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Supply Chain Disruption, Resilience Capability, and Firm Survival in Medan's Palm Oil Industry Post-COVID-19

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ABSTRACT

This study aims to examine the impact of supply chain disruption on firm survival in the palm oil industry in Medan following the COVID-19 pandemic. It also investigates the mediating role of resilience capability in mitigating the negative effects of disruptions on organizational sustainability. This research employs a mixed-methods approach using a sequential explanatory design. Quantitative data were collected from 196 palm oil companies in Medan and surrounding areas through structured questionnaires. The data were analyzed using structural equation modeling (SEM) to assess the relationships between variables. Additionally, qualitative insights were used to enrich the interpretation of the findings. Resilience capability was measured through four dimensions: adaptability, agility, robustness, and collaborative networking. The results indicate that supply chain disruption has a significant negative effect on firm survival. However, resilience capability plays a crucial mediating role in reducing this negative impact. Firms with higher levels of resilience are better able to maintain operational performance despite severe disruptions. Furthermore, factors such as technology adoption and firm size also influence a company's ability to survive during crisis conditions. This study contributes to the supply chain management literature by integrating supply chain disruption and firm survival within the context of the palm oil industry in a developing country. It highlights the strategic importance of resilience capability as a mediating mechanism and provides empirical evidence from the post-pandemic period, offering practical implications for building more adaptive and resilient supply chains.

Keywords: Supply Chain Disruption, Resilience Capability, Firm Survival, Palm Oil Industry, COVID-19

INTRODUCTION

The COVID-19 pandemic, which began spreading globally in early 2020, did something no business textbook had fully prepared companies for it broke multiple links of the supply chain at the same time. Most global supply chains were built around a philosophy of maximum efficiency keeping inventories lean, sourcing from the cheapest suppliers, and moving goods as fast as possible. This works well in stable conditions. But when a pandemic hit, that efficiency became a fragility.

Few industries felt this more sharply than palm oil. Indonesia produces more crude palm oil (CPO) than any other country on earth, accounting for approximately 59.6% of global supply in 2021 (GAPKI, 2022). Yet despite that dominant position, Indonesian palm oil companies especially those operating in Medan, the country's third-largest city and the commercial heart of North Sumatra's palm oil trade faced disruptions from multiple directions at once: raw material shortages, export blockages, labor restrictions, and volatile demand from overseas buyers (Brandon-Jones et al., 2021).

National CPO production fell from 47.12 million metric tons in 2019 to 46.88 million metric tons in 2020 (Ministry of Agriculture of Indonesia, 2022). That 0.5% decline looks modest on paper, but the aggregate number hides the real pain experienced at the company level. Some firms lost 40–60% of their operational capacity during the peak disruption months of April to August 2020. Others barely noticed. Understanding why companies responded so differently is the central question of this study.

North Sumatra Province is home to 1.52 million hectares of palm oil plantations producing approximately 18.4 million tons of fresh fruit bunches (FFB) annually (North Sumatra Plantation Agency, 2023). Medan serves as the region's commercial hub, with the Port of Belawan functioning as the primary export gateway for CPO and its derivatives.During the height of the pandemic, cargo handling at Belawan dropped by 31.4% between April and August 2020, driven by ship schedule cancellations, a severe shortage of shipping containers, and movement restrictions that kept port workers at home (Huo et al., 2020). At the same time, PSBB (Pembatasan Sosial Berskala Besar) Indonesia's version of a social restriction policy made it difficult for harvest workers to reach plantations, leading to FFB spoilage in the field at farms without alternative logistics access (Dubey et al., 2021).

A preliminary survey of 42 companies registered with APKASINDO (Indonesian Palm Oil Producers Association) North Sumatra revealed striking variation in outcomes. Some companies maintained 85–100% of their pre-pandemic operational capacity throughout the crisis. Others fell below 50%. A small number temporarily halted operations entirely. Importantly, company size alone did not explain these differences. Some small firms outperformed much larger competitors. This points toward something more organizational in nature specifically, the set of capabilities a firm has built to absorb, adapt to, and recover from disruptions.

