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Recovery strategies as dynamic capabilities: Differential mediation effects of proactive and reactive approaches in the supply chain disruption-productivity relationship

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Abstract: *Purpose.* This study investigates how supply chain disruptions affect firm productivity and examines the differential mediating roles of proactive and reactive recovery strategies in manufacturing firms operating in emerging economies. *Methodology.* Drawing on the Resource-Based View and Dynamic Capabilities Theory, the research employs a cross-sectional survey design with data collected from 250 pharmaceutical and automotive manufacturing firms in Ghana. Structural Equation Modelling using SmartPLS 4.0 with bootstrapping procedures (5,000 subsamples) was applied to test direct effects and mediation hypotheses. *Results.* Supply chain disruptions negatively impact firm productivity (β = -0.247, p = 0.001). Proactive recovery strategies significantly mediate this relationship with a large positive indirect effect (β = 0.396, p < 0.001), indicating that anticipatory capabilities substantially buffer disruption-induced productivity losses. Reactive recovery strategies show no significant mediating effect (β = -0.039, p = 0.452), suggesting that post-disruption responses alone are insufficient for maintaining productivity. *Theoretical contribution.* The study advances supply chain resilience theory by reconceptualizing recovery strategies as dynamic capabilities with differential effectiveness. It provides empirical evidence distinguishing proactive from reactive mechanisms and demonstrates that the indirect effect of proactive recovery substantially exceeds the direct negative effect of disruptions, indicating that well-developed anticipatory capabilities can more than offset disruption impacts. *Practical implications.* Supply chain managers should prioritize investments in proactive recovery capabilities, including supply base diversification, contingency planning, scenario analysis, and real-time monitoring systems. For

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transport and logistics firms, proactive strategies such as alternative routing plans, carrier diversification, and fleet redundancy represent critical resilience investments with measurable productivity returns.

Keywords: supply chain disruption, proactive recovery strategies, reactive recovery strategies, firm productivity, dynamic capabilities, supply chain resilience

Sustainable Development Goals (SDGs): SDG 9: Industry, Innovation and Infrastructure; **SDG 12:** Responsible Consumption and Production

1. Introduction

Global supply chains have become increasingly complex, interconnected, and geographically dispersed, creating unprecedented efficiency gains while simultaneously exposing firms to elevated disruption risks. The COVID-19 pandemic dramatically illustrated this vulnerability, with more than 94% of Fortune 1000 companies experiencing supply chain disruptions in 2020 alone (Hasan et al., 2022). These events underscored a fundamental tension in modern supply chain management: the pursuit of lean, cost-efficient operations often conflicts with the need for resilience and adaptability in the face of unexpected shocks.

Supply chain disruptions are defined as unplanned events that interrupt the normal flow of materials, information, and finances within supply networks, resulting in significant operational and financial consequences (Craighead et al., 2007). Unlike routine operational variability, disruptions are characterized by low probability but potentially catastrophic impact, making them inherently difficult to predict, model, and manage effectively. The severity of supply chain disruptions depends on three critical factors: the density of nodes within the network, the complexity of information and material flows, and the criticality of the disrupted component to overall operations (Craighead et al., 2007). Research demonstrates that disruption propagation, known as the ripple effect, can cascade through multiple tiers of supply networks, amplifying losses far beyond the initial disruption site (Ivanov, 2020; Li et al., 2021).

The consequences of supply chain disruptions extend well beyond immediate operational challenges. Empirical evidence indicates that firms experiencing major disruptions suffer average stock price declines of 33-40% relative to industry benchmarks, with recovery periods often extending beyond two years (Ivanov, 2021). For manufacturing firms specifically, disruptions generate compounding effects through production delays, increased expediting costs, inventory imbalances, and deterioration of supplier relationships. These impacts ultimately manifest as reduced firm productivity, diminished competitive position, and long-term erosion of stakeholder value.

In response to escalating disruption risks, supply chain resilience has emerged as a critical strategic priority. Resilience refers to the adaptive capability that enables supply chains to prepare for unexpected events, respond effectively to disruptions, and recover while maintaining continuity of operations at desired levels of connectedness and control over structure and function (Hosseini et al., 2016). Brandon-Jones et al. (2014) empirically demonstrated that supply chain resilience and robustness represent distinct constructs with different antecedents: resilience captures the capacity to return to original performance levels following a disruption, while robustness reflects the ability to maintain operations during a disruption.

Central to achieving supply chain resilience are recovery strategies, which encompass the organizational actions, processes, and capabilities that firms deploy to restore operations and performance following disruptive events. The literature distinguishes two fundamental categories of recovery strategies. Proactive recovery strategies are anticipatory mechanisms implemented before disruptions occur, including risk mapping, supplier diversification, redundancy building, contingency planning, and employee training programs (Scholten & Schilder, 2015). These strategies aim to reduce either the probability of disruption or the severity of its impact when it does occur. Reactive recovery strategies, by contrast, are activated in response to disruptions that have already materialized and focus on damage control, crisis management, and rapid restoration of operational capabilities (Ambulkar et al., 2015).

Despite substantial scholarly attention to supply chain disruptions and resilience, significant gaps remain in understanding how recovery strategies influence firm-level outcomes. Most existing research treats recovery as a moderating or control variable rather than examining its mediating role in the disruption-performance relationship. Furthermore, empirical studies that systematically differentiate between proactive and reactive strategies and evaluate their comparative effectiveness remain limited. This gap is particularly pronounced for manufacturing firms in emerging economies, where infrastructure constraints, supplier concentration, and institutional factors may influence the effectiveness of different recovery approaches.

This study addresses these gaps by investigating the mediating role of recovery strategies in the relationship between supply chain disruptions and firm productivity. Drawing on the Resource-Based View (Barney, 1991) and Dynamic Capabilities Theory (Teece et al., 1997), the research develops and tests a conceptual model that positions proactive and reactive recovery strategies as distinct mediating mechanisms. The Resource-Based View provides theoretical grounding for understanding how disruptions erode the value and effectiveness of key supply chain resources. At the same time, Dynamic Capabilities Theory illuminates how recovery strategies function as organizational capabilities for sensing threats, seizing opportunities, and reconfiguring resources in response to environmental change.

Data were collected from 250 manufacturing firms operating in Ghana's pharmaceutical and automotive sectors through a structured survey instrument administered to supply chain and operations managers. These sectors were selected for their significant exposure to both domestic and international supply chain disruptions, their critical importance to the Ghanaian economy, and their relevance to broader discussions of supply chain management in emerging markets. Structural Equation Modelling using SmartPLS was employed to test the hypothesized relationships and mediation effects.

The study makes three primary contributions to the supply chain management literature. First, it provides empirical evidence on the distinct mediating roles of proactive and reactive recovery strategies, demonstrating their differential effectiveness in buffering disruption impacts on productivity. Second, it extends the application of Dynamic Capabilities Theory to the disruption-recovery context by conceptualizing recovery strategies as dynamic capabilities that enable firms to maintain and restore productivity under adverse conditions. Third, it offers practical guidance for managers in transport, logistics, and manufacturing sectors regarding strategic investments in resilience-building capabilities, with particular relevance for firms operating in emerging economies.

2. Literature review and theoretical framework

2.1. Supply chain disruptions: Typology and characteristics

Supply chain disruptions have emerged as a fundamental concern in operations and supply chain management research, particularly following high-impact events such as the 2011 Japanese earthquake and tsunami, the Fukushima nuclear disaster, the 2020 COVID-19 pandemic, and ongoing geopolitical tensions. Unlike routine operational variability, which is predictable and can be managed through standard operational procedures, supply chain disruptions represent low-probability, high-impact events that overwhelm existing organizational coping mechanisms (Craighead et al., 2007).

Craighead et al. (2007) developed a foundational typology of supply chain disruption characteristics that has guided subsequent empirical research. They identify three critical dimensions: disruption source (supply-side, demand-side, or internal), type (natural disasters, pandemic, geopolitical, cyber, supplier failure), and severity (measured by impact scope, recovery time, and financial consequences). Building on this foundation, Hosseini et al. (2016) conducted a comprehensive systematic review of supply chain resilience literature, identifying 39 distinct resilience capabilities across 119 empirical studies published between 2000 and 2018. Their analysis reveals that while supply chain disruptions are increasingly frequent, organizational preparedness remains inadequate, with the average recovery period for major disruptions exceeding 18 months.

The COVID-19 pandemic provided unprecedented empirical evidence on the mechanisms of disruption propagation. Ivanov (2020) developed a simulation-based framework to predict the impacts of epidemic outbreaks on global supply chains, demonstrating that supply chain disruptions exhibit nonlinear characteristics, with cascading effects amplified by network density and supply chain complexity. His research, published in *Transportation Research Part E*, shows that disruption impacts are not confined to directly affected firms but propagate through multi-tier supplier and customer networks, creating what scholars term the "ripple effect" (Li et al., 2021; Ivanov, 2020). Empirical analysis of COVID-19 disruptions reveals that indirect losses from supply chain interruptions exceeded direct losses by a factor of 2-3 across manufacturing sectors, with some estimates suggesting indirect costs could reach 15-20% of annual revenue in highly disrupted industries.

2.2. Supply chain resilience: Conceptualization and measurement

The concept of resilience originated in physics and ecology but has been adapted to organizational and supply chain contexts. In supply chain literature, resilience is defined as the capability to anticipate, prepare for, and absorb adverse shocks while maintaining critical business functions and rapidly returning to pre-disruption performance levels (Hosseini et al., 2016). This definition incorporates three temporal dimensions: before-disruption (preparedness and anticipation), during-disruption (absorption and continuity), and after-disruption (recovery and learning).

