



Journal of Advanced Research in Social and Behavioural Sciences

Journal homepage:
<https://karyailham.com.my/index.php/jarsbs/index>
ISSN: 2462-1951



When Portfolio Diversity Pays: Resource Orchestration Pathways to Resilience and Sustainable Supply Chain Performance

Lubna Khan¹, Au Yong Hui Nee^{1,*}, Foo Meow Yee²

¹ Teh Hong Piow Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Malaysia

² Faculty/Institute of Accountancy and Management, Universiti Tunku Abdul Rahman, Malaysia

ARTICLE INFO

Article history:

Received 10 June 2026

Received in revised form 16 July 2026

Accepted 5 September 2026

Available online 10 September 2026

Keywords:

Resource Orchestration; Supply Chain Resilience; Sustainable Supply Chain Performance; Supplier Portfolio Diversity; Customer Portfolio Diversity; Digital Technology; PLS-SEM and fsQCA

ABSTRACT

Supply chain portfolio diversity is often treated as a hedge against disruption, but a broader set of suppliers and customers can also create monitoring, coordination, and information burdens. The unresolved issue is therefore not whether diversity is beneficial in principle, but when firms can convert portfolio breadth into a usable strategic option. Drawing on resource orchestration logic, this study examines how top management support, digital technology adoption, supplier portfolio diversity, and customer portfolio diversity are associated with sustainable supply chain performance through supply chain resilience. Survey data from 345 Malaysian manufacturing firms were analysed using partial least squares structural equation modelling and fuzzy set qualitative comparative analysis. The structural model shows that all four resource domains are positively associated with resilience and sustainable performance. Supplier portfolio diversity has the strongest association with resilience ($\beta = .401$), while resilience has the largest association with sustainable supply chain performance ($\beta = .556$). Significant complementary indirect effects are present for all four resource domains. The configurational analysis identifies two sufficient pathways to high performance: a managerial supplier resilience pathway and a digital market resilience pathway. Their combined solution consistency is .909 and coverage is .558. No single condition reaches the .90 necessity threshold. Low performance follows different combinations, most often involving weak digital adoption, limited supplier portfolio diversity, and weak resilience. Conceptually, the study distinguishes average resource productivity from configurational indispensability and shows that comparable performance can be supported by alternative managerial and digital coordination complements. The findings show that portfolio diversity creates value through different resource architectures rather than through a single universal formula.

* Corresponding author.

E-mail address: auyonghn@utar.edu.my

<https://doi.org/10.37934/jarsbs.44.1.375401>

1. Introduction

Manufacturers are expected to maintain continuity during disruption without sacrificing economic, environmental, or social performance. These demands are related, but they are not the same. A firm may recover production quickly by relying on expensive emergency freight, poorly screened suppliers, or temporary practices that weaken environmental and social standards. Another firm may perform well against sustainability targets in normal periods but lack the flexibility to preserve those standards when supply, logistics, regulation, or demand changes abruptly. Sustainable supply chain performance therefore depends on more than efficient operations in stable conditions. It also depends on whether firms can preserve and reconfigure responsible operations when normal arrangements fail [5, 16, 39].

This problem is especially visible in the design of supplier and customer portfolios. Diversification can create options. Alternative suppliers reduce dependence on a single source, while a broader customer base can spread demand risk and expose firms to different market signals. Yet diversity is not free. Larger and more heterogeneous portfolios can increase qualification costs, monitoring requirements, forecasting difficulty, service variation, and coordination effort [3, 6, 27]. The relevant managerial question is therefore not simply whether firms should diversify. It is whether the organization has the governance, information, and adaptive capacity required to make diverse relationships usable when conditions change.

Existing research leaves three related questions unresolved. First, studies of supply-base complexity and diversification explain why portfolio breadth can spread risk or increase coordination cost, but they rarely examine the organizational conditions that turn that breadth into options that can actually be activated during disruption. Second, resource orchestration research explains why resources must be structured, bundled, and leveraged, yet supply-chain studies have seldom separated option-bearing boundary resources, such as supplier and customer portfolios, from the governance and information-processing resources needed to mobilize them. Third, most empirical studies rely on net-effect models. They can show that leadership, digitalization, diversity, or resilience is positively associated with performance, but they cannot establish whether the same resource is indispensable in every high-performing firm or whether another resource can compensate for its absence. Recent configurational evidence points to equifinality in resilience and performance [17, 21, 24], but it has not resolved the specific tension between portfolio diversity and the coordination burden created by that diversity.

This gap is important because supplier and customer diversity do not simply counts of external relationships. They are potential option portfolios whose value depends on whether the firm can interpret, coordinate, and redeploy them. Supplier diversity may provide alternative capacity, technologies, or locations, but it also increases qualification and monitoring demands. Customer diversity can reduce dependence and broaden market information, while simultaneously increasing forecasting and service heterogeneity. Previous studies usually examine these benefits and costs as separate net effects. What remains underexplained is the conversion mechanism: why similar portfolio breadth becomes a resilience resource in some firms but remains costly complexity in others.

A third issue concerns the role of supply chain resilience. Resilience is often modelled either as an outcome of preparedness or as a direct predictor of performance. That treatment underplays its role as an adaptive conversion capability. Resilience allows firms to detect disruption, mobilize alternatives, absorb shocks, recover, and adapt their operating arrangements [2, 28]. In this sense, resources do not create sustainable value merely because they exist. Their value depends partly on

whether the firm can activate and reconfigure them when established routines no longer fit the situation.

This study addresses the unresolved conversion problem through resource orchestration theory [33, 34]. The theoretical advancement is not the simple addition of resilience or the combination of two analytical techniques. The framework distinguishes three roles within an orchestration architecture: top management support and digital technology adoption provide coordination capacity; supplier and customer portfolio diversity provide external, option-bearing resources; and supply chain resilience represents the adaptive capability through which those options can be mobilized when operating conditions change. This distinction extends to orchestration reasoning from resource possession to the usability of external portfolio options. It also produces a testable theoretical contrast. PLS-SEM assesses whether each resource is productive on average and whether part of its association with performance operates through resilience, whereas fsQCA assesses whether the same resource is indispensable, substitutable, or relevant only within particular high-performance configurations. The methods therefore test different implications of the same theoretical argument rather than being combined as a methodological novelty.

Malaysian manufacturing provides a theoretically informative and practically consequential setting for this problem. The New Industrial Master Plan 2030 reports that manufacturing contributed about 24% of national GDP, 84% of total exports, and approximately 2.7 million jobs in 2022 [22]. This export-oriented structure places manufacturers inside geographically dispersed supplier and customer networks, making them exposed to logistics disruption, demand shifts, geopolitical change, and sustainability requirements. At the same time, NIMP 2030 asks manufacturers to advance digitalization, strengthen domestic linkages, pursue net-zero objectives, and safeguard economic security [22]. Malaysia therefore concentrates the central tension examined in this study: firms need external portfolio options for flexibility, but those options become more difficult to coordinate as networks become broader and more heterogeneous. The sector is also diverse in firm size, ownership, industry, and digital maturity, providing meaningful variation in the resources available for orchestration. Against this setting, the study asks how managerial support, digital technology, upstream and downstream portfolio diversity, and resilience are associated with sustainable supply chain performance, and which alternative resource configurations are associated with high performance.

The paper makes three connected contributions. First, it reframes supplier and customer diversity as option-bearing boundary resources rather than assuming that greater breadth is inherently beneficial. Second, it refines resource orchestration logic by separating coordination enablers, external portfolio options, and resilience as an adaptive conversion capability. This makes it possible to explain how resources with different functions can be combined rather than treating all antecedents as interchangeable inputs. Third, it distinguishes average resource productivity from configurational indispensability. A resource can have a positive net association with performance and still be unnecessary in a particular successful architecture when another complement performs a comparable coordinating role. The joint use of PLS-SEM and fsQCA is therefore theory-driven. It tests both the average conversion route through resilience and the equifinal resource combinations through which portfolio options become usable.

