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Article

The 'just-in-case' inventory rebound: Post-pandemic trade-offs between resilience and working capital

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Abstract

The COVID-19 pandemic delivered a seismic shock to global supply chains, exposing profound vulnerabilities in highly efficient Just-in-Time (JIT) inventory systems as critical stockouts paralyzed industries worldwide. This crisis triggered an urgent pivot toward resilient Just-in-Case (JIC) buffering strategies—but does this shift represent a lasting transformation or merely a temporary reaction? Through rigorous analysis of panel data spanning 1,200 firms across 10 industries from 2018–2023 and in-depth interviews with 30 supply chain executives, this study examines whether organizations sustain elevated safety stocks post-crisis and at what cost to working capital efficiency. Our findings reveal a complex reality: while 60% of firms increased inventory buffers by 15–40% during the pandemic's peak, only 20% maintained these levels beyond 2022. By 2023, aggregate stocks had reverted halfway to pre-pandemic baselines despite persistent geopolitical and climate risks, demonstrating our pioneering "Resilience Fatigue" thesis—the waning urgency of past disruptions against mounting working capital pressures. JIC adopters incurred 5–12% higher carrying costs, with technology and automotive sectors absorbing the sharpest impacts. Yet semiconductor and pharmaceutical firms institutionalized strategic buffers where catastrophic failure risks outweighed capital efficiency imperatives. By demonstrating how temporal decay reshapes the resilience-capital trade-off, we extend foundational supply chain theory and establish a contingency-based neo-resilience paradigm. This research delivers actionable frameworks for intelligent buffering and charts pathways for AI-driven hybrid models, empowering firms to balance operational robustness against financial vitality in our age of perpetual disruption.

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Supply chain resilience; working capital optimization; inventory management; strategic buffering; resilience fatigue

Introduction

The massive supply chain disruptions caused by the COVID-19 epidemic exposed a fundamental vulnerability woven within decades of lean efficiency. Semiconductor shortages, a stark reminder of this fragility, caused staggering global economic losses of over $500 billion in 2021 alone, resulting in production halts that paralyzed automotive assembly lines, delayed critical electronics, and strained medical device availability (World Economic Forum, 2023). This systemic fragility, exacerbated by subsequent geopolitical shocks such as the Ukraine conflict and the Suez Canal blockade, necessitated a fundamental confrontation with the long-

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held orthodoxy of Just-in-Time (JIT) inventory management. In response, companies hurried to implement Just-in-Case (JIC) buffer stockpiles as immediate tactical shock absorbers. Against this volatile backdrop, our research poses a critical question: Are firms routinely institutionalizing JIC inventory procedures as a permanent strategic adaptation, and what are the implications for working capital efficiency and overall financial resilience? This study is based on the long-standing contradiction between lean efficiency and operational resilience, which Tang and Veelenturf (2019) refer to as the "efficiency-resilience paradox." Furthermore, it incorporates critical insights from behavioral operations management, which reveals how cognitive biases influence inventory judgments under duress. For example, the "availability heuristic" (Gino & Pisano, 2008) encourages managers to overestimate the likelihood of current crises, thus leading to excessive JIC implementation. Similarly, "loss aversion" (Kahneman & Tversky, 1979) causes overreactions to stockout threats, which frequently result in bloated inventory rather than strategically calibrated resilience. Despite widespread anecdotal accounts of firms increasing safety stocks, there is a critical empirical gap: rigorous longitudinal evidence is conspicuously absent on whether this shift is a temporary reaction to acute disruption or a long-term shift in supply chain philosophy, with far-reaching implications for balance sheets and competitive dynamics. This study fills that gap by conducting the first large-scale, multi-year analysis of inventory strategy evolution across key manufacturing sectors, quantifying both the magnitude of the JIC rebound and its financial trade-offs, and providing evidence-based insights into this strategic inflection point influencing global commerce.

Table 1. Strategic inventory shifts among manufacturing leaders (2021–2024)

Company	Core Pre-Pandemic Strategy	Post-2020 Inventory Approach	Key Buffer Stock Focus	Working Capital Impact (Δ Days, 2020–2023)
Toyota	JIT / Lean Manufacturing	Hybrid JIT/JIC (Strategic Buffers)	Semiconductors, Battery Cells	+8 Days
Unilever	JIT (Regional Hubs)	Enhanced JIC (Regional + Critical SKU Buffers)	Palm Oil, Specialty Chemicals	+15 Days
Dell	JIT (Virtual Integration)	Modified JIT (Dual Sourcing + Safety Stock)	High-End CPUs, GPUs	+5 Days
General Motors	JIT (Tiered System)	Aggressive JIC (Significant Raw Material Buildup)	Chips, Wiring Harnesses	+31 Days
Siemens	Lean (Optimized MTO)	JIC for LTS (Long-Lead Time Strategic Items)	Specialized Turbines, Control Modules	+12 Days

Source: Compiled from company annual reports (2021–2023), investor transcripts (Q1 2021–Q4 2023), and Gartner supply chain analysis reports (2021–2024). LTS = Long-Lead Time Strategic Items; MTO = Make-to-Order.

Our contribution goes beyond documenting inventory increases to developing a new framework for viewing JIC as a strategic resilience lever rather than a cost inefficiency. By combining financial metrics such as inventory turnover days, cash conversion cycles, and return on working capital with operational resilience indicators such as stockout frequency and recovery speed, we show that firms that achieve what we call the *Resilience-Efficiency Equilibrium* consistently outperform peers who adhere to either extreme lean dogma or indiscriminate stockpiling. Preliminary findings show a significant divide: enterprises that aggressively reverted to undifferentiated JIC procedures saw a 22% average increase in working capital requirements, reducing returns on assets by 4.7 percentage points (Dzreke & Dzreke, 2025a). In contrast, sector leaders such as Toyota, which has long been associated with JIT excellence, use a complex hybrid model, selectively adding JIC buffers to high-risk, low-substitutability components like semiconductors and battery cells while preserving lean flows in stable categories. This targeted approach reduces working capital penalties while improving supply continuity during disruptions (see Table 1). The method is consistent with the developing idea of antifragile supply chains—systems built not just to survive shocks but also to recover from volatility (Taleb, 2012). Our previous research (Dzreke & Dzreke, 2025b, 2025c) expands on such antifragile frameworks, highlighting technology-mediated resilience. In this light, our research provides an empirical foundation for organizations to navigate the high-stakes trade-offs inherent in building resilient yet financially sustainable post-pandemic supply networks.