This study addresses all three gaps by testing a structural model in which resilience capability measured across four dimensions: adaptability, agility, robustness, and collaborative networking mediates the relationship between supply chain disruption and firm survival. We also test whether firm size and technology adoption moderate how strongly resilience capability translates into actual survival outcomes.

This study extends Dynamic Capability Theory to the context of tropical agribusiness under systemic crisis, and confirms the mediating not merely moderating role of resilience capability in the disruption to survival pathway. Practically, the findings offer evidence based guidance for palm oil company managers in designing more crisis-resistant supply chain systems, and for institutions like GAPKI and the North Sumatra Provincial Government in shaping industry policy.

METHODOLOGY

This study uses a sequential explanatory mixed-methods design, combining two phases conducted in order: a qualitative phase to build context-specific understanding, followed by a quantitative phase to test and generalize the findings statistically (Tiwari et al., 2021) . This design was chosen because resilience capability is a multidimensional construct that cannot be measured reliably using standardized instruments alone without first exploring how it actually manifests in the local industry context (Wamba et al., 2020).

Population, Sample, and Unit of Analysis

The study population consists of all business entities operating in the palm oil sector covering plantation companies, refinery operations, and CPO traders and brokers that are domiciled or operationally active in the Medan Metropolitan Area (Earnshaw, 2023; Puspita Sari & Miranda, 2023). This area includes Medan City and the surrounding regencies of Deli Serdang, Serdang Bedagai, and Langkat. According to combined data from GAPKI North Sumatra and BKPM (2023), there are 383 such entities meeting these criteria (Saberi et al., 2019).

Sampling was carried out using stratified random sampling, with strata defined by company size following the classification of Indonesia's Ministry of Industry: large (more than 250 employees), medium (50–250 employees), and small (fewer than 50 employees). Sample size was calculated using Slovin's formula at a 5% margin of error, yielding a required minimum of n = 193, rounded up to 210 to account for expected non-response (Ali et al., 2020).

The unit of analysis is the firm. Each questionnaire was completed by the individual most knowledgeable about supply chain operations: the company director, operations manager, or supply chain manager, with a minimum of three years' tenure at the company (Kache & Seuring, 2019).

Conceptual Model and Hypotheses

The research model (Figure 2) is built on a synthesis of Dynamic Capability Theory (Teece, 2007) and the Supply Chain Resilience Framework (Ponomarov & Holcomb, 2009). It positions resilience capability as the key bridge between disruption and survival, with firm size and technology adoption shaping how strong that bridge is(Gustiari, 2023; Sihotang & Damiyati, 2023).

