effective sourcing expenditure to remain sunk when fulfillment fails.

3.5. Decision Sequence and Model Assumptions

These primitives imply the following decision sequence. The platform first observes the economic-security environment and supplier quotations and then jointly chooses retail price p and the ex ante sourcing share x . The two shocks enter through the tariff-equivalent cost t and fulfillment-loss rate q , while wholesale prices are known contractual or market terms. Demand and realized fulfillment follow from these choices. For analytical tractability, we first optimize price conditional on a sourcing share and then maximize the resulting indirect profit over the feasible sourcing interval. This solution sequence is algebraic: the platform's economic decision remains a joint pricing-and-sourcing choice.

The platform's optimization problem is

$$\begin{aligned} \max_{\substack{0 < p < a/b \\ 0 \leq x \leq 1}} \Pi_P(p, x) &= [p - (w_1 + t)](1 - q)x D_0(p) + [p - w_2](1 - x) D_0(p) - F(1 - x)^2. \end{aligned} \quad (2)$$

The model is based on the following assumptions.

Assumption 1. The focal platform is modeled as the unified decision maker and jointly chooses the retail price and the ex ante sourcing share assigned to the original supplier to maximize platform profit. This institutional specialization captures the platform's role in transaction design and fulfillment coordination while retaining a general joint pricing-and-sourcing structure.

Assumption 2. The original supplier has lower production and wholesale costs than the alternative supplier. Wholesale prices are exogenous in the baseline model; production costs enter supplier profit and welfare calculations but do not alter the platform's first-order conditions.

Assumption 3. The tariff-equivalent cost raises the original supplier's effective unit-sourcing cost and summarizes tariffs, customs and declaration requirements, compliance reviews, and related per-unit policy burdens.

Assumption 4. Disruption risk is confined to the original supply chain. Sourcing shares are selected ex ante, and orders that the original supply chain fails to fulfill cannot be reassigned immediately after disruption. The benchmark treats sourcing expenditure associated with those failed orders as fully avoidable; Section 6.4.5 relaxes this cost-incidence assumption.

Assumption 5. The alternative supplier is a lower-risk source with sufficient capacity to fulfill the orders assigned to it after basic qualification and capacity screening.

Assumption 6. Global sourcing, partial de-risking, and decoupling from the original supply chain correspond respectively to full reliance on the original supplier, an interior sourcing mix, and complete reliance on the alternative supplier.

Assumption 7. Introducing and expanding the alternative supply chain entails the continuous convex supply-chain switching-cost function specified in Equation (1). This cost is distinct from the alternative supplier's unit-sourcing price and represents the increasing marginal difficulty of deeper supply-chain reconfiguration.

Assumption 8. The parameters satisfy the positive-demand, feasibility, and scenario-specific concavity conditions stated in Section 4. When global concavity is not imposed, the numerical procedure compares all feasible stationary points with the boundary candidates.

With the model setup complete, Section 4 derives the conditional optimal price and indirect profit function and uses them to characterize the GS, DR, and DC regions.

3.6. Notation

Table 5 defines the principal notation and its economic interpretation.

Table 5. Main notation and economic interpretation.

Symbol	Definition
P	Cross-border e-commerce platform
S_1	Original supplier with a lower cost but higher supply-disruption risk
S_2	Alternative supplier with a higher cost but lower supply-disruption risk
s	Platform supply-chain strategy, $s \in \{GS, DR, DC\}$

Table 5. *Cont.*

Symbol	Definition
GS	Global sourcing strategy
DR	Partial de-risking strategy
DC	Decoupling from the original supply chain; the platform assigns no orders to the original supplier
p	Retail price set by the platform
x	Ex ante sourcing share assigned to the original supplier
$1 - x$	Ex ante sourcing share assigned to the alternative supplier
w_1	Exogenous wholesale price of the original supplier
w_2	Exogenous wholesale price of the alternative supplier
Δw	Wholesale-price disadvantage of the alternative supplier, $\Delta w = w_2 - w_1$
c_1	Unit production cost of the original supplier
c_2	Unit production cost of the alternative supplier
t	Per-unit tariff-equivalent cost or per-unit compliance cost
q	Expected order-level fulfillment-loss rate in the original supply chain
a	Potential market size
b	Consumer price-sensitivity parameter
$D_0(p)$	Potential demand absent supply disruption
Q_1	Quantity actually fulfilled by the original supply chain
Q_2	Quantity fulfilled by the alternative supply chain
$D_e(p, x, q)$	Total fulfilled demand after accounting for supply disruption
$R(x, q)$	Supply-chain stability (fulfillment success rate)
F	Intensity parameter of the continuous convex supply-chain switching cost; the switching cost equals F when $x = 0$
$C_S(r) = Fr^2 = F(1 - x)^2$	Continuous convex cost of adjusting the supplier portfolio
Π_P	Profit of the cross-border e-commerce platform
Π_{S_1}	Profit of the original supplier
Π_{S_2}	Profit of the alternative supplier
CS	Consumer surplus based on realized fulfilled demand
W	System welfare, used as a supplementary analytical measure

4. Model Solution and Strategy Analysis

With the model primitives defined, the analysis turns to the platform's optimal pricing and sourcing decisions under economic-security shocks. The solution proceeds through four nested scenarios: M0 (no shock), M1 (cost shock), M2 (fulfillment shock), and M3 (compound shock). This sequence isolates the effects of the cost shock, the fulfillment shock, and their interaction, and identifies when diversification begins, how far the sourcing mix adjusts, and when decoupling becomes optimal.

4.1. Baseline Scenario: No Economic Security Shock

The baseline scenario (M0) sets $t = 0$ and $q = 0$ and characterizes the platform's decisions in the absence of economic security shocks. The original supply chain faces neither additional policy-related costs nor fulfillment-failure risk, while the alternative supplier provides no risk-mitigation benefit. The platform's sourcing structure is therefore

determined by the cost difference between the two suppliers and the supply-chain switching cost. Because S_1 has a cost advantage, M0 establishes an efficiency benchmark based on low-cost global sourcing and provides a reference point for the three shock scenarios that follow.

Proposition 1 (Platform's Optimal Decision in the Baseline Scenario). *In the baseline scenario, $t = 0$ and $q = 0$. Suppose that $a > 0$, $b > 0$, $F > 0$, and $0 < w_1 < w_2 < a/b$. The platform's unique optimal sourcing strategy is global sourcing: $x_{M0}^* = 1$.*

The corresponding optimal decisions and outcomes are

$$p_{M0}^* = \frac{a+bw_1}{2b}, D_{M0}^* = \frac{a-bw_1}{2}, Q_{1,M0}^* = \frac{a-bw_1}{2}, Q_{2,M0}^* = 0, \\ \Pi_{P,M0}^* = \frac{(a-bw_1)^2}{4b}, \Pi_{S_1,M0}^* = (w_1 - c_1) \frac{a-bw_1}{2}, \Pi_{S_2,M0}^* = 0.$$

If $w_1 > c_1$, the original supplier earns a positive profit in the baseline scenario.

Proof. See Supplementary Note S1.1. $\square$

Proposition 1 establishes that global sourcing is the platform's unique optimum in the no-shock benchmark under the stated parameter conditions. With no tariff-equivalent cost or fulfillment loss, the original supplier combines the lower unit-sourcing cost with full fulfillment, so reallocating orders cannot create an offsetting reliability benefit. Any positive alternative sourcing share instead introduces the alternative supplier's cost premium and switching cost, while the platform can still adjust its retail price optimally around the lower-cost sourcing base. The benchmark therefore isolates the efficiency value of the original supply chain before economic-security exposure is introduced. This mechanism provides the reference point from which the trigger, depth, and boundary of later reconfiguration are evaluated.

Corollary 1 (Optimality and Parameter Independence of Global Sourcing in the Baseline Scenario). *In the baseline scenario (M0), global sourcing is the platform's strictly optimal strategy. For every $x \in [0, 1)$, $\hat{\Pi}_P^{M0}(x) < \hat{\Pi}_P^{M0}(1)$.*

Hence, neither partial de-risking nor decoupling from the original supply chain is optimal. The optimal price $p_{M0}^* = \frac{a+bw_1}{2b}$, and optimal profit $\Pi_{P,M0}^* = \frac{(a-bw_1)^2}{4b}$, depend only on market size a , the price-sensitivity parameter b , and the original supplier's wholesale price w_1 . They are independent of the alternative supplier's wholesale price w_2 and the switching-cost intensity F .

Proof. See Supplementary Note S1.2. $\square$

Corollary 1 shows that the baseline optimum is independent of the alternative supplier's wholesale price and the switching-cost intensity. Because the platform assigns no orders to the alternative supplier in M0, neither the alternative unit cost nor the cost of changing the sourcing mix is activated at the optimum. Retail price and platform profit are therefore determined by demand conditions and the original supplier's wholesale price, rather than by parameters attached to an unused sourcing option. This distinction is useful for the later shock scenarios, where the same parameters become economically relevant only after alternative sourcing is positive. The result thus separates parameters that define an available option from parameters that affect an active decision margin.

Corollary 2 (Profit Loss from Alternative Sourcing in the Baseline Scenario). *Suppose that, in the baseline scenario (M0), the platform deviates from global sourcing and assigns a share $r = 1 - x$ of its orders to the alternative supplier. Relative to global sourcing, the platform incurs the profit loss*

$$L_{M0}(r) = \frac{\Delta w r}{2}(a - bw_1) - \frac{b(\Delta w)^2 r^2}{4} + Fr^2, \quad \Delta w = w_2 - w_1 > 0. \quad (3)$$

If $0 < w_1 < w_2 < a/b$ and $F > 0$, then $L_{M0}(r) > 0$ for every $r \in (0, 1]$.

Proof. See Supplementary Note S1.3. $\square$

Corollary 2 demonstrates that any positive shift toward the alternative supplier reduces platform profit in the baseline scenario. The loss has two sources: the platform pays a higher unit-sourcing cost on the reallocated share and also incurs convex supply-chain switching costs as the sourcing mix moves away from the original supplier. Since both suppliers provide full fulfillment in M0, alternative sourcing generates no reliability gain that could compensate for these additional costs. The profit penalty therefore increases as the platform moves further from global sourcing, making partial de-risking and decoupling dominated in the absence of a shock. This one-sided cost structure explains why diversification requires a sufficiently strong cost or fulfillment motive before it becomes optimal.

4.2. Cost-Shock Scenario: Rising Tariff-Equivalent Costs

The cost-shock scenario (M1) sets $t > 0$ and $q = 0$. The tariff-equivalent cost raises the original supplier's effective sourcing cost without affecting its fulfillment capacity. The platform retains global sourcing as long as the original supplier's effective cost does not exceed the alternative supplier's cost. Once the cost ranking reverses, the platform begins to source from the alternative supplier, while the switching-cost intensity determines reconfiguration depth. Research on trade policy uncertainty and tariff expectations provides empirical context for this cost channel by showing that such factors affect firm entry, exit, and supply-chain configuration [12,13,23].