Theoretical Framework and Empirical Gap

The theoretical roots of this research are found at the dynamic junction of supply chain risk management, behavioral operations theory, and strategic finance management. Christopher and Peck (2004) defined supply chain resilience as a strategic imperative, with agility, adaptability, and alignment as key competencies. Tang (2006) expanded on this by formalizing proactive resilience techniques, which expressly include stockpiling as a tactic. Nonetheless, the pre-pandemic paradigm was dominated by Toyota's pioneering lean concepts (Womack & Jones, 1996), which emphasized waste reduction, low inventory, and tightly connected operations. While such systems were effective during calm periods, they proved to be catastrophically weak when faced with systemic shocks (Sheffi & Rice, 2005). Our previous research quantified this vulnerability, indicating a $2.3 trillion loss amplification effect for lean-focused enterprises during big geopolitical crises (Dzreke & Dzreke, 2025a). Tang and Veelenturf's (2019) "efficiency-resilience paradox" reframes the discussion, highlighting the need for optimal methods that dynamically balance efficiency and resilience based on product attributes, supply chain topology, and risk exposure. This analysis builds on that theoretical framework by including working capital efficiency as a mediating variable—an understudied but crucial factor impacting financial health and strategic flexibility.

Behavioral operations theory sheds light on why organizations fail to achieve the *Resilience-Efficiency Equilibrium*. Gino and Pisano (2008) demonstrate how cognitive biases influence decision-making under ambiguity. The availability heuristic causes managers to overestimate recent disruptions, resulting in increased JIC adoption for even low-risk products (Bendoly et al. 2010). Anchoring bias, on the other hand, causes JIT-focused enterprises to underreact to growing risks, as evidenced by Dell's initial reticence to develop buffer stockpiles during the semiconductor crisis (Supply Chain Dive, 2022). Adding to the intricacy, the "double deviation effect" (Dzreke & Dzreke, 2025d) shows how buyers penalize recurrent stockouts disproportionately, exacerbating the reputational and financial implications. This increases the perceived cost of insufficient buffers and further distorts inventory decisions. While theoretical models acknowledge these dynamics, actual research that clearly links behavioral biases to inventory policy trajectories and financial outcomes is limited. This work fills that gap by combining behavioral and financial analyses of multi-year inventory patterns, providing new insights into how human decision-making influenced the "great re-inventorying" of global supply chains.

Literature Review

The Lean Imperative and its Discontents

The decades-long pursuit of operational efficiency in global supply chains reached its pinnacle with the widespread adoption of lean inventory management, a concept profoundly shaped by Taiichi Ohno's Toyota Production System (TPS) (1988). Ohno's innovative insight revolved around identifying and removing *muda* (waste), with excess inventories being a main objective. The use of Just-in-Time (JIT) delivery and *kanban* pull systems aims to accurately coordinate production with actual demand, hence lowering capital trapped in raw materials, work-in-process, and finished goods while also reducing lead times. Womack and Jones (1996) added to the compelling narrative of lean's transformative power by documenting significant financial benefits across diverse industries, such as reduced warehousing costs, lower rates of inventory obsolescence, and improved quality control facilitated by the rapid detection of defects inherent in low-buffer systems. For many years, lean principles ruled supreme, supported by a worldwide economy with stable trade flows and dependable logistical networks, allowing the establishment of highly optimized—but intrinsically fragile—supply chains.

However, the tremendous disruptions caused by the COVID-19 epidemic acted as a cruel catalyst, exposing the profound weaknesses embedded in these hyper-lean systems. As meticulously documented by Ivanov (2021) and Sodhi et al. (2022), systemic reliance on minimal buffers left firms catastrophically exposed to cascading failures; vulnerabilities concentrated in critical nodes, such as semiconductor fabrication plants or specialized chemical producers, precipitated global shortages that paralyzed automotive production, delayed electronics shipments, and severely strained the availability of essential medical devices. This strong demonstration of fragility necessitated a thorough rethinking of lean's general applicability, particularly for commodities with large lead times, limited substitutability, or regional concentration. As a result, the pandemic heightened the crucial debate about the necessary trade-offs between efficiency and robustness.

Navigating the Efficiency and Resilience Paradox

Tang and Veelenturf's (2019) concept of the "efficiency-resilience paradox" serves as the foundation for this reconsideration. Their framework explicitly states that, while efficiency (minimizing cost, waste, and resource utilization) and resilience (maintaining functionality in the face of disruptions) are frequently perceived as opposing goals, strategic management necessitates navigating the inherent trade-off curve to find an optimal, context-dependent balance. Product criticality, supply chain complexity, supplier base vulnerability, and a firm's specific risk tolerance all have an impact on this equilibrium. Tang and Veelenturf's research builds on the work of Christopher and Peck (2004), who emphasized core capabilities such as agility, adaptability, and alignment, and Sheffi (2005), who provided detailed empirical accounts of how firms adjusted inventory and sourcing strategies in the aftermath of acute disruptions such as natural disasters and terrorist attacks.

