
# Opening the black box of disaster recovery in SMEs: Unpacking the antecedent roles of anticipation capabilities, risk management culture, and supply chain agility.

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# Opening the black box of disaster recovery in SMEs: Unpacking the antecedent roles of anticipation capabilities, risk management culture, and supply chain agility


## Abstract

**Purpose:** This study examines how risk management culture fosters disaster recovery and analyses the serial mediation roles of anticipation capabilities and supply chain agility, while assessing opportunities to improve risk management culture, anticipation capabilities, and supply chain agility to enhance disaster recovery. Further, the study examines the necessity of risk management culture, anticipation capabilities, and supply chain agility for disaster recovery.

**Methodology:** We combined Partial Least Squares Structural Equation Modelling, Importance-Performance Map Analysis and Necessary Condition Analysis to explore the sufficient and necessary roles of risk management culture, anticipation capabilities and supply chain agility in enhancing or enabling disaster recovery among a sample of 357 Ghanaian Small and Medium-sized Enterprises.

**Findings:** The findings suggest that risk management culture and supply chain agility, but not anticipation capabilities, have a positive influence on disaster recovery. Moreover, anticipation capabilities and supply chain agility serially mediate the positive nexus between risk management culture and disaster recovery. Furthermore, the findings indicate that risk management culture and supply chain agility, rather than anticipation capabilities, are necessary for effective disaster recovery.

**Originality/Value:** We present one of the first attempts to broaden our understanding of the drivers of disaster recovery among SMEs, while also providing managers with complementary insights regarding the sufficient and necessary antecedents of disaster recovery.


**Keywords:** Disaster recovery; Sufficiency analysis; Small and medium-sized enterprises (SMEs); Importance-Performance Map Analysis; Necessary Condition Analysis; Ghana.

## Introduction

In 2021, a global chip shortage severely disrupted automotive production, costing the industry $210 billion and exposing the fragility of supply chains (Fortune, 2021). By 2025, escalating geopolitical tensions, climate-driven disasters, and cyberattacks have transformed disruptions into systemic crises, costing industries billions of dollars annually (Bloomberg, 2024; Alicke et al., 2020). For instance, the 2023 East Coast port strike halted $3 billion in daily trade, and a ransomware attack crippled a UK SME to the tune of £1.2 million (Financial Times, 2023). These events underscore a pressing need for disaster recovery, which denotes the strategic process of restoring operations, minimising losses, and adapting post-crisis (Ivanov et al., 2017; Chen et al., 2019). Yet, what enables firms, particularly resource-constrained small and medium-sized enterprises (SMEs), to not only survive but thrive amidst such volatility and potentially transform disruptions into opportunities, via recovery (Ivanov, 2022)? This question drives an evolving discourse in management. Risk management culture—the shared values that prioritise risk identification and mitigation—emerges as a pivotal yet underexplored driver of disaster recovery (Power, 2007; Foli et al., 2022).

Supply chain disruptions, which halt material, information, or financial flows, have shifted from occasional setbacks to pervasive risks, rendering traditional reactive strategies, such as inventory buffering, inadequate (Bode et al., 2011; Tang, 2006; Hu et al., 2013). Contemporary research emphasises resilience, with recovery as a critical phase requiring proactive capabilities (Bhamra et al., 2011; Kamalahmadi & Parast, 2016; Duchek, 2020). Ivanov (2022) advocates for a viable supply chain model that integrates agility, resilience, and sustainability; however, the specific mechanisms enabling recovery, particularly for SMEs, remain under-examined. Grounded in dynamic capabilities theory, we focus on three key antecedents: risk management culture, anticipation capabilities, and supply chain agility (Teece et al., 1997). Risk management culture fosters organisational vigilance, distinct from the creative focus of innovation culture (Power, 2007; Kimbrough & Componation, 2009). Anticipation capabilities involve leveraging analytics and scanning, enabling preemptive risk detection (Beheregarai Finger et al., 2014; Munir et al., 2022). Supply chain agility refers to the ability to respond rapidly and flexibly, facilitating dynamic adaptation (Carvalho et al., 2012; Altay et al., 2018). These capabilities collectively underpin resilience; however, their roles in disaster recovery warrant deeper exploration (Gligor et al., 2019).

With these antecedents defined, existing research provides initial insights but reveals persistent gaps. Current scholarship links risk management culture to resilience and competitive advantage, often through agility (Abeysekara et al., 2019; Kumar & Anbanandam, 2020; Sun et al., 2024), and highlights anticipation and agility as resilience drivers (Zhang et al., 2024; Um & Han, 2021; Chopra et al., 2021). However, critical gaps persist. First, the effects of risk management culture on agility and anticipation capabilities remain underexplored, limiting our understanding of how culture drives proactive adaptation (Kwak et al., 2018). Second, while these antecedents enhance resilience, their specific effect on disaster recovery is unclear, particularly through mediation pathways (DuHadway et al., 2019; Chen et al., 2019). Third, and for SMEs, the sequential mediating role of anticipation and agility in channelling risk management culture to recovery remains untested (Foli et al., 2022; Zeiringer et al., 2022). Fourth, SMEs' potential to strengthen these capabilities to improve recovery outcomes is uncertain, hindering prioritisation strategies (Marcazzan et al., 2022; Shishodia et al., 2023).

Beyond these, a further oversight lies in how studies often assume sufficiency to the neglect of necessity; hence, whether these capabilities are necessary conditions (indispensable enablers) without which recovery fails remains unaddressed (Brusset & Teller, 2017; Nikookar et al., 2024). Thus, there is a lack of a comprehensive framework elucidating how risk management culture, anticipation capabilities, and supply chain agility enable disaster recovery for SMEs, and whether these capabilities are necessary conditions for successful disaster recovery. This uncertainty hinders firms from leveraging cultural strengths, prioritizing capability development, and ensuring robust recovery in an era of frequent disruptions (Ivanov, 2022), and may misdirect resources and potentially exacerbate losses, as illustrated by studies on resource orchestration challenges in dynamic environments (Sirmon et al., 2011; van der Vegt et al., 2015; Shen & Sun, 2023).

Consequently, to address these gaps, we pose the following research questions:

> ***RQ1:*** *Do risk management culture, anticipation capabilities, and supply chain agility directly enhance the disaster recovery of SMEs?*
>
> ***RQ2:*** *Do anticipation capabilities and supply chain agility mediate the effect of risk management culture on disaster recovery of SMEs?*

***RQ3:*** *Do opportunities exist for improving the levels of risk management culture, anticipation and recovery capabilities reached by SMEs to positively impact their disaster recovery?*

***RQ4:*** *Are risk management culture, anticipation capabilities and supply chain agility necessary conditions of disaster recovery?*

To address these gaps, we employ partial least squares structural equation modelling (PLS-SEM), importance-performance map analysis (IPMA), and necessary condition analysis (NCA) to test these relationships in SMEs (Hair et al., 2022; Ringle & Sarstedt, 2016; Dul, 2024).

This study makes multifaceted contributions to supply chain management and organisational resilience scholarship. Theoretically, this study advances dynamic capabilities theory by proposing a novel framework where risk management culture drives supply chain agility and anticipation capabilities, with these capabilities mediating disaster recovery and challenging sufficiency assumptions in prior models (Ivanov, 2022; Zhang et al., 2024). Empirically, it not only identifies opportunities for SMEs to enhance these capabilities but also establishes them as necessary conditions for disaster recovery. Practically, it equips managers with strategies for antifragile supply chains—which gain strength from adversity and align with dynamic capabilities principles—informing crisis leadership and resource orchestration for SMEs (Sirmon et al., 2011).

## 2. Theoretical foundation

### 2.1 A Dynamic Capabilities Perspective on Disaster Recovery in SMEs

The dynamic capabilities framework (Teece et al., 1997; Teece, 2007) offers an integrative lens for understanding why some small and medium-sized enterprises (SMEs) recover rapidly and even improve their performance after major disasters, while others struggle or fail. Dynamic capabilities—higher-order abilities to sense, seize, and reconfigure—are particularly relevant in extreme contexts where environmental shocks are sudden, severe, and non-routine (Williams et al., 2017).

In this study, we argue that three focal constructs in this study—risk management culture, anticipation capabilities, and supply chain agility—serve as critical microfoundations that directly map onto the sensing–seizing–reconfiguring sequence and explain heterogeneity in SME disaster

recovery. Sensing involves identifying and interpreting threats and opportunities in real time. A strong risk management culture—shared norms and values that prioritise proactive risk awareness (Srinivasan & Swink, 2018)—directs attentional resources toward systematic scanning of the external environment and internal vulnerabilities. Anticipation capabilities further sharpen sensing by enabling SMEs to detect weak signals well before disruption occurs. Together, these mechanisms enable SMEs to achieve disproportionately early and accurate threat detection compared to their peers, who lack such cultural and cognitive infrastructure.

Seizing entails mobilising resources to address sensed threats. Supply chain agility—the capacity to rapidly reconfigure supply, production, and distribution processes (Gligor et al., 2016)—represents the core mechanism for seizing opportunities during the acute phase of a disaster. Agile firms can quickly activate backup suppliers, reroute shipments, adjust production schedules, or modify product specifications. Investments in flexibility and redundancy are more likely when a proactive risk management culture frames such expenditures as strategic rather than wasteful. Anticipation capabilities enhance seizing effectiveness by pre-identifying plausible contingencies and preparing response protocols, thereby reducing decision latency when disaster strikes.

Reconfiguring requires ongoing renewal and realignment of the resource base to sustain fit with the altered post-disaster environment. Effective recovery often demands structural transformations. A deeply embedded risk management culture, therefore, facilitates post-event learning and overcomes inertia, while anticipation capabilities supply forward-looking scenarios that guide resource recombination. Supply chain agility lowers the time and cost of transformation, enabling SMEs not only to restore operations but frequently to "bounce forward" into a stronger competitive position (Linnenluecke, 2017).

To this end, risk management culture primarily fuels sensing and reconfiguring through vigilance and learning orientation; anticipation capabilities enhance sensing precision and inform seizing and reconfiguring choices; and supply chain agility operationalises seizing while accelerating reconfiguration. By embedding these constructs within the dynamic capabilities framework, we not only offer a theoretically coherent, process-oriented explanation for differential disaster recovery outcomes among SMEs but also establish a robust foundation for empirical testing.

Similarly, building on foundational insights from Teece et al. (1997), contemporary studies highlight how a strong risk management culture aligns with DCT's sensing phase, embedding

proactive risk identification into organisational routines (Yang et al., 2021). For instance, firms with embedded risk awareness can reconfigure processes more effectively, thereby enhancing agility as an adaptive response (Herburger et al., 2024; Wieland & Wallenburg, 2012). Moreover, DCT illuminates the mediating pathways through which anticipation and agility translate cultural orientations into recovery outcomes, suggesting that resilience emerges from orchestrated capabilities rather than isolated traits (Reynolds, 2024; Ivanov, 2022). This integrated view not only deepens understanding of supply chain dynamics but also addresses gaps in prior research (Munir et al., 2022; Kamalahmadi & Parast, 2016).

## 3. Hypothesis Development

### 3.1 Sufficiency hypotheses

#### 3.1.1 The sufficient relationship between risk management culture and disaster recovery

A robust risk management culture, characterised by shared values that prioritise risk identification and mitigation, strengthens disaster recovery by fostering proactive behaviours and organisational cohesion (Hopkin, 2018; Biedermann & Kotzab, 2021). In SMEs, where formal systems are often limited, enhancing this culture through training and cross-functional alignment amplifies preparedness, reduces downtime, and improves restoration post-disruption (Zsidisin et al., 2024; Kumar & Anbanandam, 2020). Recent studies, particularly those arising from the COVID-19 crisis, demonstrate that firms with advanced risk cultures recover more quickly by integrating risk considerations into their strategic processes, thereby enhancing resilience beyond basic recovery (Polyviou et al., 2022; Filyppova et al., 2019). This suggests that strengthening risk management culture significantly boosts SMEs' ability to achieve superior disaster recovery outcomes. Based on the foregoing, we propose that a risk management culture enhances disaster recovery. Accordingly, we hypothesise that:

H1a: Enhancing risk management culture positively impacts disaster recovery in SMEs.