Proposition 2 (Platform's Optimal Decision in the Cost-Shock Scenario). *In the cost-shock scenario (M1), $t > 0$ and $q = 0$. Suppose that $a > 0$, $b > 0$, $F > 0$, $0 < w_1 < w_2 < a/b$, and $0 < w_1 + t < a/b$. Let $W_t = w_1 + t$ denote the original supplier's effective unit-sourcing cost. When $W_t > w_2$, further define $\mu_t = W_t - w_2 > 0$, and $\bar{F}_{M1} = \frac{\mu_t(a-bw_2)}{4}$. The platform's optimal sourcing share is*

$$x_{M1}^* = \begin{cases} 1, & W_t \leq w_2, \\ 0, & W_t > w_2, 0 < F \leq \bar{F}_{M1}, \\ 1 - \frac{\mu_t(a-bW_t)}{4F-b\mu_t^2}, & W_t > w_2, F > \bar{F}_{M1}. \end{cases} \quad (4)$$

If $W_t \leq w_2$, the optimal price, demand, and platform profit are

$$p_{M1}^* = \frac{a + bW_t}{2b}, \quad D_{M1}^* = \frac{a - bW_t}{2}, \quad \Pi_{P,M1}^* = \frac{(a - bW_t)^2}{4b}.$$

If $W_t > w_2$ and $0 < F \leq \bar{F}_{M1}$, the platform decouples from the original supply chain. In this case,

$$p_{M1}^* = \frac{a + bw_2}{2b}, \quad D_{M1}^* = \frac{a - bw_2}{2}, \quad \Pi_{P,M1}^* = \frac{(a - bw_2)^2}{4b} - F.$$

In the partial de-risking region, where $W_t > w_2$ and $F > \bar{F}_{M1}$,

$$\begin{aligned} r_{M1}^* &= 1 - x_{M1}^* = \frac{\mu_t(a-bW_t)}{4F-b\mu_t^2}, \quad C_{M1}^* = W_t - \mu_t r_{M1}^*, \\ p_{M1}^* &= \frac{a+bC_{M1}^*}{2b}, \quad D_{M1}^* = \frac{2F(a-bW_t)}{4F-b\mu_t^2}, \\ \Pi_{P,M1}^* &= \frac{F(a-bW_t)^2}{b(4F-b\mu_t^2)}. \end{aligned}$$

Proof. See Supplementary Note S1.4. $\square$

Proposition 2 establishes a piecewise sourcing response to a tariff-equivalent cost shock. Global sourcing remains optimal while the original supplier preserves its effective cost advantage; once that advantage reverses, alternative sourcing becomes profitable. The platform then balances savings from avoiding the higher effective sourcing cost against convex supply-chain switching costs, creating a partial-de-risking region before decoupling is reached. Retail pricing adjusts simultaneously to the new sourcing-cost structure. In April 2025, SHEIN and Temu announced U.S. price increases as tariff changes and the scheduled removal of de minimis treatment raised operating costs. This real-world response illustrates how a policy-induced cost increase can alter platform pricing and sourcing incentives. The mechanism links the cost shock to an endogenous GS–DR–DC transition [53].

Corollary 3 (Trigger Condition for Sourcing Reconfiguration and the Global-Sourcing Region under the Cost Shock). *In the cost-shock scenario (M1), the cost shock triggers alternative sourcing at $t = w_2 - w_1$. When $w_1 + t \leq w_2$, the platform retains global sourcing, so that $x_{M1}^* = 1$, and*

$$\frac{\partial p_{M1}^*}{\partial t} = \frac{1}{2}, \quad \frac{\partial D_{M1}^*}{\partial t} = -\frac{b}{2}, \quad \frac{\partial \Pi_{P,M1}^*}{\partial t} = -\frac{a-b(w_1+t)}{2} < 0.$$

When $w_1 + t > w_2$, the platform assigns a positive share to the alternative supplier: $1 - x_{M1}^* > 0$.

Under the quadratic switching cost $F(1-x)^2$, the marginal switching cost at the global-sourcing point is zero. Therefore, the original supplier's effective cost exceeding the alternative supplier's cost is both necessary and sufficient for the platform to initiate de-risking.

Proof. See Supplementary Note S1.5. $\square$

Corollary 3 shows that the cost-shock trigger is determined by the point at which the original supplier's effective unit cost exceeds the alternative supplier's cost. Under the quadratic switching-cost specification, the marginal switching cost is zero at the global-sourcing point, so the switching-cost intensity does not shift the initial diversification threshold. It becomes relevant only after the platform has begun reallocating orders. Economically, the platform can therefore start de-risking as soon as the marginal sourcing advantage changes sign, even though moving a large share of orders may still be expensive. This distinction separates the decision to initiate diversification from the decision about how far to diversify. The mechanism is the first element of the paper's trigger–depth–boundary decomposition.

Corollary 4 (Switching-Cost Intensity and Reconfiguration Depth under the Cost Shock). *In the cost-shock scenario (M1), suppose that $w_1 + t > w_2$. The switching-cost intensity F determines the platform's reconfiguration depth.*

If $0 < F \leq \bar{F}_{M1} = \frac{(w_1+t-w_2)(a-bw_2)}{4}$, the platform decouples from the original supply chain. If $F > \bar{F}_{M1}$, the platform adopts partial de-risking, and the optimal alternative sourcing share

$$r_{M1}^* = \frac{(w_1 + t - w_2)[a - b(w_1 + t)]}{4F - b(w_1 + t - w_2)^2}$$

is strictly decreasing in F throughout the partial de-risking region.

Proof. See Supplementary Note S1.6. $\square$

Corollary 4 demonstrates that switching-cost intensity determines reconfiguration depth after the cost trigger has been crossed. Once alternative sourcing has a positive marginal benefit, a higher switching-cost intensity raises the penalty from moving the sourcing share away from the original supplier and therefore reduces the optimal alternative share. Lower switching-cost intensity permits a larger reallocation and can make decoupling optimal when the cost shock is sufficiently strong. SHEIN's 2024 Sustainability and Social Impact Report records 4288 on-site audits of China-based suppliers and sub-contractors, illustrating the kind of supplier-governance infrastructure associated with qualification and monitoring frictions in large supplier networks [54]. The result therefore separates shock intensity from adjustment capability: the shock creates the incentive to move, while switching-cost intensity governs how far the platform moves [54].

4.3. Fulfillment-Shock Scenario: Supply Disruption and Impaired Fulfillment

The fulfillment-shock scenario (M2) sets $t = 0$ and $q \in (0, 1)$. A supply disruption reduces the quantity actually fulfilled by the original supply chain and affects the platform's profit and sourcing structure through realized sales. The alternative supplier has a higher unit cost but provides more reliable fulfillment. The platform determines its sourcing share by comparing the benefit of greater fulfillment reliability with the alternative supplier's cost premium and the supply-chain switching cost. Because disruptions can also propagate through supply-chain networks, related research emphasizes the trade-off between low-cost sourcing and fulfillment reliability [19–21].

Proposition 3 (Platform's Optimal Decision in the Fulfillment-Shock Scenario). *In the fulfillment-shock scenario (M2), $t = 0$ and $q \in (0, 1)$. Suppose that $a > 0$, $b > 0$, $F > 0$, and $0 < w_1 < w_2 < a/b$. Define*

$$\Delta w = w_2 - w_1 > 0, \quad \Lambda_1 = a - bw_1 > 0, \quad \Lambda_2 = a - bw_2 > 0,$$

Let $r = 1 - x \in [0, 1]$ denote the alternative sourcing share. The platform's indirect profit as a function of r is

$$\hat{\Pi}_P^{M2}(r) = \frac{N_q(r)^2}{4bA_q(r)} - Fr^2, \quad (5)$$

$$A_q(r) = 1 - q + qr, \quad N_q(r) = (1 - q)\Lambda_1 + [q\Lambda_1 - b\Delta w]r.$$

Hence, the optimal sourcing decision satisfies

$$r_{M2}^* \in \arg \max_{r \in [0, 1]} \hat{\Pi}_P^{M2}(r), \quad x_{M2}^* = 1 - r_{M2}^*.$$

If the sufficient concavity condition $F \geq F_{M2}^c(q) \equiv \frac{b(\Delta w)^2}{4(1-q)}$ holds, the platform's indirect profit is concave in r .

The marginal fulfillment-loss threshold for initiating de-risking is

$$\underline{q}_{M2} = \frac{2b\Delta w}{\Lambda_1}. \quad (6)$$

When $q > \underline{q}_{M2}$, the decoupling threshold is

$$\bar{F}_{M2}(q) = \frac{\Lambda_2[q\Lambda_1 - b\Delta w(2-q)]}{8b}. \quad (7)$$

Under this concavity framework, the optimal sourcing share is

$$x_{M2}^* = \begin{cases} 1, & q \leq \underline{q}_{M2}, F \geq F_{M2}^c(q), \\ 0, & q > \underline{q}_{M2}, F_{M2}^c(q) \leq F \leq \bar{F}_{M2}(q), \\ 1 - r_{M2}^I, & q > \underline{q}_{M2}, F \geq F_{M2}^c(q), F > \bar{F}_{M2}(q). \end{cases} \quad (8)$$

where the interior alternative sourcing share $r_{M2}^I \in (0, 1)$ is the unique solution on $(0, 1)$ to the first-order condition

$$\frac{N_q(r) \{2[q\Lambda_1 - b\Delta w]A_q(r) - qN_q(r)\}}{4bA_q(r)^2} - 2Fr = 0. \quad (9)$$

The decoupling region is nonempty only if $\bar{F}_{M2}(q) \geq F_{M2}^c(q)$. When $F < F_{M2}^c(q)$, the indirect profit function need not be globally concave. The optimal sourcing share is then determined by comparing profit at all stationary points in the interval and at the boundary points $r = 0$ and $r = 1$.

Given r_{M2}^* , define $A_{M2}^* = A_q(r_{M2}^*)$, and $B_{M2}^* = w_1(1-q)(1-r_{M2}^*) + w_2r_{M2}^*$. The optimal price, potential demand, fulfilled demand, and platform profit are

$$p_{M2}^* = \frac{aA_{M2}^* + bB_{M2}^*}{2bA_{M2}^*}, D_{M2}^* = \frac{aA_{M2}^* - bB_{M2}^*}{2A_{M2}^*}, \\ D_{e,M2}^* = \frac{aA_{M2}^* - bB_{M2}^*}{2}, \Pi_{P,M2}^* = \frac{(aA_{M2}^* - bB_{M2}^*)^2}{4bA_{M2}^*} - F(r_{M2}^*)^2.$$

Proof. See Supplementary Note S1.7. $\square$

Proposition 3 demonstrates that a fulfillment shock can reconfigure sourcing even when the suppliers' nominal unit-cost ranking is unchanged. A higher fulfillment-loss rate reduces the expected quantity successfully delivered through the original supply chain and therefore lowers the revenue generated by orders assigned to that source. The alternative supplier remains more expensive, but its greater reliability becomes increasingly valuable as the fulfillment-loss rate rises. The platform consequently balances the alternative supplier's cost premium against the expected fulfillment gain and switching cost. Under the stated concavity conditions, this trade-off can move the optimum from global sourcing to partial de-risking or decoupling. The mechanism shows how fulfillment loss can overturn an initially cost-efficient sourcing structure.