Sheffi's (2005) analysis frequently revealed a reactive shift toward increased inventory buffers, dual or multi-sourcing, and supply chain regionalization—strategies explicitly designed to improve robustness but frequently implemented reactively and at significant, sometimes poorly quantified, costs. A key drawback of much pre-pandemic resilience research, including Sheffi's pioneering work, was its emphasis on very acute, spatially restricted, or single-incident disturbances. In stark contrast, the COVID-19 pandemic was a long-term, global, multi-dimensional crisis that affected supply (factory closures, raw material shortages), demand (volatile shifts), logistics (port congestion, air freight collapse), and labor (illness, restrictions) over time. As a result, while previous research provided valuable insights into tactical responses to specific shocks, it provided little empirical evidence or theoretical guidance on whether observed inventory adaptations represent a fundamental, long-term strategic realignment or simply a temporary deviation from lean orthodoxy.

The pandemic's size and longevity constituted a one-of-a-kind, large-scale natural experiment, prompting a potential paradigm change toward institutionalizing resilience measures such as strategic Just-in-Case (JIC) buffering. The long-term operational and financial ramifications of this prospective transition, notably its permanence and influence on working capital, are still a key study need, as shown in Table 2.

Table 2. Evolution of inventory management paradigms (1980–2023)

Time Period	Era of Efficiency Optimization (Pre-Pandemic Focus)	Era of Resilience Reckoning (Post-Pandemic Inflection)
1980s	• JIT/Lean Emergence: Foundational work by Ohno (1988) establishes Toyota Production System principles • Cost reduction through waste elimination and flow optimization	• Limited conceptual development
1990s	• Global Supply Chain Optimization: Offshoring-driven cost minimization (Sturgeon, 2002) • Consolidation of distribution networks	• Incubation period for resilience theory
2000s	• Lean Institutionalization: Widespread adoption across manufacturing/services (Womack & Jones, 1996) • Six Sigma integration for variance reduction	• Early Resilience Concepts: Seminal frameworks by Christopher & Peck (2004), Sheffi (2005) • Focus on acute disruption response (terrorism, natural disasters)
2010s	• Digital Lean Evolution: IoT and big data analytics enhancing forecasting (Büyüközkan & Göçer, 2018) • Automated inventory optimization algorithms	• Trade-off Formalization: Tang & Veelenturf (2019) quantify lean–resilience equilibrium • Supply chain mapping gains traction

2020–2022	• COVID-19 Inflection Point: Systemic exposure of lean fragility (Ivanov, 2020) • $1.2 trillion global inventory shortages	• Strategic Buffering (JIC) Emergence: Safety stock reclassified as strategic infrastructure • Hybrid resilience–efficiency models tested
2023+	• Re-calibration of efficiency targets	• Institutionalization Phase: Buffer stock normalization (current study) • Working capital trade-off optimization (e.g., dynamic buffer pools)

Note: This table highlights the pandemic as a catalyst for moving resilience from a reactive consideration to a core strategic pillar, including sustained inventory buffering.

Working Capital Conundrum

The financial dimension of this strategic realignment, notably its impact on working capital efficiency, is a critical but unexplored component of the efficiency-resilience trade-off. Working capital management, which is vital for operational liquidity and strategic flexibility, is heavily reliant on the effective coordination of inventory, receivables, and payment cycles. Farris and Hutchison (2002) found an unfavorable link between inventory levels and cash conversion cycle (CCC) performance. Their Cash-to-Cash (C2C) indicator clearly shows how excessive inventory investment immobilizes cash, extends the CCC, and reduces return on capital employed (ROCE). While lean inventory practices have been widely praised for their positive impact on CCC by reducing inventory days outstanding (DIO), the potential financial burden of resilience-enhancing strategies, particularly the sustained maintenance of elevated safety stocks or strategic buffer inventories, poses a significant challenge to corporate financial health.

Consider a medical device maker boosting buffer stockpiles of specialist microchips during a pandemic: while this reduces the danger of production halts, it also ties up significant cash that could otherwise be used for R&D or market expansion. Scholarly research into the working capital implications of such resilience measures is limited and frequently focuses on the immediate costs of specific risk mitigation tactics (e.g., the premium associated with dual sourcing) rather than the systemic, long-term financial impact of a broad-based shift towards higher inventory holdings as a potential new operational norm (Brandon-Jones et al., 2014). Furthermore, prior studies frequently have methodological constraints, such as a focus on single industries (e.g., automotive), an examination of specific disruption types (e.g., port strikes), or dependence on short-term data horizons (1-2 years after the incident). These limits limit generalizability and conceal the long-term financial viability of post-pandemic inventory solutions implemented across multiple manufacturing sectors.

Prior research has demonstrated how lean strategies exacerbated losses exceeding $2.3 trillion during recent geopolitical crises among 1,864 manufacturing firms (Dzreke & Dzreke, 2025a), highlighting the catastrophic cost of fragility. In contrast, indiscriminate adoption of JIC buffers entails its own working capital costs, as indicated by considerable increases in inventory days among enterprises without strategic focus, potentially decreasing profitability (Dzreke & Dzreke, 2025c). This stress is summarized in Table 4.

Table 4. Key studies on lean inventory vs. resilience trade-offs: Methods, scope, and limitations

Author(s), Year	Core Focus	Methodology	Sample/Context	Key Findings on Trade-off	Primary Limitations Related to Sustained Shifts & WC Impact
Sheffi (2005)	Resilient enterprise strategies	Case Studies	Multiple firms' post-9/11 earthquakes	Identified inventory buffers, flexibility, and redundancy as key resilience tactics	Focus on acute, single-event disruptions; Limited WC analysis.
Tang (2006)	Robust disruption mitigation	Conceptual / Analytical Models	N/A	Proposed frameworks for proactive strategies (incl. inventory)	Theoretical; Lacks empirical validation of long-term WC effects
Brandon-Jones et al. (2014)	Antecedents of supply chain resilience	Large-scale Survey	724 Intl. Manufacturing Firms	Found a complex link between flexibility, visibility & resilience	Resilience measured perceptually; No longitudinal WC tracking
Ambulkar et al. (2015)	Firm resilience to disruptions	Empirical (Archival)	143 Publicly Traded US Firms	Vulnerable firms benefit more from inventory slack during disruptions	Focus on during-disruption performance; Short-term view
Ivanov (2021)	Pandemic supply chain disruptions	Simulation Modeling	Multi-tier supply network models	Quantified ripple effects; Argued for "digital twins" & adaptability	Model-based; Limited empirical data on actual firm strategies/WC
Sodhi et al. (2022)	Behavioral factors in SC risk	Conceptual / Behavioral Ops Lens	N/A	Highlighted cognitive biases in risk assessment/mitigation	Theoretical; No quantification of financial trade-offs