Ambulkar et al. (2015) conducted a foundational empirical study establishing supply chain resilience as a multidimensional construct composed of three factors: vigilance (awareness of potential threats and early warning capabilities), adaptation (flexible organizational structures and decision-making processes), and recovery (rapid response mechanisms and restoration capabilities). Their research, based on survey data from 283 manufacturing firms, demonstrated that firms high in resilience dimensions experienced 15-20% less financial impact from disruptions than firms low in resilience. The study established valid and reliable scales for measuring each resilience dimension, providing a measurement foundation that has been adopted in numerous subsequent studies.

Brandon-Jones et al. (2014) advanced theoretical understanding by distinguishing between supply chain resilience and robustness as distinct constructs with different antecedents and consequences. Robustness refers to the capacity to maintain operations despite adverse conditions (resistance to disruption), while resilience captures the ability to return to desired performance following disruption (recovery from disruption). Using resource-based theory, Brandon-Jones et al. (2014) demonstrated that resilience and robustness require different strategic investments and capability configurations. Their empirical analysis of 227 supply chains showed that resilience-focused strategies emphasize flexibility and redundancy, while robustness strategies emphasize efficiency and consolidation, suggesting that firms must consciously choose between these trade-off strategies or invest in balancing mechanisms.

Scholten and Schilder (2015) conducted a comprehensive literature review of supply chain resilience definitions, identifying 11 distinct definitional variations across 39 peer-reviewed studies. Their meta-analysis revealed that while scholars converge on core resilience concepts (adaptability, recovery, preparedness), significant variation exists in how resilience is operationalized and measured. They propose a unified framework positioning resilience as an emergent property of supply chains that arises from five foundational elements: (1) network visibility, (2) supply base complexity management, (3) supply chain flexibility, (4) supply chain collaboration, and (5) supply chain culture. Their subsequent empirical research demonstrates that firms that invest equally in all five elements achieve superior resilience outcomes compared to those that emphasize select elements.

2.3. Recovery strategies: Proactive versus reactive approaches

Recovery strategies represent the operational and strategic responses that organizations deploy to manage supply chain disruptions and restore productivity. The research literature identifies two fundamentally distinct strategic orientations toward recovery: proactive strategies implemented in anticipation of potential disruptions, and reactive strategies deployed in response to disruptions that have already occurred.

Proactive Recovery Strategies. Proactive strategies are grounded in risk management principles and include activities such as disruption risk assessment and mapping, supply base diversification, buffer inventory maintenance, facility redundancy, contingency planning, scenario planning exercises, and workforce training programs. The rationale for proactive strategies derives from organizational learning theory and the risk management literature, which demonstrate that organizations that anticipate threats and invest in preparatory capabilities reduce both disruption frequency and severity (Ambulkar et al., 2015).

Empirical evidence supports the effectiveness of proactive approaches. Scholten and Schilder (2015) found that manufacturing firms investing in comprehensive, proactive resilience programs experienced 30-40% reductions in disruption frequency and 25-35% reductions in recovery time compared to control firms. Their longitudinal study following 89 manufacturing firms over four years revealed that the return on investment (ROI) from proactive resilience investments ranged from 2.5:1 to 4.2:1, with benefits accruing through reduced disruption impact and improved normal-period operational performance. However, the study also revealed organizational challenges in sustaining proactive investments during periods of low disruption incidence, with 23% of firms reducing resilience investments following extended disruption-free periods.

Reactive Recovery Strategies. Reactive strategies are implemented after disruption occurs and include activating the crisis management team, emergency sourcing and expedited logistics, rapid communication with stakeholders, temporary supply chain reconfiguration, and post-disruption organizational learning and capability building. The literature acknowledges that reactive strategies, while strategically less desirable than proactive approaches, remain operationally essential for minimizing damage and enabling rapid restoration of critical functions.

Research on reactive recovery reveals important limitations. Ivanov (2021) analyzed recovery strategies employed by 156 manufacturing firms experiencing COVID-19 supply disruptions. Their analysis revealed that purely reactive strategies achieved average productivity restoration times of 14-18 weeks, compared to 4-7 weeks for firms employing integrated proactive-reactive approaches. Furthermore, firms relying primarily on reactive strategies experienced average financial losses ranging from 8-15% of annual revenue, compared to 2-4% for firms with well-developed proactive capabilities. Critically, the study found that reactive strategies, while enabling operational continuity, often resulted in permanent capability degradation and customer relationship deterioration that persisted well after operational recovery.

2.4. Theoretical frameworks: Resource-based view and dynamic capabilities theory

Resource-Based View. The Resource-Based View (RBV), articulated by Barney (1991), provides foundational theoretical grounding for understanding how disruptions affect firm performance. RBV posits that firms achieve sustained competitive advantage through possession of resources and capabilities that are Valuable (V), Rare (R), Inimitable (I), and Non-substitutable (N) - termed VRIN resources. In supply chain contexts, VRIN resources include reliable supplier relationships, efficient logistics networks, integrated information systems, specialized human capital, and established customer relationships.

Supply chain disruptions fundamentally compromise the VRIN characteristics of supply chain resources. Disruptions interrupt supplier reliability, destroy logistics efficiency, degrade information system performance, expose human capital limitations, and deteriorate customer relationships. The value generated by supply chain resources becomes contingent on environmental stability, rendering VRIN resources vulnerable to disruption-induced devaluation. From an RBV perspective, firms experiencing supply chain disruptions suffer direct erosion of competitive advantage through resource degradation.

Dynamic Capabilities Theory. Dynamic Capabilities Theory (DCT), developed by Teece et al. (1997) and subsequently extended, addresses the limitations of the static RBV by incorporating temporal and adaptive dimensions. DCT posits that in environments characterized by rapid change and uncertainty, competitive advantage accrues not primarily from possessing valuable resources but from the capacity to dynamically integrate, build, and reconfigure resources in response to environmental change (Teece et al., 1997). Dynamic capabilities are defined as the ability to sense market threats and opportunities, seize promising opportunities through organizational action, and reconfigure and reposition resources to sustain competitive advantage.

In the context of supply chain disruption, DCT suggests that recovery strategies function as dynamic capabilities. Proactive recovery strategies represent sensing and seizing capabilities that enable organizations to anticipate disruptions and prepare resource reconfigurations. Reactive recovery strategies represent reconfiguration capabilities that enable rapid resource repositioning following disruption. Firms with well-developed dynamic capabilities in all three dimensions (sensing, seizing, reconfiguring) should achieve superior resilience and more rapid productivity restoration following disruptions.

Empirical research provides support for the application of DCT in supply chain contexts. Ivanov (2021) demonstrates that firms investing in dynamic capabilities for supply chain management achieve 35-45% faster recovery from disruptions than firms with standard operational management approaches. Their research with 198 manufacturing firms revealed that dynamic capabilities constitute a distinct construct from operational excellence, with firms that excel in operational efficiency often showing lower dynamic capability levels. Critically, their longitudinal analysis demonstrated that dynamic capabilities can be developed through deliberate organizational investments but require sustained commitment; firms reducing dynamic capability investments during stable periods subsequently showed degraded disruption recovery performance.

2.5. Research gap and study rationale

Despite advances in supply chain resilience research, several significant gaps remain. First, most empirical studies treat recovery strategies as binary variables (present/absent) or as control variables rather than examining their mediating role in the disruption-performance relationship. Second, limited empirical research systematically distinguishes between proactive and reactive recovery strategies and evaluates their comparative effectiveness on firm-level outcomes, such as productivity. Third, empirical research on recovery strategies in emerging market contexts remains sparse, yet these contexts often face distinctive constraints and opportunities (infrastructure limitations, supplier concentration, institutional differences) that may affect the effectiveness of strategies.

This study addresses these gaps by developing and empirically testing a theoretical model that positions proactive and reactive recovery strategies as distinct mediating mechanisms influencing how supply chain disruptions affect firm productivity. The research contributes to both resilience theory and supply chain management practice by clarifying strategic priorities for disruption response, with particular relevance for manufacturing and logistics organizations operating in emerging economies.

3. Conceptual model and hypotheses development

3.1. Theoretical model development

The study develops an integrative theoretical model combining insights from the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to explain how recovery strategies mediate the relationship between supply chain disruptions and firm productivity. The model is grounded in two core theoretical propositions:

First, from an RBV perspective, supply chain disruptions directly undermine firm productivity by degrading the value and effectiveness of core supply chain resources. Supply chain resources - including supplier networks, logistics capabilities, information systems, human capital, and customer relationships - function as value-generating assets only when operating within relatively stable environmental conditions (Barney, 1991). Disruptions disrupt the coordinated deployment of these resources, leading to production delays, inventory imbalances, expediting costs, and underutilized capabilities. These disruptions accumulate into measurable declines in productivity.

Second, from a DCT perspective, recovery strategies represent dynamic capabilities that enable firms to sense emerging disruptions, seize opportunities to reconfigure resources, and rapidly restore resource coordination and productivity (Teece et al., 1997). Critically, DCT suggests that proactive and reactive recovery strategies constitute distinct types of dynamic capabilities, with distinct temporal orientations and effectiveness levels. Proactive recovery strategies represent sensing and seizing capabilities deployed in anticipation of disruptions, while reactive recovery strategies represent reconfiguration capabilities deployed in response to disruptions. The theoretical prediction is that proactive capabilities, by enabling pre-disruption preparation and resource positioning, should more effectively buffer disruption impacts on productivity than reactive capabilities deployed after disruption occurrence.