2. Theoretical Framework and Hypotheses

2.1 Resource Orchestration, Portfolio Options, and Resilience

Resource orchestration theory extends the resource based view by focusing on what managers do with the resources available to the firm. Structuring concerns the acquisition, accumulation, and

divestment of resources. Bundling concerns the creation and refinement of capabilities. Leveraging concerns the coordinated deployment of those capabilities in particular competitive situations [34]. The central implication is straightforward: resource endowments have potential value, but that potential remains unrealized when firms cannot combine and deploy them effectively.

This logic is useful for supply chain portfolios because many strategically important resources lie outside firm boundaries. A list of qualified suppliers, a broad customer base, and access to digital systems create options, but they do not guarantee that those options can be used. Alternative suppliers must be visible, qualified, and activated. Customer information must be interpreted and translated into production or sourcing decisions. Managers must also decide when to accept redundancy, switching costs, or short term inefficiency in order to protect continuity and stakeholder commitments. Portfolio value therefore depends on an architecture that links governance, information, external options, and adaptive response.

The framework deliberately separates resource domains from the orchestration process they support. Top management support represents senior attention, resource commitment, and decision authority, while digital technology adoption provides information-processing capacity and visibility. Supplier and customer portfolio diversity represent upstream and downstream option sets located beyond the firm boundary. Supply chain resilience is treated as the adaptive conversion capability through which these resources can be combined and redeployed during disturbance. The constructs are therefore not claimed to measure every structuring, bundling, and leveraging activity in resource orchestration [34]. Instead, they operate distinct roles in an orchestration-informed architecture. This distinction is theoretically important because portfolio diversity creates potential value and coordination burden at the same time; whether that value is realized should depend on the complementary governance, information, and adaptive capabilities available to make the options deployable.

2.2 Top Management Support

Resilience and sustainability initiatives usually cut across functional boundaries and compete with short term operating priorities. Senior managers influence whether firms commit resources to alternative sourcing, contingency capacity, digital visibility, supplier development, environmental controls, and cross functional response procedures. They also establish decision rights when a disruption requires rapid trade offs among cost, service, risk, and sustainability. Without senior backing, such investments can remain fragmented or be deferred when immediate financial pressures intensify [25].

Top management support can also be associated with sustainable performance outside disruption periods. Leadership attention influences supplier selection criteria, investment decisions, performance systems, and the legitimacy given to environmental and social objectives. It is therefore reasonable to expect both a direct association with sustainable supply chain performance and an indirect association that operates through resilience.

H1a. Top management support is positively associated with supply chain resilience.

H1b. Top management support is positively associated with sustainable supply chain performance.

2.3 Digital Technology Adoption

Digital technologies improve the speed and reach of supply chain information. Enterprise systems, cloud platforms, analytics, connected sensors, and digitally enabled communication can

shorten detection time, support scenario analysis, improve inventory and order visibility, and coordinate decisions across organizational boundaries. These capabilities are particularly valuable during disruption because response quality depends on how quickly firms can identify a problem, understand its consequences, and compare alternative actions [7, 11, 40].

Digital adoption can also support sustainable performance directly. Better data can improve scheduling, traceability, resource efficiency, waste monitoring, emissions reporting, and coordination with suppliers and customers. At the same time, technology does not create these outcomes automatically. Its value depends on complementary routines and relationships. This qualification becomes important in the configurational analysis, where digital adoption can be examined as one element of a broader resource architecture rather than as a universally necessary condition.

H2a. *Digital technology adoption is positively associated with supply chain resilience.*

H2b. *Digital technology adoption is positively associated with sustainable supply chain performance.*

2.4 Supplier and Customer Portfolio Diversity

Supplier portfolio diversity enlarges the set of sourcing alternatives available to a firm. Different suppliers may provide distinct technologies, geographic locations, capacities, or material options. During disruption, these differences can reduce dependence on a single node and create opportunities for order reallocation [35, 38]. Yet the same breadth can increase qualification, transaction, sustainability assurance, and monitoring costs [3, 6]. The theoretical value of diversity therefore lies less in supplier count than in the existence of usable alternatives.

On average, a broader supplier option set should still be positively associated with resilience because it reduces concentration and expands the range of responses available during disturbance. It can also be associated with sustainable performance by improving access to alternative inputs, innovation, competition, geographic flexibility, and suppliers that meet environmental or social requirements. Whether those benefits appear in every high performing firm is a separate configurational question.

H3a. *Supplier portfolio diversity is positively associated with supply chain resilience.*

H3b. *Supplier portfolio diversity is positively associated with sustainable supply chain performance.*

Customer portfolio diversity creates a different form of option value. Dependence on a narrow set of customers can expose a firm to abrupt demand loss or bargaining pressure. A broader customer base can spread market risk, provide information from different segments, and reduce reliance on one dominant buyer [27]. The downside is greater variation in demand patterns, service requirements, product specifications, and forecasting needs. Downstream diversity may therefore require stronger information processing and coordination than a simple concentration argument suggests.

A diversified customer base should nevertheless be positively associated with resilience because it broadens demand options and market intelligence. It can also support sustainable performance by reducing dependence, enabling market learning, and connecting the firm to heterogeneous customer expectations. The magnitude of these average relationships may be smaller than for upstream options if the coordination burden is greater, and the configurational analysis allows this possibility to be examined without imposing it as a linear hypothesis.

H4a. *Customer portfolio diversity is positively associated with supply chain resilience.*

H4b. *Customer portfolio diversity is positively associated with sustainable supply chain performance.*

2.5 Supply Chain Resilience as a Conversion Capability

Supply chain resilience refers to the capacity to prepare for disruption, absorb its effects, respond, recover, and adapt while maintaining strategic objectives. It is broader than redundancy or emergency reaction because it combines awareness, flexibility, coordination, learning, and reconfiguration [2, 30]. More recent work similarly emphasizes adaptation and viability rather than a narrow return to the pre disruption state [15, 16].

Resilience should be positively associated with sustainable supply chain performance because continuity protects service and revenue, while timely reconfiguration can reduce wasteful emergency action and help firms preserve stakeholder commitments during disruption [18]. It also provides a plausible conversion mechanism for the four resource domains. Leadership, digital systems, and diversified portfolios may improve current operations directly, but part of their value should operate through the firm's ability to mobilize those resources under disturbance. Because direct routes remain plausible, the expected pattern is complementary rather than full statistical mediation.

***H5.** Supply chain resilience is positively associated with sustainable supply chain performance.*

***H6a.** Supply chain resilience carries a positive indirect association between top management support and sustainable supply chain performance.*

***H6b.** Supply chain resilience carries a positive indirect association between digital technology adoption and sustainable supply chain performance.*

***H6c.** Supply chain resilience carries a positive indirect association between supplier portfolio diversity and sustainable supply chain performance.*

***H6d.** Supply chain resilience carries a positive indirect association between customer portfolio diversity and sustainable supply chain performance.*

2.6 Configurational Expectations

The net effect hypotheses ask whether each resource is associated with the outcome while the other predictors are held constant. A configurational perspective asks a different question: which combinations of conditions are sufficient for high sustainable performance? This distinction matters because leadership and digital infrastructure may provide different forms of coordination, while supplier and customer diversity may complement or substitute for one another across firms. A resource that is beneficial on average may therefore be irrelevant in one successful configuration if another condition performs a similar coordinating role [9, 31].