Corollary 5 (Trigger Condition for Sourcing Reconfiguration and the Global-Sourcing Region under the Fulfillment Shock). *In the fulfillment-shock scenario (M2), under the sufficient concavity condition $F \geq F_{M2}^c(q)$, the fulfillment-loss rate triggers alternative sourcing at*

$$\underline{q}_{M2} = \frac{2b(w_2 - w_1)}{a - bw_1}.$$

When $q \leq \underline{q}_{M2}$, the platform retains global sourcing, so that

$$x_{M2}^* = 1, \text{ and } p_{M2}^* = \frac{a+bw_1}{2b},$$

$$D_{e,M2}^* = (1-q)\frac{a-bw_1}{2}, \Pi_{P,M2}^* = (1-q)\frac{(a-bw_1)^2}{4b}, \text{ and } \frac{\partial \Pi_{P,M2}^*}{\partial q} = -\frac{(a-bw_1)^2}{4b} < 0.$$

When $q > \underline{q}_{M2}$, the platform assigns a positive share to the alternative supplier. The fulfillment-loss rate can trigger de-risking within the feasible interval if and only if $\underline{q}_{M2} < 1$, or equivalently,

$$2b(w_2 - w_1) < a - bw_1.$$

If $\underline{q}_{M2} \geq 1$, no $q \in (0, 1)$ is sufficient to initiate alternative sourcing.

Proof. See Supplementary Note S1.8. $\square$

Corollary 5 establishes a fulfillment-loss threshold below which the platform continues to source globally and above which alternative sourcing becomes optimal. When fulfillment loss is limited, the reliability gain from the alternative supplier is too small to offset its higher sourcing cost, so the original supply chain retains its advantage. As the fulfillment-loss rate rises, the expected value of orders assigned to the original supplier falls until the marginal gain from a more reliable source becomes positive. If the alternative supplier's cost premium is sufficiently large, however, the required fulfillment-loss rate may lie outside the feasible interval. This mechanism links reconfiguration to the economic severity, rather than merely the occurrence, of disruption.

Corollary 6 (Switching-Cost Intensity and Reconfiguration Depth under the Fulfillment Shock). *In the fulfillment-shock scenario (M2), suppose that the platform adopts partial de-risking, so that $0 < r_{M2}^* < 1$, and that the objective function is strictly concave at the interior optimum. Then the optimal alternative sourcing share is strictly decreasing in the switching-cost intensity:*

$$\frac{\partial r_{M2}^*}{\partial F} < 0.$$

Proof. See Supplementary Note S1.9. $\square$

Corollary 6 shows that, conditional on partial de-risking, the optimal alternative sourcing share decreases as switching-cost intensity rises. The reliability motive created by the fulfillment shock remains present, but a larger reconfiguration penalty makes each additional shift of orders more expensive and therefore preserves a greater share with the original supplier. Conversely, lower switching-cost intensity allows the platform to translate the reliability advantage of the alternative supplier into a deeper reconfiguration. For a platform that must qualify suppliers, redesign contracts, and adapt fulfillment interfaces, such switching costs can remain material even when fulfillment loss is substantial. The mechanism separates the strength of the reliability motive from the platform's capacity to act on it.

4.4. Compound-Shock Scenario: Rising Costs and Impaired Fulfillment

The compound-shock scenario (M3) sets $t > 0$ and $q \in (0, 1)$, incorporating both an increase in the original supply chain's effective cost and a decline in realized fulfillment through the original supply chain. The tariff-equivalent cost changes the relative cost of the two suppliers, while fulfillment loss reduces the expected fulfillment generated by the original supply chain. The alternative supplier provides reliable fulfillment at a higher baseline sourcing cost. The platform allocates its sourcing share by balancing tariff-equivalent cost, fulfillment loss, the alternative supplier's cost premium, and switching costs. When $q = 0$, M3 reduces to the cost-shock scenario M1. When $t = 0$, M3 reduces to the fulfillment-shock scenario M2. This setting reflects operating environments in which policy-related costs, customs uncertainty, transportation delays, and fulfillment risk occur jointly [34,35,45].

Proposition 4 (Platform's Optimal Decision in the Compound-Shock Scenario). *In the compound-shock scenario (M3), $t > 0$ and $q \in (0, 1)$. Suppose that $a > 0$, $b > 0$, $F > 0$, $0 < w_1 < w_2 < a/b$, and $0 < w_1 + t < a/b$. Define*

$$W_t = w_1 + t, \quad \Lambda_t = a - bW_t > 0, \quad \Lambda_2 = a - bw_2 > 0,$$

Let $r = 1 - x \in [0, 1]$. The platform's indirect profit as a function of the alternative sourcing share is

$$\hat{\Pi}_P^{M3}(r) = \frac{N_{tq}(r)^2}{4bA_q(r)} - Fr^2, \quad (10)$$

$$A_q(r) = 1 - q + qr, \quad N_{tq}(r) = (1 - q)\Lambda_t + \Gamma_{tq}r, \quad \Gamma_{tq} = q\Lambda_t + b(W_t - w_2).$$

Hence, the optimal sourcing decision satisfies

$$r_{M3}^* \in \arg \max_{r \in [0, 1]} \hat{\Pi}_P^{M3}(r), \quad x_{M3}^* = 1 - r_{M3}^*.$$

If the sufficient concavity condition $F \geq F_{M3}^c(t, q) \equiv \frac{b(W_t - w_2)^2}{4(1 - q)}$ holds, the platform's indirect profit is concave in r .

The marginal gain from de-risking under the compound shock is

$$\eta_{tq} = q\Lambda_t + 2b(W_t - w_2). \quad (11)$$

When $\eta_{tq} > 0$, the decoupling threshold is

$$\bar{F}_{M3}(t, q) = \frac{\Lambda_2[2\Gamma_{tq} - q\Lambda_2]}{8b}. \quad (12)$$

Under this concavity framework, the optimal sourcing share is

$$x_{M3}^* = \begin{cases} 1, & \eta_{tq} \leq 0, F \geq F_{M3}^c(t, q), \\ 0, & \eta_{tq} > 0, F_{M3}^c(t, q) \leq F \leq \bar{F}_{M3}(t, q), \\ 1 - r_{M3}^I, & \eta_{tq} > 0, F \geq F_{M3}^c(t, q), F > \bar{F}_{M3}(t, q). \end{cases} \quad (13)$$

where the interior alternative sourcing share $r_{M3}^I \in (0, 1)$ is the unique solution on $(0, 1)$ to the first-order condition

$$\frac{N_{tq}(r)[2\Gamma_{tq}A_q(r) - qN_{tq}(r)]}{4bA_q(r)^2} - 2Fr = 0. \quad (14)$$

The decoupling region is nonempty only if $\bar{F}_{M3}(t, q) \geq F_{M3}^c(t, q)$. Otherwise, when $\eta_{tq} > 0$ and $F \geq F_{M3}^c(t, q)$, the platform adopts partial de-risking. When $F < F_{M3}^c(t, q)$, the indirect profit function need not be globally concave. The optimal sourcing share is then determined by comparing profit at all stationary points in the interval and at the boundary points $r = 0$ and $r = 1$.

Given r_{M3}^* , define $A_{M3}^* = A_q(r_{M3}^*)$, and $B_{M3}^* = W_t(1 - q)(1 - r_{M3}^*) + w_2 r_{M3}^*$. The platform's optimal price, potential demand, fulfilled demand, and optimal profit are

$$p_{M3}^* = \frac{aA_{M3}^* + bB_{M3}^*}{2bA_{M3}^*}, D_{M3}^* = \frac{aA_{M3}^* - bB_{M3}^*}{2A_{M3}^*},$$

$$D_{e,M3}^* = \frac{aA_{M3}^* - bB_{M3}^*}{2}, \Pi_{P,M3}^* = \frac{(aA_{M3}^* - bB_{M3}^*)^2}{4bA_{M3}^*} - F(r_{M3}^*)^2.$$

Proof. See Supplementary Note S1.10. $\square$

Proposition 4 demonstrates how tariff-equivalent cost and fulfillment loss jointly shape the platform's sourcing choice under a compound shock. The cost channel erodes the original supplier's unit-cost advantage, while the fulfillment channel reduces the expected return from orders that remain with that supplier. Because both changes increase the marginal value of alternative sourcing, moderate shocks on both margins can induce reconfiguration even when either margin alone would be insufficient. In early 2025, Reuters reported that Temu had expanded its semi-managed model, increased the use of U.S. warehouse inventory, and moved more goods by ocean freight as scrutiny of de minimis shipments intensified. This operational adjustment illustrates how platforms can modify fulfillment architecture when policy costs and delivery considerations change together. The interaction creates the strongest endogenous pressure toward de-risking [55].

Corollary 7 (Trigger Condition for Sourcing Reconfiguration and the Global-Sourcing Region under the Compound Shock). *In the compound-shock scenario (M3), under the sufficient concavity condition $F \geq F_{M3}^c(t, q)$, define*

$$\eta_{tq} = q(a - bW_t) + 2b(W_t - w_2), \quad W_t = w_1 + t.$$

When $\eta_{tq} \leq 0$, the platform retains global sourcing, so that $x_{M3}^* = 1$, and

$$p_{M3}^* = \frac{a + bW_t}{2b}, \quad D_{M3}^* = \frac{a - bW_t}{2}, \quad D_{e,M3}^* = (1 - q) \frac{a - bW_t}{2}.$$

$$\Pi_{P,M3}^* = (1 - q) \frac{(a - bW_t)^2}{4b}, \quad \frac{\partial p_{M3}^*}{\partial t} = \frac{1}{2}, \quad \frac{\partial \Pi_{P,M3}^*}{\partial q} = - \frac{(a - bW_t)^2}{4b} < 0.$$

$$\frac{\partial \Pi_{P,M3}^*}{\partial t} = - \frac{(1 - q)(a - bW_t)}{2} < 0.$$

When $\eta_{tq} > 0$, the platform assigns a positive share to the alternative supplier. If $W_t \geq w_2$, this condition necessarily holds. If $W_t < w_2$, it is equivalent to $q > \frac{2b(w_2 - W_t)}{a - bW_t}$.

Proof. See Supplementary Note S1.11. $\square$

Corollary 7 shows that the compound-shock trigger depends jointly on tariff-equivalent cost and fulfillment loss. When the effective sourcing cost of the original supplier has already lost its advantage, alternative sourcing has a positive marginal incentive even without a further increase in the fulfillment-loss rate. When the original supplier still retains a cost advantage, a sufficiently high fulfillment-loss rate can nevertheless make

diversification optimal, and the required fulfillment-loss rate falls as the tariff-equivalent cost rises. The threshold is therefore a combination boundary rather than a single-shock cutoff. Each shock channel changes a different component of expected profit, but both raise the marginal value of alternative sourcing. This mechanism captures how multiple moderate pressures can jointly move the platform across the GS–DR trigger.

