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From Digital Adoption to Operational Recovery: An Integrative Review of SME Capability Complementarities and Resilience Measurement

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Abstract: The relationship between digital transformation and small and medium-sized enterprise (SME) resilience has attracted multiple systematic reviews. Reported outcomes, however, range from technology-adoption success and perceived adaptability to firm performance and supply-chain robustness. These outcomes cannot automatically establish how quickly operations resume after a specific disruption. This integrative review combines directly relevant empirical research, recent evidence syntheses, set-theoretic studies and resilience-measurement scholarship identified through a bounded, source-traceable search conducted to 8 October 2026 and updated on 22 November 2026. We develop a four-part conceptual distinction between digital possession, deployable capabilities, disturbance-specific response and observable restoration. We then assess five potentially complementary capability domains: process integration, employee substitutability, supplier visibility, operational slack and adaptive decision-making. Existing studies support the relevance of digital and organisational capabilities in several settings. Their heterogeneous endpoints, reliance on retrospective surveys and limited event-level verification, however, restrict inference about recovery speed. The few duration-based studies concern survival or large-firm recovery rather than restoration of a named SME service. A capability-to-recovery framework therefore links pre-event resources to detection, mobilisation, restoration and subsequent stability, with event severity and sector as boundary conditions. The review advances a measurement-centred research agenda for Malaysian manufacturing and retail SMEs, including dated service thresholds, provenance grading, negative cases and comparisons between configurational and additive models. Its contributions are an evidence-qualified synthesis and a testable framework, not new empirical estimates or a claim that technology alone causes resilience.

Keywords: small and medium-sized enterprises, digital transformation, operational recovery, resilience measurement, capability configurations

1. Introduction

Small and medium-sized enterprises (SMEs) digitise purchasing, inventory, ordering, payments and customer relationships under pressure to improve efficiency and reach markets. Whether those investments help the same firms resume critical operations after an interruption is a distinct question. A business may have cloud software and a digital sales channel yet lack what recovery requires. It may have no staff who can run alternative workflows, no supplier who can confirm a substitute consignment, no reserves to bridge a delay, or no authority to change standard procedures. Digital transformation concerns organisational changes in capabilities, processes and business models rather than the installation of applications (Verhoef et al., 2021). When the outcome of interest is operational continuity, counting applications therefore risks mistaking a possible enabler for a tested recovery capability.

The literature on resilience has expanded rapidly. Duchek (2020) distinguishes anticipation, coping and adaptation, and Conz and Magnani (2020) describe a dynamic process. Saad, Hagelaar, van der Velde, and Omta (2021) show how differently SME business resilience is defined and measured. More recent evidence syntheses examine crisis strategies, digital transformation pathways, emerging-economy constraints and inter-organisational adaptation (Koporcic, Kukkamalla, Markovic, & Maran, 2026; Malik & Terzidis, 2026; Sagala & Őri, 2025, 2026). These contributions establish why the topic matters. They also make a generic claim that “digitalisation improves SME resilience” an

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insufficient basis for another review. The remaining question is more precise: what, exactly, has been measured, and what additional evidence is required to explain recovery from a particular disturbance?

An endpoint distinction has direct practical consequences. Digital adoption or digital-transformation success is not a resilience endpoint. A favourable manager rating of adaptive capacity is not equivalent to a dated restoration milestone. A change in sales or profitability following a crisis captures a mixture of exposure, strategy, demand and recovery. Supply-chain resilience refers to a networked domain that may not coincide with recovery of the focal SME's order fulfilment, production or customer service. Although the outcome types can be related, their units and timescales differ. Quantitative resilience research provides recovery curves and restoration indices (Bruckler, Wietschel, Messmann, Thorenz, & Tuma, 2024; Tang & Shen, 2024), but their transfer to event-level SME datasets cannot be presumed. Organisational research has occasionally measured the endpoint directly. After the 2008 financial crisis, DesJardine, Bansal and Yang (2019) treated the severity of loss and the time taken to recover as distinct dimensions of resilience. That distinction has rarely been carried into SME digitalisation research.

This review responds by combining business, entrepreneurship, information-systems and operations perspectives around the distinction between possession of resources and restoration of service. It retains the Malaysian context of the originating research problem without assuming that evidence from India, Australia, Spain or international supply-chain samples already applies to Malaysia. A Malaysian study of accounting practices offers useful local evidence on digital capabilities and perceived resilience (Taib, Awang, Said, & Mohd Akhir, 2025). Its sector and endpoint, however, differ from those of a time-to-recovery study of manufacturing and retail firms.

Four questions guide the paper. First, which digital, human, relational and managerial capabilities are linked to SME resilience in the existing evidence? Second, how do empirical studies operationalise the outcome, and which claims are supportable at each evidence level? Third, what configurations and boundary conditions plausibly translate capability endowments into operational restoration? Fourth, which designs and measurements would most decisively distinguish these propositions in Malaysian SMEs? The contribution is an integrative interpretation and a falsifiable measurement framework rather than a numerical meta-analysis or a claim of previously unobserved causal effects.