***P1.** High sustainable supply chain performance can arise from multiple equifinal configurations that combine portfolio options with managerial or digital coordination and resilience.*

***P2.** No single resource condition is expected to be universally necessary for high sustainable supply chain performance because alternative complements can compensate for its absence.*

***P3.** Configurations associated with low sustainable supply chain performance are expected to differ from simple inversions of the high performance configurations.*

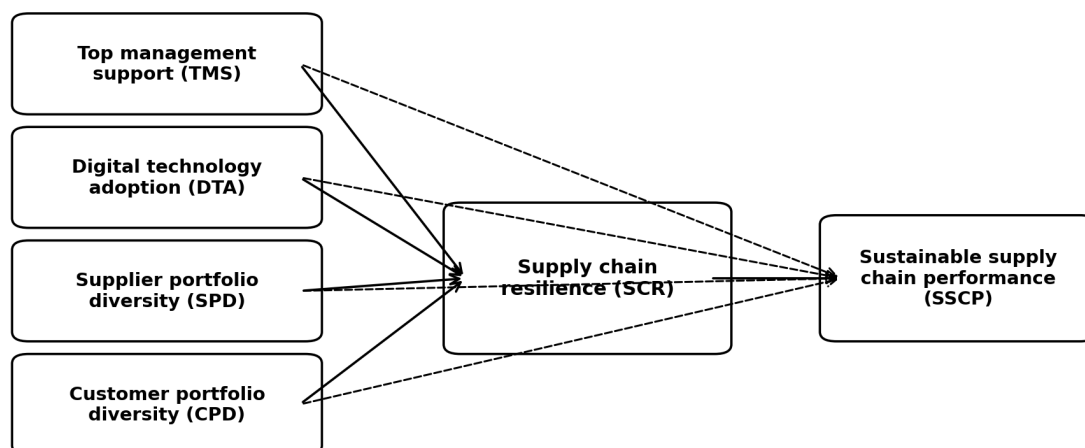


Fig. 1. Conceptual Framework

Note. TMS = top management support; DTA = digital technology adoption; SPD = supplier portfolio diversity; CPD = customer portfolio diversity; SCR = supply chain resilience; SSCP = sustainable supply chain performance. Solid arrows indicate associations with resilience. Dashed arrows indicate direct associations with SSCP.

3. Methodology

3.1 Research Setting, Sampling, and Respondents

The study used a cross-sectional, firm-level survey of manufacturing firms operating in Malaysia. Manufacturing was selected because the sector combines extensive upstream and downstream interdependence with direct exposure to disruption, digitalization, and sustainability requirements. In the Malaysian context, these pressures are reinforced by the national industrial agenda, which simultaneously emphasizes technology upgrading, stronger domestic linkages, net-zero transition, and economic security [22]. The Federation of Malaysian Manufacturers directory served as the organizational sampling frame. Questionnaires were administered through physical drop-off and collection as well as online channels to reach firms across different industries and locations. A total of 354 questionnaires were returned, and 345 complete responses were retained for analysis.

The firm was the unit of analysis. Respondents were owners, chief executive officers, managing directors, managers, assistant managers, and supervisors. Owners and managerial respondents represented 81.4% of the sample, while supervisors represented 18.6%. Supervisors were included because the questionnaire addressed operational and supply chain practices that can be observed below the executive level. However, the study did not contain a separate key informant competence scale, and this is treated as a limitation rather than assumed away. The final sample covered machinery and equipment, plastics, rubber, electronics, chemicals, food, and furniture manufacturing.

Table 1
Sample Characteristics

Characteristic	Category	N	%
Gender	Male	252	73.0
	Female	93	27.0
Age	24–29 years	23	6.7
	30–39 years	131	38.0
	40–49 years	108	31.3
	50–59 years	79	22.9
	60 years or older	4	1.2
Education	Secondary/SPM	8	2.3
	STPM/certificate/diploma	108	31.3
	Bachelor's degree	122	35.4
	Master's degree	104	30.1
	Doctoral degree	3	0.9
Position	Owner	18	5.2
	Chief executive officer	20	5.8
	Managing director	82	23.8
	Manager	96	27.8
	Assistant manager	65	18.8
	Supervisor	64	18.6
Industry	Electronics	46	13.3
	Chemicals	36	10.4
	Food	29	8.4
	Machinery and equipment	90	26.1
	Rubber	58	16.8
	Furniture	26	7.5
	Plastic	60	17.4
Annual revenue	< RM500,000	19	5.5
	RM500,000–RM2 million	42	12.2
	RM2–RM10 million	116	33.6
	RM10–RM25 million	136	39.4
	> RM25 million	32	9.3
Employees	< 100	162	47.0
	100–250	57	16.5
	251–500	82	23.8
	501–1,000	39	11.3
	> 1,000	5	1.4
Firm age	< 6 years	18	5.2

Characteristic	Category	N	%
Ownership	6–10 years	26	7.5
	11–15 years	62	18.0
	> 15 years	239	69.3
	Fully Malaysian owned	294	85.2
	Joint venture	26	7.5
	American owned	5	1.4
	Japanese owned	18	5.2
	European owned	2	0.6

Note. Percentages are based on valid responses and may not sum to 100 because of rounding

3.2 Measures and Measurement Specification

Each construct was measured with six items using five point response scales. The SmartPLS model treated all six constructs reflectively. Top management support captured senior commitment, support, and resource allocation. Digital technology adoption captured the use of digital technologies in supply chain activities. Supplier and customer portfolio diversity captured respondents' perceptions of breadth and heterogeneity in upstream and downstream relationships. Supply chain resilience captured preparedness, response, recovery, and adaptation. Sustainable supply chain performance captured economic, environmental, and social performance. The operational definitions were informed by established work on resilience, digitalization, portfolio complexity, and sustainable supply chain performance [1, 2, 6, 7, 10].

Reflective specification was retained because the administered instrument and the original SmartPLS model treated the indicators as manifestations of underlying organizational perceptions. This decision deserves conceptual caution. Portfolio diversity can also be represented as a composite of distinct dimensions, and sustainable supply chain performance may be modelled as a higher order construct that separates economic, environmental, and social dimensions. The present analysis therefore reports the reflective model transparently and treats alternative specifications as an important robustness issue for future replication.

3.3 Common Method Risk

The design relied on a single respondent per firm, so common method risk cannot be eliminated statistically. Procedural safeguards included anonymity, neutral wording, and separation of predictor and outcome sections. Statistical checks were used only as diagnostics. The Kaiser Meyer Olkin measure was .933, and Bartlett's test of sphericity was significant, $\chi^2(630) = 9,210.345$, $p < .001$. An unrotated principal component analysis extracted six components with eigenvalues above 1, and the first component accounted for 29.87% of total variance. This value is below the conventional 50% warning benchmark, but Harman's test has limited diagnostic power and is not treated as evidence that common method bias is absent [19, 29].

Table 2

Common Method and Factorability Diagnostics

Diagnostic	Value	Interpretation
Kaiser–Meyer–Olkin measure	.933	Excellent sampling adequacy
Bartlett's test	$\chi^2(630) = 9,210.345, p < .001$	Correlations were factorable
Components with eigenvalues > 1	6	Consistent with the six-construct structure
Variance explained by first unrotated component	29.87%	No dominant single component
Cumulative variance explained by six components	71.75%	Substantive common variance captured

Note. Harman's single factor analysis is a limited diagnostic and does not eliminate common method risk.

3.4 PLS-SEM Procedure

PLS-SEM was used to estimate the latent variable measurement model, the direct associations, and the specific indirect effects. It also provided construct scores for the configurational stage. The choice of PLS-SEM was therefore linked to the study's explanatory objective and to the integration of the symmetric and configurational analyses rather than to an assumption that PLS offers a universal solution for complex models [12, 13].