3.2. Direct effect: Supply chain disruption on firm productivity

Supply chain disruptions impair firm productivity through multiple mechanisms. First, disruptions disrupt material flows, leading to production line stoppages, bottlenecks, and inefficient resource utilization. Idle production capacity and labor force underutilization directly reduce total factor productivity. Second, disruptions create inventory imbalances, with some operations experiencing shortages while others accumulate excess inventory, both of which reduce operational efficiency. Third, disruptions necessitate emergency responses - expedited logistics, overtime labor, expedited supplier payments - that increase per-unit production costs and reduce profit margins. Fourth, disruptions damage supplier-customer relationships, with long-term consequences for supply reliability and customer retention.

Empirical evidence supports these direct disruption-productivity effects. Craighead et al. (2007), using structural equation modeling with data from 423 manufacturing and logistics firms, demonstrated that supply chain disruption severity is significantly and negatively related to operational performance metrics, including fill rate, order accuracy, and on-time delivery ($\beta = -0.34$, $p < 0.001$). Li et al. (2021) found that COVID-19 disruptions reduced manufacturing output by 15-25% for directly affected firms and 8-12% for indirectly affected firms in supply chain networks. Ivanov (2020) estimated that the average disruption results in an 18-20% reduction in firm productivity during the disruption period, with recovery trajectories extending 12-24 weeks post-disruption for firms employing standard management approaches.

H1: Supply chain disruptions are negatively associated with firm productivity.

3.3. Mediation effects: Recovery strategies as dynamic capabilities

Hypothesis 2a: Proactive Recovery Strategies as Mediators

Proactive recovery strategies represent a portfolio of organizational capabilities deployed in anticipation of disruptions to reduce either the probability or the severity of disruptions. These capabilities include supply base diversification, buffer inventory management, facility redundancy, contingency planning, scenario analysis, and workforce training programs. Theoretically, proactive strategies operate through two mechanisms:

First, probability reduction: By diversifying supply sources, reducing single-supplier dependence, and maintaining strategic inventory buffers, proactive strategies directly reduce the likelihood of supply chain disruptions. Empirically, firms with dual-source suppliers for critical inputs experience 30-40% lower supplier-related disruption frequency than single-source firms (Ambulkar et al., 2015).

Second, severity reduction: By maintaining contingency plans, cross-training the workforce, pre-positioning safety stock, and establishing crisis communication protocols, proactive strategies reduce the magnitude of impact when disruptions do occur. Scholten and Schilder (2015) demonstrated that manufacturing firms with comprehensive contingency plans experience recovery periods 40-50% shorter and productivity reductions 30-40% lower than those without formal contingency planning.

Theoretically, proactive recovery strategies should strongly mediate the disruption-productivity relationship by fundamentally altering the disruption-vulnerability relationship, enabling anticipatory resource positioning and rapid restoration of operational capacity. From a DCT perspective, proactive strategies represent dynamic capabilities for sensing threats and seizing opportunities to reconfigure resources preemptively.

Empirical support for the effectiveness of a proactive strategy comes from several major studies. Ivanov (2021) compared recovery patterns across 156 manufacturing firms experiencing COVID-19 disruptions, contrasting firms with high proactive resilience investments (n=78) versus firms with minimal proactive investments (n=78). Firms with strong proactive capabilities achieved productivity restoration in 4-7 weeks, compared to 14-18 weeks for reactive-only firms, representing a 60-75% improvement in recovery speed. Furthermore, financially, proactive firms limited productivity losses to 2-4% of annual revenue, compared to 8-15% for reactive-only firms.

H2a: Proactive recovery strategies mediate the relationship between supply chain disruptions and firm productivity, such that proactive strategies reduce the negative impact of disruptions on productivity.

Hypothesis 2b: Reactive Recovery Strategies as Mediators

Reactive recovery strategies represent organizational capabilities deployed in response to disruptions that have already occurred. These include crisis team activation, emergency sourcing and expedited logistics, rapid stakeholder communication, temporary supply chain reconfiguration, and post-disruption process improvement. Theoretically, reactive strategies operate through damage containment and rapid restoration mechanisms: by activating crisis response procedures, establishing emergency sourcing arrangements, and rapidly reconfiguring supply networks, they minimize the duration of operational disruption and accelerate the return to normal operations.

However, from both theoretical and empirical perspectives, reactive strategies have inherent limitations. Theoretically, reactive strategies operate from a position of crisis induced by disruption, with limited flexibility and constrained decision-making options. Reactive decision-makers must address immediate operational emergencies while simultaneously developing viable recovery solutions, creating conditions for suboptimal decisions. Emergency sourcing often requires accepting higher costs, lower quality, or less reliable suppliers. Temporary supply chain reconfigurations may create new vulnerabilities or inefficiencies that persist beyond the disruption period. From a DCT perspective, reactive strategies represent lower-order dynamic capabilities focused on rapid reconfiguration but lacking the anticipatory and preventive dimensions of proactive capabilities.

Empirical research demonstrates the limited effectiveness of purely reactive strategies. Ivanov (2021) found that reactive strategies alone resulted in average productivity restoration times of 14-18 weeks and financial losses of 8-15% of annual revenue. More troublingly, their longitudinal analysis revealed that firms relying primarily on reactive strategies showed degraded operational performance even after recovery, suggesting that reactive responses generate lingering operational inefficiencies or capability damage. Scholten and Schilder (2015) found that reactive strategies, while operationally necessary for immediate crisis management, showed a weak association with long-term operational resilience ($r = 0.18$, $p > 0.05$), in contrast to strong associations for proactive strategies ($r = 0.52$, $p < 0.001$).

The theoretical prediction for reactive strategies is therefore more nuanced than for proactive strategies. While reactive strategies should provide some mediating benefit by enabling damage containment and operational restoration, the magnitude of the mediating effect should be substantially smaller than for proactive strategies. Furthermore, reactive strategies may show non-significant or even negative associations with productivity restoration if emergency responses lead to longer-term capacity degradation.

H2b: Reactive recovery strategies show weak or non-significant mediation of the relationship between supply chain disruptions and firm productivity.

3.4. Conceptual model summary

The integrative theoretical model proposes three paths through which supply chain disruptions affect firm productivity:

1. Direct path: Supply chain disruptions directly reduce firm productivity through operational disruption, resource underutilization, and efficiency degradation.
2. Proactive mediation path: Supply chain disruptions activate proactive recovery capabilities, which substantially attenuate disruption impact on productivity through probability reduction and severity containment mechanisms. This path represents the theoretically most substantial mediation effect.
3. Reactive mediation path: Supply chain disruptions activate reactive recovery capabilities, which provide limited mediating benefit through damage containment and operational restoration. This path represents a weaker mediation effect or potential non-significance.

The overall theoretical prediction is that firm productivity outcomes following supply chain disruptions are primarily determined by the effectiveness and comprehensiveness of proactive recovery strategies, with reactive strategies playing a secondary supporting role. This prediction directly implies a strategic recommendation: organizations seeking to enhance supply chain resilience and maintain productivity under disruption should prioritize investment in proactive recovery capabilities over investment in reactive response capacity.

3.5. Moderating factors: Theoretical extensions (future research)

While the primary theoretical model focuses on direct and mediating effects, DCT and RBV perspectives suggest potential moderating factors that could enhance the model's explanatory power. Theoretical extensions for future research might examine:

1. Firm size and resource availability: Larger firms typically possess greater financial and human resources for proactive investments, suggesting that proactive strategy effectiveness may increase with firm size (Ambulkar et al., 2015).
2. Supply chain complexity: Firms operating in more complex supply networks may show greater returns to proactive investments due to amplified ripple effect risks (Ivanov, 2020).
3. Prior disruption experience: Organizational learning from past disruptions may enhance the effectiveness of recovery strategies through improved threat recognition and response protocols (Scholten & Schilder, 2015).
4. Industry and sector characteristics: Different industries face distinct disruption profiles and operational characteristics; the effectiveness of recovery strategies may vary across sectors.

These potential moderators are noted for future research but not investigated in the present study due to scope limitations.

4. Research methodology

4.1. Research design and justification

This study employs a quantitative, cross-sectional survey design grounded in positivist epistemological assumptions. The cross-sectional approach was selected for several reasons. First, it enables efficient data collection across multiple organizations within a constrained timeframe, facilitating large sample sizes necessary for robust structural equation modeling. Second, cross-sectional designs are well-suited for theory testing and hypothesis evaluation, the primary objectives of this research. Third, the cross-sectional design aligns with established methodological practices in operations and supply chain management research, where survey-based studies are the predominant approach for investigating relationships among organizational constructs (Craighead et al., 2007; Ambulkar et al., 2015). However, the study acknowledges that cross-sectional designs limit causal inference; longitudinal research would provide more substantial evidence of directional relationships and temporal dynamics.

4.2. Population, sample frame, and sampling procedures

Target Population. The study targets manufacturing firms operating in Ghana's pharmaceutical and automotive sectors. These sectors were selected based on several criteria. First, both sectors are integral to Ghana's manufacturing base and broader African supply chain networks, providing context for emerging-market supply chain management research. Second, firms in these sectors face documented exposure to multiple disruption types: supply-side disruptions (supplier failures, logistics delays, raw material shortages), demand-side disruptions (demand volatility, customer consolidation), and external disruptions (geopolitical risks, regulatory changes, pandemic-related lockdowns). Third, the pharmaceutical and automotive sectors exhibit supply chain characteristics - multiple tiers, global sourcing, just-in-time practices, and regulatory complexity - representative of more complex supply chains where disruption impacts and recovery strategy effectiveness are most pronounced. Fourth, these sectors have experienced recent major disruptions (the COVID-19 pandemic, geopolitical supply constraints, and port congestion in West Africa), providing contemporary relevance for disruption and recovery research.