2. Review Methodology

2.1 Review type and scope

An integrative review was selected because the question spans qualitative crisis case studies, cross-sectional SME surveys, configuration analyses, recent systematic reviews, business theory and operational resilience metrics. Integrative reviews accommodate heterogeneous methods where the purpose is to critique concepts and generate a framework rather than pool a common effect size (Whittemore & Knafl, 2005; Snyder, 2019). The unit of synthesis was a reported claim paired with its population, measured outcome and method, not an assumed interchangeable "resilience effect". This distinction is important when a survey latent variable, a financial performance change and an observed restoration trajectory appear under the same general label.

2.2 Search, eligibility and source assessment

A bounded and transparent targeted search was conducted through 8 October 2026 using public scholarly search results, publisher and DOI landing pages, open-access full articles, and relevant institutional sources. Core combinations included (SME OR "small and medium enterprise") AND (digital transformation OR digital capability) AND (resilience OR disruption OR recovery); "supply chain resilience" AND (measurement OR recovery time); fsQCA AND SME AND digital transformation; and Malaysia AND SME AND resilience. Recent publications from 2020–2026 were prioritised, complemented by foundational theory and methodology. Citation chaining from directly relevant reviews identified additional candidate papers. A supplementary benchmark search on 22 November 2026 targeted journals of Elsevier, Wiley, Springer Nature, Sage, Emerald and Taylor & Francis to identify studies with event-anchored, duration or recovery-speed outcomes. It added nine publications, and all bibliographic records were re-resolved against Crossref. This was not a complete search of subscription databases such as Scopus and Web of Science; no comprehensive search-return counts or PRISMA flow are claimed.

Priority was given to scholarly journal studies with explicit digital/capability antecedents, a stated crisis or continuity outcome, or a substantial measurement or method contribution. Primary empirical studies, reviews, conceptual works and one official Malaysian SME-definition source were eligible for different purposes. Studies of large firms or engineered infrastructure were retained only as labelled methodological analogues; they were not coded as SME outcome evidence. Publisher or accessible full text was used where available; where access stopped at a verifiable abstract, interpretation was restricted to that abstract and methods summary. No unpublished data, arbitrary effect sizes or unseen significance results were added. The literature is purposefully selected rather than claimed exhaustive.

2.3 Analytic coding and limitations

Each key source was compared on five fields: geographical/sectoral unit, study design, digital or organisational mechanism, resilience endpoint and claim boundary. The synthesis then used four analytic lenses: outcome proximity to verified restoration; the distinction between resources and enactable routines; cross-level dependence on workers and suppliers; and susceptibility to selection, severity or reverse-timing bias. Table 1 defines the outcome-proximity ladder; Table 2 presents representative comparisons rather than a statistical census of the literature. The review did not independently reanalyse authors' datasets, conduct a formal study-level risk-of-bias instrument, obtain full text for every paywalled paper or estimate a pooled effect. Consequently, statements of evidence strength are qualitative and conditional.

Table 1. Outcome-proximity ladder used in the synthesis

Tier	Typical observable endpoint	What it can support	What it cannot establish
D0: adoption	Software use; digital maturity; transformation success	Technology or implementation status	Service recovery after a disruption
R1: perception	Manager-rated resilience, flexibility or robustness	Perceived organisational capacity and associations	Verified interruption-to-restoration duration
R2: performance	Revenue, orders or operating-performance change across a period	Post-shock consequences within the chosen window	Exact restoration time without a service chronology
R3: event record	Documented onset, pre-event baseline, repeated operational performance and restoration date	Observed time-to-threshold and post-restoration stability for one event	Causal effect without a defensible comparison and severity control

3. Conceptual Foundations

3.1 Resilience is a process; recovery is a narrower endpoint

Dynamic-capabilities theory emphasises the ability to sense change, seize responses and transform resource configurations rather than only to possess valuable assets (Teece, 2007). A capability-based account of organisational resilience places anticipation, coping and adaptation in a sequence (Duchek, 2020). The SME literature adds a practical constraint: responses often involve the same owner-manager, a small workforce, limited liquidity and concentrated trading partners. The firm's recovery cannot be assumed from any one element of readiness. The literature synthesis by Saad et al. (2021) found substantial diversity of definitions and measurements; the umbrella review by Koporcic et al. (2026) reinforces the relevance of crisis type and coping strategy.

Recovery speed concerns the interval needed to regain a defined level of a specified service after a qualifying interruption. It is related to, but different from, resistance to initial loss, stability after apparent recovery, learning after the event and long-run survival. A business that avoids a decline altogether has high robustness but no meaningful recovery interval. One that restores throughput quickly but fails again the following week has a short time to first restoration but poor stability. Tang and Shen (2024) distinguish robustness, recovery and reconfigurability in system-level recovery functions. Bruckler et al. (2024) systematically organise resilience-curve measures and actions in supply chains. Their metrics offer transferable measurement logic, not direct results about Malaysian SME firms. In firm-level research, DesJardine et al. (2019) provide a rare precedent for operationalising time to recovery from observed performance data, and Herbane (2010) argues for a chronological, crisis-based view of small businesses that distinguishes threat, response and impact. Both support treating recovery as a dated sequence rather than a general disposition.