Corollary 8 (Switching-Cost Intensity and Reconfiguration Depth under the Compound Shock). *In the compound-shock scenario (M3), suppose that the platform adopts partial de-risking, so that $0 < r_{M3}^* < 1$, and that the objective function is strictly concave at the interior optimum. Then $\frac{\partial r_{M3}^*}{\partial F} < 0$. A higher switching-cost intensity therefore increases the share retained with the original supplier. Conversely, a lower switching-cost intensity increases the alternative sourcing share and, when sufficiently low, can make decoupling optimal.*

Proof. See Supplementary Note S1.12. $\square$

Corollary 8 establishes that switching-cost intensity governs reconfiguration depth after a compound shock has triggered de-risking. A higher switching-cost intensity makes large reallocations increasingly expensive, so the platform retains more orders with the original supplier even when both the cost and fulfillment shocks favor diversification. Lower switching-cost intensity allows the joint shock to translate into a larger alternative sourcing share and can make decoupling optimal when the shock is sufficiently strong. Platforms facing comparable exposure can therefore choose different sourcing structures if their reconfiguration capabilities differ. The result separates external pressure from internal adjustment capacity and explains why stronger exposure does not automatically imply decoupling. This mechanism connects shock intensity with the friction shaping the final sourcing position.

5. Scenario Comparison and De-Risking Mechanisms

5.1. Comparison of Optimal Decisions Across the Four Scenarios

Having derived the four scenarios separately, we now compare their trigger conditions, sourcing responses, and strategy boundaries. Table 6 summarizes the resulting mechanism map.

Table 6. Shock mechanisms, trigger conditions, and sourcing structures across the four scenarios.

Scenario	Shock Type	Key Condition or Indicator	Implication for the Sourcing Structure
Baseline scenario (M0)	No cost shock and no fulfillment shock	$t = 0, q = 0$	The platform adopts global sourcing, $x_{M0}^* = 1$. In the absence of external shocks, the low-cost original supply chain provides a cost-efficiency advantage.
Cost-shock scenario (M1)	Cost-shock only	$W_t = w_1 + t$; the cost ranking reverses when $W_t > w_2$	The platform retains global sourcing when $W_t \leq w_2$. When $W_t > w_2$, it has an incentive to introduce alternative sourcing.
Fulfillment-shock scenario (M2)	Fulfillment-shock only	$\underline{q}_{M2} = \frac{2b(w_2 - w_1)}{a - bw_1}$	Under the relevant concavity condition, the platform retains global sourcing when $q \leq \underline{q}_{M2}$ and begins to source from the alternative supplier when $q > \underline{q}_{M2}$.

Table 6. Cont.

Scenario	Shock Type	Key Condition or Indicator	Implication for the Sourcing Structure
Compound-shock scenario (M3)	Cost shock and fulfillment shock	$\eta_{tq} = q(a - bW_t) + 2b(W_t - w_2)$	Under the relevant concavity condition, the platform retains global sourcing when $\eta_{tq} \leq 0$ and has an incentive to de-risk when $\eta_{tq} > 0$.

Across all four scenarios, global sourcing is the common starting point. It is optimal in M0 and remains optimal in M1–M3 until the relevant cost, fulfillment, or compound-shock trigger is crossed. Before that point, the original supply chain's cost advantage offsets both its expected fulfillment loss and the incremental unit and switching costs of alternative sourcing. Crossing the trigger activates partial de-risking; DC emerges only under sufficiently strong shocks and sufficiently low switching-cost intensity.

5.2. Distinct Reconfiguration Channels Under Individual Shocks

Corollary 9 (Distinct Sourcing-Reconfiguration Channels under Individual Shocks). Under the relevant feasibility and concavity conditions, the cost-shock scenario (M1) generates a positive alternative sourcing share if $W_t = w_1 + t > w_2$, whereas the fulfillment-shock scenario (M2) generates a positive alternative sourcing share if $q > \underline{q}_{M2} = \frac{2b(w_2 - w_1)}{a - bw_1}$. The cost shock triggers de-risking by changing the ranking of the suppliers' effective unit-sourcing costs. The fulfillment shock triggers de-risking by reducing the expected fulfillment return generated by the original supply chain. Both shocks can move the platform away from global sourcing and toward alternative sourcing, but they operate through different state variables and threshold conditions.

Proof. See Supplementary Note S1.13. $\square$

Corollary 9 demonstrates that cost and fulfillment shocks induce de-risking through distinct marginal-profit channels even though both can produce a positive alternative sourcing share. The cost shock works by changing the relative effective unit costs of the two suppliers, so diversification begins when the original supplier loses its cost advantage. The fulfillment shock instead reduces the expected realized sales generated by orders allocated to the original supplier, making the alternative supplier valuable because of reliability rather than lower cost. Distinguishing these channels matters because the same observed sourcing shift can arise from different underlying exposures and threshold conditions. The mechanism prevents cost escalation and fulfillment deterioration from being treated as interchangeable shocks and clarifies the source of platform reconfiguration.

5.3. Threshold-Reducing Effect of Compound Shocks

Corollary 10 (Threshold-Reducing Effect of Compound Shocks). Suppose that $0 < t < w_2 - w_1$, so that $W_t = w_1 + t < w_2$, and that the concavity condition for the compound-shock scenario (M3) holds. Define the fulfillment-loss threshold that triggers de-risking in M3 as $\underline{q}_{M3}(t) = \frac{2b(w_2 - W_t)}{a - bW_t}$. Then $\underline{q}_{M3}(0) = \underline{q}_{M2}$, and

$$\frac{\partial \underline{q}_{M3}(t)}{\partial t} = \frac{2b(bw_2 - a)}{[a - b(w_1 + t)]^2} < 0. \quad (15)$$

Therefore, for every $t \in (0, w_2 - w_1)$, we have $\underline{q}_{M3}(t) < \underline{q}_{M2}$.

When $W_t \geq w_2$, the reversal of the cost ranking already gives the platform a positive marginal incentive to source from the alternative supplier. Hence, an increase in tariff-equivalent costs lowers the fulfillment-loss rate required to trigger de-risking.

Proof. See Supplementary Note S1.14. $\square$

Corollary 10 shows that tariff-equivalent cost and fulfillment loss reinforce each other at the diversification threshold. As the tariff-equivalent cost on the original supplier rises, a smaller fulfillment loss is needed to make the marginal return to alternative sourcing positive. The platform therefore becomes more sensitive to increases in the fulfillment-loss rate when its existing sourcing relationship has already lost part of its cost advantage. Conversely, when tariff-equivalent cost is low, a higher fulfillment-loss rate is required before the reliability benefit justifies diversification. Moderate shocks that appear insufficient in isolation may therefore become decisive when they occur together. This mechanism captures complementarity at the trigger stage without requiring the two shocks to operate through the same profit component.

5.4. Switching-Cost Intensity and the Boundary Between De-Risking and Decoupling

Corollary 11 (Switching-Cost Intensity and the Decoupling Boundary across Shock Scenarios). *Suppose that the relevant concavity conditions hold and that the platform has an incentive to de-risk. In the cost-shock scenario (M1), the platform decouples from the original supply chain when $0 < F \leq \bar{F}_{M1}$, and adopts partial de-risking when $F > \bar{F}_{M1}$. In the fulfillment-shock scenario (M2) and the compound-shock scenario (M3), decoupling from the original supply chain requires, respectively, $F_{M2}^c(q) \leq F \leq \bar{F}_{M2}(q)$ and $F_{M3}^c(t, q) \leq F \leq \bar{F}_{M3}(t, q)$, provided that the corresponding intervals are nonempty. Within the interior optimal region of each shock scenario, the optimal alternative sourcing share decreases as F increases. Higher switching-cost intensity makes partial de-risking more likely, whereas sufficiently low switching-cost intensity combined with sufficiently strong shocks makes decoupling from the original supply chain more likely.*

Proof. See Supplementary Note S1.15. $\square$

Corollary 11 establishes switching-cost intensity as the common determinant of the boundary between partial de-risking and decoupling across the shock scenarios. The trigger for leaving global sourcing differs because the cost and fulfillment shocks enter expected profit through different channels, but once diversification is active, a higher switching-cost intensity consistently discourages large reallocations. Partial de-risking therefore occupies a wider region when reconfiguration is costly, whereas sufficiently strong shocks combined with low switching-cost intensity can push the optimum to decoupling. Exposure alone does not determine whether a platform decouples from its original supply chain. This common boundary mechanism completes the trigger–depth–boundary decomposition by separating the incentive to diversify from the switching costs that limit the final sourcing position.

6. Numerical Analysis

The numerical analysis translates the analytical thresholds into case-informed magnitudes and evaluates their stability across alternative assumptions. The baseline parameterization is anchored to SHEIN's low-value U.S. direct-shipping apparel setting. The main interpretation focuses on tariff-equivalent costs $t \in [0, 12]$ and fulfillment-loss rate $q \in [0, 0.35]$, while the extended $q \leq 0.80$ domain is used as a theoretical stress test in the Supplementary Materials.

6.1. Case Background and Real-World Shocks

The case is informative because SHEIN's low-price, rapid-renewal model links digital demand to a flexible supplier network and international fulfillment, while its China-centered production base resembles the model's low-cost, externally exposed original supply chain [52,56–59]. Public retail-price information, official customs and policy documents, and published secondary sources provide the empirical anchors. Supplier-level quantities that are not directly observed enter as calibrated structural parameters; Table 7 records the source, conversion rule, and observability status of each input.

Table 7. Real-world basis and conversion logic for the parameterization.

Parameter	Data Source or Real-World Basis	Conversion Logic	Input Status
p_0	Public SHEIN U.S. dress-price evidence	USD 28.51 after a 28% increase implies a pre-increase retail-price anchor of approximately USD 22.27.	Public retail anchor
a, b	Observed low-value apparel price range	Calibrates the demand scale and reservation price ceiling.	Model calibration
w_1	No-shock optimal-pricing relationship	Calibrates the original supplier's wholesale price to reproduce the retail-price anchor.	Model calibration
w_2	Regionalized or localized sourcing alternatives	Assigns a unit-cost premium to the alternative supplier.	Scenario/structural calibration
t	U.S. de minimis and tariff-policy changes	Maps tariffs, customs declarations, and compliance burdens into the per-unit tariff-equivalent cost.	Policy-linked scenario parameter
q	U.S. Section 321 and low-value parcel enforcement	Maps inspection, clearance, delivery delays, and logistics uncertainty into the expected fulfillment-loss rate q .	Policy/logistics-linked scenario parameter
F	Supplier qualification and fulfillment reconfiguration	Represents nonlinear supply-chain switching costs through the switching-cost intensity.	Reduced-form structural parameter

Low-value parcel rules provide the principal policy setting for mapping real-world exposure into the model. Their landed-cost consequences enter through the tariff-equivalent cost t , while inspections, clearance delays, and related fulfillment frictions enter through q as expected order-level fulfillment loss. This mapping links the case background directly to the two shock channels analyzed in Sections 4 and 5.

6.2. Parameterization, Real-World Anchoring, and Data Conversion

The parameterization combines direct observations, documented conversions, and calibrated structural inputs. Table 7 maps each parameter to its empirical basis and classifies the input as observed, converted, calibrated, or scenario-based. The main results use $q \in [0, 0.35]$ as the case-informed domain; values $0.35 < q \leq 0.80$ form the extended theoretical stress test reported in the Supplementary Materials.

Using this mapping, Table 8 reports the baseline parameter values. The calibration satisfies the positive-demand and feasibility conditions and reproduces the no-shock price scale. Robustness exercises retain the baseline calibration and vary prespecified structural parameters one at a time unless the exercise defines an alternative supply-chain archetype.

Table 9 then defines the robustness design and parameter ranges. Every specification is solved using the same global candidate-comparison rule as the baseline model, allowing changes in strategy classification to be attributed to the parameter or structural assumption being varied.