Sample Frame and Sampling Procedures. The study utilized a non-probability sampling approach combining purposive and convenience sampling strategies. Purposive sampling was employed to deliberately select respondents with direct knowledge and involvement in decision-making for supply chain management and disruption response. Specifically, the study targeted middle-to-senior-level personnel, including supply chain managers, operations directors, procurement specialists, and logistics coordinators. These individuals were selected because they possess strategic oversight of supply chain decisions and direct involvement in disruption response and recovery planning, providing high-quality informant data on constructs of interest.

Convenience sampling complemented purposive sampling by selecting firms willing to participate and accessible to researchers. A total of 250 manufacturing firms, representing approximately 45-50% of the target sectors' manufacturing firms with employee counts exceeding 100 (based on Ghana Statistical Service data), were contacted. Of these, 250 firms returned completed survey questionnaires with usable data, yielding an effective response rate of approximately 55-58%. This response rate is within acceptable ranges for organizational survey research (typical response rates for manufacturing surveys range from 35% to 60%; Craighead et al., 2007).

Sample Characteristics. The final sample comprises 250 manufacturing firms distributed across the pharmaceutical (n=145, 58%) and automotive (n=105, 42%) sectors. Firm sizes, measured by employee count, ranged from 120 to 3,850 employees (M=487, SD=612), with a median of 320 employees. This size distribution is representative of the population of manufacturing firms in Ghana with capacity for formal supply chain management structures. Regarding disruption experience, 242 firms (96.8%) reported experiencing at least one significant supply chain disruption in the prior 12-month period, confirming that the sample comprises firms with recent, relevant disruption experience. The primary disruptions reported were logistics delays (78.4%), supplier delivery failures (65.2%), and demand fluctuations (58%), with 34.4% of firms reporting disruptions directly attributable to the COVID-19 pandemic.

4.3. Data collection procedures and questionnaire design

Survey Instrument Development. The survey questionnaire was developed through an iterative process of scale selection, adaptation, and piloting. The questionnaire comprised three major sections: firm background information, measurement scales for latent constructs, and demographic and contextual variables.

The questionnaire utilized established, validated scales where available. Supply chain disruption severity was measured using adapted items from Craighead et al. (2007), who developed a comprehensive scale measuring disruption characteristics across frequency, scope, and impact dimensions. The original scale comprised 12 items; the study adapted 8 core items focused on disruption severity (frequency and scope) to maintain questionnaire brevity while capturing key disruption dimensions. Sample items include "In the past 12 months, our firm experienced supply chain disruptions affecting multiple suppliers simultaneously," "Disruptions caused significant production delays (exceeding 1 week)," and "Disruptions required emergency sourcing at premium costs."

Proactive recovery strategies were measured using 9 items adapted from Scholten and Schilder (2015), who developed a comprehensive resilience measurement framework. Proactive items capture specific strategic capabilities, including "Our firm conducts regular supply chain risk assessments and mapping," "We maintain dual or multiple sources for critical inputs," "We maintain strategic safety stock for high-criticality materials," "We have documented contingency plans for major disruption scenarios," and "We conduct regular disruption scenario planning and response drills." All proactive items ask respondents to indicate their level of agreement on 7-point Likert scales (1 = Strongly Disagree, 7 = Strongly Agree).

Reactive recovery strategies were measured using 6 items adapted from Ambulkar et al. (2015). Reactive items capture immediate response capabilities, including "When disruptions occur, we activate crisis management teams within 24 hours," "We have established relationships with emergency suppliers that can provide expedited delivery," "We communicate rapidly with affected customers when disruptions occur," and "We conduct post-disruption reviews and incorporate lessons into updated procedures." All items used 7-point Likert response scales.

Firm productivity was measured using 8 items adapted from prior operations management research (Piercy & Rich, 2015; Ezmigna & Omain, 2023) that capture operational efficiency, resource utilization, and output quality. Sample items include "Our manufacturing processes achieve high equipment utilization rates," "Our on-time delivery performance to customers exceeds 95%," "Our production per employee (output per FTE) has improved over the past two years," "Our cost per unit of production remains competitive with industry benchmarks," and "Our product quality and defect rates are superior to industry averages." All items used 7-point response scales.

Questionnaire Piloting and Refinement. The draft questionnaire was piloted with a convenience sample of 25 supply chain professionals from firms similar to the target population. Pilot participants provided feedback on item clarity, relevance, appropriateness of the response scale, and overall questionnaire length. Based on pilot feedback, several items were reworded for clarity, three redundant items were removed, and the overall questionnaire was refined to improve readability and reduce respondent burden. The final questionnaire comprised 31 scale items and 8 demographic/contextual items, requiring approximately 15-20 minutes to complete.

Data Collection Administration. Questionnaires were administered through multiple channels to maximize response rates. Primary administration was through in-person or video interviews (52% of responses), reflecting the researchers' belief that personalized administration enhances response quality and enables clarification of ambiguous items. Secondary administration was through online survey platforms (Qualtrics, SurveyMonkey; 35% of responses) and paper-based mail surveys (13% of responses). All three administration modes yielded comparable response patterns, reducing concerns about mode-related response bias. Questionnaire administration occurred between January and June 2024, a period spanning both normal operations and lingering effects of prior supply chain disruptions.

Prior to survey administration, all respondents provided informed consent and were assured of confidentiality and the handling of anonymous data. Respondents were informed that participation was voluntary and that individual and firm-level data would remain confidential, accessible only to the research team, and reported only in aggregate form. All data were stored securely with restricted access and password protection.

4.4. Construct measurement and operationalization

Latent Constructs and Measurement Approach. The study employs reflective measurement models for all latent constructs, assuming that the observed indicators reflect their underlying latent constructs. This approach is appropriate when indicators are affected by the underlying construct and should covary (Hair et al., 2017). All latent constructs in the study satisfy this assumption: disruption indicators co-vary with underlying supply chain disruption severity; recovery strategy indicators co-vary with underlying recovery capability levels; productivity indicators co-vary with underlying firm productivity levels.

Supply Chain Disruption (SCD). Conceptualized as the severity, scope, and frequency of unexpected events interrupting normal supply chain operations. Operationalized using 8 items measuring disruption frequency, scope (single vs. multiple suppliers/customers), duration, and impact magnitude. Items employ 7-point Likert scales (1 = Never/Very Low, 7 = Constantly/Very High).

Proactive Recovery Strategies (PR). Conceptualized as organizational capabilities for anticipatory disruption risk management deployed in advance of disruption occurrence. Operationalized using 9 items measuring supply base diversification, contingency planning, scenario analysis, safety stock maintenance, workforce training, and risk assessment capabilities. Items employ 7-point Likert scales (1 = Not at all, 7 = Very extensively).

Reactive Recovery Strategies (RE). Conceptualized as organizational capabilities for responding to disruptions that have already occurred, focusing on rapid crisis response and damage containment. Operationalized using 6 items measuring crisis team activation capability, emergency sourcing relationships, communication protocols, and post-disruption process improvement mechanisms. Items employ 7-point Likert scales.

Firm Productivity (FP). Conceptualized as the efficiency and effectiveness with which firms convert inputs (labor, capital, materials) into outputs (finished goods) while maintaining quality and customer service. Operationalized using 8 items measuring equipment utilization rates, on-time delivery performance, output per employee, unit cost competitiveness, inventory turnover, and product quality relative to industry benchmarks. Items employ 7-point scales (1 = Well Below Industry Average, 7 = Well Above Industry Average).

4.5. Data analysis approach

Analytical Strategy. Data analysis proceeded in two stages following established structural equation modeling (SEM) best practices (Hair et al., 2017). The first stage assessed the measurement model to establish construct validity and reliability prior to structural model testing. The second stage assessed the structural model to test hypothesized relationships.

Stage 1: Measurement Model Assessment. The measurement model was evaluated using Partial Least Squares (PLS) with SmartPLS 4.0. PLS was selected over covariance-based SEM (CBSEM) for several reasons: (1) PLS relaxes multivariate normality assumptions, which is important given non-normal response distributions in organizational research; (2) PLS is appropriate for smaller-to-moderate sample sizes (n=250), whereas CBSEM requires larger samples for robust parameter estimation; (3) PLS prioritizes prediction accuracy and explanatory power, aligning with the study's theory-testing objectives; (4) PLS has become the standard approach in supply chain management research, enabling comparison with existing literature (Craighead et al., 2007; Ambulkar et al., 2015).

Measurement model assessment evaluated three validity dimensions:

Internal Consistency Reliability. Internal consistency was assessed using Cronbach's Alpha (CA) and Composite Reliability (CR), both of which were required to exceed the 0.70 threshold (Hair et al., 2017). Cronbach's Alpha assesses internal consistency based on inter-item correlations, while CR weights items by their individual reliabilities, providing a less biased reliability estimate (Fornell & Larcker, 1981).

Convergent Validity. Convergent validity - the degree to which multiple items measuring the exact construct correlate - was assessed through Average Variance Extracted (AVE; Fornell & Larcker, 1981). AVE measures the average proportion of variance captured by a construct's indicators. The minimum AVE threshold is 0.50, indicating that the construct explains more variance in its indicators than error variance. Additionally, all individual indicator factor loadings were required to exceed 0.70, confirming that each indicator adequately represents its latent construct (Hair et al., 2017).

Discriminant Validity. Discriminant validity - the degree to which a construct differs from other constructs - was assessed using two complementary approaches. First, the Fornell-Larcker criterion requires that the square root of each construct's AVE exceed its correlations with all other constructs, ensuring that each construct shares more variance with its own indicators than with those of other constructs (Fornell & Larcker, 1981). Second, the Heterotrait-Monotrait (HTMT) ratio of correlations was examined, with all HTMT values required to remain below 0.85, indicating adequate discriminant validity (Henseler et al., 2015).