The measurement model was evaluated using indicator loadings, Cronbach's alpha, rho_A, composite reliability, average variance extracted, the heterotrait monotrait ratio, and the Fornell Larcker criterion. The structural model was assessed using inner variance inflation factors, R^2 , adjusted R^2 , effect sizes, and bootstrapped path estimates based on 5,000 resamples. SRMR, d_ULS, d_G, chi square, and NFI are reported as descriptive PLS diagnostics. Indirect effects were interpreted from the signs and significance of the direct and indirect associations. A positive significant indirect effect alongside a positive significant direct effect was classified as complementary partial mediation. Because the data are cross sectional, mediation is used here as a statistical description of an indirect association, not as proof of temporal causality.

3.5 fsQCA Procedure

Construct scores for TMS, DTA, SPD, CPD, SCR, and SSCP were exported from SmartPLS and calibrated into fuzzy set memberships using the direct method. The 95th percentile represented full membership, the median represented the crossover point, and the 5th percentile represented full nonmembership. Exact .500 memberships were adjusted to .501 for truth table assignment. These anchors define relative positions within the sample rather than universal substantive thresholds, so calibration sensitivity was examined separately.

Necessity analysis was performed for each condition and its negation for both high and low SSCP. A consistency value of .90 was used for formal necessity. With five conditions, the truth table contained 32 logically possible configurations. A row was coded as sufficient when its frequency was at least two cases, raw consistency was at least .85, and proportional reduction in inconsistency was at least .70. Positive directional expectations were used for the intermediate solution. Conditions appearing in both parsimonious and intermediate solutions were treated as core, while conditions appearing only in the intermediate solution were treated as peripheral [9, 26, 31]. Robustness checks

varied calibration anchors, frequency, raw consistency, and PRI thresholds. The negated outcome was analysed separately to assess configurational asymmetry [20, 32].

4. Results

4.1 Measurement Model

All outer loadings exceeded .70 and ranged from .776 to .934. Cronbach's alpha ranged from .898 to .964, rho_A from .898 to .965, and composite reliability from .921 to .971. AVE values ranged from .662 to .846. These results support indicator reliability, internal consistency, and convergent validity within the reflective specification used in the study. The particularly high reliability of SSCP indicates strong item homogeneity and reinforces the need for future work to compare the present specification with higher order or composite alternatives.

Discriminant validity was supported by both reported criteria. The highest HTMT value was .771 between SCR and SSCP, which is below the conservative .85 threshold [14]. In the Fornell Larcker matrix, the square root of AVE for each construct exceeded its correlations with the other constructs. Several correlations among the resource domains were close to zero. This pattern reduces collinearity, but it is unusual enough to warrant replication with raw item composites and independent samples.

Table 3

Reflective Measurement Model Assessment

Construct	Items	Loading range	A	rho_A	CR	AVE
Customer portfolio diversity (CPD)	6	.789–.863	.899	.917	.922	.662
Digital technology adoption (DTA)	6	.776–.852	.899	.908	.922	.665
Supplier portfolio diversity (SPD)	6	.814–.879	.915	.918	.934	.703
Supply chain resilience (SCR)	6	.815–.883	.927	.928	.943	.733
Sustainable supply chain performance (SSCP)	6	.897–.934	.964	.965	.971	.846
Top-management support (TMS)	6	.790–.839	.898	.898	.921	.662

Note. CR = composite reliability; AVE = average variance extracted.

Table 4

Heterotrait Monotrait Ratios

Construct	CPD	DTA	SPD	SCR	SSCP	TMS
CPD	—					
DTA	.083	—				
SPD	.076	.045	—			
SCR	.173	.276	.477	—		
SSCP	.207	.322	.437	.771	—	
TMS	.058	.049	.102	.408	.372	—

Note. Lower triangular matrix. The maximum HTMT ratio was .771.

Table 5

Fornell Larcker Criterion

Construct	CPD	DTA	SPD	SCR	SSCP	TMS
CPD	.814					
DTA	-.064	.815				
SPD	.063	.002	.838			
SCR	.162	.255	.442	.856		
SSCP	.199	.303	.414	.730	.920	
TMS	-.007	.000	.091	.374	.347	.814

Note. Diagonal values are square roots of AVE; off diagonal values are latent variable correlations.

4.2 Structural Model

Inner VIF values ranged from 1.004 to 1.657, indicating no material collinearity problem in the structural model. The model explained 39.7% of the variance in SCR and 58.4% of the variance in SSCP. The saturated and estimated SRMR values were .039, and NFI was .911. These fit statistics are reported descriptively rather than treated as substitutes for measurement quality and structural interpretation.

All hypothesized direct associations were positive and statistically significant. Supplier portfolio diversity had the strongest association with SCR ($\beta = .401$, $t = 9.848$, $p < .001$), followed by top management support ($\beta = .338$), digital technology adoption ($\beta = .264$), and customer portfolio diversity ($\beta = .155$). SCR had the largest association with SSCP ($\beta = .556$, $t = 13.146$, $p < .001$). The direct resource associations with SSCP were smaller: DTA ($\beta = .168$), SPD ($\beta = .149$), TMS ($\beta = .126$), and CPD ($\beta = .111$). Effect sizes followed a similar pattern. SCR had a large effect on SSCP, while SPD and TMS were the most consequential resource antecedents of SCR.

Table 6

Bootstrapped Structural Path Results

Hypothesis	Path	B	SE	T	P	f ²	Decision
H1a	TMS → SCR	.338	.039	8.616	< .001	.188	Supported
H1b	TMS → SSCP	.126	.037	3.431	.001	.032	Supported
H2a	DTA → SCR	.264	.045	5.833	< .001	.115	Supported
H2b	DTA → SSCP	.168	.036	4.623	< .001	.061	Supported
H3a	SPD → SCR	.401	.041	9.848	< .001	.263	Supported
H3b	SPD → SSCP	.149	.039	3.838	< .001	.042	Supported
H4a	CPD → SCR	.155	.044	3.507	< .001	.040	Supported
H4b	CPD → SSCP	.111	.035	3.169	.002	.028	Supported
H5	SCR → SSCP	.556	.042	13.146	< .001	.449	Supported

Note. Two tailed tests based on 5,000 bootstrap resamples. Approximate f² benchmarks are .02 (small), .15 (medium), and .35 (large).

Table 7

Explanatory Power and Descriptive Model Diagnostics

Measure	SCR	SSCP	Estimated Model
R ²	0.397	0.584	—
Adjusted R ²	0.390	0.578	—
SRMR	—	—	0.039
d_ULS	—	—	1.034
d_G	—	—	0.431
χ ²	—	—	854.036
NFI	—	—	0.911

Note. PLS model fit indices are reported as descriptive diagnostics and are not treated as substitutes for measurement quality or structural estimates.

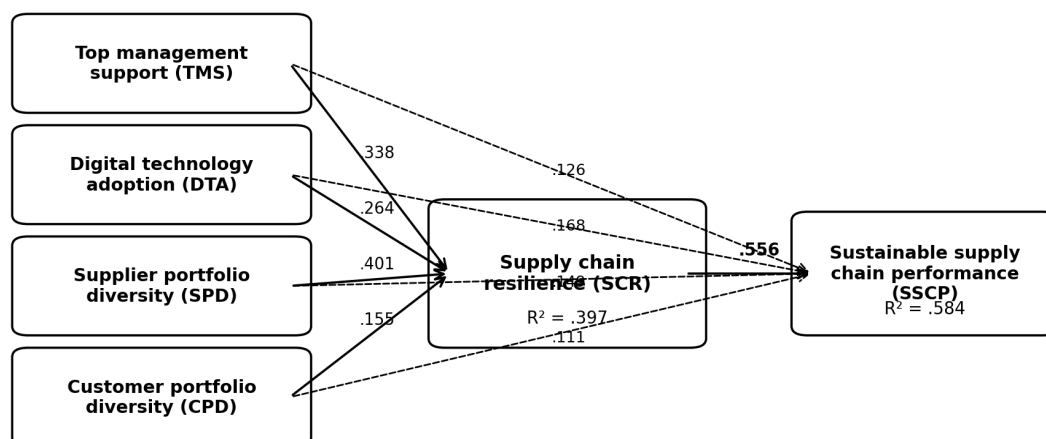


Fig. 2. PLS-SEM Structural Results

Note. Standardized coefficients are reported. All displayed paths are statistically significant at $p \leq .002$. R² values are shown inside the endogenous constructs.