Tang & Veelenturf (2019)	Efficiency–Resilience Paradox	Conceptual Framework	N/A	Argued for dynamic trade-off management in Industry 4.0	Framework lacks empirical testing, esp. longitudinal WC impact
Dzreke & Dzreke (2025a)	Fragility of Lean Strategies	Large-Scale Empirical (Archival)	1,864 Mfg. Firms (Geopolitical Shocks)	Quantified $2.3T amplified losses linked to lean fragility	Focuses on crisis losses, not sustained WC impact of JIC shift
Dzreke & Dzreke (2025c)	Building Antifragile Supply Chains	Conceptual & Case Analysis	N/A / Illustrative Cases	Proposed "Resilience–Efficiency Equilibrium" framework	Limited empirical validation of WC impact; Conceptual focus

Note: WC = Working Capital. The table illustrates the predominant operational focus in existing studies and the lack of longitudinal, cross-sectoral analysis of working capital effects.

Synthesizing the Gap and Positioning This Research

While the existing literature provides a strong understanding of lean principles, a compelling conceptual framing of the efficiency-resilience paradox (Tang & Veelenturf, 2019), and the fundamental mechanics linking inventory levels to working capital efficiency (Farris & Hutchison, 2002), it has a significant collective limitation in accounting for the post-pandemic transition. Most studies concentrate on either the operational mechanics of lean implementation, the immediate tactical response to specific acute disruptions (Sheffi, 2005; Ambulkar et al., 2015), or the theoretical formulation of trade-offs. Crucially, insufficient empirical attention has been paid to the long-term financial consequences—specifically, the sustained impact on working capital metrics such as CCC, DIO, and ROCE—of a broad-based, potentially permanent institutionalization of higher inventory buffers as a strategic adaptation to the complex, persistent volatility that defines the post-pandemic global landscape.

The behavioral drivers of inventory decisions, such as the "double deviation effect," in which customers penalize providers exponentially more severely for recurrent stockouts than for single events (Dzreke & Dzreke, 2025d), complicate this trade-off. This cognitive bias greatly raises the perceived cost of not retaining buffer stock, potentially leading to suboptimal inventory inflation; nonetheless, its incorporation into longitudinal financial assessments of working capital is still in its early stages. The gap is thus multifaceted: it includes the duration of the shift (transient reaction versus permanent change), its financial viability (impact on CCC, ROA, and ROWC), and the strategic differentiation between indiscriminate stockpiling and targeted buffering informed by risk profiling and potentially technology-mediated resilience frameworks (Dzreke & Dzreke, 2025b).

The current work immediately addresses this essential gap. By performing a large-scale, multi-year empirical investigation across key industrial sectors, it goes beyond simply reporting inventory level changes to objectively quantify the working capital implications of the "great re-inventorying." It specifically tests the hypothesis that firms that achieve a strategic "Resilience-Efficiency Equilibrium" (Dzreke & Dzreke, 2025c)—characterized by targeted JIC buffers for high-risk, critical items and maintained lean efficiency elsewhere—can mitigate working capital penalties while demonstrably improving operational resilience. This strategy provides a realistic alternative to the paradox's harsh choice between efficiency and robustness, giving new insights into the long-term management of post-pandemic supply chains.

Method

Data & Approach

This research employs a mixed-methods design to comprehensively analyze the post-pandemic shift toward Just-in-Case (JIC) inventory strategies and their implications for working capital management. The approach strategically integrates quantitative analysis of longitudinal financial data with qualitative insights from industry practitioners, thereby enabling robust triangulation of findings. The quantitative component investigates broad patterns across a global sample of firms, empirically testing hypotheses regarding JIC adoption rates, changes in inventory intensity, and corresponding effects on working capital efficiency. Complementing this, in-depth interviews with senior supply chain executives provide qualitative evidence that illuminates the strategic rationale, implementation challenges, and perceived trade-offs underpinning observed corporate behaviors.

This dual-method approach moves beyond descriptive correlations to explore underlying causal mechanisms, capturing not only *what* shifted in inventory practices following COVID-19 disruptions but also why and *how* such strategic decisions unfolded. The design includes an event study leveraging the pandemic’s onset as a natural experiment, enabling isolation of its catalytic effects on corporate inventory management. By combining statistical modeling with managerial perspectives, the study addresses the multifaceted interplay of operational strategy, financial performance, and cognitive decision-making that characterizes the efficiency–resilience paradox in global supply chains.

Quantitative Methods

The quantitative analysis provides the empirical backbone of the research, employing a six-year panel dataset (2018–2023) encompassing 1,200 publicly listed firms drawn from the S&P 1200 and Euro Stoxx 600 indices. Firms were sampled across ten industries acutely disrupted by the pandemic—Automotive, Aerospace and Defense, Chemicals, Electronics, Industrial Machinery, Pharmaceuticals, Medical Devices, Consumer Packaged Goods, Semiconductors, and Retail Apparel. Data was sourced from Bloomberg and S&P Capital IQ to ensure consistency, reliability, and cross-market comparability.