#### 3.1.2 The sufficient relationship between anticipation capabilities and disaster recovery

Anticipation capabilities, which encompass environmental scanning and foresight, enhance recovery by enabling SMEs to pre-empt disruptions through proactive strategies like contingency planning and resource prepositioning (Hohenstein et al., 2015; Duchek, 2020). Hence,

strengthening these capabilities allows firms to detect subtle signals early, minimising disruption impacts and accelerating restoration (Munir et al., 2022; Rozhkov et al., 2022). Prior DCT research underscores anticipation as a core sensing mechanism (Teece et al., 1997) while recent studies highlight its amplified role in technology-intensive sectors, where enhanced foresight translates into superior recovery efficiency (Chopra et al., 2024). Deduces surmise For SMEs, advancing anticipation capabilities thus serves as a critical lever for elevating disaster recovery outcomes. Thus we surmise that, strong anticipation capabilities enhance disaster recovery among SMEs Hence, we purport the following hypothesis:

H1b: Enhancing anticipation capabilities positively impacts disaster recovery in SMEs.

### 3.1.3 The sufficient relationship between supply chain agility and disaster recovery

Supply chain agility refers to the ability to rapidly adjust operations and reallocate resources (Carvalho et al., 2012). It enhances recovery by enabling swift responses to disruptions, such as supplier failures or demand shifts (Baah et al., 2020). For SMEs, strengthening agility through flexible logistics or modular processes overcomes resource constraints and facilitates faster operational realignment and sustained performance (Çetindaş et al., 2023; Aldhaheri & Ahmad, 2023). Recent research (Singh & Modgil, 2025) confirms that agile firms exhibit superior recovery through enhanced adaptability, which amplifies responsiveness beyond basic resilience (Gligor et al., 2019). Hence, enhanced agility thus significantly boosts SMEs' recovery outcomes through robust adaptation in complex supply chains, thereby in line with the DCT's transformation phase (Wieland & Wallenburg, 2012; Reynolds, 2024). Consequently, we posit that increased agility leads to improved disaster recovery among SMEs. Thus, we put forth the following hypothesis:
H1c: Enhancing supply chain agility positively impacts disaster recovery in SMEs.

### 3.1.4 The mediating role of anticipation capabilities

Anticipation mediates the culture-recovery link by channelling risk awareness into proactive strategies, such as early signal detection and strategic foresight, which bridge cultural norms to tangible recovery outcomes (Gurtu & Johny, 2021; Lévy, 2008). This mediation occurs as anticipation enables timely decisions and resource deployment, thereby reducing the severity of

disruptions and accelerating restoration (Rozhkov et al., 2022). Prior empirical studies (e.g., Munir et al., 2022) support this indirect pathway, demonstrating that without strong anticipation, cultural efforts yield limited benefits in terms of resilience (Munir et al., 2022). Furthermore, in dynamic environments, anticipation transforms embedded risk values into operational advantages, highlighting its role as a critical intermediary in resilience models (Duchek, 2020). This perspective aligns with DCT by emphasising how capabilities orchestrate disaster recovery through foresight, rather than relying solely on direct cultural influences (Ivanov, 2022). Hence, inferring from the foregoing, a risk management culture enhances the development of anticipation capabilities, resulting in improved disaster recovery. Thus, we propose the following hypothesis:

H2a: Anticipation capabilities mediate the relationship between risk management culture and disaster recovery.

### 3.1.5 The mediating role of supply chain agility

Similarly, agility mediates the RCL and DRC link by translating culture into responsive actions, fostering adaptability and quick operational shifts that enhance recovery (Çetindaş et al., 2023; Reynolds, 2024). This role is evident in how agility operationalises risk awareness, enabling decentralised responses and flexibility (Barhmi, 2023). Recent analyses indicate that agility's mediation is particularly pronounced in volatile settings, where it converts foresight into real-time adjustments, mitigating losses and supporting resilience (Boubaker et al., 2019). For SMEs, this indirect effect amplifies limited resources, as agile practices mediate cultural practices to achieve faster recovery (Shishodia et al., 2023). Overall, we posit that the development and deployment of a risk management culture to support agility, which in turn produces increased disaster recovery outcomes (Zhang et al., 2024). Therefore, we hypothesise the following:

H2b: Agility mediates the relationship between risk management culture and disaster recovery.

### 3.1.6 Sequential mediation role of anticipation capabilities and supply chain agility

The influence of risk management culture on recovery often unfolds sequentially, with anticipation preceding agility in capability cascades, where culture first generates foresight, which then enables responsive adaptations (Gurtu & Johny, 2021; Lévy, 2008). This sequence is supported by

evidence showing that anticipation provides the predictive foundation for agility, through allowing firms to deploy resources preemptively (Munir et al., 2022). In turn, agility operationalises these insights into recovery actions, forming a chained process that enhances resilience (Rozhkov et al., 2022). Empirical work from recent disruptions confirms this cascading effect, particularly in SMEs, where sequential capabilities compensate for structural limitations (Çetindaş et al., 2023). Hence, and aligned with DCT, this mediation pathway illustrates how resilience emerges from integrated, step-wise transformations rather than isolated factors and actions (Ivanov, 2022). Following from these arguments, we suggest that RCL relate to DRC first through ANTC and then through SGL. Hence, we put forth propose the following hypothesis:

H3: Anticipation capabilities and agility sequentially mediate the relationship between risk management culture and disaster recovery.

### 3.2 Necessity hypothesis

#### 3.2.1 The necessity relationship between risk management culture and disaster recovery

A robust risk management culture, defined by shared values prioritising risk identification and mitigation, is fundamental to organisational resilience, as it embeds proactive behaviours essential for recovery (Hopkin, 2018; Biedermann & Kotzab, 2021). Without this cultural foundation, SMEs struggle to align processes or foster preparedness, rendering recovery unattainable amid disruptions (Kumar & Anbanandam, 2020). Prior empirical evidence demonstrates that firms lacking a risk-aware culture face prolonged downtime, as reactive approaches fail to systematically address vulnerabilities (Polyviou et al., 2022; Filyppova et al., 2019). This culture underpins strategic alignment and decision-making, making its presence non-negotiable (necessary condition) for effective disaster recovery (Shishodia et al., 2023). Thus, we propose the following hypothesis:

H4a: Risk management culture is a necessary condition for disaster recovery in SMEs.

#### 3.2.2 The necessity relationship between anticipation capabilities and disaster recovery

Anticipation capabilities are critical for detecting disruptions early, enabling SMEs to devise contingency plans that prevent escalation and support recovery (Hohenstein et al., 2015; Duchek, 2020). Without these capabilities, firms cannot proactively position resources or interpret signals,

undermining the ability to restore operations post-disruption (Wagner & Disparte, 2016; Rozhkov et al., 2022). Prior studies have highlighted that SMEs with weak anticipation suffer severe losses during crises, as they lack the predictive insights necessary for timely interventions (Munir et al., 2022; Chopra et al., 2024). Hence, grounded in DCT's sensing phase, anticipation is indispensable (necessary) for translating risk awareness into actionable strategies, therefore making it a prerequisite for disaster recovery in volatile supply chains (Teece et al., 1997; Kamalahmadi & Parast, 2016). Therefore, we propose the following hypothesis:

H4b: Anticipation capabilities are a necessary condition for disaster recovery in SMEs.

### 3.2.3. The necessity relationship between agility and disaster recovery

Supply chain agility, the ability to rapidly reconfigure resources and operations, is vital for adapting to disruptions, ensuring SMEs can mitigate impacts and restore functionality (Baah et al., 2020; Carvalho et al., 2012). Without agility, firms cannot respond effectively to unforeseen changes, leading to disaster recovery failures in dynamic environments (Gligor et al., 2019; Aldhaheri & Ahmad, 2023). Recent studies suggest that agile SMEs recover faster by realigning logistics and procurement, whereas those lacking flexibility face prolonged disruptions (Çetindaş et al., 2023; Singh & Modgil, 2025). Therefore, in line with DCT's transformation phase, agility serves as an essential enabler (necessary condition), bridging foresight to action and ensuring operational continuity (Wieland & Wallenburg, 2012; Reynolds, 2024). Consequently, we propose the following hypothesis:

H4c: Supply Chain Agility is a necessary condition for disaster recovery in SMEs.

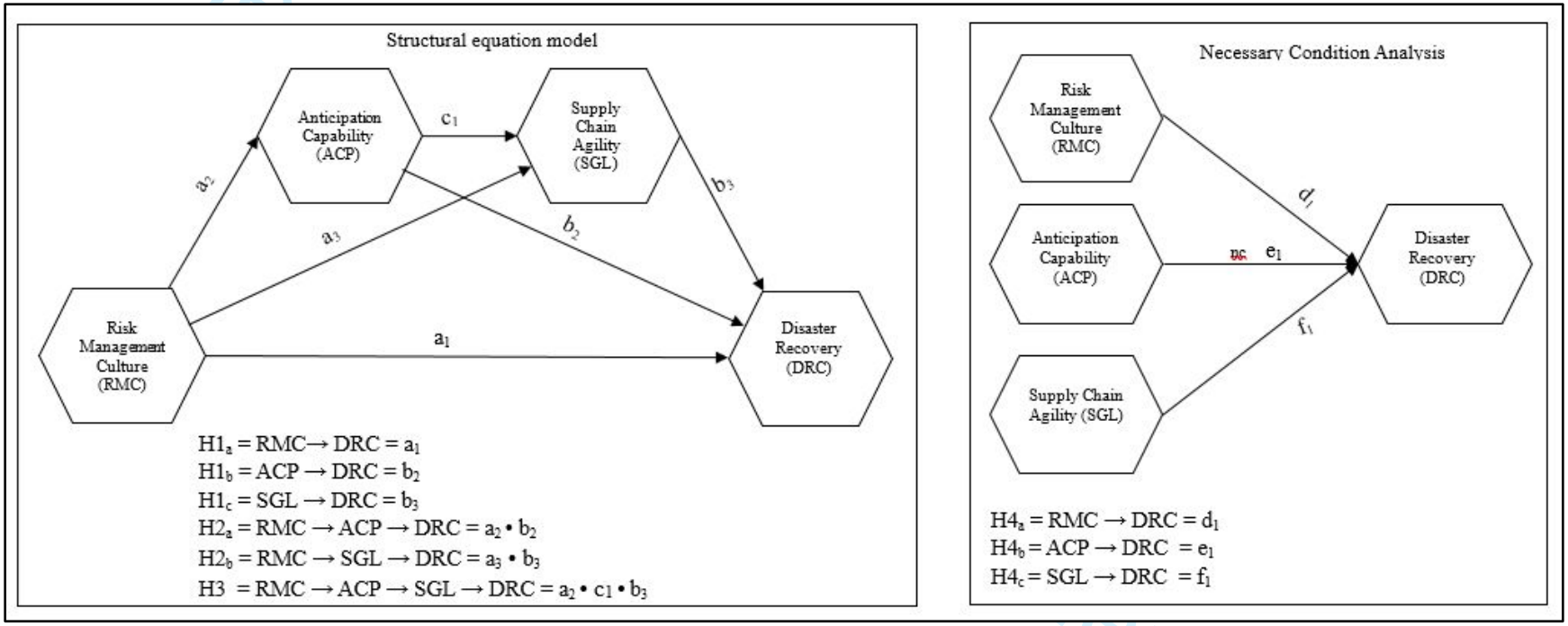


Figure 1: Research framework

## 4. Methods

### 4.1 Context, sample and data

We situate this study in Ghana, an ideal setting for research on SMEs in sub-Saharan Africa and lower-middle-income economies worldwide. SMEs dominate the economy, representing over 92% of registered firms, contributing ~70% of GDP, and employing 85% of the manufacturing workforce (Ghana Statistical Service, 2021; World Bank, 2022). With 80–85% operating informally, these conditions are typical of most emerging markets. Ghana offers rare political stability (three decades of peaceful democratic transitions) alongside classic developing-economy constraints: severe credit constraints, ethnic and spatial heterogeneity, and a pronounced north–south divide. This combination reduces confounding shocks while providing rich variation for causal identification. As a frequent pilot site for donor-funded SME programmes and home to Africa's most advanced mobile-money ecosystem, Ghana yields immediate policy relevance and high-quality identification opportunities. Despite these advantages, it remains relatively understudied compared to Kenya or South Africa, making it a uniquely valuable context for generating rigorous, generalisable insights into SME dynamics in emerging markets. We limited our sample to SMEs in Ghana's Central Region, targeting key decision-makers, such as owner-managers, operations, supply chain, and procurement managers.