3.2 Capabilities require orchestration

Five complementary domains are analytically useful. Digital process integration connects transactional information across customer, inventory, purchasing and fulfilment workflows. Workforce substitutability rests on trained backups and documented procedures. Supplier visibility gives access to credible status and alternative supply options. Operational slack includes stock, liquidity and unused execution capacity that can be deployed quickly. Adaptive decision-making concerns escalation, delegation and the authority to deviate from a stalled routine. The domains are separated because a digital dashboard cannot itself staff a production shift, move stock or approve a substitute supplier. Conversely, trained personnel may be ineffective without timely and reliable information.

These distinctions join resource orchestration to dynamic capabilities without claiming that the five domains constitute an established, universally validated scale. A strong digital integration measure should record not whether software was purchased but whether information can travel between the affected processes when continuity decisions are needed. A strong cross-training measure should identify which critical tasks have a trained replacement rather than ask

managers whether their people are generally “flexible”. Slack should be normalised to operational scale so that size is not mistaken for preparation. Supplier visibility should concern the specific bottleneck affected by the index disturbance, not only total supplier counts. Leadership should be based on documented pre-event decision rights where feasible, rather than satisfaction with decisions after recovery is known.

3.3 Configurations and cross-level boundaries

The conditional value of a resource motivates configurational reasoning. N’Dri and Su (2024) combine partial least squares structural equation modelling with fuzzy-set qualitative comparative analysis (fsQCA) and report multiple combinations associated with successful digital transformation in exporting manufacturing SMEs. That outcome is D0 in Table 1, not a verified interruption-recovery endpoint. Shao et al. (2025) likewise investigate SME digital-transformation conditions using configurational reasoning. Fiss (2011) and Ragin (2008) explain why necessary conditions, sufficient combinations, equifinality and asymmetry deserve explicit attention. These constructs are methods for testing set relations; they do not turn nonexperimental associations into causal effects.

Several boundary conditions are just as important as the proposed capabilities. A system outage may reward workflow redundancy and local delegation; a supplier failure may require substitute sourcing, transport capacity and available cash; a site closure may overwhelm both. Sectoral production processes differ from retail replenishment and customer-service processes. Disruption intensity, pre-existing decline, market access, firm size and digital dependence can alter both exposure and restoration. Miklian and Hoelscher (2022) make the same point about shocks. Exogenous shocks differ in scale, type and the time needed to “return to normal”, so a single resilience model may not fit every disruption. Resource endowments may also be endogenous: capable managers may simultaneously build better systems and report more optimistic resilience. The direction of influence can even run the other way. In a crisis-period study of SMEs, Őri, Szabó, Kő and Kovács (2024) modelled organisational resilience as a driver of digitalisation, and the effect was stronger among firms that received government support. A review that collapses these distinctions risks offering managerial recipes that are artefacts of event mix or respondent perception.

4. Synthesis of the Literature

4.1 Digital transformation and organisational reconfiguration

The wider digital-transformation literature characterises transformation as change in organisational processes and value creation (Verhoef et al., 2021). In an Indian crisis case study involving eight entrepreneurs, Khurana, Dutta, and Ghura (2022) interpreted the interaction of technology-enabled change and entrepreneurial ecosystems as a developing resilience capability. This qualitative account offers mechanisms and temporal narratives but not a representative estimate of recovery speed. A Spanish survey study of 206 SMEs links digital technologies, transformational leadership and innovation capabilities to organisational resilience through structural-equation modelling (Martín-Rojas, Garrido-Moreno, & García-Morales, 2026). The analysis contributes a relational model but a rated resilience construct should not be silently reinterpreted as observed days to restoration. Timing within the crisis has also been studied directly. In a survey of 229 French SMEs during the COVID-19 pandemic, Williams, Colovic and You (2026) examined how the speed of external technology transfer relates separately to response and to recovery. They draw attention to possible time-compression diseconomies when technology is acquired in haste. Their separation of response from recovery is close to the endpoint distinction proposed here, although both outcomes were measured with established survey scales rather than dated operational records.

The Malaysian evidence is informative for setting but has a narrower population. Taib et al. (2025) surveyed 255 owners/managers of Malaysian accounting practices and reported a moderate positive relationship between digital capability characteristics and perceived practice resilience. This supports a local rationale for studying the complementarity of human, collaborative, innovative and technological skills. A multigroup study of 204 Malaysian and 335 Indonesian SMEs adds broader local evidence. Government support, technology use and compliance costs were directly associated with post-pandemic business resilience, and technology adoption acted as a quasi-moderator (Lestari, Abd Hamid, Shamsuddin, Kurniasari, & Yaacob, 2024). The outcome is again a perceived resilience construct. It does not measure recovery of manufacturing or retail order throughput, and accounting-practice evidence should not be advertised as representative of every Malaysian SME sector. The official SME Corporation Malaysia definition similarly constrains how a future sample is framed: manufacturing qualifies under a turnover or employment threshold distinct from services and retail (SME Corporation Malaysia, n.d.).