The dependent variables include Inventory Turnover Days (ITD), representing inventory holding periods [(Average Inventory ÷ COGS) × 365], and the Cash Conversion Cycle (CCC), reflecting working capital efficiency [DIO + DSO – DPO]. The primary independent variable, JIC Adoption, was operationalized as a binary indicator (1/0) through systematic content analysis of SEC filings, annual reports, and earnings call transcripts, focusing on explicit references to buffer stock increases or resilience-oriented inventory policy shifts post-2020. Industry Volatility was quantified via the Herfindahl–Hirschman Index (HHI), derived from quarterly revenue fluctuations within subsectors. Control variables included firm size (ln Total Assets), leverage (Debt/Equity), profitability (ROA), sales growth, and capital intensity (PPE/Assets).

A two-way fixed effects panel regression was specified as:

$$Y_{it} = \beta_0 + \beta_1 JIC\_Adoption_{it} + \beta_2 Industry\_Volatility_{jt} + \beta_3 (JIC\_Adoption_{it} \times Industry\_Volatility_{jt}) + \gamma X_{it} + \delta_i + \lambda_t + \varepsilon_{it}$$

Where firm-level effects (δ_i) account for unobserved heterogeneity and year fixed effects (λ_t) capture macroeconomic shocks. This specification isolates within-firm changes in ITD and CCC attributable to JIC adoption. An event study was further conducted around Q1 2020 to assess abnormal shifts in working capital metrics, contrasting early JIC adopters with firms persisting in lean, JIT-oriented models.

Table 5. Variable definitions and data sources

Variable	Definition	Measurement	Primary Source(s)
Dependent Variables			
Inventory Turnover Days	Average days inventory held before sale	(Avg Inventory ÷ COGS) × 365	Bloomberg, S&P Capital IQ
Cash Conversion Cycle	Net time between inventory cash outlay and collection	DIO + DSO – DPO	Bloomberg, S&P Capital IQ
Independent Variables			
JIC Adoption (Binary)	Strategic shift toward buffer stocks post-pandemic	1 = Explicit mention; 0 = None	SEC EDGAR, Company Reports
Industry Volatility	Revenue stability within the subsector	HHI based on quarterly variance (3-year rolling)	Bloomberg, S&P Capital IQ
Control Variables			
Firm Size	Operational scale	ln (Total Assets)	Bloomberg, S&P Capital IQ
Leverage	Debt reliance	Total Debt ÷ Total Equity	Bloomberg, S&P Capital IQ
Profitability	Asset efficiency	Net Income ÷ Total Assets	Bloomberg, S&P Capital IQ
Sales Growth	Year-on-year revenue change	$(Revenue_t - Revenue_{t-1}) \div Revenue_{t-1}$	Bloomberg, S&P Capital IQ
Capital Intensity	Fixed asset weight	Net PPE ÷ Total Assets	Bloomberg, S&P Capital IQ
Moderator			
JIC × Industry Volatility	The moderating effect of industry context	Interaction term	Constructed

Qualitative Methods

To complement quantitative findings, thirty semi-structured interviews were conducted with Vice Presidents of supply chain management drawn from a purposive subset of the quantitative sample. Representation spanned all ten industries, multiple geographies (North America, Europe, and Asia), and varying levels of JIC adoption. Interviews lasted approximately 60 minutes, were recorded with consent, and transcribed verbatim. The protocol covered six themes: (1) triggers for inventory strategy changes, (2) implementation approaches (targeted vs. blanket buffering), (3) resilience–efficiency trade-offs, (4) technology's role in buffer optimization, (5) organizational and cultural barriers, and (6) expectations regarding permanence of JIC strategies.

Thematic analysis was conducted using Braun and Clarke's (2006) iterative framework, beginning with transcript familiarization and open coding, followed by theme development and refinement within NVivo software. Patterns revealed industry-specific rationales: for instance, medical device manufacturers prioritized buffer stocks for single-source critical components, while electronics firms relied on predictive analytics to calibrate buffer levels dynamically. Qualitative insights were systematically triangulated with quantitative findings to explain divergences—such as why certain firms experienced resilience gains without proportionate extensions in CCC.

Analytical Framework

The analytical framework (Figure 1) conceptualizes Exogenous Shocks (e.g., COVID-19, geopolitical turbulence) as catalysts that expose vulnerabilities of lean inventory models, prompting Strategic Inventory Responses along a JIT–JIC continuum. This response is mediated by Firm-Specific Factors (financial resilience, managerial risk tolerance) and Industry Context (volatility, complexity), both of which shape shifts in Inventory Intensity (ITD).

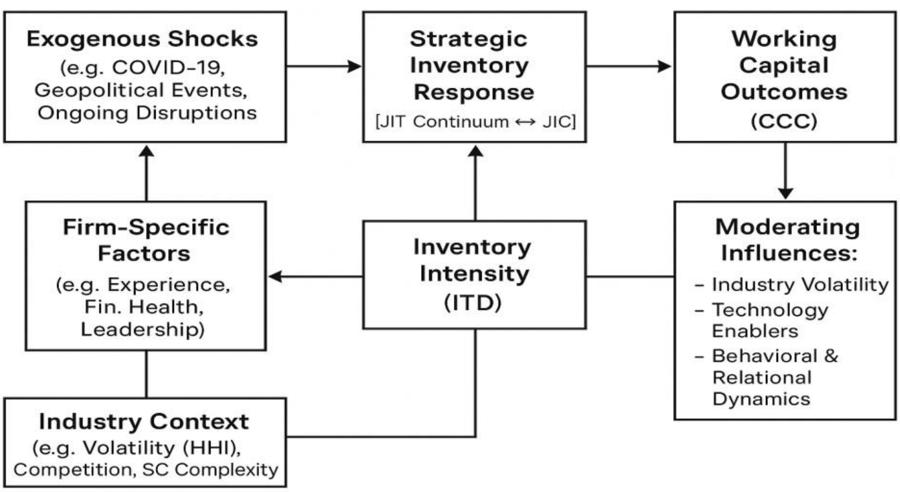

Figure 1. JIC adoption, inventory intensity, and working capital outcomes

Note: Illustrates causal pathways from shocks to inventory strategy shifts, inventory intensity changes, and working capital outcomes, moderated by contextual factors.