To ensure methodological clarity, reproducibility, and comparability with most contemporary empirical studies on Ghanaian firms, this study defines small and medium enterprises (SMEs) exclusively based on the number of permanent full-time employees, and specifically as enterprises with fewer than 100 full-time employees. This aligns with the official definition of SMEs currently used by the Government of Ghana through the Ghana Enterprises Agency (GEA) and the Ghana Statistical Service (GSS), as well as the most widely applied criterion in Ghanaian management and entrepreneurship research (e.g., Amankwah-Amoah et al., 2021). This employee-based definition was adopted not only because it has become the de facto standard in Ghanaian SME research, but also for several reasons. First, employee numbers are objective, easily verifiable, and far less prone to manipulation or seasonal fluctuation than annual turnover figures. Second, virtually all recent large-scale surveys conducted in Ghana (e.g., World Bank Enterprise Surveys – Ghana), as well as most peer-reviewed studies (e.g., Amankwah-Amoah et al., 2021), use the

same employee thresholds. Third, sector-specific differences in capital intensity that plague turnover- or asset-based definitions are largely neutralised when size is measured by employment, making the sample considerably more homogeneous and the findings more interpretable.

Using a random sampling approach, we secured a representative sample of 357 usable responses. Out of these usable responses, 193 were into Services (including Trade, Hospitality, and Tourism), 77 were into Agriculture & Fishing, 42 were into Manufacturing and industry (including food processing, packaging, textiles, and woodwork), 24 were into Construction & Transport, while 21 were into Education, Health, and ICT. We gathered data through a drop-and-pick survey method, utilising a structured questionnaire crafted from validated scales after a comprehensive literature review. This method ensured broad coverage of SME supply chain dynamics while accommodating diverse respondent preferences. The demographic composition of our final sample is presented in Section 4.1.

### 4.2. Measures

We assessed all constructs— risk management culture, anticipation capabilities, agility, and supply chain disaster recovery—using a 7-point Likert scale (1 = least agreement, 7 = strongest agreement) to capture nuanced respondent perspectives and enhance measurement precision. These multi-item scales were already validated in similar emerging-market settings, such as Sri Lankan apparel manufacturing (Abeysekara et al., 2019) and Pakistani manufacturing (Munir et al., 2021). Specifically, we measured disaster recovery with three items adapted from Riley et al. (2016). Similarly, we evaluated RCL and anticipation capabilities using eight items from Abeysekara et al. (2019) and five items from Munir et al. (2022), respectively. Likewise, we assessed agility with seven items from Abeysekara et al. (2019).

Minor wording tweaks for the Ghanaian context were made only after consultation with two senior professors who specialise in resilience, recovery and SMEs in developing economies. The draft was then gone through two rigorous checks. First, cognitive interviews with these experts helped eliminate ambiguity and aligned items with local managerial language. Second, a pilot involving 58 SME owners and senior managers in Greater Accra confirmed that everything was clear and flowed well. Internal reliabilities exceeded 0.78; exploratory factor analysis revealed clean

structures with no cross-loadings, and only minor changes were required. Only after these expert and field validations was the final instrument rolled out to the full sample. This iterative process ensures strong content validity, face validity, and psychometric quality, assuring high confidence in the measures.

### 4.3. Demographic characteristics of respondents

We collected and analysed data on key demographic characteristics, including gender, age, educational attainment, and organisational tenure, on a sample of 357 respondents, revealing distinct patterns. The gender distribution showed a male majority, with 213 men (60%) and 144 women (40%). Age-wise, the sample was predominantly young: 14 respondents (4%) were under 20 years, 163 (46%) were aged 21–30, 144 (40%) were 31–40, 32 (9%) were 41–50, and only 4 (1%) were 51–60, with no respondents over 60. Education levels varied, with 25 (7%) holding a Senior High School certificate, 57 (16%) possessing a diploma or Higher National Diploma, 200 (56%) having an undergraduate degree, and 75 (21%) earning a master's degree, but none holding a PhD. Organisational tenure was short, with 67 (19%) having less than 1 year, 183 (51%) with 1–5 years, 105 (29%) with 6–10 years, and 2 (1%) with 11–15 years, and none exceeding 15 years. These characteristics indicate a young, educated workforce with moderate turnover, which may shape our interpretations of the findings on organisational dynamics (Hair et al., 2019).

Among the SMEs we surveyed, the services sector clearly dominated, accounting for a total of 57% of the sample—203 businesses in all—encompassing a wide range of activities, from wholesale and retail trade to transportation, hotels and restaurants, education, healthcare, and various personal and professional services. The industry sector came in next at 27% (98 firms), encompassing manufacturing, construction, mining and quarrying, utilities, and water/waste management. Rounding out the picture was agriculture, forestry, and fishing—including crop and animal production, aquaculture, and forestry—which made up the remaining 15%, or 56 companies.

### 4.4 Data Analysis

We adopted PLS-SEM as our primary analytical approach to test the direct and mediating effects posited in RQ1 and RQ2, given its suitability for complex models with latent constructs and its

predictive orientation in exploratory supply chain research. Moreover, PLS-SEM accommodates smaller sample sizes and non-normal data distributions common in SME studies, allowing us to robustly examine relationships among risk management culture, anticipation capabilities, agility, and disaster recovery (Hair et al., 2019; Sarstedt et al., 2022). To address RQ3 on opportunities for enhancing these capabilities, we extended PLS-SEM with IPMA, which evaluates both the importance and performance of constructs to pinpoint practical improvement areas for bolstering SME resilience. This technique is particularly suitable for resource-constrained contexts, such as SMEs, as it translates model results into actionable insights by highlighting underperforming yet critical factors (Ringle & Sarstedt, 2016). Finally, for assessing the necessity of these capabilities in achieving disaster recovery, we applied NCA, which identifies indispensable conditions that must be present at certain levels for the outcome to occur, complementing PLS-SEM's focus on average effects. NCA's emphasis on necessity logic is ideal for empirical studies probing necessary enablers, ensuring a comprehensive view of resilience prerequisites (Dul, 2016).

## 5. Results

### 5.1. Descriptive Statistics

We present the descriptive statistics for the key constructs—supply chain agility (SGL), anticipation capabilities (ACP), risk management culture (RCL), and disaster recovery (DRC)—in Table 2, highlighting central tendencies and dispersion patterns among Ghanaian SMEs. The highest mean score emerged for RCL (M = 4.090, SD = 0.841), closely followed by SGL (M = 4.026, SD = 0.951), indicating that respondents perceived their organisations as cultivating risk-aware cultures and agile responses amid disruptions. In contrast, DRC recorded a mean of 3.849 (SD = 0.968), while ACP showed the lowest at 3.460 (SD = 1.153), suggesting room for bolstering foresight mechanisms in resource-constrained settings. All constructs exhibited negative skewness, with RCL (−1.243) and SGL (−1.042) displaying pronounced left-skewed distributions, reflecting a concentration of responses toward higher agreement levels. Excess kurtosis varied, with RCL at 1.379 indicating a leptokurtic profile and tighter clustering around the mean, whereas ACP (−1.312) pointed to a platykurtic spread. Furthermore, Cramér-von Mises tests yielded p-values < 0.001 across all constructs, rejecting normality assumptions and justifying PLS-SEM's application, which accommodates non-normal data effectively (Hair et al., 2019). These insights

not only underscore SMEs' cultural strengths but also reveal perceptual gaps in anticipation and recovery, aligning with dynamic capabilities theory in volatile environments (Teece et al., 1997).

## 5.2. PLS-SEM Results

### 5.2.1. Measurement model assessment

The evaluation of the measurement model followed the recommendations of Hair et al. (2022). Based on the results (Table 1), the model confirmed strong psychometric properties across all constructs. For individual item reliability, all item loadings surpassed the 0.707 threshold recommended by Carmines and Zeller (1979), ranging from 0.719 to 0.840 for Anticipation Capabilities, 0.736 to 0.772 for Disaster Recovery, 0.755 to 0.823 for Agility, and 0.688 to 0.752 for Risk Management Culture. In terms of construct reliability, composite reliability (CR) scores for all constructs exceeded the strict benchmark of 0.7, with values of 0.888 (Anticipation Capabilities), 0.792 (Disaster Recovery), 0.863 (Agility), and 0.870 (Risk Management Culture), well above the acceptable threshold of 0.7. Convergent validity was established through the average variance extracted (AVE), with all constructs surpassing the minimum recommended value of 0.5, as outlined by Fornell and Larcker (1981): 0.614 (Anticipation Capabilities), 0.560 (Disaster Recovery), 0.612 (Agility), and 0.528 (Risk Management Culture).

Furthermore, discriminant validity was confirmed as the square root of the AVE for each construct—0.784 (Anticipation Capabilities), 0.748 (Disaster Recovery), 0.782 (Agility), and 0.727 (Risk Management Culture)—exceeded the correlations between constructs, which ranged from 0.346 to 0.811. Item loadings were also higher within their respective constructs compared to cross-loadings with other constructs. Additionally, the HTMT index was calculated for reflective constructs to assess discriminant validity among indicators within and across constructs. All HTMT ratios (Table 2), including 0.483 (Anticipation Capabilities vs. Agility), 0.684 (Anticipation Capabilities vs. Risk Management Culture), and 0.556 (Disaster Recovery vs. Agility), were below the 0.85 conservative threshold recommended by Hair et al. (2022). As presented in Table 2, these findings indicate a robust and reliable measurement model.

**Table 1: Reliability and Convergent Validity**

| Constructs | Item | loadings | Weights | VIF | CA | CR | AVE |
|---|---|---|---|---|---|---|---|
| **Anticipation Capabilities** | | | | | 0.843 | 0.888 | 0.614 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | rmcac1 | 0.763 | 0.225 | 1.714 | | |
| | rmcac2 | 0.840 | 0.295 | 2.043 | | |
| | rmcac3 | 0.827 | 0.289 | 1.954 | | |
| | rmcac4 | 0.723 | 0.184 | 1.626 | | |
| | rmcac5 | 0.757 | 0.275 | 1.543 | | |
| **Disaster Recovery** | | | | | 0.610 | 0.792 | 0.560 |
| | rmcrc1 | 0.736 | 0.432 | 1.217 | | |
| | rmcrc2 | 0.736 | 0.398 | 1.255 | | |
| | rmcrc3 | 0.772 | 0.504 | 1.180 | | |
| **Supply Chain Agility** | | | | | 0.788 | 0.863 | 0.612 |
| | scrag2 | 0.790 | 0.341 | 1.630 | | |
| | scrag3 | 0.823 | 0.345 | 1.771 | | |
| | scrag4 | 0.757 | 0.293 | 1.575 | | |
| | scrag5 | 0.755 | 0.297 | 1.549 | | |
| **Risk Management Culture** | | | | | 0.822 | 0.870 | 0.528 |
| | scrco2 | 0.719 | 0.265 | 1.514 | | |
| | scrco4 | 0.752 | 0.248 | 1.627 | | |
| | scrco5 | 0.688 | 0.211 | 1.493 | | |
| | scrco6 | 0.749 | 0.226 | 1.667 | | |
| | scrco7 | 0.703 | 0.190 | 1.608 | | |
| | scrco8 | 0.745 | 0.235 | 1.621 | | |

**Table 2: Descriptive Statistics and Discriminant Validity**

| | Descriptive statistics | | | | | | Discriminant validity | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cramér-von Mises | | | | | |
| **Construct** | **Mean** | **Std.** | **Kurtosis** | **Skewness** | **Test stats.** | **P-value** | **1** | **2** | **3** | **4** |
| 1. SGL | 4.026 | 0.951 | 0.378 | -1.042 | 1.980 | 0.000 | **0.782** | 0.483 [0.365 - 0.591] | 0.684 [0.566 - 0.783] | 0.811 [0.698 - 0.911] |
| 2. ACP | 3.460 | 1.153 | -1.312 | -0.181 | 1.492 | 0.000 | 0.405 | **0.783** | 0.556 [0.462 - 0.642] | 0.460 [0.319 - 0.594] |
| 3. RCL | 4.090 | 0.841 | 1.379 | -1.243 | 1.650 | 0.000 | 0.557 | 0.478 | **0.727** | 0.644 [0.499 - 0.773 |
| 4. DRC | 3.849 | 0.968 | -0.260 | -0.708 | 1.000 | 0.000 | 0.573 | 0.346 | 0.458 | **0.748** |