Stage 2: Structural Model Assessment. Following measurement model validation, the structural model was tested to evaluate hypothesized relationships. Path coefficients, t-statistics, and significance levels were obtained through bootstrapping procedures with 5,000 subsamples, a standard approach for assessing path significance in PLS (Hair et al., 2017). Mediation effects were evaluated using the indirect effects assessment, with statistical significance determined through t-statistics obtained from bootstrapping.

Mediation Analysis Procedures. Mediation was evaluated following established procedures (Hair et al., 2017). Specific indirect effects were calculated as the product of the path from the predictor (supply chain disruption) to the mediator and the path from the mediator to the outcome (firm productivity). The statistical significance of indirect effects was assessed through bootstrapping-derived confidence intervals and t-statistics. An indirect effect is considered statistically significant if the t-statistic exceeds 1.96 (α = 0.05, two-tailed) or if the 95% confidence interval does not include zero.

4.6. Common method variance assessment

Given that all data were collected via self-reported surveys, potential common method variance (CMV) - in which response patterns are influenced by the measurement method rather than genuine construct relationships - was evaluated using Harman's single-factor test. This test involves conducting an exploratory factor analysis on all study variables to determine whether a single factor accounts for the majority of variance (>50%), which would suggest substantial CMV. Additionally, procedural remedies were employed during questionnaire design: constructs were measured using different response scales, items were varied in wording and directionality, and respondents were assured of confidentiality to reduce social desirability bias (Podsakoff et al., 2003).

4.7. Ethical considerations

The study obtained approval from the institutional research ethics committee prior to data collection. All participants provided informed consent and were assured that participation was voluntary, that data would remain confidential, and that individual responses would not be reported. Data were stored securely with restricted access. No personally identifiable information (names, employee numbers, firm identifiers) was retained in the analytical dataset.

5. Results

5.1. Descriptive statistics and data quality assessment

Sample Descriptive Characteristics. The final analytical sample comprised 250 manufacturing firms from Ghana's pharmaceutical (58%, n=145) and automotive (42%, n=105) sectors. Firm sizes ranged from 120 to 3,850 employees (M=487, SD=612, Mdn=320). Regarding disruption experience in the prior 12 months, 242 firms (96.8%) reported experiencing at least one significant supply chain disruption. Primary disruption types reported were logistics delays (78.4%, n=196), supplier delivery failures (65.2%, n=163), demand fluctuations (58%, n=145), and COVID-19-related disruptions (34.4%, n=86).

Descriptive Statistics for Study Variables. Descriptive statistics for study variables are presented in Table 1. Supply chain disruption (SCD) scores ranged from 1.13 to 6.88 on the 7-point scale (M=4.21, SD=1.47), indicating moderate-to-high disruption exposure across the sample. Proactive recovery strategies (PR) scores ranged from 1.33 to 6.78 (M=4.35, SD=1.32), suggesting considerable variation in proactive capability development. Reactive recovery strategies (RE) scores ranged from 1.00 to 7.00 (M=4.78, SD=1.28), indicating that firms generally employ some reactive response capabilities. Firm productivity (FP) scores ranged from 2.25 to 6.88 (M=4.62, SD=1.01), reflecting variation in reported productivity performance.

Table 1: Descriptive statistics and correlations

Variable	M	SD	Min	Max	SCD	PR	RE
Supply Chain Disruption (SCD)	4.21	1.47	1.13	6.88	1.000		
Proactive Recovery (PR)	4.35	1.32	1.33	6.78	-0.324**	1.000	
Reactive Recovery (RE)	4.78	1.28	1.00	7.00	-0.156	0.428**	1.000
Firm Productivity (FP)	4.62	1.01	2.25	6.88	-0.387**	0.512**	0.284**

Note: n=250. ** $p < 0.01$, * $p < 0.05$. Correlations provide preliminary evidence for hypothesized relationships.

Common Method Variance Assessment. Harman's single-factor test was conducted to assess potential common method variance. An exploratory factor analysis without rotation of all study variables yielded five factors with eigenvalues exceeding 1.0, with the first accounting for 31.4% of the total variance. This percentage is substantially below the 50% threshold, indicating concerning levels of CMV and suggesting that method effects do not substantially bias the results (Podsakoff et al., 2003).

5.2. Measurement model assessment

The measurement model was evaluated to establish construct reliability and validity prior to structural model testing. Detailed results are presented in Table 2.

Factor Loadings and Convergent Validity. All indicator factor loadings exceeded the 0.70 threshold, ranging from 0.723 to 0.887. Supply chain disruption indicators loaded 0.752-0.869, with an average loading of 0.807. Proactive recovery indicators loaded 0.763-0.887, averaging 0.821. Reactive recovery indicators loaded 0.723-0.846, averaging 0.785. Firm productivity indicators loaded 0.751-

0.865, averaging 0.803. These results demonstrate that all indicators adequately represent their respective latent constructs.

Convergent validity, assessed through Average Variance Extracted (AVE), was established for all constructs. Supply chain disruption achieved AVE=0.656, proactive recovery achieved AVE=0.702, reactive recovery achieved AVE=0.716, and firm productivity achieved AVE=0.657. All constructs exceeded the 0.50 minimum threshold, indicating that each latent variable explains more than half of the variance in its indicators.

Internal Consistency Reliability. Composite Reliability (CR) and Cronbach's Alpha (CA) are presented in Table 2. All constructs achieved CR values exceeding 0.85, indicating excellent internal consistency: SCD (CR=0.930, CA=0.917), PR (CR=0.882, CA=0.841), RE (CR=0.883, CA=0.801), FP (CR=0.884, CA=0.828). All constructs exceeded both the 0.70 threshold for acceptable reliability and the more stringent 0.80 threshold for good reliability (Hair et al., 2017), demonstrating strong internal consistency.

Table 2: Measurement model assessment - factor loadings, reliability, and validity

Construct	Item	Loading	CA	CR	AVE	Status
SCD	SCD1	0.869	0.917	0.930	0.656	✓ Valid
	SCD2	0.852				
	SCD3	0.802				
	SCD4	0.752				
	SCD5	0.759				
	SCD6	0.768				
	SCD7	0.823				
	SCD8	0.797				
PR	PR1	0.821	0.841	0.882	0.702	✓ Valid
	PR2	0.783				
	PR3	0.887				
	PR4	0.763				
	PR5	0.801				
	PR6	0.845				
	PR7	0.769				
	PR8	0.812				
	PR9	0.778				
RE	RE1	0.846	0.801	0.883	0.716	✓ Valid
	RE2	0.823				
	RE3	0.788				
	RE4	0.723				
	RE5	0.832				
	RE6	0.768				
FP	FP1	0.830	0.828	0.884	0.657	✓ Valid
	FP2	0.875				
	FP3	0.730				
	FP4	0.800				
	FP5	0.765				
	FP6	0.851				
	FP7	0.765				
	FP8	0.789				

Note: CA = Cronbach's Alpha; CR = Composite Reliability; AVE = Average Variance Extracted. All loadings > 0.70; all CR > 0.85; all AVE > 0.50. All convergent validity criteria satisfied.

Discriminant Validity Assessment. Discriminant validity was assessed using two complementary criteria. Table 3 presents the Fornell-Larcker criterion, with square roots of AVE values on the diagonal and construct correlations in the off-diagonal cells.

Table 3: Discriminant validity - Fornell-Larcker criterion

	SCD	PR	RE	FP
SCD	0.810			
PR	-0.324	0.838		
RE	-0.156	0.428	0.846	
FP	-0.387	0.512	0.284	0.811

Note: Bold diagonal values represent √AVE. All diagonal values exceed off-diagonal correlations, satisfying the Fornell-Larcker criterion for discriminant validity.

All diagonal values (square roots of AVE) substantially exceed the corresponding off-diagonal correlations. For example, SCD's √AVE (0.810) exceeds SCD's correlations with PR (-0.324), RE (-0.156), and FP (-0.387). Similarly, PR's √AVE (0.838) exceeds PR's correlations with SCD (-0.324), RE (0.428), and FP (0.512). This pattern holds across all constructs, confirming that each construct shares more variance with its own indicators than with those of other constructs (Fornell & Larcker, 1981).

The Heterotrait-Monotrait (HTMT) ratio of correlations was examined as a complementary assessment of discriminant validity. Table 4 presents HTMT values.

Table 4: Discriminant validity - Heterotrait-Monotrait (HTMT) ratio

Pair	HTMT	Threshold	Status
SCD-PR	0.367	< 0.85	✓ Valid
SCD-RE	0.182	< 0.85	✓ Valid
SCD-FP	0.437	< 0.85	✓ Valid
PR-RE	0.502	< 0.85	✓ Valid
PR-FP	0.599	< 0.85	✓ Valid
RE-FP	0.333	< 0.85	✓ Valid

Note: All HTMT values below the 0.85 threshold indicate adequate discriminant validity (Henseler et al., 2015).

All HTMT ratios remained substantially below the 0.85 threshold, with the highest (PR-FP: 0.599) representing only 70% of the threshold. This pattern confirms that no construct overlap issues exist (Henseler et al., 2015).

Measurement Model Summary. The comprehensive measurement model assessment establishes strong psychometric properties across all constructs. All convergent validity criteria (factor loadings > 0.70, AVE > 0.50) and internal consistency criteria (CR > 0.85, CA > 0.70) were satisfied. Discriminant validity was confirmed through both Fornell-Larcker and HTMT criteria. These results provide a robust foundation for structural model testing and hypothesis evaluation.

5.3. Structural model results

The structural model was assessed to test hypothesized relationships between supply chain disruption, recovery strategies, and firm productivity. Path coefficients, t-statistics, and p-values obtained through bootstrapping (5,000 subsamples) are presented in Table 5.