Table 8. Baseline parameters for the SHEIN U.S. market case.

Parameter	Meaning	Value	Basis
a	Potential market size	160	Together with $b = 4$, determines $a/b = 40$.
b	Consumer price-sensitivity parameter	4	Reflects the relatively strong price sensitivity of consumers purchasing low-priced apparel.
a/b	Reservation price ceiling	40	Represents the upper bound of the price range for a low-value apparel order.
w_1	Wholesale price of the original supplier	4.5	Set using the public price anchor and the baseline optimal-pricing relationship.
w_2	Wholesale price of the alternative supplier	9.5	Reflects the cost premium associated with overseas warehousing, localization, or third-country sourcing.
Δw	Cost disadvantage of the alternative supplier	5	$\Delta w = w_2 - w_1$.
c_1	Unit production cost of the original supplier	3.0	Satisfies $c_1 < w_1$, ensuring the original supplier's participation constraint.
c_2	Unit production cost of the alternative supplier	6.5	Satisfies $c_2 < w_2$, ensuring the alternative supplier's participation constraint.
F	Switching-cost intensity	300	Represents supplier certification, overseas-warehouse development, and system adaptation.
t	Per-unit tariff-equivalent cost	$[0, 12]$	Represents per-unit cost burdens arising from tariffs, customs declarations, and compliance requirements.
q	Fulfillment-loss rate in the original supply chain	$[0, 0.35]$	Expected order-level nonfulfillment arising from clearance, inspection, logistics-time variability, and related direct-shipping frictions.

Table 9. Expanded parameter-robustness design.

Robustness Dimension	Test Levels/Specification	Purpose
Switching-cost intensity F	150, 300, 450	Assess GS–DR and DR–DC boundary sensitivity to switching-cost intensity.
Alternative-supplier cost premium Δw	3.75, 5.00, 6.25	Assess how relative sourcing costs affect the reconfiguration trigger and depth.
Demand scale a	144, 160, 176	Assess sensitivity to market size.
Price sensitivity b	3.6, 4.0, 4.4	Assess sensitivity to consumer price response.
Demand specification	Linear vs. isoelastic (matched at the no-shock operating point)	Assess whether demand curvature changes strategy classification.
Sourcing granularity	Continuous; 5% and 10% increments	Assess robustness to minimum-order/discrete allocation.
Alternative-supplier capacity	$\bar{r} = 0.50, 0.75, 1.00$	Assess whether capacity limits reconfiguration depth.
Initial switching-cost wedge κ	0, 30, 60	Assess linear–quadratic switching-cost robustness.
Alternative-supplier relative risk	$q_2/q_1 = 0, 0.25, 0.50$	Assess robustness when the alternative supplier is relatively, not perfectly, reliable.
Failed-order sunk-cost fraction φ	0, 0.25, 0.50, 0.75, 1.00	Assess whether sourcing triggers and reconfiguration depth depend on the benchmark assumption that failed orders generate no sourcing expenditure.

6.3. Numerical Solution and Reproducibility

The numerical analysis uses a deterministic global candidate-comparison protocol. For the linear-demand model, the conditional optimal retail price is substituted into the indirect profit function, the derivative numerator is expressed as a polynomial, and every real stationary sourcing candidate in the feasible interval is enumerated. Profit at these candidates is then compared with both sourcing boundaries, providing a common solution rule for the baseline model and the robustness exercises.

The numerical analysis was implemented in Python 3.13.5. The case-informed strategy maps evaluate 121 tariff-cost points over $t \in [0, 12]$ and 71 fulfillment-loss points over $q \in [0, 0.35]$, yielding 8591 parameter combinations. The extended theoretical stress test expands the fulfillment-loss range to $q = 0.80$. Candidate enumeration requires no random initialization, and the robustness analyses follow the same deterministic solution principle. Further details on the numerical implementation and reproducibility are provided in Supplementary Note S3.

6.4. Numerical Results and Discussion

6.4.1. Baseline Scenario and Representative Decisions

Table 10 summarizes the baseline decision pattern. GS is optimal under zero or weak shocks. Crossing either the cost or fulfillment trigger activates alternative sourcing, and compound exposure can induce DR while the original supplier still retains a unit-cost advantage. The benchmark thus separates the decision to begin diversification from the depth of the sourcing adjustment that follows.

Table 10. Representative optimal decisions under the baseline parameterization.

Scenario	t	q	r^*	x^*	p^*	D_e^*	Π_p^*
No external shock	0	0	0.000	1.000	22.25	71.00	1260.25
Low tariff shock	3	0	0.000	1.000	23.75	65.00	1056.25
Higher tariff shock	6	0	0.099	0.901	25.20	59.20	873.16
High tariff shock	8	0	0.284	0.716	25.82	56.70	779.64
Low fulfillment shock	0	0.15	0.000	1.000	22.25	60.35	1071.21
Higher fulfillment shock	0	0.35	0.162	0.838	22.82	48.55	826.16
Compound shock 1	4	0.25	0.310	0.690	24.44	51.51	772.84
Compound shock 2	8	0.30	0.673	0.327	25.13	53.64	661.75

Note: r is the alternative sourcing share, and fulfilled demand accounts for the expected fulfillment loss in the original supply chain.

6.4.2. Cost-Shock and Fulfillment-Shock Effects

Figure 2 traces the sourcing response to the cost shock. The cost-reversal threshold is $t^c = w_2 - w_1 = 5$. Below this value, the original supply chain retains its effective cost advantage and GS remains optimal. Once t exceeds the threshold, the alternative sourcing share rises gradually because switching cost makes deeper substitution increasingly costly.

Figure 3 traces the response to the fulfillment-loss rate over the case-informed domain. At $t = 0$, the GS–DR trigger is $q^c \approx 0.282$. Below this value, the platform retains GS as expected fulfillment declines; above it, the reliability gain from the alternative supplier supports a positive alternative sourcing share. The figure therefore illustrates a mechanism distinct from the cost channel: q changes expected fulfilled sales, whereas t changes the original supplier's effective unit-sourcing cost.

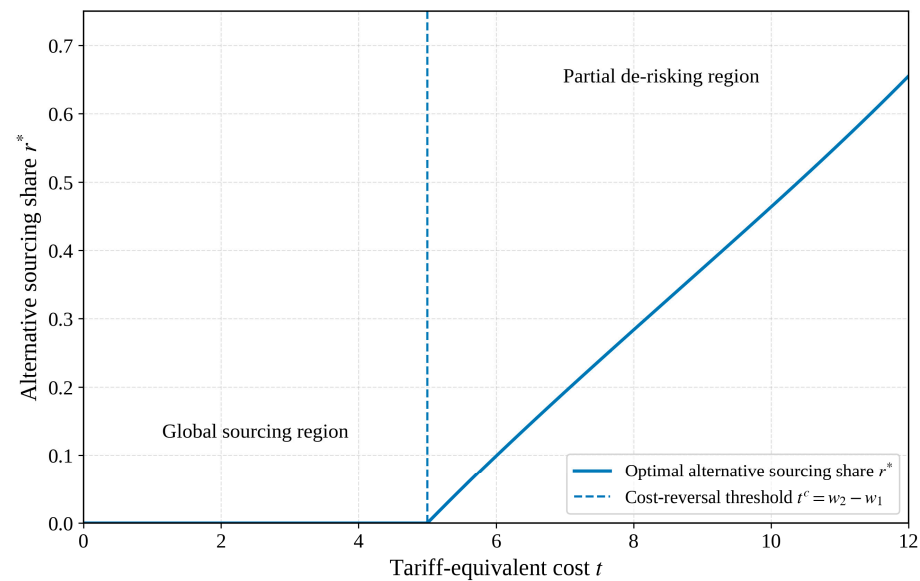


Figure 2. Alternative Sourcing under Tariff-Equivalent Cost Shocks.

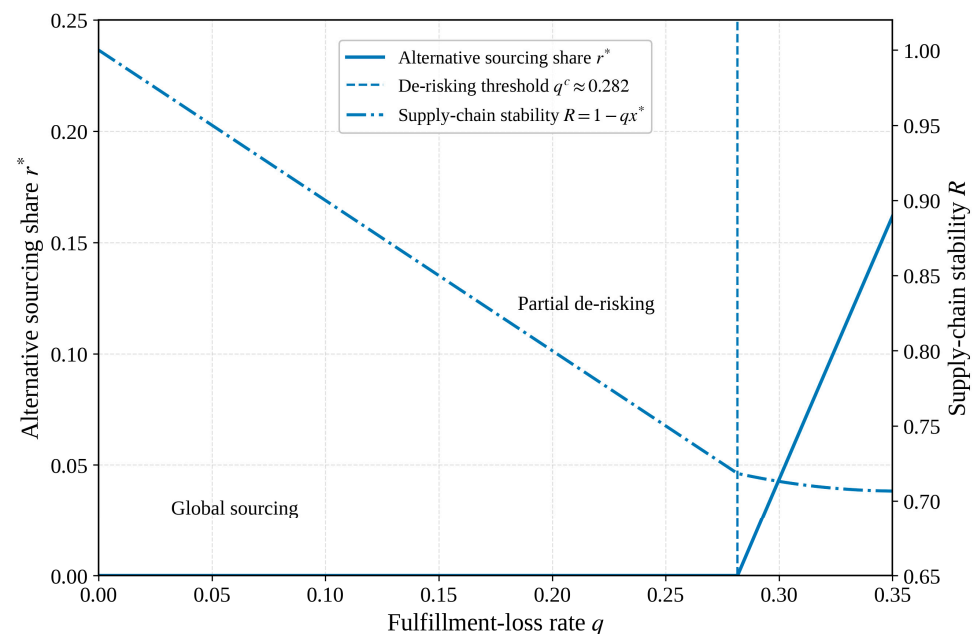


Figure 3. Alternative sourcing and supply-chain stability under fulfillment shocks.

6.4.3. Compound Shocks and Strategy Regions

Figure 4 combines the two channels and maps the resulting strategy regions over the case-informed domain. The black dashed curve is the exact analytical GS–DR boundary, and the inset enlarges the small DC region in the upper-right corner. Of the 8591 evaluated shock combinations, 17.87% remain in GS, 82.11% fall in DR, and 0.023% fall in DC. The predominance of DR reflects the joint effect of the alternative-supplier cost premium and convex supply-chain switching costs: diversification becomes profitable well before decoupling does.

Figure 5 complements the discrete strategy map by showing the optimal alternative sourcing share over the same domain. The black dashed curve reproduces the analytical GS–DR trigger, while the $r^* = 0.25, 0.50$, and 0.75 contours mark progressively deeper reconfiguration. Both tariff-equivalent cost and fulfillment loss increase alternative sourcing. The contour geometry further reveals partial substitution between the two shock channels:

a larger cost shock reduces the fulfillment loss required to reach a given sourcing depth, and vice versa.