4.3 Indirect and Total Associations

All four specific indirect effects through SCR were positive and significant. The largest indirect association was SPD → SCR → SSCP ($\beta = .223$), followed by TMS ($\beta = .188$), DTA ($\beta = .147$), and CPD ($\beta = .086$). Each corresponding direct association also remained positive and significant. The statistical pattern is therefore complementary partial mediation. Resilience is an important conversion route, but it does not absorb the full association between the resource domains and performance.

The total effects provide a similar substantive ordering. SPD had the largest total association with SSCP (.372), while DTA (.315) and TMS (.314) were almost identical. CPD had the smallest total association (.198), although it remained statistically significant.

Table 8
Specific Indirect Effects and Mediation Classification

Hypothesis	Indirect path	Direct	Indirect	Total	SE indirect	T	p	Classification
H6a	TMS → SCR → SSCP	.126	.188	.314	.026	7.351	< .001	Complementary partial
H6b	DTA → SCR → SSCP	.168	.147	.315	.028	5.294	< .001	Complementary partial
H6c	SPD → SCR → SSCP	.149	.223	.372	.027	8.235	< .001	Complementary partial
H6d	CPD → SCR → SSCP	.111	.086	.198	.026	3.377	.001	Complementary partial

Note. Mediation refers to the observed statistical indirect effect pattern. The cross sectional design does not establish temporal causality.

4.4 Calibration and Necessity Analysis

No condition, and no negated condition, reached the .90 consistency threshold for formal necessity in the high SSCP analysis. SCR had the highest necessity consistency (.827), followed by SPD (.727), but neither met the conventional threshold. No condition was necessary for low SSCP either. The absence of SCR was closest, with consistency of .816. These results support the expectation that high performance does not depend on one universally required condition and justify the examination of conjunctural sufficiency.

Table 9
Direct Calibration Anchors

Set	Full non-membership (5th)	Crossover (50th)	Full membership (95th)
TMS	-1.5748	0.0450	1.5702
DTA	-1.8100	0.0160	1.6830
SPD	-1.7140	-0.0310	1.7180
CPD	-1.6470	-0.0210	1.6054
SCR	-1.7100	-0.0460	1.6330
SSCP	-1.4610	-0.1090	1.4880

Note. Anchors are percentiles of SmartPLS construct scores. Exact .500 memberships were adjusted to .501.

Table 10

Necessary Condition Analysis for High and Low SSCP

Outcome	Condition	Consistency	Coverage	Necessary $\geq .90$
High SSCP	TMS	0.684	0.714	No
High SSCP	~TMS	0.560	0.564	No
High SSCP	DTA	0.699	0.710	No
High SSCP	~DTA	0.567	0.586	No
High SSCP	SPD	0.727	0.741	No
High SSCP	~SPD	0.541	0.558	No
High SSCP	CPD	0.671	0.683	No
High SSCP	~CPD	0.581	0.600	No
High SSCP	SCR	0.827	0.825	No
High SSCP	~SCR	0.461	0.486	No
Low SSCP	TMS	0.545	0.541	No
Low SSCP	~TMS	0.712	0.682	No
Low SSCP	DTA	0.580	0.560	No
Low SSCP	~DTA	0.700	0.689	No
Low SSCP	SPD	0.549	0.532	No
Low SSCP	~SPD	0.733	0.719	No
Low SSCP	CPD	0.592	0.574	No
Low SSCP	~CPD	0.672	0.660	No
Low SSCP	SCR	0.487	0.463	No
Low SSCP	~SCR	0.816	0.817	No

Note. A tilde (~) denotes the absence of a condition.

4.5 Sufficient Configurations for High SSCP

Five truth table rows met the frequency, raw consistency, and PRI thresholds. Boolean minimization produced two sufficient configurations: TMS*SPD*SCR and DTA*SPD*CPD*SCR. Under the baseline specification, the complex, parsimonious, and intermediate expressions were identical. All displayed conditions were therefore classified as core and no peripheral conditions were identified.

The first configuration combines high top management support, high supplier portfolio diversity, and high resilience. Digital adoption and customer portfolio diversity do not distinguish membership in high SSCP within this recipe. Its consistency was .918, raw coverage .498, and unique coverage .169. This configuration is labelled the managerial supplier resilience pathway because leadership and upstream options are combined with an adaptive response capability.

The second configuration combines high digital technology adoption, high supplier portfolio diversity, high customer portfolio diversity, and high resilience. Top management support is irrelevant in this recipe, which means that its level does not determine membership in the outcome for cases covered by the configuration. Consistency was .931, raw coverage .389, and unique

coverage .060. This configuration is labelled the digital market resilience pathway because digital coordination connects both upstream and downstream option portfolios with resilience.

Overall solution consistency was .909 and solution coverage was .558. SPD and SCR recur across both baseline pathways, which makes their conjunction a recurrent feature of the baseline high performance solution. This recurrence should not be described as formal necessity because both conditions failed the .90 necessity test. P1 and P2 are therefore supported in the set theoretic sense used in this study.

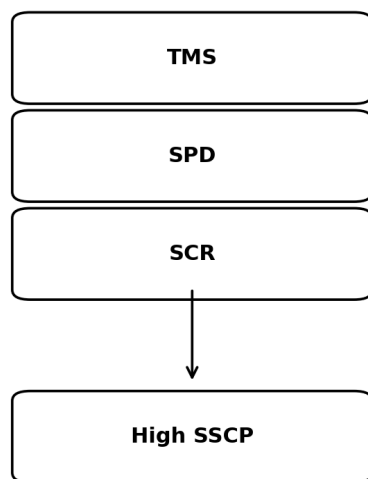
Table 11

Configurations Sufficient for High SSCP

Condition or metric	C1: Managerial-supplier resilience	C2: Digital-market resilience
TMS	●	
DTA		●
SPD	●	●
CPD		●
SCR	●	●
Consistency	.918	.931
Raw coverage	.498	.389
Unique coverage	.169	.060

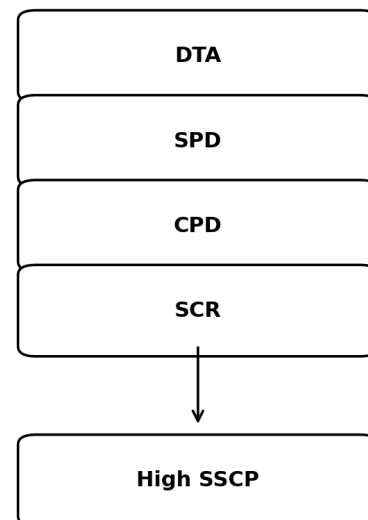
Note. ● = core condition present; blank = condition is irrelevant. Overall solution consistency = .909; overall solution coverage = .558.

Managerial supplier resilience pathway



Consistency = .918
Raw coverage = .498
Unique coverage = .169

Digital market resilience pathway



Consistency = .931
Raw coverage = .389
Unique coverage = .060

Fig. 3. Equifinal Configurations Associated with High SSCP

Note. Each pathway is sufficient but not necessary. SPD and SCR recur in both baseline pathways. TMS, DTA, and CPD provide different complements across the two configurations.