**Note (s)**: ACP = Anticipation Capabilities, SGL = Supply Chain Agility, RCL = Risk Management Culture, DRC = Disaster Recovery. Items in bold represent the square root of AVEs; items below the diagonal are correlations amongst the constructs. HTMT point estimates are above the diagonal, while items in parentheses represent the upper and lower bounds of the 95% biased corrected and accelerated confidence intervals; Min = observed minimum; Max = Observed Maximum"

### 4.2.2. Structural model assessment

The evaluation of the structural model's predictive capabilities assessed both in-sample and out-of-sample performance, confirming its explanatory and generalizable power for endogenous constructs in Ghanaian SMEs, as recommended by Hair et al. (2019). In-sample analysis revealed that Risk Management Culture (RCL) explained 22.9% of the variance in Anticipation Capabilities (ACP) ($R^2 = 0.229$, adjusted $R^2 = 0.227$) and, alongside ACP, accounted for 33.5% of the variance in Supply Chain Agility (SGL) ($R^2 = 0.335$, adjusted $R^2 = 0.331$). For Disaster Recovery (DRC), predictors collectively explained 36.2% of the variance ($R^2 = 0.362$, adjusted $R^2 = 0.356$), indicating moderate explanatory strength per Chin (1998). Positive $Q^2$ values (e.g., 0.227 for ACP) affirmed predictive relevance beyond sample means, aligning with dynamic capabilities theory's emphasis on cultural drivers of adaptive outcomes (Teece et al., 1997). Out-of-sample analysis, using PLS-Predict with 10-fold cross-validation, yielded $Q^2$_predict values above zero (0.963 for SGL, 0.922 for ACP, 0.952 for DRC), with low RMSE (e.g., 0.798 for SGL, 0.869 for DRC) and MAE (e.g., 0.594 for SGL, 0.688 for DRC), though ACP showed slightly higher errors (RMSE 1.019, MAE 0.848) due to greater dispersion (Shmueli et al., 2016). These results confirm the model's robust predictive accuracy and generalizability, offering actionable insights for enhancing SME resilience in volatile supply chains (Quansah et al., 2022).

### 5.2.3. Hypothesis testing

The evaluation of path coefficients, conducted using 10,000 bootstrap iterations, produced beta coefficients (β), t-statistics, p-values, and $f^2$ effect sizes, as outlined by Nitzl et al. (2016). Risk Management Culture (RCL) exerted a strong influence on Anticipation Capabilities (ACP) ($\beta = 0.656$, $t = 13.546$, $p < 0.001$, $f^2 = 0.297$) and Supply Chain Agility (SGL) ($\beta = 0.532$, $t = 9.031$, $p < 0.001$, $f^2 = 0.257$), with large effect sizes confirming its foundational role. SGL significantly predicted Disaster Recovery (DRC) ($\beta = 0.451$, $t = 7.579$, $p < 0.001$, $f^2 = 0.205$), whereas ACP's direct effect on DRC was not significant ($\beta = 0.071$, $t = 1.575$, $p = 0.115$). ACP positively influenced SGL ($\beta = 0.148$, $t = 3.610$, $p < 0.001$, $f^2 = 0.037$). RCL's direct effect on DRC ($\beta = 0.197$, $t = 2.705$, $p = 0.007$, $f^2 = 0.028$) suggested partial mediation. Variance Inflation Factors (VIFs) below 5 confirmed the absence of multicollinearity. These results highlight coordinated capabilities, supporting dynamic capabilities theory in the context of SMEs (Ivanov, 2022).

The mediation analysis, based on bootstrapped indirect effects, confirmed partial mediation of RCL's effect on DRC. RCL's total effect on DRC ($\beta = 0.527$, $p < 0.001$) reduced to a direct effect of $\beta = 0.197$ after accounting for mediators. The pathway through SGL was significant ($\beta = 0.240$, $p < 0.001$), accounting for 46% of the total effect, whereas the path through ACP alone was not significant ($\beta = 0.047$, $p = 0.120$). The serial mediation pathway (RCL → ACP → SGL → DRC) was significant ($\beta = 0.044$, $p = 0.002$), accounting for 8% of the total effect. With a Variance Accounted For (VAF) of 63%, mediators transmitted the majority of RCL's effect, emphasising a sequential process (Henseler, 2021). These findings underscore SGL's critical role in translating cultural strengths into effective disaster recovery, enhancing resilience frameworks for SMEs (Çetindaş et al., 2023).

### 5.2.4. PLS-SEM Robustness Test

The robustness of the PLS-SEM results was assessed by examining linearity assumptions, ensuring the model's structural paths are not biased by non-linear relationships (Hair et al., 2019). Subsequently, quadratic effect tests were conducted for structural paths in the model, and the results (Appendix 1) showed non-significant quadratic effects for all structural paths. These findings confirm linear relationships, supporting the model's validity, as non-linear effects do not distort the structural paths for SME disaster recovery (Teece et al., 1997; Ivanov, 2022).

Additionally, a Gaussian copula approach was tested for endogeneity in the PLS-SEM model across seven configurations, assessing RCL, ACP, and SGL paths to DRC (Hair et al., 2019). However, before the Gaussian copula test, we assessed the data for non-normal distribution (via the Cramér-von Mises test), a critical prerequisite for applying the Gaussian copula approach. The results reveal significant deviations from normality across all constructs (Table 2), indicating non-normal distributions typical in SME datasets (Hair et al., 2019). This non-normality necessitates robust methods to ensure unbiased PLS-SEM results (Teece et al., 1997). Consequently, the Gaussian copula approach was employed for the robustness test, as it effectively addresses endogeneity in non-normal data without assuming linear relationships, ensuring reliable path estimates (Henseler, 2021). The results of all Gaussian copula terms were non-significant (Appendix 2), indicating no endogeneity bias. These consistent results across configurations affirm the model's robustness, ensuring the reliability of path estimates.

**Table 3: Structural model results**

| Relationship | Beta (β) | STD | T statistics | P-value | 95% BCa CI | $f^2$ | VIF |
|---|---|---|---|---|---|---|---|
| **Direct effects** | | | | | | | |
| H1a: RMC ➔ DRC | 0.197 | 0.073 | 2.705 | 0.007 | [0.052 - 0.337] | 0.028 | 1.630 |
| H1b: ACP ➔ DRC | 0.071 | 0.045 | 1.575 | 0.115 | [-0.019 - 0.158] | 0.008 | 1.345 |
| H1c: SGL ➔ DRC | 0.451 | 0.060 | 7.579 | 0.000 | [0.330 - 0.562] | 0.205 | 1.503 |
| **Total Effects** | | | | | | | |
| RCL ➔ DRC | 0.527 | 0.056 | 9.388 | 0.000 | [0.402 - 0.628] | | |
| **Specific Indirect effects** | | | | | | | |
| H2a: RCL ➔ ACP ➔ DRC | 0.047 | 0.030 | 1.557 | 0.120 | [-0.012 - 0.105] | Not Supported | *9%* |
| H2b: RCL ➔ SGL ➔ DRC | 0.240 | 0.040 | 5.957 | 0.000 | [0.165 - 0.320] | Supported | *46%* |
| H3: RCL ➔ ACP ➔ SGL ➔ DRC | 0.044 | 0.014 | 3.125 | 0.002 | [0.019 - 0.075] | Supported | *8.%* |
| **In-sample predictive statistics** | | | | | | | |
| **$R^2$** | | | | | | | |
| ACP | 0.229 | 0.038 | 6.091 | 0.000 | [0.156 - 0.302] | | |
| SGL | 0.335 | 0.052 | 6.412 | 0.000 | [0.226 - 0.430] | | |
| DRC | 0.362 | 0.047 | 7.743 | 0.000 | [0.260 - 0.443] | | |
| **$R^2$ Adjusted** | | | | | | | |
| ACP | 0.227 | 0.038 | 6.016 | 0.000 | [0.154 - 0.300] | | |
| SGL | 0.331 | 0.052 | 6.304 | 0.000 | [0.222 - 0.427] | | |
| DRC | 0.356 | 0.047 | 7.563 | 0.000 | [0.253 - 0.438] | | |
| **Out-of-sample predictive statistics** | **$Q^2$predict** | **RMSE** | **MEA** | | | | |
| ACP | 0.922 | 1.019 | 0.848 | | | | |
| SGL | 0.963 | 0.798 | 0.594 | | | | |
| DRC | 0.952 | 0.869 | 0.688 | | | | |
| SRMR | 0.070 | | | | | | |

**"Note (s)**: ACP = Anticipation Capabilities, SGL = Supply Chain Agility, RMC = Risk Management Culture, DRC = Disaster Recovery, BCa CI = Bias-corrected and accelerated confidence interval"

### 5.2.5 IPMA results

To identify strategic priorities for improving disaster recovery in Ghanaian SMEs, an Importance-Performance Matrix Analysis (IPMA) was conducted, building on PLS-SEM results to assess the effect strength (importance) and operational performance of Risk Management Culture (RCL), Anticipation Capabilities (ACP), and Supply Chain Agility (SGL) on Disaster Recovery (DRC) (Ringle & Sarstedt, 2016). Grounded in dynamic capabilities theory, this approach highlights constructs with high influence but suboptimal performance, offering actionable insights for resource-constrained SMEs in volatile supply chains (Teece et al., 1997; Hair et al., 2019). By mapping importance against performance, the analysis pinpoints areas where targeted enhancements can yield significant recovery benefits, aligning with calls for practical resilience strategies (Quansah et al., 2022). As shown in Table 4, the results provide distinct profiles for each construct, guiding SME interventions in disruption-prone environments.

RCL demonstrated the strongest total effect on DRC (β = 0.527) and a high performance score of 77.254, underscoring its role as a cornerstone of resilience. This strong performance indicates that Ghanaian SMEs have developed risk-aware cultures, embedding proactive practices consistent with dynamic capabilities theory's focus on sensing and adaptation (Hopkin, 2018; Biedermann & Kotzab, 2021). However, its high importance suggests that further enhancements through training and cross-functional coordination could amplify recovery outcomes, particularly given SMEs' resource constraints (Zsidisin et al., 2024). These findings emphasize the need to sustain and refine cultural investments, as incremental improvements in this high-performing construct can drive substantial resilience gains in volatile markets (Polyviou et al., 2022).

**Table 4: Importance-Performance results for Recovery**

| Construct | Total Effect | Performance |
|---|---|---|
| Supply Chain Agility | 0.451 | 75.662 |
| Anticipation Capabilities | 0.138 | 61.508 |
| Risk Management Culture | 0.527 | 77.254 |

SGL exhibited a significant effect on DRC (β = 0.451) with a performance score of 75.662, positioning it as a critical dynamic capability with potential for improvement. This aligns with studies emphasising agility's role in enabling rapid operational adjustments during

disruptions (Baah et al., 2020; Çetindaş et al., 2023). While SMEs show considerable agility, the performance score suggests opportunities to strengthen flexible logistics, decentralised decision-making, and real-time resource allocation. Such enhancements could significantly boost recovery effectiveness, especially in high-risk supply chains where swift adaptation is essential (Singh & Modgil, 2025). Prioritising agility improvements enables SMEs to operationalise cultural strengths, reinforcing dynamic capabilities theory (Wieland & Wallenburg, 2012).

ACP recorded the lowest effect ($\beta = 0.138$) and performance score (61.508), indicating an underutilized capability with significant room for improvement. This finding is consistent with research highlighting SMEs' limited access to foresight tools, which restricts proactive disruption detection (Hohenstein et al., 2015; Munir et al., 2022). Investments in early warning systems, scenario planning, and predictive analytics could enhance ACP's impact, enabling SMEs to anticipate disruptions and improve recovery (Duchek, 2020). Given its low performance, ACP represents a key leverage point, where targeted interventions could yield substantial resilience benefits, aligning with dynamic capabilities' emphasis on sensing environmental changes (Chopra et al., 2024).