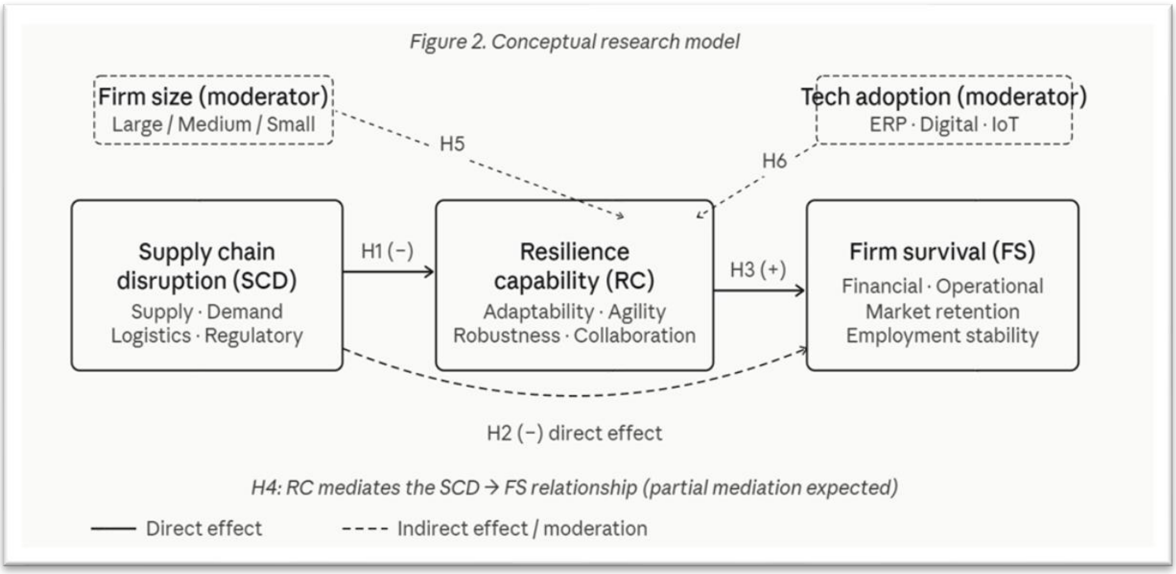

Figure 2. Conceptual research model

Six hypotheses are derived from Figure 2:
H1: Supply chain disruption has a significant negative effect on resilience capability.
H2: Supply chain disruption has a significant negative direct effect on firm survival.
H3: Resilience capability has a significant positive effect on firm survival.
H4: Resilience capability mediates the relationship between supply chain disruption and firm survival.
H5: Firm size moderates the relationship between resilience capability and firm survival.
H6: Technology adoption strengthens the relationship between resilience capability and firm survival.

Variable Measurement

All constructs are measured using a five-point Likert scale (1=strongly disagree / not at all affected, 5 = strongly agree / severely affected). Instruments were adapted from validated scales in the literature, translated into Indonesian, and verified through back-translation and expert panel review, achieving a content validity ratio (CVR) ≥ 0.70 for all items. Table 1 summarizes the operationalization (Chowdhury et al., 2021; Ivanov & Das, 2020; Sharma et al., 2020; Wieland, 2020).

Table 1. Variable Operationalization

Variable	Dimension	Items
Supply chain disruption (SCD)	Supply-side disruption	4
	Demand-side disruption	3
	Logistics disruption	4
	Regulatory disruption	3
Resilience capability (RC)	Adaptability	4
	Agility	4
	Robustness	3
	Collaboration	4
Firm survival (FS)	Financial survival	3
	Operational continuity	3
	Market retention	3
	Employment stability	2
Firm size (moderator)	—	2
Technology adoption (moderator)	—	5

Data were collected in two stages. In Stage 1 (January–February 2023), in-depth semi-structured interviews were conducted with eight senior managers from companies varying in size and business type. Interviews were audio-recorded with informed consent and lasted an average of 72 minutes (Queiroz et al., 2020; Tarigan et al., 2021; Yildiz Çankaya & Sezen, 2019). Transcripts were analyzed using thematic analysis in NVivo 12. The findings from this stage were used to refine and contextualize the survey instrument for Stage 2 (El Safira et al., 2023; Rismawati & Gultom, 2023; Sakinah et al., 2023).

In Stage 2 (March–May 2023), structured questionnaires were distributed through direct office visits (self-administered) assisted by two trained enumerators (Alif Ramadhan, 2023; Ohimain Ozumba, 2023; Sari Lubis, 2023). Of the 210 questionnaires distributed, 203 were returned (response rate: 96.7%). After removing questionnaires with more than 10% missing values, 196 were retained for analysis (Zhang et al., 2020).

Analytical Strategy

The analysis followed a four-step sequence using SmartPLS 4.0 and SPSS 26. Table 2 summarizes each step, its purpose, and the criteria used to judge results.