Reviews published recently should change how novelty is framed. Sagala and Őri (2024) review the antecedents of SME digital-transformation success, and Sagala and Őri (2025) synthesise digital strategies for resilience and antifragility. Their framework study (2026) connects digital transformation to SME resilience through agility. Malik and Terzidis (2026) incorporate multi-level and inter-organisational dimensions, while Koporcic et al. (2026) connect crisis characteristics to coping responses. These works make a fresh, general taxonomy of “digital enablers of SME resilience” redundant. The underdeveloped issue targeted here is the evidential bridge between a capability claim and a documented recovery episode.

4.2 Digital visibility and supplier relationships

Supply-chain studies illustrate why organisational boundaries cannot be ignored. An Australian study of 626 SMEs reports associations between digital capabilities, previous disruption experience, supplier relationships, supply-chain robustness and resilience, while considering disruption intensity and government assistance (Nakandala, Chen, & Chikweche, 2025). The survey results offer a credible reason to combine digital information with relational resources, but the named endpoint is supply-chain resilience. They do not independently establish how many days an individual retailer required to resume fulfilment after a known consignment interruption.

Xu, Jia, Wang, and Chen (2024) examine whether digital transformation is associated with firm resilience to supply-chain disruptions using changes in operating performance and the moderating role of diversification strategies. Their performance-based outcome is closer to an economic consequence of the interruption than technology adoption, but it still need not reveal when a specific workflow was restored. These cases illustrate a recurrent inferential step: a firm may perform better across a crisis interval because of higher demand, diversification or smaller exposure, rather than because its halted service restarted faster. A resilience claim should state which interpretation the operational measure can discriminate.

Operations research adds a complementary point: visibility without operational options is unlikely to restore a blocked flow. Roshani, Walker-Davies, and Parry (2024) review supply-chain network mitigation strategies including capacity and flexibility. Bruckler et al. (2024) classify resilience actions against capacities and recovery-curve metrics. Such work supports the distinction between information, alternatives and the ability to use alternatives. It is relevant by analogy rather than by direct statistical transfer from network models to independent SMEs. No single study in this bounded comparison demonstrates that adding a dashboard alone shortens verified restoration time in Malaysian manufacturing and retail firms.

4.3 Human substitutability, slack and adaptive authority

Digital systems can expose a disruption before employees are able to act on it. Cross-training concerns task coverage. If a person with a critical skill is unavailable, another worker must know the work, have access to the relevant systems and be authorised to perform the substitute step. Adaptive leadership concerns rapid delegation and exception handling. A firm with strong technological integration but bottlenecked decisions may remain inactive. Conversely, delegated people cannot necessarily restore orders if no feasible input, vehicle, inventory or working capital is available. The empirical studies reviewed here provide indirect support for these interactions through digital skills, leadership, collaboration and supplier relationships; they do not jointly validate the five-domain recovery model proposed in this paper.

Slack warrants particular care. Redundancy can protect a firm from immediately lost capacity and can support temporary alternative operations, but it carries inventory, cash-holding and unused-capacity costs. What appears to be a positive reserve in a sample may also reflect selection into richer or older firms. The framework therefore regards pre-event slack both as a hypothesised resource and as a possible proxy for prior success; testing it requires firm-scale normalisation and sensitivity to size, financial capacity and sector. The economic question is not whether all firms should maximise redundancy, but which limited buffers interact with information and decisions under specified threats.

4.4 Endpoint heterogeneity and the recovery-measurement gap

The synthesis finds four non-equivalent families of outcomes (Table 1). First, digital-transformation research explains implementation success: useful for antecedents, but not a shock endpoint (N'Dri & Su, 2024; Shao et al., 2025). Second, survey models treat resilience, robustness or adaptability as latent or perception-based constructs (Martín-Rojas et al., 2026; Nakandala et al., 2025; Taib et al., 2025). Third, performance studies observe economic changes after disruption (Xu et al., 2024). Fourth, operations and infrastructure researchers model recovery trajectories directly, generally in different units and systems (Bruckler et al., 2024; Tang & Shen, 2024). A small number of studies approach a fifth, duration-based family. Using World Bank Enterprise Survey data for 5,469 SMEs in 16 European countries, Audretsch, Aronica, Belitski, Caddemi and Piacentino (2025) estimated that adopting at least one digital tool reduced the hazard of market exit during the pandemic. Adopting two or more tools reduced it further. Survey evidence also links dynamic capabilities to faster recovery of MSME performance after COVID-19 (Supramono, Damayanti, & Adhitya, 2025). Liu, Tatano and Kajitani (2021) use post-disaster business recovery data to estimate the production capacity that remains after lifeline disruptions; earlier estimates, they note, relied on hypothetical surveys or expert opinion. Survival and capacity loss are not restoration of a named service, but these studies show that time-indexed outcomes are feasible. None should be discarded; each answers a different question. However, evidence from one tier cannot answer a more specific tier without additional assumptions and measurements.