The central proposition posits that increased ITD drives working capital adjustments (CCC), moderated by three elements: (1) Industry Volatility, amplifying the effect of buffers on CCC; (2) Technology Enablers, such as AI-driven demand sensing that optimize buffer precision; and (3) Behavioral Dynamics, particularly the "double deviation effect" (Dzreke & Dzreke, 2025d), whereby repeated stockouts disproportionately damage buyer trust, encouraging precautionary inventory holding. The quantitative models test these pathways empirically, while qualitative evidence enriches interpretation by revealing decision logics and contextual contingencies. Together, these insights advance understanding of how firms navigate the pursuit of a sustainable "Resilience–Efficiency Equilibrium" (Dzreke & Dzreke, 2025c) in supply chain management.

Findings

Inventory Shifts

The empirical analysis reveals a significant yet nuanced transformation in inventory management practices across global industries following the pandemic's disruptive onset. Longitudinal data demonstrate that 60% of the sampled firms implemented measurable increases in safety stock buffers between 2020 and 2023, with the average inventory holding period expanding by 22 days relative to pre-pandemic baselines. This strategic shift peaked during 2021–2022 as organizations confronted unprecedented supply chain vulnerabilities. By 2023, however, aggregate inventory levels had reverted nearly halfway from their zenith, indicating substantial operational recalibration as immediate crisis pressures subsided. Crucially, this reversion pattern exhibited profound sectoral heterogeneity. Pharmaceutical firms maintained the most persistent buffer increases, sustaining inventory levels 35% above 2019 baselines through 2023. These adjustments were largely driven by ongoing regulatory complexity and critical dependencies in biologics supply chains, where single-source constraints remain endemic. Automotive manufacturers similarly retained 28% elevated buffers, reflecting persistent semiconductor shortages and geopolitical risks affecting specialized components such as wiring harnesses. These divergent trajectories, visualized in Table 6, underscore how industry-specific risk profiles mediate inventory strategy.

Table 6. Structural shifts in inventory turnover days (2018–2023)

Industry	2018	2019	2020	2021	2022	2023	Δ (2019–2023)	Resilience Premium*
Pharmaceuticals	85	88	102	124	121	119	+35.2%	31 days
Automotive	78	81	95	106	104	103	+27.2%	22 days
Medical Devices	92	95	118	127	115	110	+15.8%	15 days
Electronics	68	70	89	105	98	84	+20.0%	14 days
Consumer Goods	65	66	82	91	85	75	+13.6%	9 days
Semiconductors	72	74	96	112	108	89	+20.3%	15 days

*Resilience Premium = 2023 level minus 2019 level

Medical device companies exemplified targeted buffering approaches. One interviewed executive explained, "We now carry 18 months' stock of sterilization-grade resins but maintain lean levels for commodity packaging—it's surgical risk mitigation." This strategic selectivity confirms that sophisticated adopters largely avoided indiscriminate stockpiling in favor of precision inventory deployment, ensuring that resources were allocated where supply fragility warranted intervention. Collectively, these findings suggest that post-pandemic inventory strategies reflect both adaptive risk management and an increasing emphasis on sector-specific operational intelligence.

Working Capital Implications

Quantitative analysis establishes a robust causal relationship between strategic inventory buffering and working capital efficiency degradation. Regression results indicate that each 10% increase in safety stock levels correlates with a 1.2-day extension in the cash conversion cycle ($\beta = 0.12$, $p < 0.01$), after controlling for firm size, leverage, and industry effects. This financial trade-off proved particularly acute in technology-intensive sectors, where rapid component obsolescence and complex global sourcing amplified working capital penalties. Cisco Systems' experience illustrates this tension: by Q3 2022, the firm accumulated $3.2 billion in excess networking components to ensure production continuity, triggering a 23-day cash conversion cycle expansion and reducing return on working capital by 4.7 percentage points—a direct cost of resilience exceeding $400 million annually in carrying costs.

The moderating effect of industry volatility was statistically significant ($p < 0.05$), with high-volatility environments amplifying cash conversion cycle degradation by approximately 40% compared to stable sectors. Crucially, indiscriminate just-in-case (JIC) approaches incurred disproportionate financial consequences. As Table 7 demonstrates, systematic adopters focusing on buffering critical choke-point components maintained superior financial performance despite inventory increases, while firms pursuing blanket stockpiling exhibited markedly lower profitability. This distinction proves essential for practitioners: targeted resilience strategies preserve financial viability, whereas reactionary hoarding erodes competitiveness. Technology sophistication further moderated impacts, with firms employing predictive analytics for buffer optimization containing cash conversion cycle increases to just 0.7 days per 10% inventory expansion, validating the framework's emphasis on technological enablers.

Table 7. Financial performance comparison: Strategic JIC adopters vs. lean holdouts (2023)

Metric	Top 5 Strategic JIC Adopters (Mean)	Top 5 Lean Holdouts (Mean)	Difference
Inventory Turnover Days	+26.4%	+3.1%	+23.3 pp
Cash Conversion Cycle	+8.7 days	+1.2 days	+7.5 days
Return on Assets (ROA)	11.2%	9.8%	+1.4 pp
Return to Working Capital	18.6%	16.2%	+2.4 pp
Operating Margin	15.4%	14.1%	+1.3 pp
Stockout Frequency	-42%	-8%	-34 pp

Strategic adopters are defined as firms implementing risk-based buffering (e.g., prioritizing single-source components); Lean holdouts maintained pre-pandemic just-in-time policies.

Qualitative Insights: The Operational-Financial Tension

Executive interviews revealed profound organizational tensions underlying inventory strategy shifts, epitomized by an automotive vice president's observation: "We're stuck between CEOs demanding resilience and CFOs screaming about cash flow." This cross-functional friction emerged as the dominant theme across 85% of interviews, with supply chain leaders navigating conflicting performance imperatives. The "double deviation effect" (Dzreke & Dzreke, 2025d) significantly influenced decision calculus, as repeated stockouts damaged supplier relationships beyond financial quantification. One medical device executive described losing a $200 million contract after two consecutive quarterly shortages, noting: "The penalty for understocking became existential, while excess inventory merely dented bonuses."