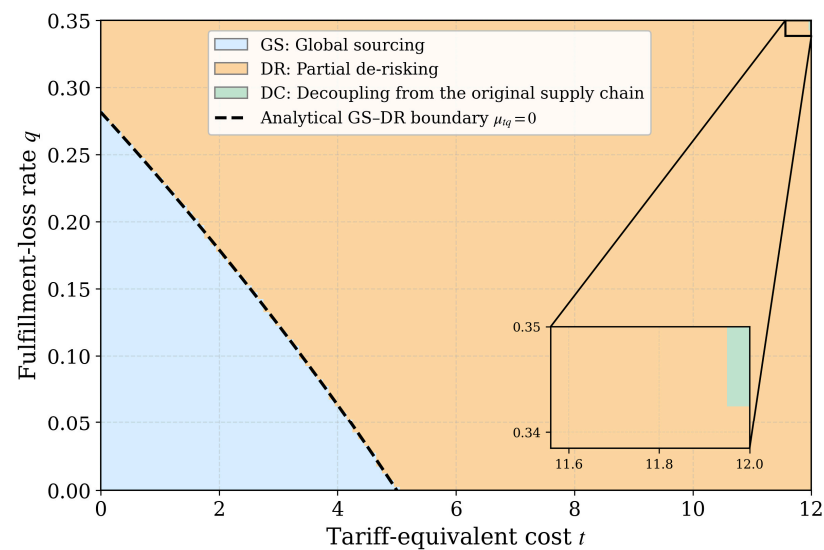


Figure 4. Supply-chain strategy regions under compound shocks.

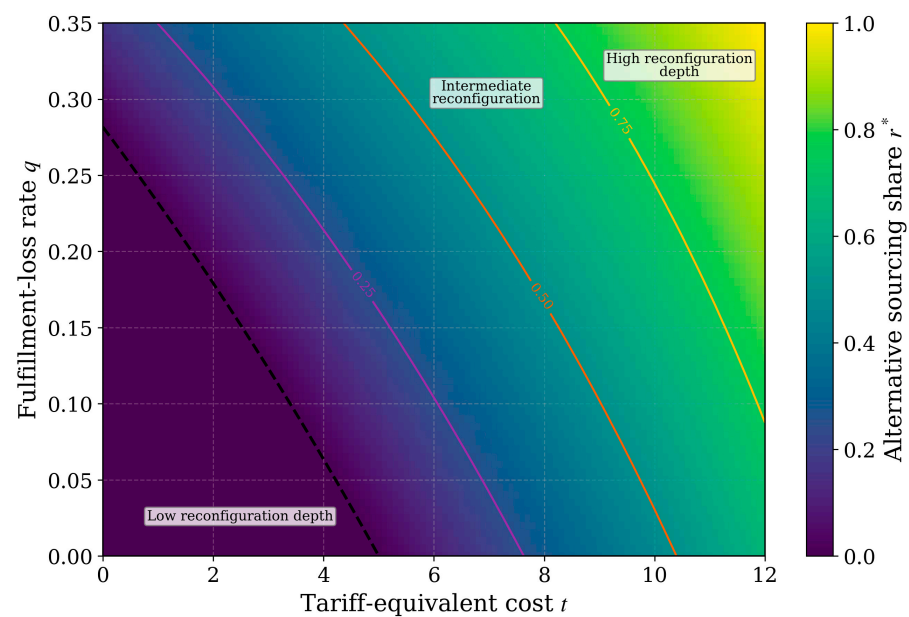


Figure 5. Reconfiguration depth under compound shocks.

6.4.4. Switching-Cost Intensity and Reconfiguration Boundaries

Figure 6 isolates the role of switching-cost intensity by comparing low, baseline, and high values of F . Panels (a)–(c) correspond to $F = 150, 300$, and 450 . Under $C(r) = Fr^2$, the black dashed GS–DR boundary is identical across panels because $C'(0) = 0$. The GS share therefore remains 17.87%, whereas the DC share falls from 37.42% at $F = 150$ to 0.023% at $F = 300$ and 0% at $F = 450$. The comparison confirms the analytical distinction between trigger and depth: under the quadratic specification, switching-cost intensity shifts the DR–DC boundary without changing the local GS–DR trigger.

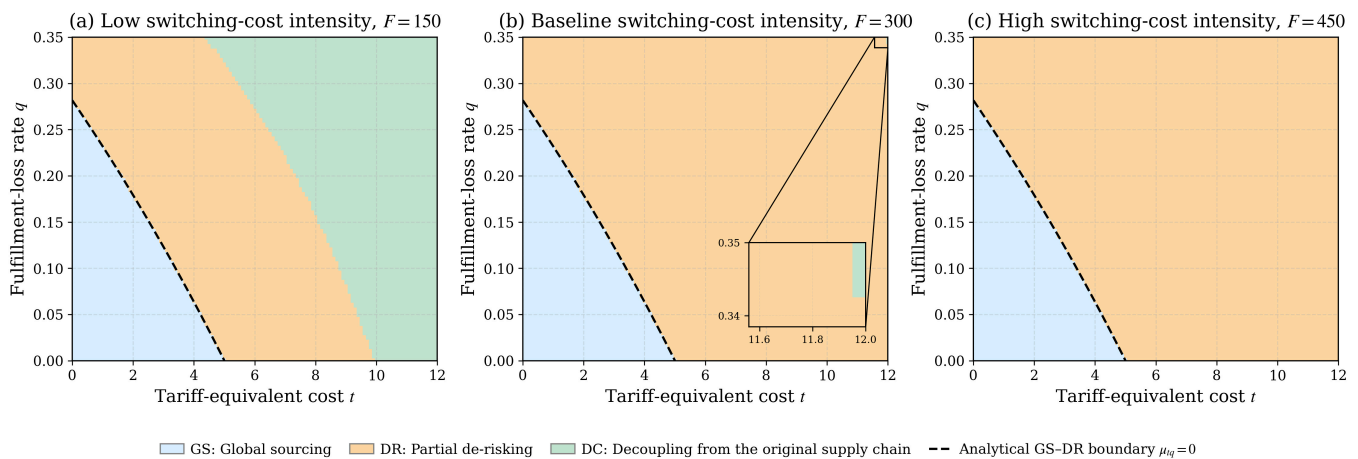


Figure 6. Strategy regions under different switching-cost intensities.

6.4.5. Demand and Sourcing-Decision Robustness

Demand-specification robustness evaluates whether the sourcing mechanism depends on the linear benchmark. Replacing linear demand with an isoelastic specification calibrated to the same no-shock price, demand level, and local price elasticity produces the same strategy classification for approximately 95.15% of case-informed shock combinations. Figure 7 maps the absolute difference in optimal alternative sourcing shares. The largest quantitative differences are concentrated at high tariff-equivalent costs and high fulfillment losses, while the cost-only trigger $t = 5$ and fulfillment-only trigger $q \approx 0.282$ remain unchanged. The trigger mechanism is therefore stable across the two demand specifications, although local reconfiguration depth varies.

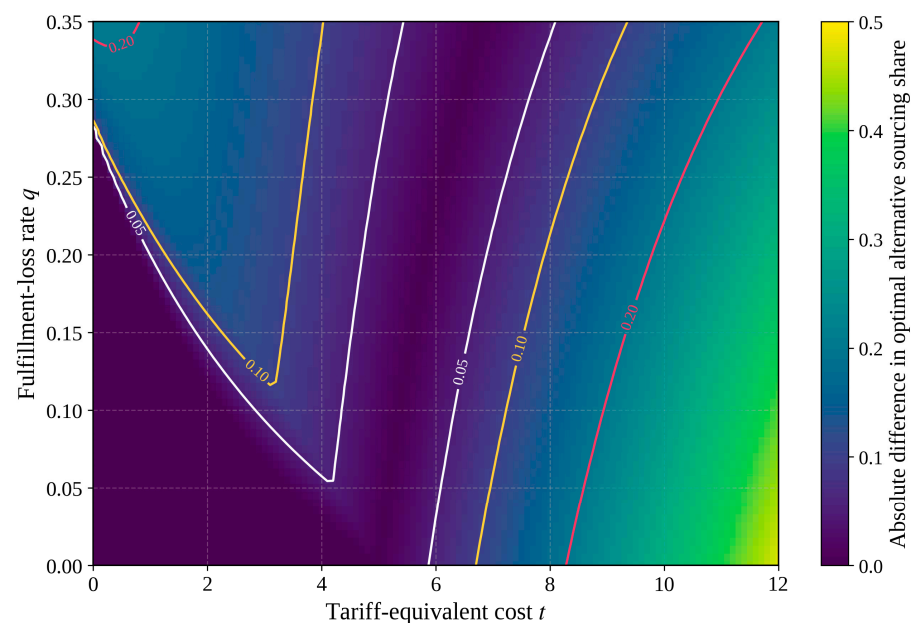


Figure 7. Robustness of alternative sourcing under linear and isoelastic demand.

A second set of checks evaluates the continuous-share and capacity assumptions. Restricting alternative sourcing to 5% increments yields 98.20% agreement in strategy classification and a mean absolute change in r of 0.0103; 10% increments yield 96.02% agreement and a mean absolute change of 0.0206. Capacity constraints act on reconfiguration depth: capping alternative-supplier capacity at 50% or 75% of planned orders leaves the GS trigger unchanged but binds the feasible sourcing share in stronger-shock regions. The

trigger mechanism therefore remains stable under operational granularity, while capacity determines how far the platform can reconfigure after diversification begins.

A third check relaxes the failed-order cost assumption. Let $\varphi \in [0, 1]$ denote the fraction of the original-source effective sourcing expenditure that remains sunk when an assigned order fails to be fulfilled; $\varphi = 0$ nests the benchmark, while $\varphi = 1$ treats the full effective sourcing expenditure as sunk. Re-solving the 8591 case-informed shock combinations shows a monotone response. The fulfillment-only GS–DR threshold falls from 28.17% at $\varphi = 0$ to 26.21%, 24.55%, 23.11%, and 21.85% for $\varphi = 0.25, 0.50, 0.75$, and 1.00, respectively, while the cost-only trigger remains $t = 5$ because $q = 0$ makes failed-order cost incidence irrelevant. Across the same grid, the GS share declines from 17.87% to 12.91% and the DC share rises from 0.023% to 16.60% as φ increases from 0 to 1. The three-region sourcing structure remains intact: higher unrecoverable failed-order costs shift the fulfillment threshold toward earlier diversification and increase reconfiguration depth without eliminating the distinct GS, DR, and DC regions.

6.4.6. Comparative Supply-Chain Structures and Strategy Performance

A final set of comparative scenarios varies the underlying sourcing economics across three stylized supply-chain archetypes. A flexible diversified structure combines a smaller alternative-supplier cost premium ($\Delta w = 3.75$) with lower switching-cost intensity ($F = 150$); the SHEIN baseline uses $\Delta w = 5$ and $F = 300$; and a concentrated high-switching-cost structure uses $\Delta w = 6.25$ and $F = 450$. These archetypes span low to high switching-cost intensity and show how supply-chain structure shifts the relative size of the GS, DR, and DC regions. Table 11 summarizes the key quantitative results across these robustness checks.

Table 11. Summary of the revised robustness results.