This distinction also affects scale and temporal order. A digital capability assessed today could have been developed after a past disruption, whereas the outcome concerns that earlier episode. A manager can recall a date without possessing a document that independently corroborates it. An observed restoration date can itself be misleading if "normal" throughput varies seasonally, if postponed orders accumulate after reopening, or if a first day above threshold is followed by another outage. Recovery should therefore be represented as a service trajectory with a baseline, onset, disruption-

specific reference window, first-restoration threshold and stability check rather than as a single retrospective satisfaction item.

Quantitative reviews have begun to systematise these problems. Bruckler et al. (2024) derive a set of metrics describing supply-chain resilience curves. Tang and Shen (2024) formulate indices based on service trajectories and illustrate them using post-hurricane electricity restoration data, not SME survey data. A 2026 meta-analysis synthesising the digital-transformation–supply-chain-resilience association across many studies reports heterogeneity by capabilities, supply-chain resilience dimensions and contextual boundaries (Li, & Liu, 2026). Such synthesis establishes that the level and content of digitisation matter; it does not provide a transferable numerical estimate for a Malaysian SME's days to 90% order throughput. The main remaining measurement question is how operational traces, respondent accounts and event severity can be linked at the same firm–event unit.

Table 2. Representative evidence and the endpoint boundary (the sources are not treated as a meta-analytic sample)

Study	Setting / method	Reported endpoint / focus	Interpretive boundary
Khurana et al. (2022)	India; eight crisis case studies	Emerging digital-enabled resilience capability	Mechanism-rich; no firm-level recovery-time estimate
N'Dri & Su (2024)	Export manufacturing SMEs; SEM + fsQCA	Digital-transformation success	Adoption outcome, not event restoration
Xu et al. (2024)	Firms; quantitative performance analysis	Operating-performance change after supply disruption	Performance period ≠ verified service-restoration date
Nakandala et al. (2025)	Australia; 626 SMEs; PLS-SEM	Supply-chain robustness and resilience	Survey and network context; no proven recovery speed
Taib et al. (2025)	Malaysia; 255 accounting-practice respondents	Digital-capability correlation with reported resilience	Local evidence; service-profession sample and perception outcome
Martín-Rojas et al. (2026)	Spain; 206 SMEs; SEM	Organisational resilience as an outcome	No equivalent event-specific restoration-time finding
DesJardine et al. (2019)	Firms; 2008 financial crisis; archival performance data	Severity of loss and time to recovery as separate outcomes	Large listed firms; not SME service restoration
Audretsch et al. (2025)	5,469 European SMEs; survival analysis	Digital tools associated with lower hazard of market exit	Survival is not restoration of a named service
Lestari et al. (2024)	Malaysia and Indonesia; 539 SMEs; PLS-SEM	Government support, technology use and compliance cost related to resilience	Perceived resilience; no event dating
Sagala & Őri (2026)	Review-based framework	Digital transformation, agility and resilience	Integrative account rather than primary event data
Koporcic et al. (2026)	Umbrella review of SME crisis reviews	Crisis types, capabilities and coping	Higher-order synthesis; outcome definitions remain diverse
Bruckler et al. (2024)	Supply-chain metrics review	Restoration-curve concepts and indicators	Operational analogue, not Malaysian SME validation
Tang & Shen (2024)	Systems study with utility restoration example	Quantitative indices of recovery functions	Different sector and unit; transfer requires validation

4.5 Reconciling findings and apparent tensions

The evidence is not necessarily inconsistent when study outcomes and disruptions differ. Digital integration may correlate positively with a survey rating of adaptability yet show little relationship with recovery after a physical closure. In that case an offline stock buffer or a supplier substitute is the binding constraint. Digital capability can be useful for detecting an outage but expose a firm to more digital dependence if there is no manual fallback. A firm with higher prior profitability may show a smaller post-crisis sales decline without being faster at repairing the affected operation. These are hypotheses that reconcile heterogeneous results; they are not inferences from a pooled effect estimate. The proper response is to name the endpoint and possible moderators, not average unlike measures or claim a universal effect.

A particularly important uncertainty concerns asymmetric paths. Set-theoretic analysis can test whether different combinations accompany high and low recovery. Its results remain sensitive to calibration anchors, limited diversity, contradictory rows and case support (Fiss, 2011; Greckhamer, Furnari, Fiss, & Aguilera, 2018; Pappas & Woodside,

2021). The existence of digital-transformation recipes in one population does not prove rapid-recovery recipes in another. Nor does failure to identify a stable recipe establish that capabilities do not matter. The alternative explanation may be a single dominant factor such as severity, a nonlinear duration model, omitted suppliers or noisy outcome measurement. A convincing future study should compare these possibilities without treating fsQCA coverage as numerically identical to regression R-squared.