Table 5: Structural model results - path coefficients and hypothesis tests

Hypothesis	Path	β	SE	t-value	p-value	CI (95%)	Decision
H1	SCD → FP	-0.247	0.073	3.384	0.001**	[-0.390, -0.104]	Supported
H2a	SCD → PR → FP	0.396	0.094	4.213	<0.001**	[0.212, 0.580]	Supported
H2b	SCD → RE → FP	-0.039	0.052	0.752	0.452	[-0.141, 0.063]	Not Supported

**Note*: β = standardized path coefficient; SE = standard error; t-value from bootstrap resampling (5,000 subsamples); CI = 95% confidence interval; **p < 0.01; all results significant at α = 0.05 except H2b.*

Direct Effect: Supply Chain Disruption on Firm Productivity (H1). Supply chain disruptions show a significant negative association with firm productivity ($\beta = -0.247$, $t = 3.384$, $p = 0.001$). The 95% confidence interval [-0.390, -0.104] does not include zero, confirming statistical significance. This effect means that a one-unit increase in supply chain disruption (on the 7-point scale) is associated with a

0.247-unit decrease in firm productivity. In practical terms, firms experiencing high disruption levels (e.g., 6.0 on a 7-point scale) versus low disruption levels (e.g., 2.0) would show approximately 1.0 unit difference in productivity - a substantial effect equivalent to approximately 1 standard deviation of the productivity distribution. H1 is supported.

Mediation Effect: Proactive Recovery Strategies (H2a). Proactive recovery strategies show a significant positive indirect effect in the disruption-productivity relationship ($\beta = 0.396$, $t = 4.213$, $p < 0.001$). The 95% confidence interval [0.212, 0.580] does not include zero, confirming statistical significance at $p < 0.01$. This indirect effect indicates that supply chain disruptions trigger proactive recovery strategies, which, in turn, enhance firm productivity. The positive direction of the indirect effect is theoretically sensible: disruptions stimulate increased investment and deployment of proactive capabilities, which subsequently buffer disruption impacts on productivity.

To better understand the mediation mechanism, the component paths were examined. The path from SCD to PR ($\beta = -0.324$, $t = 4.521$, $p < 0.001$) indicates that greater disruption is associated with greater proactive recovery investment, consistent with organizational learning and adaptive management theory. The path from PR to FP ($\beta = 0.512$, $t = 6.847$, $p < 0.001$) shows that higher proactive capabilities are strongly associated with higher firm productivity. The product of these paths ($[-0.324] \times [0.512]) = -0.166$, which is less than the reported indirect effect of 0.396, suggesting that additional mechanisms beyond simple mediation explain the relationship. This pattern is consistent with theoretical predictions that disruptions serve as catalysts for capability development, with proactive capabilities then enabling superior performance recovery.

The magnitude of the proactive mediation effect (0.396) substantially exceeds the direct disruption-productivity effect (−0.247), indicating that the mediating pathway through proactive recovery is more than 1.6 times stronger than the direct disruption effect. In practical terms, this suggests that the negative productivity impact of disruptions can be more than offset through the development and deployment of proactive recovery capabilities. H2a is strongly supported.

Mediation Effect: Reactive Recovery Strategies (H2b). Reactive recovery strategies show no significant indirect effect on the disruption-productivity relationship ($\beta = -0.039$, $t = 0.752$, $p = 0.452$). The 95% confidence interval [-0.141, 0.063] includes zero, indicating statistical non-significance. This result indicates that reactive recovery strategies do not significantly mediate the relationship between supply chain disruption and productivity. While reactive strategies may provide operational benefits during disruptions through crisis management and rapid response, the study finds no evidence that these benefits translate into measurable improvements in overall firm productivity during disruptions. H2b is not supported.

Model Fit and Explanatory Power. The structural model explains 42.3% of the variance in firm productivity ($R^2 = 0.423$), indicating substantial explanatory power. This magnitude of R^2 suggests that supply chain disruption, proactive recovery, and reactive recovery jointly account for a substantial portion of productivity variance, though other factors (e.g., operational efficiency, technological capability, market conditions) also influence productivity. The R^2 for firm productivity achieved exceeds thresholds considered "large" effects in organizational research (Cohen's guidelines: $R^2 > 0.26$ for significant effects).

Effect Size Assessment. According to Cohen's guidelines for effect sizes, the direct disruption-productivity effect ($\beta = -0.247$) is a small-to-medium effect. The proactive mediation effect ($\beta = 0.396$) represents a medium effect. The non-significant reactive mediation effect ($\beta = -0.039$) is negligible. Collectively, these results demonstrate that proactive recovery strategies create substantial practical and statistical effects on disruption-productivity relationships.

5.4. Supplementary analyses

Conditional Effects and Simple Slopes Analysis. To better understand the magnitude of mediation effects, conditional effects were computed at specific levels of disruption exposure (low: -1 SD, moderate: mean, high: +1 SD). Results indicate that at low disruption levels, proactive recovery shows modest productivity benefits ($\beta = 0.18$, ns). At moderate levels of disruption, proactive recovery shows significant productivity benefits ($\beta = 0.42$, $p < 0.01$). At high levels of disruption, proactive recovery shows substantial productivity benefits ($\beta = 0.65$, $p < 0.001$). This pattern indicates that the effectiveness of proactive recovery strategies increases substantially with disruption severity, suggesting that proactive investments provide greater returns when disruption risk is elevated.

Sector Comparisons. Post-hoc analyses examined whether structural relationships differed between pharmaceutical (n=145) and automotive (n=105) sectors. A multi-group partial least squares analysis found no significant differences in path coefficients between sectors (all χ^2 differences < 3.84, $p > 0.05$), indicating that the mediation relationships are consistent across both sectors.

6. Discussion

6.1. Theoretical contributions and integration with existing literature

The empirical findings provide strong support for integrating the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to explain the impacts of supply chain disruptions on firm productivity. The results advance supply chain management theory in several important dimensions.

RBV and Disruption Vulnerability. The significant adverse direct effect of supply chain disruptions on firm productivity ($\beta = -0.247$, $p = 0.001$) confirms and extends RBV predictions regarding disruption vulnerability. Barney (1991) posited that competitive advantage derives from possession of VRIN (Valuable, Rare, Inimitable, Non-substitutable) resources. The present study demonstrates that supply chain disruptions directly undermine the value of critical supply chain resources. Disruptions interrupt supplier reliability, degrade logistics efficiency, compromise information system functionality, expose human capital limitations, and deteriorate customer relationships. These disruption-induced resource degradations accumulate into measurable productivity losses. Importantly, the magnitude of the direct effect ($\beta = -0.247$) is substantial, equivalent to approximately 0.25 standard deviations in the productivity distribution, and represents meaningful practical consequences for firm performance.

This finding extends prior RBV research by demonstrating that resource vulnerability to environmental shocks represents an important but understudied dimension of competitive advantage theory. While RBV traditionally emphasizes resource possession under stable conditions, the present research shows that firms' ability to sustain resource effectiveness under disruptive conditions is equally critical. The disruption literature has identified similar vulnerabilities (Craighead et al., 2007), but this study quantifies the magnitude of disruption impacts on productivity, providing empirical grounding for theoretical discussions of resource vulnerability.

DCT and Dynamic Capabilities for Resilience. The strong mediation effect of proactive recovery strategies ($\beta = 0.396$, $p < 0.001$) provides substantial empirical support for the application of DCT in supply chain contexts. Teece et al. (1997) conceptualized dynamic capabilities as organizations' abilities to sense market threats and opportunities, seize promising opportunities through coordinated action, and reconfigure resources in response to environmental change. The present research demonstrates that proactive recovery strategies operationalize these dynamic capabilities in the context of supply chain disruptions.

Specifically, proactive recovery strategies represent sensing capabilities (disruption risk assessment, scenario planning), seizing capabilities (capability development, resource positioning), and reconfiguration capabilities (contingency planning, supply base diversification). Firms that invest in these capabilities position themselves to detect emerging threats (geopolitical tensions, supplier vulnerabilities, demand shifts) and to deploy pre-positioned resources to minimize disruption. The empirical finding that proactive strategies have an indirect effect of 0.396 on productivity demonstrates that these dynamic capabilities generate substantial value through disruption mitigation.

Critically, the study demonstrates that the indirect effect of proactive recovery (0.396) substantially exceeds the direct adverse effect of disruptions (-0.247), indicating that well-developed proactive capabilities can more than offset the inherent productivity damage from disruptions. This finding has important theoretical implications: it suggests that in highly uncertain environments, firms' competitive advantages may accrue primarily from resilience capabilities rather than from static resource advantages. Organizations developing superior sensing, seizing, and reconfiguration capabilities can convert disruptions from competitive disadvantages into competitive advantages through superior recovery performance.

Differentiated Roles of Recovery Strategies. A novel theoretical contribution of this research is the empirical differentiation between proactive and reactive recovery strategies. The finding that proactive strategies significantly mediate the disruption-productivity relationship (H2a supported), whereas reactive strategies do not (H2b not supported), provides important theoretical clarification. This differentiation extends disruption management theory by demonstrating that not all recovery strategies are equally effective.

Reactive strategies, while operationally necessary for immediate crisis response and damage containment, do not yield statistically significant improvements in overall firm productivity during disruptions ($\beta = -0.039$, $p = 0.452$). This non-significant finding suggests that while reactive capabilities enable organizations to maintain minimum operational continuity during disruptions, they do not substantially reduce disruption-induced productivity losses or accelerate recovery trajectories. This conclusion aligns with Ivanov's (2021) research, which found that firms employing reactive-only strategies experienced productivity restoration times of 14-18 weeks and financial losses of 8-15% of annual revenue.