Robustness Check	Key Quantitative Result	Interpretation
Switching-cost intensity F	DC share: 37.42% $\rightarrow$ 0.02% $\rightarrow$ 0% as $F = 150 \rightarrow 300 \rightarrow 450$; GS share remains 17.87%.	Switching-cost intensity mainly governs reconfiguration depth and the DR–DC boundary.
Alternative-supplier cost premium Δw	Mean r^* : 0.490 $\rightarrow$ 0.371 $\rightarrow$ 0.269 as $\Delta w = 3.75 \rightarrow 5.00 \rightarrow 6.25$.	More expensive alternative sourcing delays and weakens reconfiguration.
Isoelastic demand	95.15% strategy agreement with the linear-demand benchmark.	Demand curvature mainly changes quantitative reconfiguration depth within the interior region.
Discrete sourcing	98.20% agreement for 5% increments; 96.02% for 10% increments.	The continuous sourcing share is a close high-volume relaxation; differences concentrate near boundaries.
Capacity/switching-cost form	At $\bar{r} = 0.50$, 35.99% of the evaluated grid is capacity-constrained; positive κ raises the GS share to 21.36% ($\kappa = 30$) and 25.20% ($\kappa = 60$).	Capacity limits feasible reconfiguration depth, while initial marginal switching cost raises the reconfiguration trigger.
Comparative structures	DC share: 50.86%/≈0.02%/0% for flexible diversified/SHEIN baseline/concentrated high-switching-cost structures.	The core mechanism persists, but regime prevalence is structure-dependent.
Failed-order cost incidence	Fulfillment-only GS–DR trigger: 28.17% $\rightarrow$ 21.85% as $\varphi: 0 \rightarrow 1$; GS share: 17.87% $\rightarrow$ 12.91%; DC share: 0.023% $\rightarrow$ 16.60%.	Allowing a sunk fraction of effective sourcing expenditure on failed orders induces earlier diversification, while GS, DR, and DC remain distinct optimal regions.

To connect the strategy regions with their economic consequences, Figure 8 maps the platform's equilibrium profit across the compound-shock domain. Profit is highest

when the tariff-equivalent cost and fulfillment-loss rate are both low and generally falls as either shock strengthens. A larger cost shock compresses the unit margin, while a larger fulfillment shock reduces fulfilled demand. Endogenous alternative sourcing partially cushions these effects, but it also introduces the alternative supplier's cost premium and supply-chain switching costs. The profit surface therefore shows that reconfiguration can mitigate, but not eliminate, the profitability loss generated by stronger compound shocks.

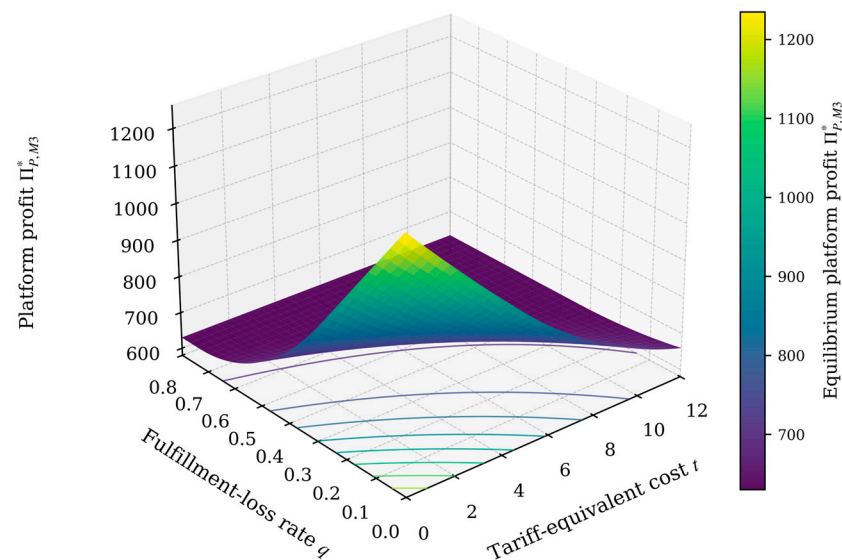


Figure 8. Platform's equilibrium profit surface under compound shocks.

Additional robustness ranges, numerical solution details, and extension analyses are reported in Supplementary Notes S2–S4. With the baseline mechanism established across these specifications, Section 7 examines how policy uncertainty and resilience investment alter the trigger and depth of reconfiguration.

7. Extensions

The baseline analysis takes the tariff-equivalent cost shock t , fulfillment-loss rate q , and switching-cost intensity F as model primitives. Two extensions then broaden the framework. The first introduces trade-policy uncertainty into risk-adjusted sourcing cost; the second endogenizes switching-cost intensity through ex ante resilience investment.

7.1. Trade Policy Uncertainty: Risk-Adjusted Costs and De-Risking Decisions

Trade-policy uncertainty adds a forward-looking component to the deterministic cost shock in M1. Platforms face possible changes in tariffs, rules of origin, customs scrutiny, and compliance costs, and this volatility can make early supplier qualification valuable before expected costs fully reverse the supplier ranking. Evidence that policy uncertainty influences investment, export-market entry, risk expectations, and capability development [14,15,24] motivates an extension in which sourcing from the original supplier S_1 exposes the platform to the random tariff-equivalent cost $\tilde{t} = \bar{t} + \varepsilon$, where $E(\varepsilon) = 0$ and $\text{Var}(\varepsilon) = \sigma_t^2$. The parameter $\bar{t}$ denotes the expected tariff-equivalent cost, while σ_t^2 measures policy uncertainty and the associated exposure to future compliance costs, delivery delays, and profit volatility.

To translate policy volatility into the static decision framework, we adopt a reduced-form risk-adjusted cost specification. Let $\rho \geq 0$ denote the risk-loading parameter. Its risk-adjusted effective unit-sourcing cost is $W_\rho = w_1 + \bar{t} + \rho\sigma_t^2$, where $\rho\sigma_t^2$ is the reduced-form uncertainty premium associated with policy volatility. The conditions

$0 < w_2 < \frac{a}{b}$ and $0 < W_\rho < \frac{a}{b}$ ensure economically meaningful optimal prices, demand, and profits under linear demand. This specification isolates the threshold effect of policy volatility while retaining the joint pricing-and-sourcing structure of the baseline model.

Supplementary Note S4.1 provides the complete profit specification, conditional pricing solution, and indirect-profit derivation.

Proposition 5 (Platform's Optimal Decision under Trade Policy Uncertainty). *Suppose that $0 < w_2 < \frac{a}{b}$ and $0 < W_\rho < \frac{a}{b}$. The platform assigns a positive sourcing share to the alternative supplier if and only if $W_\rho > w_2$, or equivalently, $w_1 + \bar{t} + \rho\sigma_t^2 > w_2$.*

Thus, trade policy uncertainty induces de-risking when $\bar{t} > w_2 - w_1 - \rho\sigma_t^2$.

The platform's optimal sourcing share is

$$x_U^* = \begin{cases} 1, & W_\rho \leq w_2, \\ 0, & W_\rho > w_2, 0 < F \leq \bar{F}_U, \\ 1 - r_U^*, & W_\rho > w_2, F > \bar{F}_U. \end{cases} \quad (16)$$

where the decoupling threshold is

$$\bar{F}_U = \frac{(W_\rho - w_2)(a - bw_2)}{4}, \quad (17)$$

In the partial de-risking region, the optimal alternative sourcing share is

$$r_U^* = \frac{(W_\rho - w_2)(a - bW_\rho)}{4F - b(W_\rho - w_2)^2}. \quad (18)$$

Proof. See Supplementary Note S4.1. $\square$

Proposition 5 demonstrates that trade-policy uncertainty can induce de-risking before the expected tariff-equivalent cost alone reverses the suppliers' cost ranking. Under the risk-adjusted-cost specification, greater policy volatility raises the effective exposure associated with continued reliance on the original supplier, especially under a larger risk loading. Alternative sourcing can therefore become optimal at a lower expected tariff level than under a deterministic policy environment. The 2024 U.S. Section 301 review provides a practical illustration: tariff modifications proposed in May were finalized with updates in September after public comments and review. Firms planning sourcing during such a process face an evolving policy schedule before final rates and effective dates are known. This mechanism shifts the diversification threshold rather than merely changing reconfiguration depth [60].

Figure 9 illustrates the sourcing response to trade-policy uncertainty. Under the risk-adjusted specification, the optimal alternative sourcing share generally rises with policy uncertainty, and a larger risk loading increases reconfiguration depth. Supply-chain planning should consequently incorporate possible tariff adjustments, tighter rules of origin, greater customs scrutiny, and changing compliance costs alongside current tariff levels. When the risk-adjusted effective sourcing cost W_ρ approaches or exceeds the alternative supplier's cost w_2 , early supplier qualification, regional sourcing pilots, and local warehousing and distribution capabilities reduce exposure to future policy changes.

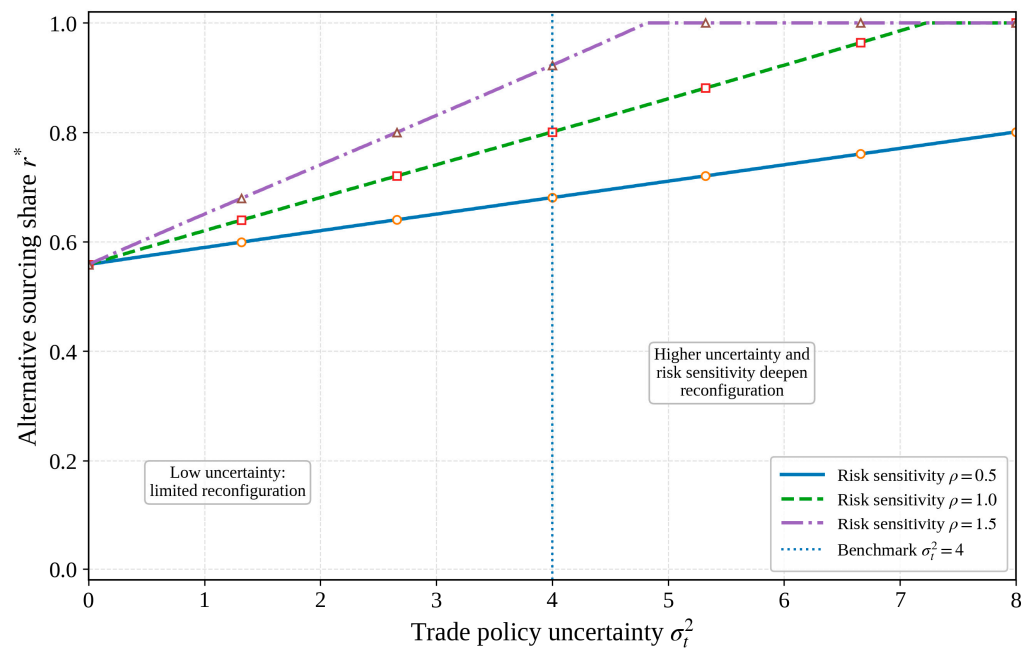


Figure 9. Alternative sourcing under trade policy uncertainty. Note: r^* denotes the optimal alternative sourcing share, σ_t^2 denotes trade-policy uncertainty, and ρ denotes the risk-sensitivity parameter. The vertical dotted line indicates the benchmark value $\sigma_t^2 = 4$.

7.2. Supply-Chain Resilience Investment: Endogenous Switching Costs and Sourcing Reconfiguration

The second extension endogenizes reconfiguration capacity through resilience investment. The baseline switching-cost intensity F can be reduced through advance supplier qualification, regional warehousing, multisupplier management systems, harmonized quality standards, and stronger cross-border compliance capabilities. Research on supply-chain resilience links adaptive and recovery capabilities to ex ante resource allocation, process improvement, and organizational capability development [31,43,61]. We therefore allow resilience investment to lower switching-cost intensity and examine how this investment changes reconfiguration depth.