### 5.3. NCA results

The application of Necessary Condition Analysis (NCA) assessed whether Risk Management Culture (RCL), Anticipation Capabilities (ACP), and Supply Chain Agility (SGL) are essential for achieving Supply Chain Disaster Recovery (DRC) in Ghanaian SMEs, complementing PLS-SEM findings with a necessity-based perspective (Dul, 2016). The Ceiling Envelope-Free Disposal Hull (CE-FDH) method was employed due to its robustness in handling complex datasets with potential outliers, common in SME studies (Dul et al., 2021). Unlike the CR-FDH, CE-FDH does not assume linear relationships, providing a conservative yet precise boundary for identifying necessity thresholds (Dul et al., 2021; Dul, 2016). This approach ensures accurate detection of necessary conditions for recovery without exaggerating effects, offering practical guidance for formulating appropriate resilience strategies (Ivanov, 2022). The results of necessity hypothesis testing and bottleneck analysis are presented in the subsequent paragraphs. The initial examination of Scatter plots (Figure 2) indicates the existence of necessary conditions for risk management culture and supply chain agility.

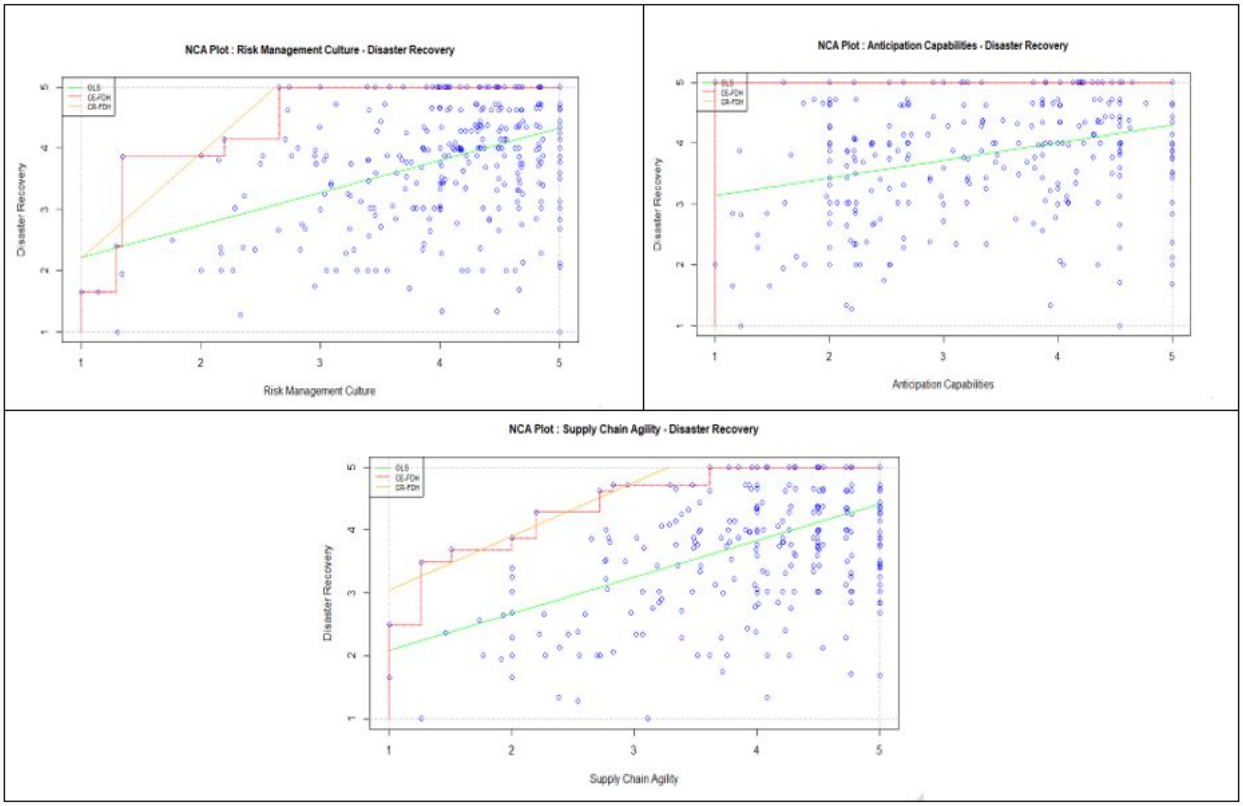


Figure 2: Scatter plots

According to Dul's (2016) effect sizes, values ranging from $0 < d < 0.1$ are classified as "small," $0.1 < d < 0.3$ as "medium," $0.3 < d < 0.5$ as "large," and $d > 0.5$ as "very large." Hence, in alignment with Dul (2025) and Nikookar et al. (2025), we adopted a minimum threshold of $d > 0.10$ for practical relevance and $p < 0.05$ as the benchmark for statistical significance. The effect sizes for risk management culture ($d = 0.154$, $p = 0.000$) and supply chain agility ($d = 0.158$, $p = 0.000$) met both criteria and are thus regarded as medium and substantively necessary, providing support for H4a and H4c. By contrast, the effect size anticipation capabilities did not reach the threshold, leading us to consider H4b as unsupported.

**Table 5: Necessary condition analysis**

| | ***Outcome construct: Supply Chain Disaster Recovery*** | | | | |
|---|---|---|---|---|---|
| | **CE-FDH** | | **CR-FDH** | | |
| | **Effect size** | **P-value** | **Effect size** | **P-value** | **Remark** |
| Supply Chain Agility | 0.158 | 0.000 | 0.140 | 0.000 | Supported |
| Anticipation Capabilities | 0.000 | 0.000 | 0.000 | 0.000 | Not Supported |
| Risk Management Culture | 0.154 | 0.000 | 0.142 | 0.000 | Supported |

The bottleneck analysis, derived from the CE-FDH line, identified minimum thresholds for RCL, ACP, and SGL required to achieve varying DRC levels, as presented in Table 6. At lower recovery levels (0–30%), no specific thresholds were needed (NN), indicating flexibility for basic recovery. However, at 40% recovery, SGL required a minimum threshold of 1.263, and by 50%, RCL demanded 1.344, reflecting their increasing importance as recovery goals escalate (Polyviou et al., 2022). ACP remained non-constraining (NN) until 70% recovery, at which point SGL's threshold increased to 2.000. At 90% recovery, RCL and SGL required 2.656 and 2.716, respectively, highlighting significant bottlenecks at higher recovery levels (Singh & Modgil, 2025). These results suggest that while minimal capabilities suffice for basic recovery, achieving superior recovery demands substantial investments in culture and agility, with anticipation playing a supportive role (Duchek, 2020). The CE-FDH method ensures these thresholds are precise, providing clear guidance for SMEs to prioritise capability enhancements in dynamic environments (Rozhkov et al., 2022).

**Table 6: Bottleneck Table**

| | CE-FDH | | CR-FDH | |
|---|---|---|---|---|
| DRC | RCL | SGL | RCL | SGL |
| 0 | NN | NN | NN | NN |
| 10 | NN | NN | NN | NN |
| 20 | 1.294 | NN | NN | NN |
| 30 | 1.294 | NN | NN | NN |
| 40 | 1.344 | 1.263 | 1.230 | NN |
| 50 | 1.344 | 1.263 | 1.462 | NN |
| 60 | 1.344 | 1.263 | 1.695 | NN |
| 70 | 1.344 | 2.000 | 1.927 | 1.419 |
| 80 | 2.656 | 2.198 | 2.159 | 1.884 |
| 90 | 2.656 | 2.716 | 2.391 | 2.348 |
| 100 | 2.656 | 3.617 | 2.624 | 2.812 |

**Note (s)**: ACP = Anticipation Capabilities, SGL = Supply Chain Agility, RCL = Risk Management Culture, DRC = Disaster Recovery

### 5.4 NCA Robustness Test

We tested the robustness of the NCA results by (a) comparing CE-FDH and CR-FDH results (Table 5), (b) analysing outliers (Appendix 3 & 4), and (c) evaluating significance across 0.05 and 0.001 p-value thresholds (Appendix 5) as outlined by Dul (2021). For RCL, CE-FDH yielded an effect size of 0.154 ($p < 0.001$), while CR-FDH showed 0.142 ($p < 0.001$). SGL recorded effect sizes of 0.158 (CE-FDH) and 0.140 (CR-FDH), both significant ($p < 0.001$). ACP exhibited a minimal effect size (0.000, $p < 0.001$) in both methods (Appendix 5). These consistent results across CE-FDH and CR-FDH confirm the necessity of RCL, SGL, and ACP

for DRC. The similarity in effect sizes ensures reliable identification of necessary conditions for DRC.

Additionally, an outlier analysis tested the stability of NCA results for DRC, as presented in Appendices 3 and 4. For RCL, six outliers (e.g., cases 233, 003) showed absolute effect size differences of 0.00–0.06 (relative differences: 0.1%–37.8%), with ceiling zone and scope outliers identified but not impacting significance. For SGL, six outliers (e.g., cases 220, 310) resulted in absolute differences of 0.00–0.01 (relative differences: 0.4%–9.5%), maintaining consistency (Appendix 3). ACP had no outliers, reinforcing its stable, minimal effect (0.000). These minor variations further confirm the robustness of our NCA findings, as the necessity of all constructs persists despite outliers. This stability ensures precise guidance for SMEs to prioritise essential capabilities in disruption-prone environments (Dul et al., 2021).

Furthermore, the NCA results were evaluated against p-value thresholds of 0.05 and 0.001 to confirm statistical robustness (Appendix 5). The tests reveal that all constructs—RCL, SGL, and ACP—achieved p-values below 0.001 in both CE-FDH and CR-FDH, satisfying both thresholds and affirming their necessity (Dul, 2016). This consistency across stringent (0.001) and standard (0.05) significance levels underscores the reliability of the findings, ensuring that RCL, SGL, and ACP are indispensable for effective disaster recovery in SMEs.

## 6. Summary of Findings, Discussions and Implications

### 6.1. Summary of Key Findings

Our empirical investigation into Ghanaian SMEs reveals that risk management culture (RCL) serves as a cornerstone for enhancing supply chain disaster recovery (DRC), exerting strong direct effects on anticipation capabilities (ACP) ($\beta = 0.656$) and supply chain agility (SGL) ($\beta = 0.532$), which in turn drive recovery outcomes. PLS-SEM results confirm SGL's significant direct impact on DRC ($\beta = 0.451$), while ACP influences SGL ($\beta = 0.148$) but not DRC directly, highlighting a sequential capability cascade. Mediation analyses demonstrate partial mediation, with SGL mediating 46% of RCL's effect on DRC, and serial mediation via ACP and SGL accounting for an additional 8%, resulting in a total of 54% variance accounted for. IPMA highlights the high importance ($\beta = 0.527$) and performance (77.254) of RCL, the substantial role ($\beta = 0.451$, performance 75.662) of SGL with refinement potential, and the underutilization ($\beta = 0.138$, performance 61.508) of ACP. NCA, via CE-FDH, affirms all as necessary conditions, with effect sizes of 0.154 (RCL), 0.158 (SGL), and 0.000 (ACP), and bottlenecks emerging at higher recovery levels for RCL and SGL. These findings, grounded in dynamic capabilities theory, illuminate orchestrated pathways for resilience, offering a holistic

view of how cultural foundations enable adaptive recovery in volatile environments (Teece et al., 1997; Ivanov, 2022).

### 6.1. Summary of Key Findings

The investigation into Ghanaian SMEs confirms that Risk Management Culture (RCL) serves as a foundational driver of Supply Chain Disaster Recovery (DRC), exerting strong direct effects on Anticipation Capabilities (ACP) ($\beta = 0.656$) and Supply Chain Agility (SGL) ($\beta = 0.532$), which in turn facilitate recovery outcomes. PLS-SEM results validate SGL's significant direct impact on DRC ($\beta = 0.451$), while ACP influences SGL ($\beta = 0.148$) but not DRC directly, indicating a sequential capability flow. Mediation analyses reveal partial mediation, with SGL mediating 46% of RCL's effect on DRC and serial mediation (RCL → ACP → SGL → DRC) contributing 8%, resulting in a 63% Variance Accounted For. IPMA highlights RCL's high importance ($\beta = 0.527$) and performance (77.254), SGL's critical role ($\beta = 0.451$, performance 75.662) with improvement potential, and ACP's underperformance ($\beta = 0.138$, performance 61.508). NCA, using CE-FDH, confirms that all constructs are necessary, with effect sizes of 0.154 (RCL), 0.158 (SGL), and 0.000 (ACP). Bottlenecks emerge at higher recovery levels for RCL and SGL. These findings, grounded in dynamic capabilities theory, reveal coordinated pathways for resilience, offering a comprehensive perspective on how cultural foundations facilitate adaptive recovery (Teece et al., 1997; Ivanov, 2022).