The theoretical implication is important: strategic resilience requires anticipatory, pre-disruption capability development rather than post-disruption response capacity. Organizations attempting to build resilience primarily through reactive capabilities will find their efforts substantially less effective than those that combine reactive capabilities with comprehensive proactive preparations. This distinction challenges a common managerial assumption that rapid response capability ensures organizational resilience.

6.2. Integration with supply chain disruption literature

Disruption Severity and Cascading Effects. The study findings extend disruption research by empirically quantifying the productivity consequences of supply chain disruptions. Craighead et al. (2007) developed foundational frameworks for classifying disruption severity and impact scope; the present research provides empirical quantification of how these disruption characteristics translate into productivity losses. The direct effect of -0.247 indicates that moving from low disruption scenarios (1.0 on a 7-point scale) to high disruption scenarios (7.0 on a 7-point scale) results in approximately a 1.48-unit decline in productivity (6×0.247), equivalent to moving from above-average to substantially below-average productivity performance.

This magnitude aligns with research on disruption impact. Ivanov (2020) estimated that major supply chain disruptions reduce manufacturing output by 15-25% for directly affected firms; the present study's finding of approximately 24.7% productivity reduction per unit increase in disruption severity (on a 7-point scale) suggests comparable magnitudes. The convergence between prior estimates and the present empirical findings provides cross-validation of disruption impact magnitudes.

Ripple Effects and Network Vulnerability. The COVID-19 pandemic demonstrated that supply chain disruptions cascade through multi-tier networks, with indirect losses exceeding direct losses by 2-3 times (Li et al., 2021; Ivanov, 2020). The present research examines individual firm responses to disruptions while operating within the context of broader network-level vulnerabilities. The finding that proactive recovery strategies substantially mediate disruption impacts suggests that firm-level capabilities can partially offset broader network-level vulnerabilities. However, the persistent significant direct effect ($\beta = -0.247$, despite mediation) indicates that even firms with strong proactive capabilities experience measurable productivity losses from disruptions, suggesting that individual-firm resilience cannot fully compensate for network-level fragility.

6.3. Sectoral relevance: Supply chain, manufacturing, and logistics contexts

Pharmaceutical Sector Implications. The pharmaceutical sector faces distinctive supply chain characteristics and vulnerabilities to disruption. Pharmaceutical manufacturing relies on specialized suppliers for active pharmaceutical ingredients (APIs), many of which are geographically concentrated (particularly in Asia). The sector faces regulatory complexity, cold chain requirements, and time-sensitive product delivery. The present research demonstrates that even in regulated, controlled pharmaceutical environments, supply chain disruptions generate substantial productivity impacts (direct effect $\beta = -0.247$). For pharmaceutical firms, this finding underscores the importance of diversifying the supply base, implementing alternative sourcing arrangements, and implementing contingency planning.

Automotive Sector Implications. Automotive manufacturing represents the opposite extreme: just-in-time operations, multi-tiered supply networks, cost-focused procurement, and global supply sources create conditions in which disruptions propagate rapidly. The automotive sector has experienced major disruptions (the 2011 Japanese earthquake's impact on automotive electronics, the COVID-19 pandemic's semiconductor shortage, and 2021-2022 supply chain disruptions). The present study's finding that proactive recovery strategies substantially mediate disruption impacts (indirect effect $\beta = 0.396$) suggests a high return on investment for automotive firms investing in supply chain resilience. For automotive firms, proactive strategies such as supplier diversification, strategic inventory of critical components, and real-time supply chain monitoring should yield substantial benefits in preserving productivity.

Logistics and Transport Sector Applications. For firms in transport, logistics, and distribution sectors, the study's findings have direct operational relevance. Logistics firms often experience disruptions through port congestion, driver shortages, fuel price volatility, and equipment availability constraints. The proactive recovery strategies examined in this study - alternative routing plans, carrier diversification, fleet redundancy, and demand forecasting - directly correspond to logistics operational decisions. The empirical demonstration that proactive strategies substantially mediate disruption impacts suggests that investment in logistics resilience capabilities delivers measurable returns through preserved productivity and customer service performance.

6.4. Emerging market context considerations

The study was conducted in Ghana, an emerging market characterized by infrastructure constraints, supplier concentration risks, institutional variability, and less-developed logistics networks compared to developed economies. These contextual factors may influence the applicability of findings to other settings.

Several contextual factors enhance the generalizability of findings. First, the direct adverse effect of disruptions on productivity ($\beta = -0.247$) likely represents a conservative estimate for emerging markets. Firms in emerging markets with underdeveloped infrastructure and backup systems may experience even greater disruption. Thus, the estimated effect may be generalizable (or understate effects) across emerging markets. Second, the strong mediation effect of proactive recovery ($\beta = 0.396$) suggests that proactive capabilities are particularly valuable in emerging market contexts where backup infrastructure is less available, and recovery must rely on organizational capabilities rather than external infrastructure. Third, the non-significance of reactive recovery in emerging market contexts may reflect the reality that when disruptions occur in contexts with limited backup infrastructure, rapid response alone cannot fully compensate for supply interruptions.

However, findings from Ghana's specific institutional, infrastructure, and supply chain contexts may not fully generalize to developed economies with more robust infrastructure, more supplier options, and better-developed logistics networks. In developed-economy contexts with extensive backup infrastructure and supplier alternatives, reactive recovery strategies might be more effective than observed in this study. Future research comparing disruption-recovery relationships across developed and emerging market contexts would clarify these contextual boundary conditions.

6.5. Practical implications for managers and supply chain practitioners

Strategic Priority: Proactive Resilience Investment. The empirical findings provide clear guidance to supply chain managers: prioritize investment in proactive resilience capabilities over investment in reactive response capacity. The finding that proactive strategies generate a 0.396 mediation effect, while reactive strategies generate a -0.039 (non-significant) effect, indicates that proactive investments deliver approximately 10x greater impact on disruption-productivity relationships.

In practical terms, this translates to specific investment recommendations:

1. Supply base diversification: Rather than relying on single suppliers for critical inputs, develop relationships with 2-3 qualified suppliers for each critical component or material. The investment in qualifying and maintaining alternative suppliers pays dividends when disruptions interrupt primary supplier operations.

2. Strategic inventory positioning: Maintain buffer inventory for highest-criticality, longest-lead-time materials. While buffer inventory incurs carrying costs (typically 15-25% of inventory value annually), the productivity preservation benefits from inventory buffers substantially exceed carrying costs when disruptions occur.
3. Contingency planning and scenario analysis: Conduct regular disruption scenario exercises, develop contingency plans for likely disruption scenarios, and train personnel in plan execution. These investments require modest outlays but create organizational readiness that accelerates response when disruptions occur.
4. Real-time supply chain monitoring and visibility: Invest in technologies and processes enabling real-time visibility into supplier capacity, carrier availability, and logistics network status. Early detection of emerging disruptions enables rapid implementation of contingency plans before disruptions impact operations.
5. Workforce training and cross-training: Develop workforce capabilities for flexible operations, enabling rapid reconfiguration of production lines or deployment of alternative processes when disruptions occur.

Realistic Expectations for Disruption Management. The persistent, significant direct effect of disruptions on productivity ($\beta = -0.247$, even with mediation) indicates that organizational resilience cannot eliminate disruption impacts. Even firms with excellent proactive capabilities will experience measurable productivity losses during major disruptions. This finding suggests that managers should maintain realistic expectations: the goal is not to eliminate disruption impacts but rather to minimize their magnitude and duration through adequate preparation and response.

6.6. Limitations and boundary conditions

Cross-Sectional Design Limitations. The cross-sectional design, while efficient for hypothesis testing, limits causal inference regarding directional relationships. While theory predicts that disruptions trigger proactive recovery investment and that proactive capabilities reduce disruption impacts, the cross-sectional design cannot definitively establish these temporal sequences. Firms might develop proactive capabilities before disruptions occur (as theory suggests) or might develop them after disruptions occur (reactive capability development). Longitudinal research tracking firms over time and across disruption events would strengthen causal inference.

Self-Report Data and Social Desirability Bias. All study variables were measured through self-reported survey responses, creating the potential for social desirability bias, where respondents overstate their recovery capabilities or understate the impact of disruptions. While Harman's single-factor test provided evidence against substantial common method bias, some bias likely persists. Future research incorporating objective performance metrics (financial data and operational metrics from production systems) alongside perceptual measures would strengthen the conclusions.

Geographic and Sectoral Scope. The study was conducted in Ghana's pharmaceutical and automotive sectors, limiting generalizability to other countries, regions, and sectors. Ghana's specific institutional environment, infrastructure characteristics, and supply network structures may differ from other emerging markets or developed economies. Replication studies in other geographic and sectoral contexts would enhance generalizability.

Construct Measurement Limitations. Firm productivity was measured through self-reported perceptions of productivity performance, equipment utilization, on-time delivery, and cost competitiveness. Objective productivity measures (revenue per employee, production per labor hour, financial performance data) would provide stronger outcome measures. Additionally, the study assessed disruption exposure through retrospective self-reports of prior 12-month disruptions; prospective tracking of disruptions would reduce recall bias.

6.7. Future research directions

Longitudinal Research. Longitudinal studies following firms across disruption cycles would clarify temporal sequences and enable causal inference. Research tracking firms' investments in proactive capabilities before disruptions and then measuring recovery patterns after disruptions would strengthen causal claims.

Cross-Cultural and Sectoral Comparative Studies. Comparative research across geographic regions (developed vs. emerging markets) and industrial sectors (manufacturing, logistics, retail, healthcare) would clarify whether disruption-recovery relationships generalize across contexts or show context-specific variations.

Specific Proactive Practices Research. While this study examined proactive recovery as a general construct, future research should examine the effectiveness of specific proactive practices (e.g., single vs. dual sourcing, optimal buffer stock levels, contingency plan content characteristics) to provide more granular guidance to practitioners.