5. A Capability-to-Recovery Framework

5.1 Mechanism and sequence

Figure 1 organises the reviewed concepts into an event-anchored explanatory sequence. Before onset, SMEs differ in digital integration, workforce substitutability, supply visibility, slack and adaptive authority. The same disruption creates different information and resource bottlenecks. During detection and mobilisation, technology can reveal the affected transaction or material flow; staff, suppliers, reserves and delegated authority determine whether a workable response is possible. Restoration then concerns regaining an explicitly measured service threshold, followed by a stability window. Context includes event type and severity, sector, firm size, baseline trajectory and network dependence. The framework is proposed as a research design guide; the arrows are hypotheses, not empirically identified causal pathways.

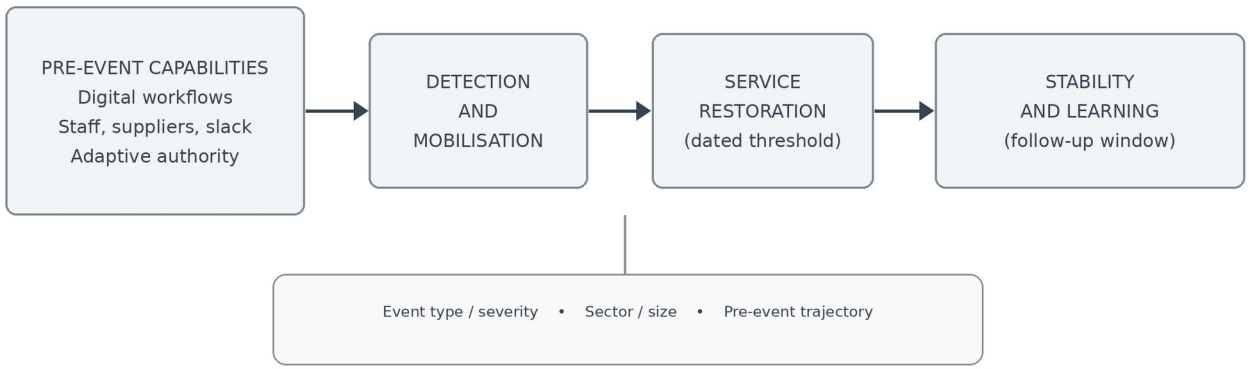

Figure 1. Proposed event-anchored capability-to-recovery framework; arrows denote research propositions, not estimated effects

5.2 Construct mapping and falsifiable propositions

The framework leads to four sets of conditional propositions. P1: broader pre-event digital workflow integration is more plausibly associated with rapid restoration when trained backups, supplier alternatives or delegated exception decisions make the information actionable. P2: the importance of any capability combination differs by disruption class and severity, so a solution identified for software outages need not describe material shortages. P3: verified restoration time and retrospective ratings of resilience are related but not equivalent, and their association will be weaker in samples with poor historical records or pronounced seasonal volatility. P4: pathways associated with rapid restoration need not be logical inverses of pathways associated with slow or failed restoration. Each proposition could be contradicted by credible negative cases, unstable configurations or a better fitting parsimonious rival.

A fifth proposition concerns measurement, not managerial success. P5: source-grading the dates and separating never-restored observations from missing dates will materially affect inferred recovery distributions whenever recollection and records availability are selective. This is a researchable information-quality claim. If date verification changes little, that outcome would support the feasibility of lower-cost manager surveys in the particular setting; if it changes estimates substantially, future studies should explicitly model record availability. Neither possibility should be assumed in advance.

Table 3. Proposed construct-to-observation register for future SME studies

Construct	Preferred pre-event observation	Threat to validity / required check
Digital integration	Share of critical order-to-fulfilment processes linked by usable data; trace demonstration	Licences and apps may exist without practical interoperability
Employee substitutability	Share of critical tasks with a demonstrably trained backup and access credentials	Self-reported flexibility may not imply actual cover
Supplier visibility	Time to obtain reliable critical-supplier status and feasible alternatives	Supplier contact list is not event-time visibility
Operational slack	Cash, stock and spare capacity normalised to the affected process	Size, wealth and stock obsolescence confound capacity
Adaptive authority	Pre-event escalation rules and named authority to approve workarounds	Successful-event recall may inflate leadership ratings
Rapid restoration	Elapsed time from corroborated disruption onset to a stable service threshold	Shock mix, false first recovery, missing vs censored intervals

5.3 An event-anchored measurement protocol

The proposed operational outcome can be expressed without asserting a new dataset. For an index event beginning at t_0, let D(t) represent the firm's operational throughput for a critical service at time t, and let B be the pre-event reference level for that service. Q(t) is then the normalised service level in Eq. (1). Let T_{90} be the first post-onset duration at which Q(t) reaches at least 0.90, provided a prospectively specified subsequent observation window does not immediately reverse that milestone. An ongoing interruption at the end of observation is right-censored rather than given an invented recovery time. Missing or contradictory records are an evidence-quality problem, not synonymous with censoring. A firm unaffected in its measured service must be labelled as having no observed qualifying loss, not assigned an artificial zero-day restoration interval.