Table 2. Data Analysis Sequence and Decision Criteria

Step	Purpose	Method / Tool	Acceptance Criteria
1. Descriptive statistics	Profile respondents; describe disruption levels	SPSS 26	—
2. Measurement model	Test validity and reliability	CFA, SmartPLS 4.0	Factor loading > 0.70; AVE > 0.50; CR > 0.70; α > 0.70
3. Discriminant validity	Confirm constructs are distinct	HTMT ratio	HTMT < 0.85
4. Structural model	Test H1, H2, H3	Path coefficients + bootstrapping (5,000 subsamples)	$t > 1.96$; $p < 0.05$
5. Mediation test (H4)	Test indirect effect of RC	Bootstrapping confidence intervals	CI does not include zero
6. Moderation test (H5, H6)	Test interactionize × RC; Tech × RC	Interaction term in PLS	$t > 1.96$; $p < 0.05$
7. Model fit	Assess overall model quality	SRMR, R^2, Q^2, f^2	SRMR < 0.08; $R^2 > 0.35$; $Q^2 > 0$

RESULTS

Respondent and Company Profile

Of the 196 usable responses, the majority of respondents held operational or supply chain management positions, with more than 85% having at least five years of experience at their current company. This seniority level gives confidence that respondents had direct, first-hand knowledge of how their companies navigated the disruption period. Table 3 presents the full profile.

Table 3. Profile of Respondents and Companies

Characteristic	Category	n	%
Position	Director / Owner	49	25.0
	Operations Manager	91	46.4
	Supply Chain Manager	56	28.6
Years at company	Less than 5 years	28	14.3
	5–10 years	84	42.9
	More than 10 years	84	42.9
Company size	Large (> 250 employees)	45	23.0
	Medium (50–250 employees)	92	46.9
	Small (< 50 employees)	59	30.1
Business type	Plantation / FFB production	78	39.8

	Refinery / processing	69	35.2
	Trading / brokerage	49	25.0
Technology adoption level	High (ERP + digital procurement + tracking)	58	29.6
	Medium (partial digital systems)	84	42.9
	Low (manual / paper-based)	54	27.6

Severity and Type of Disruption Experienced

Before testing the hypotheses, it is important to understand what kinds of disruptions companies actually experienced and how severe they were. Table 4 presents the mean scores for each disruption dimension, where 1 means the company was not affected at all and 5 means it was severely affected.

Table 4. Descriptive Statistics for Supply Chain Disruption Dimensions

Disruption Dimension	Mean	SD	Level
Supply-side (FFB scarcity, input shortages)	4.21	0.68	High
Logistics (container shortage, port delays)	4.07	0.74	High
Demand-side (export order cancellations, price volatility)	3.68	0.81	Moderate-High
Regulatory (policy changes on export quotas, movement restrictions)	3.41	0.87	Moderate
Overall SCD composite	3.84	0.61	High

Supply-side and logistics disruptions were by far the most severe. This aligns with the qualitative findings from Phase 1, where seven out of eight managers cited the container shortage at Belawan Port and the inability of harvest workers to reach plantations as the two most damaging operational challenges. One regional operations director described the situation bluntly: We had the fruit, we had the buyers, but we couldn't move anything.

Regulatory disruption, while real, was rated as moderate. This suggests that companies found government policies manageable compared to the raw operational shocks of the supply and logistics collapse.

Measurement Model Results

Before testing the structural relationships, the measurement model must be confirmed — meaning we need to verify that the survey items actually measure what they are supposed to measure, and that the constructs can be distinguished from one another.

Table 5. Measurement Model Results

Construct	Dimension	Factor Loading Range	AVE	Composite Reliability (CR)	Cronbach's α
SCD	Supply-side	0.71–0.83	0.612	0.891	0.863
	Demand-side	0.73–0.79			
	Logistics	0.72–0.85			
	Regulatory	0.70–0.77			
RC	Adaptability	0.74–0.86	0.594	0.882	0.849
	Agility	0.73–0.84			
	Robustness	0.71–0.81			
	Collaboration	0.72–0.83			
FS	Financial	0.76–0.88	0.643	0.902	0.876
	Operational	0.74–0.85			
	Market	0.73–0.82			
	Employment	0.71–0.78			

All factor loadings exceed the 0.70 threshold. AVE values are all above 0.50, confirming convergent validity. Composite reliability and Cronbach's alpha both exceed 0.70 for every construct, confirming internal consistency.