### 6.2. Discussions

For research question 1, the PLS-SEM analysis confirms that Risk Management Culture (RCL), Anticipation Capabilities (ACP), and Supply Chain Agility (SGL) directly bolster Disaster Recovery (DRC) in SMEs. RCL establishes a foundation of risk awareness, SGL facilitates swift operational adjustments, and ACP supports indirect effects, consistent with the sensing and transformation stages of dynamic capabilities theory (Teece et al., 1997; Sirmon et al., 2011). The influence of RCL aligns with studies showing that risk-conscious practices reduce operational downtime in resource-limited SMEs (Biedermann & Kotzab, 2021; Zsidisin et al., 2024). Similarly, SGL's significant impact reflects research linking agility to effective responses in volatile environments, enabling rapid resource reallocation (Wieland & Wallenburg, 2012; Çetindaş et al., 2023). While ACP's direct effect on DRC was not significant, its role in enhancing SGL highlights its complementary function in preempting disruptions, particularly in technology-driven crises (Munir et al., 2022; Chopra et al., 2024). These findings build on prior research by quantifying the direct contributions of these

capabilities in SMEs, demonstrating how integrated efforts mitigate vulnerabilities and support recovery during global disruptions like COVID-19 (Polyviou et al., 2022). Thus, the results underscore a coordinated capability framework, challenging singular approaches to resilience and emphasising dynamic interactions (Ivanov, 2022).

For the second research question RQ2, the PLS-SEM mediation analysis reveals that ACP and SGL partially mediate the relationship between RCL and DRC, with SGL accounting for 46% of the effect and the serial mediation pathway (RCL → ACP → SGL → DRC) contributing an additional 8%, indicating a sequential process where cultural foundations flow through foresight to adaptive actions (Nitzl et al., 2016; Henseler, 2021). This aligns with dynamic capabilities theory, where RCL fosters sensing (via ACP) to enable seizing and transforming through SGL, converting cultural norms into practical recovery outcomes (Teece et al., 1997; Duchek, 2020). The lack of significant single mediation through ACP alone suggests that anticipation is most effective when paired with agility, consistent with studies noting that foresight requires responsive mechanisms to impact SMEs (Munir et al., 2022; Rozhkov et al., 2022). Conversely, SGL's strong mediation role echoes findings from dynamic contexts, where agile practices amplify cultural strengths, minimising losses through timely adjustments (Çetindaş et al., 2023; Singh & Modgil, 2025). These results address gaps in prior work by clarifying sequential capability interactions, particularly in disruption-prone settings where partial mediation (63% VAF) underscores culture's indirect influence (Gurtu & Johny, 2021; Barhmi, 2023). This enriches resilience frameworks by illustrating how mediated capabilities drive enhanced recovery in SMEs.

For the third research question (RQ3), IPMA highlights opportunities to enhance RCL, ACP, and SGL to improve DRC in SMEs. ACP shows the greatest potential for improvement, followed by SGL (performance 75.662, $\beta = 0.451$), while RCL's strong performance suggests room for refinement (Ringle & Sarstedt, 2016). These findings align with dynamic capabilities theory, where underdeveloped capabilities like ACP limit overall resilience, necessitating investments in environmental scanning and contingency planning to anticipate disruptions (Hohenstein et al., 2015; Duchek, 2020). For SGL, the results support calls for improving flexible logistics in SMEs to overcome resource constraints and enhance recovery (Baah et al., 2020; Aldhaheri & Ahmad, 2023). RCL's high baseline and importance indicate that ongoing cultural reinforcement through training can sustain resilience, as observed in recoveries from crises like the pandemic (Polyviou et al., 2022; Zsidisin et al., 2024). These insights fill gaps in SME research by quantifying areas for improvement, particularly emphasising ACP as a critical leverage point in volatile markets (Munir et al., 2022; Chopra et al., 2024). Thus, IPMA

provides a strategic guide for targeting enhancements to transform weaknesses into resilience strengths amid rising risks (Quansah et al., 2022).

For the last research question (RQ4), NCA establishes RCL, ACP, and SGL as essential enablers of DRC in SMEs, with CE-FDH effect sizes confirming their necessity. Bottlenecks at higher recovery levels highlight critical thresholds for achieving superior outcomes (Dul, 2016; Dul et al., 2021). This necessity perspective complements PLS-SEM's sufficiency analysis, aligning with dynamic capabilities theory by identifying indispensable baselines, such as RCL's role in fostering vigilance, without which recovery falters (Teece et al., 1997; Biedermann & Kotzab, 2021). SGL's necessity reflects the need for adaptive capacity in disruptions, with minimum thresholds (e.g., 2.716 for SGL at 90% recovery) preventing failures (Çetindaş et al., 2023; Singh & Modgil, 2025). ACP's minimal but significant effect underscores the importance of basic foresight for preemptive resilience (Munir et al., 2022; Duchek, 2020). Bottlenecks indicate flexibility at lower recovery levels but constraints as ambitions increase, guiding SMEs to prioritise capability investments (Polyviou et al., 2022; Rozhkov et al., 2022). These findings address unexplored prerequisites, ensuring robust resilience strategies in diverse SME contexts (Kumar & Anbanandam, 2020).

### 6.3. Theoretical Implications

The PLS-SEM results advance dynamic capabilities theory by confirming that it directly enhances DRC in SMEs, while ACP plays an indirect role (Teece et al., 1997). This quantifies culture's foundational impact and agility's transformative role, challenging views of resilience as a standalone attribute and emphasising coordinated capabilities in resource-constrained settings (Biedermann & Kotzab, 2021; Wieland & Wallenburg, 2012). ACP's non-significant direct effect refines theoretical models by highlighting its complementary function, advancing understanding of capability dynamics in volatile contexts (Munir et al., 2022). This nuanced contribution clarifies how SMEs leverage integrated capabilities to mitigate disruptions, enriching resilience scholarship (Ivanov, 2022).

Further, the mediation findings show that ACP and SGL partially mediate RCL's effect on DRC, enhancing dynamic capabilities theory by illustrating how cultural norms channel through foresight to enable adaptive execution (Henseler, 2021; Duchek, 2020). This sequential pathway addresses gaps in understanding capability interplays, particularly as ACP enhances SGL rather than directly impacting DRC, refining resilience models for SMEs in complex supply chains (Çetindaş et al., 2023; Rozhkov et al., 2022). These insights deepen theoretical

perspectives on mediated resilience mechanisms in disruption-prone environments (Gurtu & Johny, 2021).

Moreover, IPMA's prioritisation of ACP, SGL, and RCL extends dynamic capabilities theory by identifying leverage points for SMEs (Ringle & Sarstedt, 2016). In addition, highlighting ACP's underperformance aligns with calls for enhanced sensing capabilities, linking performance gaps to actionable outcomes (Hohenstein et al., 2015; Quansah et al., 2022). This dynamic perspective moves beyond static models, offering a novel approach to capability development in SMEs (Chopra et al., 2024; Polyviou et al., 2022).

Finally, NCA's validation of RCL, ACP, and SGL as necessary conditions introduces a necessity logic to dynamic capabilities theory and challenges sufficiency-focused models (Dul, 2016; Dul et al., 2021). Identifying necessary thresholds, such as SGL's 2.716 for 90% DRC, refines theory by specifying critical baselines for resilience (Baah et al., 2020; Zsidisin et al., 2024). This advances SME resilience research by emphasising non-negotiable prerequisites for disaster recovery in diverse contexts (Kumar & Anbanandam, 2020; Ivanov, 2022).

### 6.4. Managerial Implications

For RQ1, the findings encourage SME managers to strengthen RCL through risk-focused training and cross-departmental coordination, leveraging its direct impact on DRC to build organisational preparedness. Also, managers should enhance SGL through flexible logistics and decentralised decision-making to help accelerate disaster recovery. Although ACP's direct effect is limited, fostering basic anticipation via partnerships supports agility. Hence, managers should prioritise these capabilities to create robust recovery systems that turn vulnerabilities into competitive strengths. Additionally, the mediation results urge managers to cultivate RCL as a foundation that flows through ACP and SGL to enhance DRC, with SGL's significant mediation (46%) emphasising its role in helping operationalise cultural strengths. Hence, managers should invest in scenario planning to bolster ACP, which can, in turn, amplify SGL's effectiveness for rapid disruption responses. This integrated approach enables the maximisation of limited resources for building robust disaster recovery capabilities. Moreover, IPMA's focus on ACP (performance 61.508) as a high-potential area suggests managers invest in predictive tools and early warning systems to enhance foresight, significantly improving DRC. Strengthening SGL (performance 75.662) through modular processes and supplier diversification addresses SME resource constraints. While RCL performs strongly (77.254), managers should continue to reinforce culture through policy integration to sustain resilience.

These insights guide resource allocation, enabling managers to target weaknesses for significant disaster recovery gains. Finally, NCA's identification of RCL, ACP, and SGL as necessary conditions emphasises the need for minimum thresholds to prevent recovery failures, particularly at higher DRC levels. Managers should therefore establish baseline RCL through risk-aware practices and SGL via adaptive processes, as their absence undermines recovery. Even minimal ACP supports preemptive actions, hence managers need to invest in basic scanning tools to foster robust disaster recovery. This necessity perspective equips managers to ensure operational resilience amid disruptions.

### 6.5. Policy recommendations

Empowering Ghanaian SMEs to thrive amid disruptions requires bold, yet practical policies that embed resilience into their very DNA. Policy makers within the SME space may start by making annual risk-culture assessments mandatory for any SME seeking government support, loans, or tenders, and require every managing director of firms with more than ten employees to complete fully subsidised ISO 31000-aligned Risk Leadership training within two years. Besides, policymakers may also launch a national Risk-Smart SME Certification (Gold, Silver, Bronze) that unlocks real rewards, ensuring that building resilience pays off. At the same time, create a GHC 50–100 million SME Agility Fund to co-finance digital inventory systems, alternative supplier networks, flexible warehousing, and transport redundancy on a generous 70:30 basis. Backed by the creation of regional Agility Hubs that offer shared warehouses, pooled truck fleets, and a national digital platform at heavily subsidised rates. Policy makers may also make agility stress-testing compulsory every two years for high-risk sectors, with free technical assistance available to any SME scoring below 70%. Additionally, they may integrate anticipation and scenario-planning modules into every NBSSI and GEA training programme. These measures are not bureaucracy for its own sake; they are deliberate, interconnected levers that turn cultural awareness into genuine agility, reward proactive firms, and give every small entrepreneur the tools, incentives, and infrastructure to bounce back stronger every single time.

### 6.7. Limitations and Future Research Suggestions

While this study provides robust insights into SME resilience using PLS-SEM, IPMA, and NCA, its focus on Ghanaian SMEs may limit generalizability. Future research could explore diverse regions to test the cross-cultural applicability (Hair et al., 2019; Dul, 2016). The cross-sectional design provides a snapshot, suggesting that longitudinal studies are needed to examine capability development over time (Munir et al., 2022). Self-reported data risks bias,

warranting the use of mixed-methods approaches with objective measures for validation (Podsakoff et al., 2012). Additionally, exploring moderators like industry type or disruption severity could extend dynamic capabilities theory (Teece et al., 1997; Ivanov, 2022). Investigating emerging technologies, such as AI-driven foresight, provides additional avenues for assessing evolving needs (Chopra et al., 2024). These directions pave the way for advancing SME resilience research.