4.6 Low SSCP and Robustness

The analysis of the negated outcome produced two configurations for low SSCP: $\sim\text{TMS}^*\sim\text{DTA}^*\sim\text{SPD}^*\sim\text{SCR}$ and $\sim\text{DTA}^*\sim\text{SPD}^*\sim\text{CPD}^*\sim\text{SCR}$. Their combined consistency was .919 and coverage was .469. Both contain the absence of DTA, SPD, and SCR, while TMS and CPD distinguish the two pathways. Low performance is therefore not generated by simply reversing either high performance recipe. P3 is supported as configurational asymmetry, not as temporal causal asymmetry.

The baseline high performance solution was unchanged when the frequency threshold increased to three and when raw consistency varied from .80 to .90. Alternative calibration anchors and PRI thresholds produced additional or modified recipes. The robust conclusion is therefore narrower than complete recipe invariance. SCR remains central across the reported checks, and SPD is recurrent in the baseline and most alternatives, while the complementary roles of TMS, DTA, and CPD are more sensitive to calibration and threshold choices.

Table 12

Configurations Sufficient for Low SSCP

Configuration for $\sim\text{SSCP}$	Consistency	Raw coverage	Unique coverage
$\sim\text{TMS}^*\sim\text{DTA}^*\sim\text{SPD}^*\sim\text{SCR}$	.924	.404	.075
$\sim\text{DTA}^*\sim\text{SPD}^*\sim\text{CPD}^*\sim\text{SCR}$	.939	.394	.065

Note. $\sim$ denotes absence. Overall solution consistency = .919; overall solution coverage = .469.

Table 13

fsQCA Robustness Checks

Test	Calibration	Frequency	Raw consistency	PRI	Minimised solution	Consistency	Coverage
Baseline	95/50/5	2	.85	.70	$\text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.909	.558
Alternative calibration	90/50/10	2	.85	.70	$\text{TMS}^*\text{DTA}^*\text{CPD}^*\text{SCR} + \text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.908	.595
Higher frequency	95/50/5	3	.85	.70	$\text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.909	.558
Lower consistency	95/50/5	2	.80	.70	$\text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.909	.558
Higher consistency	95/50/5	2	.90	.70	$\text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.909	.558
Lower PRI	95/50/5	2	.85	.65	$\text{TMS}^*\text{DTA}^*\text{CPD}^*\text{SCR} + \text{TMS}^*\text{SPD}^*\text{SCR} + \text{DTA}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.897	.617
Higher PRI	95/50/5	2	.85	.75	$\text{TMS}^*\text{DTA}^*\text{SPD}^*\text{SCR} + \text{TMS}^*\text{SPD}^*\text{CPD}^*\text{SCR}$	.928	.461

Note. The SPD and SCR pattern is more stable than the exact complementary roles of TMS, DTA, and CPD.

5. Discussion

5.1 From Resource Possession to Deployable Portfolio Options

The main finding is not simply that all four resource domains have positive coefficients. The more important result is that their strategic meaning changes when average associations are compared with configurations. The PLS-SEM model shows that management support, digital adoption, supplier diversity, and customer diversity are each positively associated with resilience and sustainable performance. The fsQCA results show that these resources do not have to appear together in one universal arrangement. This difference matters because a positive average effect answers whether a resource tends to be useful, while a sufficient configuration answers how that resource works with others in particular high performing cases.

Supplier portfolio diversity occupies the clearest position in both analyses. It has the strongest resource association with resilience, the largest resource level total association with SSCP, and it appears in both baseline high performance configurations. This result supports the option value of a diversified supply base, but it does not imply that supplier count should be maximized. Choi and Krause [6] and Bode and Wagner [3] show why complexity can increase transaction and disruption exposure. The present findings suggest a more precise interpretation: upstream diversity becomes strategically useful when firms can convert alternative relationships into an adaptive response. The value lies in deployability, not breadth alone.

This interpretation also clarifies the role of resilience. SCR is the dominant predictor of SSCP and the largest structural effect in the model. It also appears in both high performance configurations and its absence appears in both low performance configurations. Yet it does not satisfy formal necessity. The practical and theoretical implication is that resilience is central without being universally indispensable in a strictly set theoretic sense. This distinction avoids a common overstatement in resilience research, where a strong coefficient is sometimes interpreted as evidence that every high performing firm must possess the capability to the same degree.

5.2 Why Upstream and Downstream Diversity Behave Differently

The contrast between supplier and customer diversity is particularly informative. CPD has the smallest average direct and indirect associations, but it becomes core in the digital market pathway. A regression ranking alone would therefore understate its strategic relevance. Customer diversity appears to matter most when digital coordination, supplier options, and resilience are already in place. This is consistent with the underlying coordination argument. Heterogeneous customers create valuable demand signals, but those signals also increase forecasting and service complexity. Digital information processing can make the downstream portfolio more interpretable and actionable.

Supplier diversity is less contingent in the baseline solution because sourcing alternatives are more directly linked to disruption response. A firm facing a shortage can switch or redistribute orders only if viable alternatives exist. Customer diversity provides a different form of protection because it spreads demand dependence and broadens market knowledge, but its value may be more conditional on the firm's ability to integrate information across both sides of the supply chain. The findings therefore suggest that upstream and downstream diversity should not be treated as interchangeable manifestations of the same relational resource.

5.3 Leadership and Digital Coordination as Alternative Complements

The two high performance pathways also show that firms can coordinate portfolio options in different ways. In the managerial supplier pathway, strong top management support combines supplier diversity and resilience, while digital adoption and customer diversity are irrelevant to the recipe. This does not mean that technology is unimportant. It means that within this pathway, variation in digital membership does not distinguish the cases that achieve high SSCP. A leadership centered architecture can therefore support the mobilization of supplier options when decision authority and resilience routines are strong.

The digital market pathway follows a different logic. Digital adoption is combined with both upstream and downstream portfolio diversity and resilience, while top management support is irrelevant. This pathway is more information intensive because the firm must coordinate heterogeneous relationships on both sides of the supply chain. The result is consistent with recent work showing that digitalization contributes to resilience through complementary organizational capabilities rather than through technology investment alone [7, 11, 41]. It also provides a useful qualification to the strong average association between TMS and resilience: leadership matters on average, but it is not configurationally indispensable.

5.4 Theoretical Contributions

The first contribution is to resource orchestration theory. The study extends the theory beyond a primarily internal resource-bundling view by treating supplier and customer portfolios as external, option-bearing resources whose value depends on how the focal firm coordinates and activates them. It also refines the theory by separating three functions that are often collapsed in empirical models: coordination capacity (TMS and DTA), external option availability (SPD and CPD), and adaptive conversion (SCR). This separation makes the orchestration mechanism more explicit without claiming that the survey directly measures the complete structuring, bundling, and leveraging process described by Sirmon et al. [33, 34].

The second contribution is to the portfolio diversity literature. Upstream and downstream diversity create different forms of option value and different coordination burdens. The evidence shows that supplier portfolio diversity has a comparatively robust relationship with resilience, whereas customer portfolio diversity has a more pathway dependent role. This distinction refines the simple claim that diversification is beneficial by showing that the value of diversity depends on where the option is located and what complementary resources are available to mobilize it.

The third contribution is to resilience research. Resilience acts as a major statistical conversion pathway between resources and sustainable performance, but the remaining direct associations show that it is not the only route through which resources are linked to performance. The configurational results add a second qualification: a condition can recur across minimized solutions without satisfying formal necessity. Separating centrality, sufficiency, and necessity produces a more precise account of what it means for resilience to matter.