Table 6. Discriminant Validity — HTMT Ratios

	SCD	RC	FS
SCD	—		
RC	0.621	—	
FS	0.548	0.593	—

All HTMT ratios are well below the 0.85 threshold, confirming that supply chain disruption, resilience capability, and firm survival are empirically distinct constructs. The measurement model is therefore sound and the structural analysis can proceed.
Structural Model and Hypothesis Testing

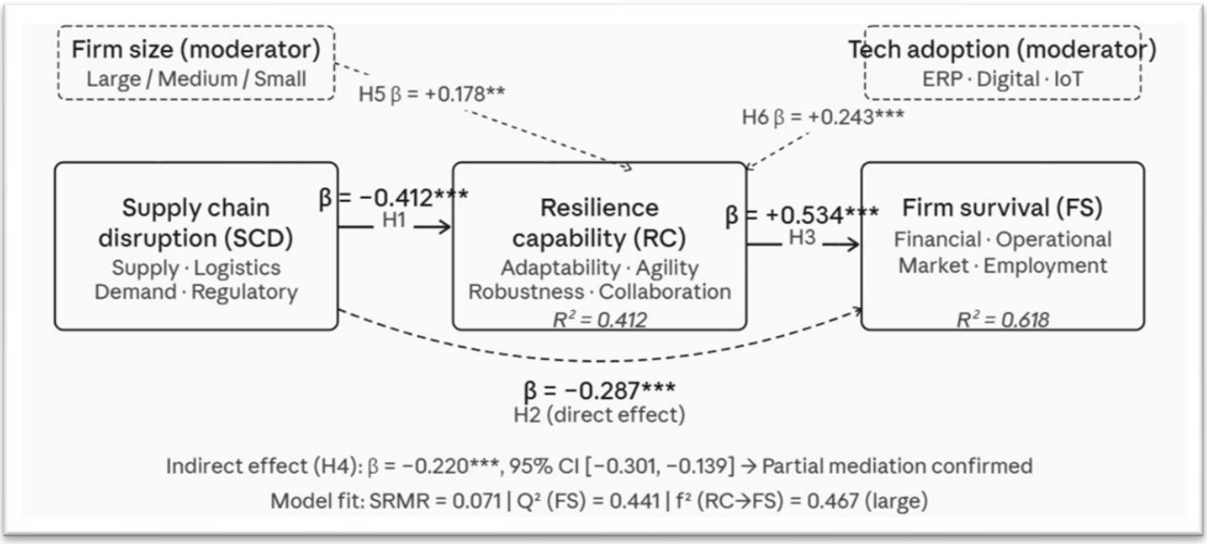

Table 7. Hypothesis Testing Results

Hypothesis	Path	β	t-value	p-value	95% CI	Decision
H1	SCD → RC	–0.412	6.831	< 0.001	[–0.527, –0.297]	Supported
H2	SCD → FS (direct)	–0.287	4.219	< 0.001	[–0.421, –0.153]	Supported
H3	RC → FS	+0.534	9.047	< 0.001	[+0.419, +0.649]	Supported
H4	SCD → RC → FS (indirect)	–0.220	5.613	< 0.001	[–0.301, –0.139]	Partial mediation
H5	Firm Size × RC → FS	+0.178	2.934	< 0.01	[+0.058, +0.298]	Supported
H6	Tech Adoption × RC → FS	+0.243	3.781	< 0.001	[+0.116, +0.370]	Supported

Mediation Analysis: H4

To test whether resilience capability truly mediates the disruption–survival relationship (H4), we examined both the direct and indirect paths before and after including RC in the model. Before mediation, the direct path from SCD to FS carried a coefficient of -0.412. After resilience capability was introduced as a mediator, this direct effect dropped to −0.287 and remained statistically significant.