Before choosing its sourcing structure, the platform selects the supply-chain resilience investment level I . Investment reduces the switching-cost intensity according to

$$F(I) = F_0 - \theta I, F_0 > 0, \theta > 0$$

To ensure positive switching costs, assume that $0 \leq I \leq \bar{I}$ and $0 < \bar{I} < \frac{F_0}{\theta}$. It follows that $F(I) > 0$ for every feasible I . The platform incurs the investment cost

$$K(I) = \frac{k}{2} I^2, \quad k > 0, \quad (19)$$

where k captures the increasing marginal cost of resilience investment.

Resilience investment precedes the operating decision. In the first stage, the platform chooses the investment level I . In the second stage, conditional on I , it jointly chooses the alternative sourcing share r and retail price p , as characterized by the indirect-profit formulation in Supplementary Note S4.2. This timing captures the role of ex ante capability building in shaping the cost of subsequent sourcing adjustment.

Proposition 6 (Platform's Optimal Resilience Investment and Sourcing Decision). *Under the compound-shock scenario, let $r_R^*(I) \in (0, 1)$ denote the platform's optimal alternative sourcing share*

in the second stage, conditional on resilience investment I . Suppose that, in a neighborhood of the interior solution, the second-stage objective is strictly concave in r and the optimal response $r_R^*(I)$ is unique and differentiable. Then

$$\frac{\partial r_R^*(I)}{\partial I} = - \frac{2\theta r_R^*(I)}{\left. \frac{\partial^2 \hat{\Pi}_P^R(r, I)}{\partial r^2} \right|_{r=r_R^*(I)}} > 0. \quad (20)$$

Proof. See Supplementary Note S4.2. $\square$

Proposition 6 establishes a locally reinforcing relationship between resilience investment and sourcing reconfiguration at an interior solution. Resilience investment lowers effective switching cost, making it less expensive for the platform to access and use alternative supply capacity; the reduction in switching costs supports a larger optimal alternative sourcing share. At the same time, a larger planned sourcing shift increases the value of investments that facilitate reconfiguration, generating complementarity between the two decisions under the stated local conditions. The result therefore treats resilience capacity as an endogenous determinant of how readily the sourcing portfolio can adjust. This feedback loop links preparedness to adjustment capacity while remaining tied to the specified interior region and local comparative-static conditions.

Figure 10 translates the extension into operational terms: greater resilience investment lowers the effective switching cost and supports a larger alternative sourcing share. Investments in supplier qualification, regional warehousing, and digital integration therefore expand the platform's capacity to reconfigure sourcing when future shocks occur. Taken together, the two extensions separate two forward-looking margins: policy uncertainty shifts the trigger for diversification, whereas resilience investment changes the feasible reconfiguration depth after the trigger is crossed. This selective-adjustment logic is also consistent with recent evidence that global linkages can persist even as firms and policymakers reconfigure supply chains for resilience and security [62–64].

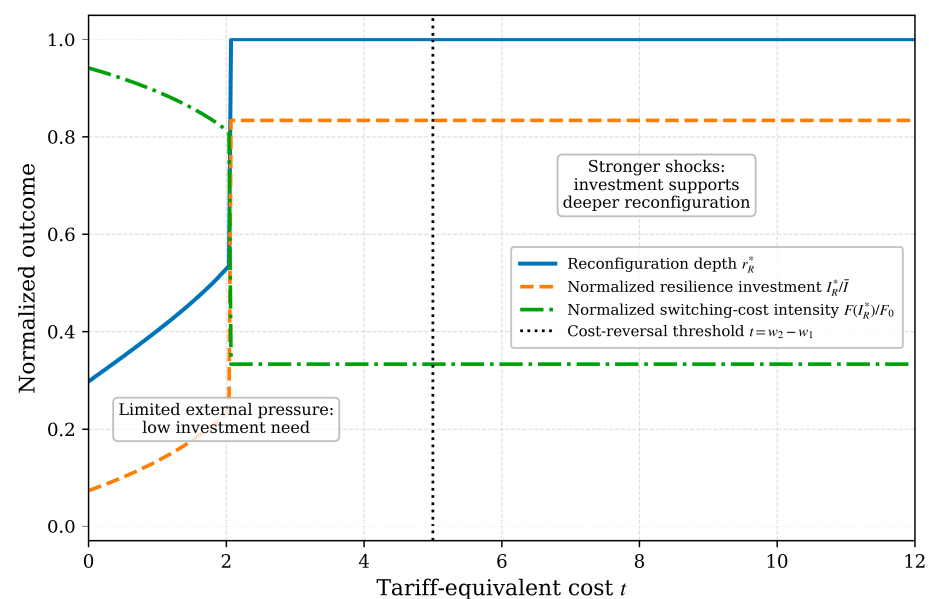


Figure 10. Resilience investment, switching costs, and alternative sourcing.

8. Conclusions and Implications

8.1. Main Findings

This study links economic-security shocks to supplier-portfolio reconfiguration through a joint pricing-and-sourcing model for cross-border e-commerce platforms.

First, global sourcing remains the efficiency benchmark in the absence of economic-security shocks and under low-intensity exposure. Under the baseline calibration, the GS–DR trigger is a tariff-equivalent cost of five in the cost-shock scenario and an expected order-level fulfillment-loss rate of approximately 28.2 percent in the fulfillment-shock scenario.

Second, the tariff-equivalent cost shock and fulfillment shock operate through different economic margins. The tariff-equivalent cost shock raises the original supplier's effective unit-sourcing cost and can reverse the suppliers' relative cost ranking, whereas the fulfillment shock lowers realized fulfillment and fulfilled sales. These distinct channels generate different GS–DR triggers and sourcing-adjustment paths.

Third, the two shock channels reinforce each other under compound exposure. Subject to the stated feasibility and concavity conditions, a larger tariff-equivalent cost shock lowers the expected order-level fulfillment-loss rate required to cross the GS–DR trigger. Partial de-risking can therefore emerge while the original supply chain still retains a unit-cost advantage.

Fourth, switching-cost intensity primarily determines reconfiguration depth and the DR–DC boundary after the GS–DR trigger is crossed. Across the case-informed parameter domain, partial de-risking accounts for 82.11 percent of evaluated combinations, whereas decoupling from the original supply chain occurs in only 0.023 percent. Lower switching-cost intensity and a smaller alternative-supplier cost premium make deeper reconfiguration more likely. The extensions preserve this trigger–depth–boundary logic: trade-policy uncertainty operates through the risk-adjusted effective unit-sourcing cost, while resilience investment reduces switching-cost intensity. The failed-order cost robustness further shows that allowing a positive sunk-cost fraction shifts the fulfillment threshold toward earlier diversification while preserving distinct GS, DR, and DC regions.

These results point to a pattern of selective and hybrid supply-chain reconfiguration in which platforms reduce concentrated exposure without necessarily abandoning existing cross-border relationships. The model further identifies the conditions under which selective diversification becomes optimal and distinguishes the shock-driven trigger for diversification from the switching costs that govern reconfiguration depth and the boundary between partial de-risking and decoupling from the original supply chain.

8.2. Managerial Implications

Based on the above findings, the study further develops differentiated decision implications for platforms, suppliers, and policymakers.

For platforms, supply-chain reconfiguration can be managed through trigger, depth, and boundary decisions. The baseline results provide two operational benchmarks: diversification begins when the original supplier loses its effective cost advantage or, when the cost channel is absent, when the expected order-level fulfillment-loss rate approaches 28.2 percent. Under compound shocks, a stronger tariff-equivalent cost shock lowers the fulfillment-loss rate required to trigger partial de-risking. After the GS–DR trigger is crossed, managers should compare global sourcing, partial de-risking, and decoupling from the original supply chain to determine reconfiguration depth. Decoupling from the original supply chain occurs in only 0.023 percent of the baseline case-informed combinations, while lower switching-cost intensity and a smaller alternative-supplier cost premium make deeper reconfiguration more attractive. Supplier qualification, harmonized standards, digi-

tal integration, backup capacity, and regional fulfillment can reduce supply-chain switching costs and expand feasible reconfiguration.

For suppliers, the results identify the operational attributes that determine whether a supplier retains or gains a position in the platform's sourcing portfolio. Original suppliers can protect their sourcing share by maintaining an effective cost advantage, reducing compliance and clearance delays, and improving fulfillment performance. Alternative suppliers can expand their role by narrowing the alternative-supplier cost premium and lowering the qualification, contracting, logistics, and system-integration components of supply-chain switching costs. Supplier evaluation should therefore extend beyond unit-sourcing cost to fulfillment performance, scalable capacity, coordination readiness, and switching requirements. These factors determine whether diversification remains limited or develops into deeper supply-chain reconfiguration.

For policymakers, economic-security measures can affect platform sourcing through both the tariff-equivalent cost channel and the fulfillment channel. Tariff arrangements, low-value parcel rules, customs-declaration requirements, and compliance reviews may alter effective unit-sourcing costs, clearance conditions, fulfillment performance, and the attractiveness of alternative sourcing. When switching-cost intensity is relatively low and viable alternative suppliers are available, stronger policy pressure is more likely to induce deeper supply-chain reconfiguration. Policy assessment should therefore consider supplier substitution, retail-price pass-through, fulfilled demand, and supply-chain switching costs alongside the intended economic-security objective.

8.3. Limitations and Future Research

This study has three main limitations. First, the baseline model treats wholesale quotations as given and represents sourcing through two supplier types. This setting isolates the platform's joint pricing-and-sourcing decision but does not capture strategic supplier pricing, contract coordination, platform competition, consumer heterogeneity, or more complex multi-supplier portfolios. Future research could relax these assumptions to examine their effects on the GS-DR trigger, reconfiguration depth, and the DR-DC boundary.

Second, the numerical analysis relies on case-informed calibration rather than direct estimation from firm-level operational data. Future research could use order, fulfillment, supplier-contracting, and customs-clearance records to estimate consumer price sensitivity, expected order-level fulfillment-loss rates, and switching-cost intensity more directly, and to test the GS-DR trigger, DR-DC boundary, and reconfiguration depth across platforms, product categories, and policy settings.

Third, the benchmark fulfillment specification assumes that sourcing expenditure associated with unfulfilled original-source orders is fully avoidable. The robustness analysis relaxes this assumption by allowing a fraction of the effective sourcing expenditure to remain sunk when fulfillment fails, and the resulting thresholds move toward earlier diversification as the sunk-cost fraction increases. The actual recoverable share is likely to depend on contract terms, payment timing, customs status, carrier arrangements, and the source of fulfillment failure. Transaction-level procurement and logistics records would allow these cost-incidence components to be estimated more directly.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/jtaer21090320/s1>. Supplementary Note S1 provides the complete proofs of the core and scenario-comparison results; Supplementary Note S2 reports parameter sources, calibration, robustness ranges, and feasibility checks; Supplementary Note S3 summarizes the numerical solution and reproducibility information; Supplementary Note S4 provides the extension derivations and robustness analysis; and Supplementary Note S5 contains additional numerical figures.

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