The configurational evidence further refines resource orchestration theory by showing that orchestration can be equifinal rather than uniform. TMS is a strong average antecedent but is irrelevant in the digital-market pathway, while DTA is core in that pathway but not in the managerial-supplier pathway. CPD has the weakest average effects yet becomes core when digital coordination, supplier diversity, and resilience are jointly present. These contrasts challenge the common empirical inference that a resource with a positive coefficient is therefore universally indispensable. Resource orchestration in supply chains is better understood as architecture-specific: different complements

can perform the coordination function, and the theoretical meaning of a resource depends on the configuration in which it is deployed.

Table 14

Integration of PLS-SEM and fsQCA Evidence

Construct	PLS-SEM evidence	fsQCA evidence	Joint interpretation
Top-management support	Positive associations with SCR and SSCP; complementary indirect effect	Core in managerial-supplier pathway; irrelevant in digital-market pathway	Important on average but not configurationally indispensable
Digital technology adoption	Positive associations with SCR and SSCP; complementary indirect effect	Core only in digital-market pathway	Immediate value and pathway-specific coordination role
Supplier portfolio diversity	Strongest resource antecedent of SCR and largest resource total effect	Core in both high-SSCP pathways	Recurring option-portfolio backbone
Customer portfolio diversity	Positive but comparatively smaller average effects	Core only in digital-market pathway	Payoff depends on digital and resilience complements
Supply chain resilience	Largest association with SSCP	Core in both high pathways and absent in both low pathways	Central conversion capability, but not individually necessary at .90

Note. PLS-SEM estimates average associations; fsQCA identifies sufficient configurations and formal necessity.

5.5 Managerial and Policy Implications

Managers should allocate attention and budget to the usability of portfolio diversity rather than to partner counts. Supplier-diversification spending should prioritize pre-qualification, verified spare capacity, geographic or technological alternatives, sustainability screening, contingency terms, and the time required to switch orders. Customer diversification should be expanded only when planning routines can absorb greater variation in demand, service requirements, and product mix. In practical terms, a broad portfolio that cannot be interpreted or activated quickly may add monitoring cost without adding resilience.

The two high-performance configurations imply different allocation sequences. In the managerial-supplier-resilience pathway, firms with strong senior coordination but limited digital maturity should first direct managerial attention to clear escalation rights, pre-approved supplier switching, cross-functional response ownership, contingency exercises, and qualified alternative sources. Digital investment in this pathway can be selective, concentrating on basic supplier and inventory visibility rather than broad technology acquisition. In the digital-market-resilience pathway, firms serving more heterogeneous markets should place capital into interoperable systems that connect customer demand, inventory, capacity, supplier alternatives, and scenario analysis. Here, customer diversification is more defensible when digital systems can convert heterogeneous market signals into timely sourcing and production decisions.

Across both baseline pathways, supplier diversity and resilience recur, although neither is formally necessary. A reasonable managerial priority is therefore to protect the quality of alternative suppliers and the routines needed to activate them before simultaneously expanding both supplier

and customer portfolios. Resilience should be funded as an operating capability through escalation protocols, supplier activation procedures, shared data standards, post-disruption learning, and sustainability criteria for emergency decisions. The key allocation question is not whether to spend more on management, technology, or diversification in isolation, but which coordination bottleneck currently prevents the firm from using the options it already possesses.

For Malaysian policy, the results are consistent with NIMP 2030's combined emphasis on digital upgrading, domestic linkages, and economic security [22]. Technology support is likely to be more useful when it is connected to supplier development, interoperability, risk information, and resilience capability building. Programs that fund isolated technology acquisition may improve equipment or reporting without necessarily improving the firm's ability to mobilize supply chain options during disruption.

5.6 Limitations and Future Research

The study has several design limitations that constrain inference. First, the cross-sectional survey does not establish temporal order or causal direction; high-performing firms may subsequently invest in technology, broaden their portfolios, or strengthen resilience. Longitudinal and event-based designs should measure resource conditions before a disruption, response capability during the event, and performance after recovery. Such designs would provide a stronger test of resilience as a temporal conversion mechanism rather than only a statistical indirect association.

Second, the constructs are self-reported and were obtained from a single informant in each firm, which leaves the study exposed to common method bias and perceptual measurement error. The first unrotated factor accounted for 29.87% of the variance, but this diagnostic cannot demonstrate that common method bias is absent. The sample also includes 64 supervisors, and the questionnaire did not contain a formal key-informant competence scale. Future research should use time-separated or multi-source designs, matched respondents from procurement, operations, information systems, and sustainability functions, and objective indicators such as supplier and customer concentration, delivery continuity, waste, emissions, labor incidents, and financial outcomes.

The reflective measurement model produced strong reliability and discriminant validity, but conceptual alternatives remain plausible. Supplier and customer portfolio diversity may be better represented as composites when distinct dimensions such as geographic spread, technological heterogeneity, or concentration jointly form the construct. SSCP may also be better represented as a higher order construct that preserves the economic, environmental, and social dimensions. Future research should compare these specifications directly rather than assuming that high reliability resolves the conceptual question.

Several correlations among the resource domains were unusually small. Although this pattern reduces multicollinearity and is internally consistent with the reported HTMT matrix, it should be replicated using raw item composites, alternative samples, and independent data collection. Future studies should also examine plausible controls and sources of endogeneity, including firm size, industry, ownership, financial slack, export exposure, regulatory pressure, and prior performance.

The fsQCA calibration uses sample percentiles, so set membership is relative to the present Malaysian sample rather than to universal standards for high digital adoption, diversity, resilience, or performance. Robustness tests preserve the central role of resilience and much of the supplier diversity pattern, but the exact complementary roles of TMS, DTA, and CPD vary under alternative calibration and PRI choices. Future studies should develop theory based or benchmark based anchors and conduct case level analysis of typical and deviant configurations.

Finally, the single-country Malaysian setting and manufacturing-sector focus limit the scope of generalization. Institutional pressures, infrastructure, digital maturity, labor conditions, and supply-network structures may differ in services, logistics, other emerging economies, and advanced economies. The five-condition fsQCA model was also intentionally limited to preserve truth-table interpretability; collaboration quality, geographic dispersion, supplier dependence, financial slack, environmental regulation, firm size, industry, and ownership may explain additional outcome membership. Cross-country and cross-sector replication with theory-based calibration anchors is therefore needed before the reported configurations are treated as broadly generalizable.

6. Conclusion

Portfolio diversity is neither automatically beneficial nor merely a source of complexity. In the present sample, top management support, digital technology adoption, supplier portfolio diversity, and customer portfolio diversity are each positively associated with resilience and sustainable supply chain performance. Supplier portfolio diversity shows the strongest resource association with resilience, and resilience is the dominant performance correlate. The configurational analysis qualifies these average relationships by showing that high performance is associated with two different resource architectures rather than one universal combination.

These findings extend resource orchestration theory by bringing external supplier and customer portfolios into the resource architecture as option-bearing resources whose value depends on coordination and activation. They refine the theory by showing that orchestration can be equifinal: strong managerial coordination supports one high-performance pathway, whereas digital coordination supports another. They also challenge the assumption that a resource that is beneficial on average must be universally indispensable. TMS, DTA, and CPD have positive PLS-SEM associations but are not required across all successful configurations, while SPD and SCR recur without meeting the formal necessity threshold. Resource orchestration in supply chains should therefore distinguish resource productivity from configurational indispensability and recognize that different coordination complements can convert portfolio options into resilient and sustainable performance.

Acknowledgement

This research is one of the outcomes of the project supported by the internal funded project No: IPSR/RMC/UTARRF/2023-C2/F02 from the Universiti Tunku Abdul Rahman, Malaysia.

Declarations

Ethics approval: The study received institutional ethics approval under reference U/SERC/56(A)-597/2025.