(1)

(2)

Recovery is also contextual. A denominator based on the last calendar week may exaggerate recovery in seasonal retail; a baseline from a rolling comparable period may be more defensible. A one-day payment outage and a prolonged transport blockade differ in both severity and feasible restoration window. Accordingly, the study should define interruption taxonomy, service baseline, threshold, date precision, observation horizon and sustainability window before estimating high/low set membership. These steps avoid selecting calibration anchors after seeing which conditions appear favourable. Tang and Shen (2024) and Bruckler et al. (2024) support attention to the trajectory rather than conflating reliability, robustness and recovery.

6. Research Agenda for Malaysian SMEs

6.1 Design and sampling

A practical next study would focus on independent Malaysian manufacturing and retail SMEs that experienced a qualifying, discrete interruption. The official definition uses turnover or employee thresholds. Manufacturing firms qualify at no more than RM50 million turnover or 200 full-time employees, and services and other sectors (including retail) at no more than RM20 million or 75 employees; registration and exclusions are defined by SME Corporation Malaysia (n.d.). These rules must be used as a screening algorithm rather than adapted to a convenient international threshold. The original planning scenario targets approximately 240 event-eligible firms, but this is a feasibility target rather than an evidence-derived required sample size. A pilot should establish whether enough disruption episodes can be placed in comparable categories and whether access to dated evidence is realistic.

The enterprise-event pair should be the analytic unit. Each firm would contribute one pre-specified index event, chosen by a standard rule based on consequences rather than retrospectively selecting its best recovery. Recruiters should keep logs of outreach, ineligibility, refusal and records availability; otherwise, SMEs with formal information systems and business-association membership may be overrepresented. Survivorship matters especially when the most affected firms have permanently closed. If possible, recruitment should supplement active-firm surveys with independently

documented closures, or explicitly limit inference to surviving firms. Sector- and event-stratified results should precede attempts at pooled conclusions.

6.2 Triangulation and analysis

Managers can supply capability descriptions and chronologies, but the strongest evidence would include order, dispatch, inventory, production or outage logs and a second operational contact. A four-grade chronology register can distinguish independent records, corroborated dates, uncorroborated dated recall and unusable chronology. All capabilities must be anchored to what existed before the index event. The same event should not both generate a capability and serve as evidence that pre-existing capability caused its favourable outcome. Record missingness can be assessed against sector, size and digital maturity to determine whether high-quality histories select better resourced companies.

Two analytical logics can then test competing explanations. A fuzzy-set QCA would seek necessity and sufficiency relationships across a small, theoretically selected number of capabilities, with externally defended calibration anchors, a complete truth table, contradictions, remainders and case support. Separate analysis of high and low recovery would test asymmetry. A conventional duration model that accommodates right censoring (as in the survival analysis of Audretsch et al., 2025), or a pre-specified outcome regression, would assess additive associations. The predictors would be disruption category, severity, size, sector and baseline trajectory. Both should report robustness to missing records, thresholds and event stratification. Set consistency, set coverage and regression fit answer different questions and must not be compared as identical numerical metrics (Greckhamer et al., 2018; Pappas & Woodside, 2021; Schneider & Wagemann, 2012).

Directly discriminating tests should be prioritised. If digital integration is associated with manager-rated resilience but not with verified restoration time, the “adoption-to-recovery” leap is not supported for the sample. If capability bundles cease to distinguish outcomes when event severity is controlled, a disruption-driven explanation is more parsimonious. If cross-training appears only among rapidly recovering firms with missing supplier dates, verify whether the effect reflects evidence selection. If an observed bundle remains stable within outage and supply-delay strata and predicts held-out cases better than a simple benchmark, the configuration offers stronger descriptive value. None of these decision rules licences causal language in a retrospective study.

Table 4. A discriminating research agenda and decision criterion

Open issue	Recommended evidence / test	Interpretation of an adverse result
Endpoint ambiguity	Pair manager rating with dated 90% service-restoration metric	Perceived resilience cannot stand in for recovery time
Capability complementarity	Pre-event conditions, calibrated configurations and additive rival	Prefer parsimonious or event-driven explanation if bundles are unstable
Shock heterogeneity	Disruption taxonomy, severity checks and within-type analysis	Do not pool incompatible events
Selective verification	Chronology grades, nonresponse and missingness comparisons	Qualify claims to record-observed enterprises
Slow/failed recovery	Track censored cases and examine negative configurations	Avoid treating unknown dates as fast recovery
Actionability and cost	Test intervention uptake, cost, reserves and service stability	Do not prescribe software or buffer levels from associations alone

6.3 Ethics, governance and practical transfer

Operational evidence can expose customer identities, suppliers, liquidity, outage vulnerabilities and commercially sensitive workarounds. Institutional review, voluntary consent, a minimal record request and separation of linkage keys from analysis files are therefore prerequisites, not retrospective administrative formalities. Only aggregate results and carefully anonymised examples should be released. Sparse fsQCA cells or unique major-event chronologies can reveal identities even without firm names. No consent, external operational records or approvals have been obtained for this review, and it should not be represented as a report on recruited participants.