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**Appendix 1: Linearity**

| | Beta | Mean | SD | T statistics | P values |
|---|---|---|---|---|---|
| QE (Supply Chain Agility) -> Disaster Recovery | -0.008 | -0.010 | 0.046 | 0.167 | 0.867 |
| QE (Anticipation Capabilities) -> Supply Chain Agility | -0.050 | -0.049 | 0.041 | 1.219 | 0.223 |
| QE (Anticipation Capabilities) -> Disaster Recovery | -0.009 | -0.007 | 0.049 | 0.182 | 0.855 |
| QE (Risk Management Culture) -> Supply Chain Agility | -0.033 | -0.032 | 0.051 | 0.655 | 0.512 |
| QE (Risk Management Culture) -> Anticipation Capabilities | 0.052 | 0.056 | 0.045 | 1.146 | 0.252 |
| QE (Risk Management Culture) -> Disaster Recovery | -0.030 | -0.028 | 0.055 | 0.549 | 0.583 |

**Appendix 1: Gaussian Copula**

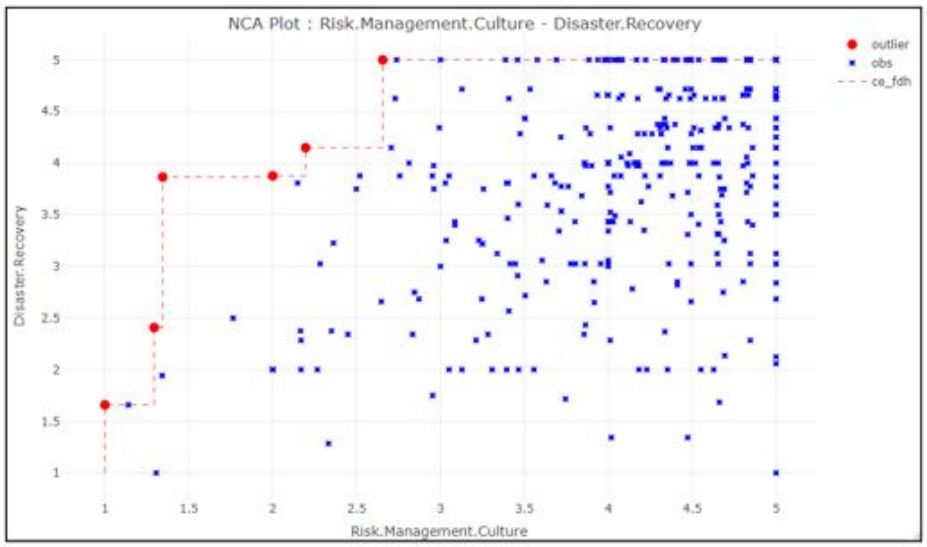
| Model | Endogenous Constructs | Structural Paths | Beta | STD | T statistics | P values |
|---|---|---|---|---|---|---|
| 1 | Risk Management Culture | AG -> DR | 0.445 | 0.063 | 7.087 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.072 | 0.048 | 1.488 | 0.137 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.204 | 0.106 | 1.918 | 0.055 |
| | | GC (RC ➔DR) ➔DR | -0.006 | 0.078 | 0.071 | 0.943 |
| 2 | Anticipation Capabilities | AG -> DR | 0.449 | 0.065 | 6.910 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.067 | 0.081 | 0.825 | 0.409 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.201 | 0.077 | 2.611 | 0.009 |
| | | GC (AC ➔DR) ➔DR | 0.009 | 0.093 | 0.095 | 0.924 |
| 3 | Agility | AG -> DR | 0.454 | 0.091 | 5.015 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.072 | 0.046 | 1.572 | 0.116 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.195 | 0.079 | 2.458 | 0.014 |
| | | GC (AG ➔DR) ➔DR | -0.009 | 0.087 | 0.100 | 0.920 |
| 4 | Risk Management Culture Anticipation Capabilities | AG -> DR | 0.448 | 0.074 | 6.037 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.067 | 0.082 | 0.827 | 0.408 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.203 | 0.107 | 1.903 | 0.057 |
| | | GC (RC ➔DR) ➔DR | -0.003 | 0.086 | 0.030 | 0.976 |
| | | GC (AC ➔DR) ➔DR | 0.007 | 0.103 | 0.070 | 0.944 |
| 5 | Risk Management Culture Agility | AG -> DR | 0.455 | 0.091 | 5.010 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.069 | 0.051 | 1.366 | 0.172 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.205 | 0.106 | 1.928 | 0.054 |
| | | GC (RC ➔DR) ➔DR | -0.011 | 0.084 | 0.134 | 0.893 |
| | | GC (AG ➔DR) ➔DR | -0.015 | 0.093 | 0.162 | 0.871 |
| 6 | Anticipation Capabilities Agility | AG -> DR | 0.454 | 0.091 | 5.007 | 0.000 |
| | | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | | AC -> DR | 0.067 | 0.083 | 0.815 | 0.415 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.198 | 0.089 | 2.229 | 0.026 |
| | | GC (AC ➔ DR) ➔DR | 0.007 | 0.100 | 0.071 | 0.943 |
| | | GC (AG ➔DR) ➔DR | -0.007 | 0.094 | 0.074 | 0.941 |

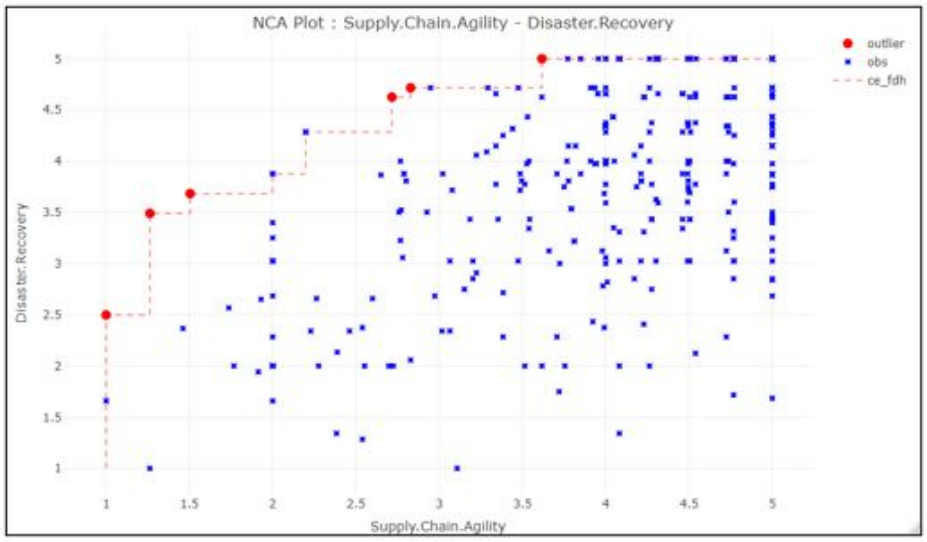
| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Risk Management Culture | AG -> DR | 0.455 | 0.091 | 5.004 | 0.000 |
| | Anticipation Capabilities | AC -> AG | 0.148 | 0.041 | 3.602 | 0.000 |
| | Agility | AC -> DR | 0.072 | 0.089 | 0.800 | 0.424 |
| | | RC -> AG | 0.533 | 0.059 | 9.066 | 0.000 |
| | | RC -> AC | 0.655 | 0.048 | 13.532 | 0.000 |
| | | RC -> DR | 0.206 | 0.107 | 1.929 | 0.054 |
| | | GC (RC ➔ DR) ➔DR | -0.005 | 0.062 | 0.089 | 0.929 |
| | | GC (AC ➔DR) ➔ DR | 0.003 | 0.073 | 0.040 | 0.968 |
| | | GC (AG ➔DR) ➔DR | -0.006 | 0.051 | 0.119 | 0.905 |

**Appendix 3: Outlier Analysis**

| | Outcome construct: Disaster Recovery | | | | | | |
|---|---|---|---|---|---|---|---|
| **Condition** | **Outliers** | **Original effect size** | **New effect size** | **Absolute difference** | **Relative difference** | **Ceiling zone outlier** | **Scope outlier** |
| RCL | 233 | 0.15 | 0.21 | 0.06 | 37.8 | X | |
| | 003 | 0.15 | 0.13 | -0.02 | -16.0 | X | X |
| | 143 | 0.15 | 0.16 | 0.01 | 05.1 | X | |
| | 108 | 0.15 | 0.16 | 0.00 | 02.7 | X | |
| | 323 | 0.15 | 0.16 | 0.00 | 01.5 | X | |
| | 351 | 0.15 | 0.15 | 0.00 | 00.1 | X | |
| ACP | - | - | - | - | - | - | - |
| SGL | 220 | 0.16 | 0.17 | 0.01 | 09.5 | X | |
| | 310 | 0.16 | 0.17 | 0.01 | 08.7 | X | |
| | 187 | 0.16 | 0.16 | 0.01 | 03.8 | X | |
| | 98 | 0.16 | 0.16 | 0.00 | 01.7 | X | |
| | 236 | 0.16 | 0.16 | 0.00 | 01.5 | X | |
| | 342 | 0.16 | 0.16 | 0.00 | 00.4 | X | |

## Appendix 4: Outlier Scatter Plots



## Appendix 5: Significance Thresholds

| Antecedent construct | *Outcome construct: Supply Chain Resilience* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***CE-FDH*** | | | | ***CR-FDH*** | | | | |
| | **Effect size** | **P-value** | **P-value < 0.05?** | **P-value < 0.01?** | **Effect size** | **P-value** | **P-value < 0.05?** | **P-value < 0.01?** | **Remark** |
| Anticipation Capabilities | 0.059 | 0.000 | Yes | Yes | 0.049 | 0.000 | Yes | Yes | Supported |
| Recovery Capabilities | 0.064 | 0.010 | Yes | Yes | 0.056 | 0.007 | Yes | Yes | Supported |
| Risk management Culture | 0.237 | 0.000 | Yes | Yes | 0.274 | 0.000 | Yes | Yes | Supported |

**Responses to reviewer comments on manuscript BPMJ-09-2025-1573**

We would like to express our appreciation to you and the esteemed reviewers for taking the time to read the revised version of our manuscript and for offering suggestions that helped improve it. We are also grateful for your insightful comments on our manuscript, to which we provide our responses (in GREEN)

**REVIEWER: 1**

**Comment #1:**
Revise the title; it is too loaded and disruptive to some extent.

**Response**
Thank you very much for this comment. As advised, the title has been revised in line with your advice. The title now reads "*Opening the black box of disaster recovery in SMEs: Unpacking the antecedent roles of anticipation capabilities, risk management culture, and supply chain agility*"

**Comment #2:**
Perhaps due to the crowded title, the background and problematisation are marred with abrupt transitions and disconnected conjectures. This negates the efforts in building a well-grounded research gap.

**Response**
Thank you very much for this comment. As advised, we have reworked the background and problematisation to improve the transitions to produce a well-grounded research gap. Kindly refer to the coloured parts of the introduction section for details.

**Comment #3:**
Replace these terms (nice-to-have and must-have) with academically friendly terms with appropriate measures. Align your subheadings 2.2.1, 2.2.2, and 2.2.3.

**Response**
Thank you very much for this comment. As advised, we have removed 'nice-to-have' and 'must-have' with 'sufficiency' and 'necessity' throughout the entire paper. We have also revised sections 2.2.1, 2.2.2, and 2.2.3 in line with this revision. Having done this, we respectively disagree with your assertion that 'nice-to-have' and 'must-have' are not academically friendly terms, as these terms are abundant in the literature in cases where sufficiency and necessity are tested. I provide a few cases below;

Costa, J., Amorim, I., Reis, J., & Melão, N. (2023). User communities: from nice-to-have to must-have. *Journal of Innovation and Entrepreneurship*, *12*(1), 25.

Tetteh, F. K., Owusu Kwateng, K., Obiri-Yeboah, H., Amoako, D. K., & Nyamekye, B. (2025). Unpacking the nice-to-have and must-have antecedents and outcomes of supplier commitment. *Journal of Manufacturing Technology Management*.

Mahapatra, S., Ramani, A. T. P., & Kulkarni, A. D. (2019). Must have or nice to have. *Journal of Business & Industrial Marketing*, *34*(1), 39-48.

Quaicoe, J., Acquah, I. S. K., & Gatsi, J. G. (2024). Unravelling the nice-to-have and must-have circular economy-oriented dynamic capabilities for sustainable product design and end-

of-life management: Insights from PLS-SEM and NCA. *Journal of Cleaner Production*, *479*, 144004.