This pattern a significant indirect effect (β=−0.220, CI does not include zero) alongside a reduced but still significant direct effect is the hallmark of partial mediation. It tells us two important things. First, resilience capability genuinely transmits part of disruption's harm: when SCD damages RC, that damaged RC then hurts FS. Second, disruption also inflicts direct damage on firm survival through channels that resilience capability cannot fully absorb such as sudden revenue losses, contract penalties for undelivered shipments, or forced asset liquidations.

Moderation Analysis: H5 and H6

H5-Firm size. The interaction term (Firm Size × RC) was positive and significant (β = +0.178, p < 0.01), meaning that larger firms extract more survival benefit from the same level of resilience capability. This is consistent with the logic of Resource-Based View (Christopher, 2019): larger companies have broader financial buffers, established relationships with multiple suppliers, and dedicated supply chain teams that can implement resilience strategies more effectively. In our qualitative interviews, managers at large refinery companies described maintaining alternative supplier contracts as standard practice something smaller plantation operators simply could not afford to do pre-pandemic. Importantly, however, firm size did not eliminate resilience capability as a significant predictor for smaller firms. Small companies with high RC still outperformed small companies with low RC. Size amplifies resilience; it does not replace it.

H6-Technology adoption. The interaction term (Tech Adoption × RC) was the stronger of the two moderators ($\beta = +0.243$, $p < 0.001$). Companies that had invested in digital supply chain tools ERP systems, digital procurement platforms, real-time cargo tracking converted their resilience capabilities into survival outcomes far more effectively than companies operating manually.

DISCUSSION

Resilience Capability is the Strongest Predictor of Firm Survival (H3, β = +0.534)

The most important finding of this study is straightforward: the single biggest determinant of whether a palm oil company in Medan survived the COVID-19 crisis in good shape was not its size, its technology, or even the severity of the disruption it faced. It was whether the company had built genuine resilience capability before the crisis hit. This finding strongly supports Dynamic Capability Theory (Centobelli et al., 2020). Firms that had developed the capacity to sense supply disruptions early (adaptability), respond quickly when conditions changed (agility), maintain minimum viable operations under pressure (robustness), and lean on trusted partner networks when internal resources fell short (collaboration) were consistently better positioned than their less-prepared competitors. The effect size ($f^2 = 0.467$) is classified as large by Cohen's (1988) convention, which is unusual in organizational studies. It suggests that resilience capability does not merely nudge survival outcomes it substantially determines them.

Disruption Damages Resilience First, Then Survival (H1, β = −0.412)

Hypothesis 1 captures a crucial but often overlooked dynamic: severe disruption does not just harm a company's financial performance directly. It first depletes the organizational capabilities that would otherwise protect the company (Ivanov, 2020). When FFB harvests were disrupted, managers and field teams spent their entire bandwidth dealing with immediate crises firefighting supplier failures, negotiating with banks for credit extensions, managing worker unrest. This left no capacity for the kind of strategic repositioning and network activation that resilience capability requires (Heizer et al., 2020).

This finding resonates with (Dolgui et al., 2020), who found that resource depletion during disruption events creates a vicious cycle: disruption weakens the firm's ability to respond, which makes subsequent shocks even more damaging. Our data confirm this cycle is real in the Indonesian palm oil context, with the disruption-to-resilience path carrying a coefficient nearly as large as the resilience-to-survival path.

Disruption Also Hits Survival Directly Resilience Cannot Do Everything (H2, H4)

The confirmation of partial rather than full mediation is theoretically significant. Several prior studies in supply chain resilience had assumed or found full mediation meaning resilience capability fully accounts for how disruption affects performance. Our data challenge that conclusion in this context (Choi, 2021).