Managerial implications remain conditional. The review favours investing in the capability to act on information rather than software purchases detached from working routines. An SME might gain more from identifying a second trained operator and validating a supplier alternative than from another unintegrated application; another might require an inventory buffer or offline ordering process. These are examples of plausible questions for a firm-level continuity audit, not universal optimisation results. Pilot interventions, costs and counterfactual evaluation would be needed before recommending subsidies or specific budgets. The value of a Malaysia-focused empirical study will depend on whether it explains event-specific restoration beyond what is already known from international surveys and reviews.

7. Discussion

Three main conclusions follow from the integrative synthesis. First, the evidence base is rich on the relationship of digital capabilities, leadership, collaboration and reported resilience, but heterogeneous in what "resilience" means. A transformation-success pathway, a perceived-capacity score and an externally dated recovery curve answer different questions. Second, mechanisms are multi-resource and context dependent: information must be combined with people, suppliers, capacity and decision rights, and shock type can change what binds the recovery process. Third, operational recovery offers a more falsifiable endpoint than generic resilience language, but verification, temporal ordering and selection present formidable design problems.

This account neither rejects existing reviews nor recycles their general message. The 2025 and 2026 syntheses by Sagala and Őri, Koporcic and colleagues, and Malik and Terzidis already cover strategic, organisational and multi-level enablers. The proposed contribution is an outcome-validity lens that asks precisely what evidence connects each theorised mechanism to observable restoration. Recent measurement studies provide a route to formalise that lens, while Malaysian evidence shows the value and limits of locally bounded survey associations. In that sense, the review is a bridge between organisational capability theory and interruption-level operations measurement.

The review's own limits are important. Searches were targeted, not exhaustive; subscription indexes were not fully queried; relevant non-English work may be missing; and an abstract-level reading of paywalled studies cannot support a granular critique of their estimates. Most comparisons are qualitative, so neither a pooled effect nor a formal prevalence of outcome types is presented. The choice of five capabilities is analytic and draws partly on an earlier research-plan question, rather than emerging from a validated global coding exercise. The framework is provisional. These boundaries permit a complete critical review but preclude presenting it as a PRISMA systematic review or an independently replicated quantitative meta-analysis.

A stronger future review could search named bibliographic databases with exported records, independent screening and a reproducible protocol, and formally code each study's objective endpoint, measurement quality and exposure timing. Where authors' primary data are available, individual-case reanalysis could ask whether the same digital or leadership measures predict restoration trajectories and whether effect directions survive severity adjustment. Until that evidence exists, the safest claim is that digital and non-digital capabilities are plausible and often correlated antecedents. Their contribution to verified rapid recovery within a specified Malaysian disruption class remains to be established.

8. Conclusions

The digital transformation of SMEs should be evaluated not only by technology uptake or perceived adaptability but also by whether firms can restore named services after a documented interruption. This integrative review distinguishes four outcome levels, synthesises the complementarity of digital integration, employees, suppliers, slack and adaptive authority, and proposes an event-anchored capability-to-recovery framework. The literature supports the relevance of these resources without yet establishing a universal combination that shortens verified recovery time in Malaysian manufacturing and retail SMEs. A well-designed next study must date disruptions, validate service baselines, track censored recoveries, account for event severity and compare configurational findings with simpler explanations. These are testable priorities rather than invented empirical conclusions.

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Data Availability and Research Ethics

This article synthesises public scholarly literature and institutional information and reports no new interviews, enterprise survey responses or confidential operational records. It therefore contains no original participant dataset. The evidence crosswalk and search-boundary notes can be supplied with the manuscript. Ethics and author approvals for a subsequent primary study would be separate from this literature review.

Conflict of Interest

[Authors to confirm: "The authors declare no conflicts of interest."]

Appendix A: Review Search and Evidence Boundaries

Search date: 8 October 2026. Search concepts: (SME OR small firm) × (digital transformation OR digital capability) × (resilience OR disruption OR recovery); supply-chain resilience × (measurement OR restoration); digital transformation × fsQCA; Malaysia × SME resilience. Sources used: targeted public academic search, journal and DOI landing pages, accessible full articles and official Malaysian SME guidance, plus directed citation chaining. Inclusion emphasis: scholarly work with directly relevant capability and outcome definitions, current reviews, cross-disciplinary

measurement analogues and foundational theory. Exclusion emphasis: off-topic digital adoption papers without a relevant outcome or mechanism, unauditable numeric claims and grey sources not essential to defining Malaysian SMEs. This is an integrative, purposive search, not a systematic review with a complete database census.

Core comparison fields: country/sector and unit; method and sample where explicitly stated; capacity or digital construct; D0/R1/R2/R3 endpoint; evidence access level; boundary of interpretation. Paywalled publisher-abstract evidence is not treated as full-text result verification. The primary study comparisons appear in Table 2; the conceptual synthesis and operational proposals are author-generated interpretations, not verbatim findings from the cited papers. No PRISMA flow, pooled effect size or independent participant analysis is claimed.

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