Meyer, K. A., & Jones, S. J. (2012). Graduate students rate institutional websites: The must have, nice to have, and delighted to have services. Journal of asynchronous learning networks, 16(1), 5-18.

**Comment #4:**
Why Ghana? Perhaps instead of simply acknowledging the importance of SMEs, you could build a case on why you chose Ghana. Could this be a similar context to all developing economies?

**Response**
Thank you very much for this comment. As advised, we've made a strong case for choosing Ghana as the study's context. Kindly refer to the coloured parts of Section 4.1 (i.e., first paragraph) for details.

**Comment#5:**
Remove abbreviations and acronyms in the abstract.

**Response**
Thank you very much for this comment. As advised, we have removed all abbreviations from the abstract. Please refer to the coloured parts of the abstract for details.

**Comment #6:**
Recast research question 3.

**Response**
Thank you very much for this comment. As advised, we have rephrased RQ3, which now reads "*RQ3: Do opportunities exist for improving the levels of risk management culture, anticipation and recovery capabilities reached by SMEs to positively impact their disaster recovery?*" Please refer to research question 3 in Section 1 for details.

**Comment #7:**
7. Propose specific policy recommendations based on your findings.

**Response**
Thank you very much for this comment. As advised, we've provided policy recommendations based on our findings. Kindly refer to Section 6.5 for details

**Comment # 8:**
Clarify the sectors where SMEs were drawn. The study background focuses on disaster recovery in the automotive and IT sectors. However, in the methodology, the sectors from which the SMEs were drawn are conspicuously missing.

**Response**
Thank you very much for this comment. As advised, we've provided clarity on the sectors where SMEs were drawn. Please refer to the coloured parts of Section 4.3 for details.

**Additional comment #1:**
1. Originality: Does the paper contain new and significant information adequate to justify publication?: Yes, the paper addresses an important nexus of Disaster recovery, risk management culture, Anticipation Capabilities, and supply chain agility among SMEs in the Ghanaian context. However, the author must revise Research Question 3, which reads, RQ3: Is there room for improving the levels of risk management culture, anticipation and recovery capabilities reached by SMEs to positively impact their disaster recovery? I am curious, how will the authors measure 'room'?

**Response**
Thank you very much for this comment. As advised, we have rephrased RQ3, which now reads "*RQ3: Do opportunities exist for improving the levels of risk management culture, anticipation and recovery capabilities reached by SMEs to positively impact their disaster recovery?*" Please refer to research question 3 in Section 1 for details.

**Additional comment #2:**
2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: The literature review is robust, except for any disruptive semantics, such as 'nice-to-have' and 'must-have', etc. For example, instead of the nice-to-have relationship between RMC and disaster recovery in section 2.2.1. Simplify by examining the relationship between risk management culture and disaster recovery in SMEs. Kindly revise the other sections accordingly to enhance the flow and reduce disruptions.

**Response**
Thank you very much for this comment. As advised, we have replaced 'nice-to-have' and 'must-have' with 'sufficiency' and 'necessity', respectively. We have also revised sections 2.2.1, 2.2.2, and 2.2.3 in line with this revision. Having done this, we respectively disagree with your assertion that 'nice-to-have' and 'must-have' with 'sufficiency' and 'necessity are not academically friendly terms, as these terms are abundant in the literature in cases where sufficiency and necessity are tested. I provide a few cases below;

Costa, J., Amorim, I., Reis, J., & Melão, N. (2023). User communities: from nice-to-have to must-have. *Journal of Innovation and Entrepreneurship*, *12*(1), 25.

Fernandes Lima, T., Bahli, B., Arbulu, A., Hamdi, A., & Saikouk, T. (2025). Differentiating "must–have" and "should–have" supply chain capabilities for enhanced performance: a necessary conditions analysis. Journal of Business & Industrial Marketing, 40(2), 313-338

Halasyamani, P. S., & Rondinelli, J. M. (2018). The must-have and nice-to-have experimental and computational requirements for functional frequency doubling deep-UV crystals. Nature communications, 9(1), 2972.

Liehr, J., & Hauff, S. (2022). Must have or nice to have? necessary leadership competencies to enable employees'innovative behaviour. International Journal of Innovation Management, 26(10), 2250070.

Mahapatra, S., Ramani, A. T. P., & Kulkarni, A. D. (2019). Must have or nice to have. *Journal of Business & Industrial Marketing*, *34*(1), 39-48.

Meyer, K. A., & Jones, S. J. (2012). Graduate students rate institutional websites: The must have, nice to have, and delighted to have services. Journal of asynchronous learning networks, 16(1), 5-18.

Quaicoe, J., Acquah, I. S. K., & Gatsi, J. G. (2024). Unravelling the nice-to-have and must-have circular economy-oriented dynamic capabilities for sustainable product design and

end-of-life management: Insights from PLS-SEM and NCA. *Journal of Cleaner Production*, *479*, 144004.

Tetteh, F. K., Owusu Kwateng, K., Obiri-Yeboah, H., Amoako, D. K., & Nyamekye, B. (2025). Unpacking the nice-to-have and must-have antecedents and outcomes of supplier commitment. *Journal of Manufacturing Technology Management*.

**Additional comment #3:**
Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: The methodology is fair based on PLS-SEM analysis. However, I have the following observations.The methodology uses adapted measures from Riley et al. (2016), Abeysekara et al. (2019) and Munir et al. (2022). While this is recommended to some extent, the author should explain in which context the measures were used and how they fit into the current study.

**Response**
Thank you very much for this comment. The multi-item scales employed in this study were already validated in similar emerging-market settings, such as Sri Lankan apparel manufacturing (Abeysekara et al., 2019) and Pakistani manufacturing (Munir et al., 2021). Minor wording tweaks for the Ghanaian context were made only after consultation with two senior professors who specialise in resilience, recovery and SMEs in developing economies. Please see the coloured parts of Section 4.2 for details.

**Additional comment #4:**
Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper? The PLS-SEM analysis is robust. However, a typical model fit in PLS-SEM must have composite reliability $\geq 0.70$, AVE $\geq 0.50$, HTMT $< 0.85$, $R^2$ values indicating at least moderate explanatory power, and SRMR $< 0.08$ to ensure reliability, validity, and acceptable overall fit. In this case, HTMT and SRMR are missing.

**Response**
Thank you very much for this comment. The HTMT values were provided in Table 2 under discriminant validity. The HTMT values and their corresponding confidence intervals are above the diagonal, whereas the correlations among the constructs are below the diagonal. The values in bold are the square root of AVEs. We apologise for not indicating this within the footnote to Table 2. This, however, has been rectified. Kindly refer to the coloured part of Table 2 for details. The SRMR is 0.07, and since this is above the threshold of 0.08, this is considered a good fit. Kindly refer to the coloured parts of Table 3 for the SRMR value.

**Additional comment #5:**
Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: The study has articulated the theoretical and managerial implications well.

**Response**
Thank you very much for this comment. We are grateful.

**Additional comment #6:**
Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: The communications could be enhanced if the authors could use acronyms sparingly.

**Response**
Thank you very much for this comment. As advised, the communications in the paper have been improved, and acronyms are used sparingly.

**REVIEWER: 2**

**Comments #1:**
**Theoretically superficial and misapplied framework**: The limitation: the study uses dynamic capabilities theory (DCT) as a label rather than a true analytical lens. The connection between the constructs (RMC, ACP, SGL) and the core tenets of DCT (sensing, seizing, transforming) is asserted but not deeply explained or critically engaged with. Most critically, the study introduces necessary condition analysis to test must-have conditions. DCT is a theory of sufficiency (what capabilities are sufficient for competitive advantage). The authors make no effort to reconcile this philosophical mismatch. Is a necessary condition the same as a dynamic capability? This unaddressed tension strikes at the logical core of the paper. Why it grounds rejection: a theoretical framework is meant to explain why relationships exist. The failure to deeply integrate and correctly apply the chosen theory means the study lacks a coherent explanatory narrative. It becomes a empirical report of correlations without a soul, significantly diminishing its theoretical contribution.

**Response**
Thank you very much for this comment. As advised, this anomaly has been corrected, and the theory, DCT, has now been applied through an analytical lens rather than being used as a label. Please refer to the coloured parts of Section 2.1 for details.

**Comments #2:**
**Fatally flawed sampling and population definition**: The limitation: the manuscript does not define what constitutes an SME in the Ghanaian context. This is a fatal flaw in methodological rigor. Without clear criteria, the study is not reproducible, and the population is not properly defined. A small manufacturing firm might have 50 employees, while a small service firm might have 10. Pooling them without a standard definition makes the sample heterogenous and the findings uninterpretable. The claim of studying SMEs becomes meaningless.
Why it grounds rejection: this is a basic requirement of empirical research. If the sample cannot be defined, the findings cannot be trusted or generalized, even within the stated context of Ghana. A reviewer could justifiably argue that this flaw alone invalidates the entire study.

**Response**
Thank you very much for this comment. As advised, we have appropriately defined the population by indicating what constitutes SMEs in the Ghanaian context. Kindly refer to the coloured parts of Section 4.1 (specifically, the second paragraph) for details.

**Comments #3:**
**Overstated and unsubstantiated claims of contribution**: The limitation: the abstract and introduction claim the study opens the black box and provides a novel framework that challenges sufficiency assumptions. However, the results largely confirm established knowledge and the discussion fails to deliver on the promised theoretical upheaval. The finding that anticipation alone doesn't directly aid recovery is interesting but is not leveraged to refine or challenge DCT in a meaningful way. Why it grounds rejection: journals publish papers based on their contribution to knowledge. If the contribution is overstated, the paper's raison d'être is weakened. A reviewer could conclude that the paper does not offer the significant, novel insights it promises and is therefore not a good fit for the journal.

**Response**
Thank you very much for this comment. As advised, we have leveraged the finding that anticipation alone doesn't directly aid recovery to refine or challenge DCT in a meaningful way. We, however, respectively disagree with your assertion that the results largely confirm established knowledge, and the discussion fails to deliver on the promised theoretical upheaval. Please refer to the coloured parts of Section xxx for details. We respectfully submit that our findings have not only provided insights from direct and mediating analysis but also uncovered fresh insights regarding how the various antecedents of disaster recovery could be enhanced to ensure optimal levels of disaster recovery. Besides, the NCA analysis helped unearth the necessity (in kind and degree) of risk management culture, anticipation capabilities and supply chain agility for disaster recovery.

**Comments #4:**
**Inadequate measurement model and construct validity**: The limitation: the psychometric properties of the key constructs are weak. Disaster recovery: the composite reliability (CR) is 0.792, which is below the 0.80 threshold the authors themselves cite as a strict benchmark. Risk management culture: the average variance extracted is 0.528, barely above the 0.5 minimum, indicating that the items explain only slightly more variance in the construct than they do in error. Why it grounds rejection: the core variables of the study are not being measured with sufficient reliability and validity. If the disaster recovery construct is not reliably measured, then all the path coefficients leading to it (the main findings of the paper) are built on a shaky foundation. A strict reviewer would argue that hypotheses tested with an unreliable outcome variable cannot be trusted.

**Response**
Thank you very much for this comment. The composite reliability for disaster recovery is 0.792, which exceeds the recommended minimum of 0.7 by Hair, Risher, Sarstedt, and Ringle (2019). The 0.8 is a typographical error for which we sincerely apologise. Same argument applies to the AVE figure for risk management culture, which stands at 0.528, also above the recommended minimum of 0.5 (Hair, Risher, Sarstedt, & Ringle, 2019). Hence, our model is both reliable and valid. We therefore respectfully but strongly disagree with your assertion that our core variable, disaster recovery, is not reliable.

**Additional comment #1.**
**Originality:** Does the paper contain new and significant information adequate to justify publication?: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.

**Additional comment #2:**
**Relationship to Literature:** Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any signficant work ignored?: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.

**Additional comment #3.**
**Methodology:** Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.

**Additional comment #4:**
**Results:** Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.

**Additional comment #5:**
**Implications for research, practice and/or society**: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.

**Additional comment #6**
**Quality of Communication:** Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: See global comments.

**Response**
Thank you very much for this comment. Please refer to my earlier response to this.