The direct damage path ($\beta = -0.287$) reflects disruption impacts that bypass organizational capabilities altogether: a company cannot "be more agile" its way out of a 31% drop in port cargo volumes or a government-mandated factory closure. Some disruptions are simply too large, too fast, or too external to be buffered by internal capability alone. This is a sobering but realistic finding for practitioners: resilience investment is necessary but not sufficient.

Technology Doubles the Return on Resilience Investment (H6, β = +0.243)

Of the two moderators, technology adoption had the stronger effect. This finding extends the TAM and resource complementarity literature into the supply chain resilience domain. Technology does not create resilience by itself companies with high technology adoption but low RC still fared poorly. But when resilience capability is present, digital tools appear to multiply its effectiveness by a substantial margin (Bag et al., 2020).

The mechanism is informational: digital platforms compress the time between a disruption signal and an organizational response. In an industry where the window to book alternative shipping containers or redirect FFB to closer mills can close within 24–48 hours, faster information is directly convertible into better survival outcomes (Prajogo et al., 2020). This finding has clear practical implications: investing in resilience capability without also investing in the digital infrastructure to activate it quickly is leaving significant value on the table.

Larger Firms Benefit More, But Smaller Firms Are Not Helpless (H5, β = +0.178)

The significant but weaker moderation effect of firm size (β = +0.178) tells a nuanced story. Large companies do benefit more from each unit of resilience capability, mainly through the resource advantages described above. However, the interaction effect is relatively modest compared to H6, suggesting that resilience capability is accessible to firms of all sizes (Singh et al., 2020).

In the qualitative data, the most striking examples of resilience among small companies came from informal collaborative arrangements small plantation owners pooling trucks, sharing cold storage, and coordinating harvest schedules to ensure FFB reached mills before spoilage (Flynn et al., 2019; Khan et al., 2021). These informal networks functioned as a form of collaborative resilience that was not captured in formal ERP systems but was just as effective operationally. Future research should examine whether informal social capital can substitute for formal firm-level resources in enabling resilience among small agribusiness operators (Pettit et al., 2019).

Practical Implications

For company managers, the findings translate into three clear priorities. Building resilience capability cannot wait for a crisis: companies that entered the pandemic with established supplier diversification, cross-functional response teams, and documented business continuity plans recovered faster and lost less. Investing in digital supply chain visibility is the highest-leverage complement to resilience capability, particularly for medium-sized companies that may lack the buffer resources of large firms. And smaller companies should actively pursue inter-firm collaboration arrangements even informal ones as a substitute for the scale resources they cannot match individually.

For GAPKI, the North Sumatra Provincial Government, and national policy bodies, the findings point to the value of industry-level resilience infrastructure: shared digital logistics platforms accessible to SMEs, alternative port facilities to reduce the Belawan bottleneck, and standardized business continuity requirements for licensed palm oil operators.

CONCLUSION

This study set out to understand why some palm oil companies in Medan survived the COVID-19 supply chain crisis in good shape while others did not. The answer that emerged from 196 company-level responses, analyzed through SEM-PLS, is both clear and practically useful: resilience capability the organizational ability to adapt, respond quickly, maintain operations under pressure, and lean on partner networks was the single most powerful predictor of firm survival, with a large and statistically robust effect.

The study makes three specific contributions to theory. It confirms that resilience capability acts as a partial not full mediator between disruption and survival, adding realism to models that had assumed disruption's effects are entirely channeled through organizational capabilities. It demonstrates that technology adoption significantly amplifies the return on resilience investment, establishing a complementarity between digital infrastructure and organizational capability that had not been empirically tested in agribusiness contexts. And it extends Dynamic Capability Theory into tropical commodity supply chains in an emerging market setting, a context that has been underserved by the dominant literature.

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