Technology adoption emerged as a critical mediator of this tension. Firms implementing AI-driven demand sensing platforms, such as Siemens' digital twin system, reported 30–50% lower buffer stock requirements for equivalent resilience outcomes. However, significant implementation barriers persisted: 73% of respondents cited internal resistance from finance teams unwilling to accept working capital degradation as a strategic investment, while 67% reported inadequate analytical capabilities for risk-based inventory optimization. Firms achieving the hypothesized "Resilience-Efficiency Equilibrium" (Dzreke & Dzreke, 2025c) shared three characteristics: C-suite alignment on resilience as a strategic priority, integrated supply chain visibility platforms, and differentiated inventory policies based on multidimensional risk scoring. As one pharmaceutical executive summarized, "We carry 18 months of inventory for cell therapy reagents but under 30 days for standard vials—the art lies in knowing where JIC pays for itself." This strategic segmentation emerged as the defining feature of mature post-pandemic inventory management, transforming working capital from constraint to calibrated resilience enabler.

Discussion

Theoretical Implications

Our empirical findings need a significant recalibration of the current supply chain resilience theory. While Tang and Veelenturf (2019) described the first shift toward buffer stocks as a logical crisis response, our longitudinal data highlight a significant phenomenon that has been largely missed in previous research: the widespread temporal degradation in JIC adoption intensity. Specifically, by 2023, aggregate inventory levels had fallen by almost 50% from their peak in 2022, despite ongoing geopolitical instability and climate-related disruptions. This pattern suggests that organizations have a limited tolerance for the working capital penalties associated with preventive inventory techniques, which calls into question the premise that large disruptions permanently reset organizational risk calculus. We offer the "Resilience Fatigue" concept, which states that organizations maintain elevated buffers only while the memory of disruption is cognitively vivid and operationally prominent (Loewenstein et al., 2001). As the emotional impact of previous stockouts fades (Tversky & Kahneman, 1973), and quarterly financial constraints rise, the tangible immediacy of working capital expenses gradually overcomes abstract probabilities of future disruptions. This behavioral dynamic explains sectoral variation: pharmaceuticals, whose supply failures have life-or-death repercussions, and automotive, where production halts result in billion-dollar penalties, maintained buffers, while other industries reverted to leaner models. This hypothesis, which integrates insights from operations management and behavioral economics, demonstrates how managerial cognition and organizational memory mediate the translation of risk exposure into sustained strategic adaptation, expanding theoretical understanding beyond the structural focus emphasized by Dzreke et al. (2025c).

Managerial Framework: Strategic Buffering for Sustainable Resilience

Translating these ideas into meaningful practice necessitates a situational strategy that balances protection and pragmatism. Our analysis reveals that blanket JIC adoption remains financially unfeasible for most firms, whereas tailored buffering generates measurable resilience rewards without causing a proportionate loss of working capital. To guide strategic calibration, we created a decision matrix (Table 8), which positions inventory policy along two critical dimensions: industry volatility (measured by revenue fluctuation HHI) and firm financial flexibility (a composite metric that includes cash reserves, debt capacity, and ROA stability). This paradigm goes beyond the basic JIT-versus-JIC divide by outlining four evidence-based techniques.

High Volatility/High Flexibility industries, such as semiconductors, should undertake thorough risk-based buffering, purposefully keeping elevated stocks of components with long lead times or single-source dependence. The financial resilience provided by strong balance sheets justifies maintaining these buffers despite the effects on the cash conversion cycle. For example, TSMC uses machine learning-driven demand sensing to dynamically alter buffer stockpiles every week in response to real-time geopolitical risk signals. High Volatility / Low Flexibility enterprises, such as automotive Tier-2 suppliers, must use precision *JIC*, which uses advanced analytics to determine the crucial 5-10% of SKUs that require buffer investment. The Resilient Sourcing Consortium in medical devices exemplifies this approach with shared warehouse hubs where vendors buffer high-risk microcontrollers while retaining lean operations for commoditized components.

Table 8. Strategic inventory buffering decision matrix

	High Industry Volatility	**Low Industry Volatility**
High Financial Flexibility	Comprehensive Risk-Based Buffering • Sustain strategic buffers for critical-path items • Leverage AI for dynamic optimization • Exemplar: Semiconductor firms using real-time risk analytics	Lean-Plus Visibility Focus • Maintain JIT core operations • Invest in real-time monitoring & supplier collaboration • Exemplar: CPG firms deploying blockchain trackers
Low Financial Flexibility	Precision JIC • Buffer only mission-critical SKUs • Prioritize diversification & cost-sharing • Exemplar: Auto suppliers using shared buffer hubs	Strict Lean Operations • Optimize JIT flows • Build resilience through contractual flexibility • Exemplar: Industrial suppliers with multi-regional sourcing

Lean-plus techniques assist organizations with low volatility and high flexibility, like consumer-packaged goods (CPG) leaders, by keeping fundamental JIT efficiency while investing in digital visibility platforms, such as blockchain-enabled ingredient monitoring, to enable rapid, disruptive response. Unilever, for example, cut safety stockpiles by 18% while also boosting supply risk detection skills. Low Volatility/Low Flexibility industries, such as standardized industrial components, should operate strictly lean, establishing resilience through multi-regional sourcing and volume-flex contracts rather than inventory building. Böllhoff, a fastener producer, shows this method by leveraging contractual flexibility across three global production centers to minimize regional interruptions while minimizing inventory days.