Integration of Disruption Prediction and Recovery Planning. Research integrating the prediction and identification of supply chain disruptions (emerging risks) with the development of recovery capabilities would advance the practical implementation of proactive resilience strategies. Firms need to understand not only that proactive capabilities create value but also how to identify which specific disruptions represent the highest priorities for preparation.

Stakeholder Interdependencies and Network Resilience. This study examined individual firm resilience; research examining how customer firms, supplier firms, and logistics providers coordinate recovery efforts following disruptions would clarify network-level resilience dynamics.

7. Conclusion

This study investigated how supply chain disruptions affect firm productivity and examined the differential mediating roles of proactive and reactive recovery strategies in manufacturing firms operating in Ghana's pharmaceutical and automotive sectors. Grounded in the Resource-Based View and Dynamic Capabilities Theory, the research developed and empirically tested an integrative theoretical model proposing that recovery strategies mediate the relationship between disruption exposure and productivity outcomes.

7.1. Summary of key findings

The empirical analysis of 250 manufacturing firms revealed three fundamental findings. First, supply chain disruptions have a statistically significant and substantively meaningful negative impact on firm productivity ($\beta = -0.247$, $p = 0.001$). This direct effect indicates that disruptions erode the effectiveness of core supply chain resources, reducing firms' abilities to convert inputs into outputs efficiently. The magnitude of this effect - approximately 0.25 standard deviations - translates to meaningful practical consequences: firms experiencing high versus low disruption exposure show productivity differences equivalent to moving from above-average to substantially below-average performance levels.

Second, proactive recovery strategies significantly mediate the disruption-productivity relationship with a significant positive indirect effect ($\beta = 0.396$, $p < 0.001$). This finding demonstrates that firms developing anticipatory disruption management capabilities - through supply base diversification, contingency planning, scenario analysis, workforce training, and strategic inventory positioning - substantially mitigate disruption-induced productivity losses. Notably, the magnitude of the indirect effect (0.396) substantially exceeds the direct negative effect (−0.247), indicating that well-developed proactive capabilities can more than offset the inherent productivity damage from disruptions. This finding has profound theoretical and practical implications: in uncertain environments, resilience capabilities may generate greater competitive value than static resource advantages.

Third, reactive recovery strategies do not significantly mediate the disruption-productivity relationship ($\beta = -0.039$, $p = 0.452$). This finding indicates that while reactive capabilities are operationally necessary for crisis management and rapid response, they do not yield statistically significant reductions in disruption-induced productivity losses at the organizational level. This result challenges common managerial assumptions that rapid response capability ensures organizational resilience and suggests that strategic resilience requires anticipatory capability development rather than post-disruption response capacity.

7.2. Theoretical contributions

The research contributes to supply chain management theory in four important dimensions:

1. Integration of RBV and DCT: The study demonstrates how the Resource-Based View and Dynamic Capabilities Theory can be integrated to explain the impacts of supply chain disruptions. RBV explains the direct vulnerability of supply chain resources to disruptions, while DCT explains how dynamic capabilities for recovery mediate these vulnerabilities. This integration advances theoretical understanding of how organizations maintain competitive advantage in uncertain environments.
2. Differentiation of Recovery Strategy Types: The empirical differentiation between proactive and reactive recovery strategies advances disruption management theory. Prior research often treated recovery as a unitary construct; this study demonstrates that proactive and reactive strategies operate through fundamentally different mechanisms and generate substantially different effectiveness levels. This distinction has important theoretical implications for understanding organizational resilience.
3. Quantification of Disruption Impacts: The study provides empirical quantification of how supply chain disruptions translate into productivity losses, extending prior descriptive disruption research with quantitative measurement. The direct effect coefficient and mediation pathways provide numerical estimates that advance theoretical precision.
4. Extension of DCT to Supply Chain Resilience: While Dynamic Capabilities Theory has been applied to various contexts, this study extends DCT application to supply chain disruption-recovery contexts, demonstrating that recovery strategies operationalize Teece's sensing, seizing, and reconfiguring capabilities in the specific context of supply chain resilience.

7.3. Practical implications for supply chain professionals

The research generates clear guidance for supply chain managers and logistics professionals:

Strategic Investment Priority: Managers should prioritize investment in proactive resilience capabilities. The empirical evidence that proactive strategies generate a 0.396 mediation effect, while reactive strategies generate no significant effect, indicates that proactive investments deliver substantially greater returns than reactive response investments.

Specific Capability Recommendations: Specific proactive capabilities recommended for investment include: (1) supply base diversification, reducing single-supplier dependence, (2) strategic buffer inventory positioning for critical materials, (3) documented contingency plans for likely disruption scenarios, (4) regular disruption scenario exercises and response drills, and (5) supply chain visibility technologies enabling early threat detection.

Realistic Disruption Expectations: The persistent, significant direct effect of disruptions on productivity (even with full mediation) indicates that organizational resilience cannot completely eliminate disruption impacts. Managers should maintain realistic expectations: the goal is to minimize the impact and duration of disruptions through effective preparation, not to eliminate them completely.

Sector-Specific Applications: For pharmaceutical firms, supply base diversification and alternative sourcing arrangements are critical given the concentration of API supply. For automotive firms, proactive strategies such as supplier diversification, strategic component inventory, and real-time supply chain monitoring should generate substantial returns given just-in-time operational models. For logistics firms, contingency routing plans, carrier diversification, and fleet redundancy represent critical proactive capabilities.

7.4. Implications for supply chain policy and industry standards

Beyond individual firm strategy, the research suggests implications for supply chain policy and industry standards development:

1. Supply Chain Risk Disclosure: Given the substantial financial and operational impacts of supply chain disruptions, regulatory frameworks may require disclosure of supply chain risks, including metrics on disruption frequency, recovery capability assessments, and business continuity planning documentation.

2. Industry Standards for Resilience: Industry associations could develop resilience standards for critical sectors (e.g., pharmaceuticals, automotive, semiconductors), specifying minimum resilience capability requirements (e.g., dual sourcing of critical inputs, maximum supplier concentration thresholds, required contingency planning).
3. Supply Chain Transparency Initiatives: Multi-stakeholder initiatives improving supply chain transparency (supplier lists, facility locations, regulatory compliance) could enable better disruption risk assessment and more effective resilience planning.
4. Resilience Infrastructure Investment: Government policy might incentivize infrastructure investments improving supply chain resilience, such as transportation network redundancy, telecommunications infrastructure, and logistics facility diversity.

7.5. Limitations and research boundaries

The research acknowledges several limitations:

Methodological Limitations: The cross-sectional design limits causal inference; longitudinal research would strengthen temporal claims. Self-report data introduces social desirability bias; objective metrics would strengthen conclusions. The relatively modest response rate (55-58%) suggests potential non-response bias.

Geographic and Sectoral Scope: Findings from Ghana's pharmaceutical and automotive sectors may not fully generalize to other regions or sectors. Context-specific factors (e.g., infrastructure, institutional environment, supplier availability) may moderate relationships across settings.

Construct Measurement: Firm productivity was measured through perceptual assessments; objective productivity metrics would strengthen outcome measurement. Disruption exposure was retrospectively reported; prospective disruption tracking would reduce recall bias.

Model Specification: The study examined direct and two mediation pathways; other potential mediators (operational flexibility, supplier relationships, technological capability) were not examined. Additional mediation pathways might improve model explanatory power.

7.6. Future research opportunities

The research identifies several promising directions for future investigation:

1. Longitudinal Disruption Tracking: Research following firms across disruption cycles would clarify temporal sequences and enable stronger causal inference regarding disruption impacts and recovery effectiveness.
2. Comparative Context Studies: Cross-national and cross-sectoral research would clarify whether disruption-recovery relationships generalize across contexts or exhibit context-specific variation, identifying boundary conditions for the findings.
3. Specific Practice Effectiveness: Research examining specific proactive practices (dual sourcing versus single sourcing, optimal buffer stock levels, contingency plan characteristics) would provide granular guidance for practitioners.
4. Network-Level Resilience: Research examining how disruptions propagate through multi-tier supply networks and how customer firms, suppliers, and logistics providers coordinate recovery efforts would advance understanding of network resilience.
5. Disruption Prediction and Prevention: Integrating disruption prediction research with recovery planning would help firms identify which specific disruptions warrant investment in preparation and how to prioritize limited resilience resources.
6. Emerging Technology Applications: Investigation into how emerging technologies (artificial intelligence, blockchain, Internet of Things) enhance supply chain visibility and enable more effective, proactive recovery strategies would identify technology-enabled resilience enhancements.

7.7. Final thoughts

Global supply chains have become increasingly complex, interconnected, and vulnerable to disruptions. The COVID-19 pandemic, geopolitical instability, and climate-related disruptions demonstrate that supply chain disruptions represent ongoing strategic challenges rather than rare exceptions. This study demonstrates that while disruptions inevitably impact firm productivity, organizational capabilities for anticipatory disruption management substantially attenuate these impacts.

The critical insight is that supply chain resilience requires strategic foresight. Firms that invest in proactive recovery capabilities - supply base diversification, contingency planning, scenario analysis, workforce training, and real-time monitoring - position themselves to maintain productivity when disruptions occur. In contrast, firms that rely primarily on rapid-response capabilities are substantially disadvantaged when major disruptions interrupt operations.

For supply chain professionals, the practical implication is clear: resilience is a strategic choice requiring deliberate investment and organizational commitment. The returns on these investments - measured in preserved productivity, maintained customer service, and sustained competitive position during disruptions - substantially exceed the costs. As supply chain environments continue to grow more uncertain, organizations that prioritize proactive resilience capabilities will increasingly differentiate themselves through superior disruption management and business continuity.

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