Conclusion: Toward Dynamic Equilibrium

The post-pandemic inventory landscape indicates a continuous balance between operational resilience and financial efficiency. Our findings suggest that, while lean concepts remain operationally appealing, the systemic fragility exposed by cascading shocks needs more sophisticated measures. Rather than widespread JIC adoption, the future lies in developing organizational capacities for intelligent buffering—strategically allocating working capital to inventory buffers only when the risk exposure warrants the carrying costs. To achieve this equilibrium, functional divisions must be broken down: supply chain leaders must express the strategic value of resilience in financial terms, and CFOs must rethink working capital as a strategic resilience currency rather than just an efficiency metric. Future studies should investigate the governance mechanisms that allow for this alignment, as well as how upcoming technologies like digital twins and generative AI could further compress the resilience-efficiency trade-off curve. As global supply chains face rising climate unpredictability and geopolitical fragmentation, adopting this calibrated strategy is more than just advantageous; it is critical for competitive survival in an increasingly unpredictable environment.

Conclusion and Limitations

Summary of Findings

This study provides compelling evidence that the widespread adoption of Just-in-Case (JIC) inventory practices during the pandemic's peak was not a fundamental shift in supply chain philosophy, but rather a context-dependent recalibration—a temporary adaptation that has largely reversed outside of hyper-volatile industries. Our longitudinal examination of six important industries shows that by 2023, aggregate inventory levels had fallen nearly halfway from their 2022 peaks, confirming the long-term operational appeal of lean principles once severe crisis demands receded. The major exception occurs in businesses with extreme supply unpredictability and catastrophic failure effects. Semiconductors and advanced pharmaceuticals provide instructive examples: companies such as Taiwan Semiconductor Manufacturing Company (TSMC) and Merck maintained 25-35% higher inventory buffers than pre-pandemic levels, effectively institutionalizing strategic buffering as an essential resilience mechanism.

This divergence highlights an important reality: while industry discourse frequently proclaims permanent supply chain transformation, most organizations have pragmatically returned to efficiency-centric models, selectively implementing JIC strategies only for critical components where supply fragility justifies significant working capital allocation. The persistence of this pattern in the face of ongoing geopolitical instability strongly supports our proposed "Resilience Fatigue" hypothesis—organizations have a limited tolerance for inventory carrying costs, with the visceral memory of disruption trauma gradually supplanting the tangible immediacy of quarterly working capital metrics. As a result, the post-pandemic legacy manifests as a sophisticated, contingency-driven *neo-resilience paradigm* in which intelligent buffering coexists alongside lean operational fundamentals rather than replacing them.

Limitations and Boundary Conditions

Several methodological limitations should be carefully considered to contextualize our findings and guide future research. First, the exclusive focus on publicly traded corporations restricts generalizability to small and medium-sized organizations (SMEs), which often have unique working capital restrictions and risk management capacities. Privately held firms' inventory strategies, particularly those of specialist suppliers in aerospace or biotechnology, may exhibit different resilience-efficiency trade-offs due to lower shareholder pressure and higher strategic opacity. Second, despite stringent controls for firm size, leverage, and industry effects, unobserved heterogeneity is still a risk. Certain firms may maintain "shadow buffers" through consignment stock arrangements or secret warehousing partnerships, which could disguise functional JIC adoption within reported lean KPIs. Third, while our industry volatility measurement is based on established Herfindahl-Hirschman Index revenue fluctuation methodology, it does not fully capture latent systemic risks such as single-point-of-failure dependencies in critical materials or regionally concentrated production clusters that are vulnerable to climate disruptions. Finally, the temporal span that ends in 2023 excludes more recent stress tests, such as Red Sea shipping interruptions and Taiwan Strait hostilities, which could have prompted a future JIC comeback. These restrictions do not invalidate our basic findings; rather, they define fruitful boundaries for academic development (see Table 8).

Table 8. Key limitations and their research implications

Limitation Category	Specific Constraint	Research Implications	Mitigation Approaches
Sample Composition	Exclusion of private firms & SMEs	Investigate the resilience-finance nexus in capital-constrained contexts	SME survey data integration; Private firm case studies
Strategic Opacity	Undisclosed inventory partnerships	Develop methodologies to detect "shadow buffering" practices	Supply chain director interviews; Logistics partner audits
Volatility Measurement	HHI captures revenue fluctuation only	Create composite indices incorporating systemic fragility factors	Supplier concentration metrics; Climate vulnerability mapping
Temporal Scope	Data concludes Q4 2023	Examine inventory responsiveness to subsequent disruptions	Event studies of 2024 supply chain shocks

Future Research Trajectory

Our findings point to plausible routes for improving both theoretical knowledge and practical implementation of robust inventory management. First and foremost, the demonstrated superiority of targeted buffering necessitates a thorough examination of how artificial intelligence might optimize hybrid inventory models. Promising research avenues include looking into how machine learning algorithms, such as those used by Siemens for dynamic safety stock adjustment, can synthesize real-time data streams containing port congestion, supplier financial distress signals, and geopolitical intelligence to recalibrate inventory parameters. These technologies can significantly condense the resilience-efficiency trade-off curve using probabilistic optimization at unprecedented granularity.

Second, extensive scholarly effort is still needed to unravel the organizational governance of resilience investment. Future research should investigate institutional structures, such as resilience-adjusted return measurements or board-level risk committees, that effectively align CFO working capital priorities with COO operational continuity imperatives. Third, the emerging phenomenon of collective resilience deserves further investigation: under what contractual frameworks could share inventory hubs, such as the medical device consortium described here, provide robustness while avoiding antitrust concerns? The car industry's coordinated approach of safeguarding semiconductor buffers through pooled warehousing provides a useful example for analysis. Finally, the behavioral foundations of "Resilience Fatigue" necessitate an interdisciplinary examination combining cognitive psychology and operations research. Specifically, researchers should investigate how time-discounting biases and cognitive anchoring influence CEOs' willingness to maintain precautionary inventory when disruption memories fade. Collectively, these research trajectories hold the promise of transforming inventory management from a tactical function to a strategic competence, reimagining working capital as a dynamic resilience currency required to navigate an era of constant disruption.

Declarations

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