Informed consent: Participation was voluntary, and respondents were informed of the research purpose and confidentiality arrangements.

Conflict of interest: The authors declare no conflict of interest.

Data availability: Deidentified data and the questionnaire may be made available by the corresponding author subject to institutional and participant consent requirements.

References

- [1] Ahi, P., and C. Searcy. 2015. "An Analysis of Metrics Used to Measure Performance in Green and Sustainable Supply Chains." *International Journal of Production Research* 53 (10): 2882–2907. <https://doi.org/10.1080/00207543.2014.970678>.

- [2] Ambulkar, S., J. Blackhurst, and S. Grawe. 2015. "Firm's Resilience to Supply Chain Disruptions: Scale Development and Empirical Examination." *Journal of Operations Management* 33–34: 111–122. <https://doi.org/10.1016/j.jom.2014.11.002>.
- [3] Bode, C., and S. M. Wagner. 2015. "Structural Drivers of Upstream Supply Chain Complexity and the Frequency of Supply Chain Disruptions." *Journal of Operations Management* 36: 215–228. <https://doi.org/10.1016/j.jom.2014.12.004>.
- [4] Brandon-Jones, E., B. Squire, C. W. Autry, and K. J. Petersen. 2014. "A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness." *Journal of Supply Chain Management* 50 (3): 55–73. <https://doi.org/10.1111/jscm.12050>.
- [5] Carter, C. R., and D. S. Rogers. 2008. "A Framework of Sustainable Supply Chain Management: Moving toward New Theory." *International Journal of Physical Distribution & Logistics Management* 38 (5): 360–387. <https://doi.org/10.1108/09600030810882816>.
- [6] Choi, T. Y., and D. R. Krause. 2006. "The Supply Base and Its Complexity: Implications for Transaction Costs, Risks, Responsiveness, and Innovation." *Journal of Operations Management* 24 (5): 637–652. <https://doi.org/10.1016/j.jom.2005.07.002>.
- [7] Dubey, R., A. Gunasekaran, S. J. Childe, S. Fosso Wamba, D. Roubaud, and C. Foropon. 2021. "Empirical Investigation of Data Analytics Capability and Organizational Flexibility as Complements to Supply Chain Resilience." *International Journal of Production Research* 59 (1): 110–128. <https://doi.org/10.1080/00207543.2019.1582820>.
- [8] Ducheck, S. 2020. "Organizational Resilience: A Capability-Based Conceptualization." *Business Research* 13: 215–246. <https://doi.org/10.1007/s40685-019-0085-7>.
- [9] Fiss, P. C. 2011. "Building Better Causal Theories: A Fuzzy Set Approach to Typologies in Organization Research." *Academy of Management Journal* 54 (2): 393–420. <https://doi.org/10.5465/amj.2011.60263120>.
- [10] Golicic, S. L., and C. D. Smith. 2013. "A Meta-Analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance." *Journal of Supply Chain Management* 49 (2): 78–95. <https://doi.org/10.1111/jscm.12006>.
- [11] Gomes, P. J., and G. M. Silva. 2025. "Navigating the Interplay between Digitalization and Triple-A Capabilities for Enhanced Supply Chain Resilience." *Journal of Business Logistics* 46 (3): Article e70018. <https://doi.org/10.1111/jbl.70018>.
- [12] Hair, J. F., G. T. M. Hult, C. M. Ringle, and M. Sarstedt. 2022. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. 3rd ed. Sage.
- [13] Hair, J. F., J. J. Risher, M. Sarstedt, and C. M. Ringle. 2019. "When to Use and How to Report the Results of PLS-SEM." *European Business Review* 31 (1): 2–24. <https://doi.org/10.1108/EBR-11-2018-0203>.
- [14] Henseler, J., C. M. Ringle, and M. Sarstedt. 2015. "A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling." *Journal of the Academy of Marketing Science* 43: 115–135. <https://doi.org/10.1007/s11747-014-0403-8>.
- [15] Ivanov, D. 2024. "Transformation of Supply Chain Resilience Research through the COVID-19 Pandemic." *International Journal of Production Research* 62 (23): 8217–8238. <https://doi.org/10.1080/00207543.2024.2334420>.
- [16] Ivanov, D., and A. Dolgui. 2020. "Viability of Intertwined Supply Networks: Extending the Supply Chain Resilience Angles towards Survivability." *International Journal of Production Research* 58 (10): 2904–2915. <https://doi.org/10.1080/00207543.2020.1750727>.
- [17] Jiang, Y., T. Feng, and Y. Huang. 2024. "Antecedent Configurations toward Supply Chain Resilience: The Joint Impact of Supply Chain Integration and Big Data Analytics Capability." *Journal of Operations Management* 70 (2): 257–284. <https://doi.org/10.1002/joom.1282>.
- [18] Kazancoglu, I., M. Ozbiltekin-Pala, S. K. Mangla, Y. Kazancoglu, and F. Jabeen. 2022. "Role of Flexibility, Agility and Responsiveness for Sustainable Supply Chain Resilience during COVID-19." *Journal of Cleaner Production* 362: Article 132431. <https://doi.org/10.1016/j.jclepro.2022.132431>.
- [19] Kock, F., A. Berbekova, and A. G. Assaf. 2021. "Understanding and Managing the Threat of Common Method Bias: Detection, Prevention and Control." *Tourism Management* 86: Article 104330. <https://doi.org/10.1016/j.tourman.2021.104330>.
- [20] Kumar, S., S. Sahoo, W. M. Lim, S. Kraus, and U. Bamel. 2022. "Fuzzy-Set Qualitative Comparative Analysis (fsQCA) in Business and Management Research: A Contemporary Overview." *Technological Forecasting and Social Change* 178: Article 121599. <https://doi.org/10.1016/j.techfore.2022.121599>.
- [21] Li, N., Q. Yao, H. Tang, and Y. Lu. 2025. "Is Digitalization Necessary? Configuration of Supply Chain Capabilities for Improving Enterprise Competitive Performance." *Journal of Business Research* 186: Article 114972. <https://doi.org/10.1016/j.jbusres.2024.114972>.

- [22] Ministry of Investment, Trade and Industry. 2023. *New Industrial Master Plan 2030*. Government of Malaysia.
- [23] Nikookar, E., I. Ali, M. Stevenson, and S. Shokouhyar. 2025. "Necessary Antecedents of Supply Chain Resilience: The Nonnegotiable Influence of Supply Chain Responsiveness and Collaboration." *Journal of Supply Chain Management* 61 (4): 54–76. <https://doi.org/10.1111/jscm.70000>.
- [24] Nikookar, E., D. Gligor, and I. Russo. 2024. "Supply Chain Resilience: When the Recipe Is More Important than the Ingredients for Managing Supply Chain Disruptions." *International Journal of Production Economics* 272: Article 109236. <https://doi.org/10.1016/j.ijpe.2024.109236>.
- [25] Nikookar, E., and Y. Yanadori. 2022. "Preparing Supply Chain for the Next Disruption beyond COVID-19: Managerial Antecedents of Supply Chain Resilience." *International Journal of Operations & Production Management* 42 (1): 59–90. <https://doi.org/10.1108/IJOPM-04-2021-0272>.
- [26] Pappas, I. O., and A. G. Woodside. 2021. "Fuzzy-Set Qualitative Comparative Analysis (fsQCA): Guidelines for Research Practice in Information Systems and Marketing." *International Journal of Information Management* 58: Article 102310. <https://doi.org/10.1016/j.ijinfomgt.2021.102310>.
- [27] Patatoukas, P. N. 2012. "Customer-Base Concentration: Implications for Firm Performance and Capital Markets." *The Accounting Review* 87 (2): 363–392. <https://doi.org/10.2308/accr-10198>.
- [28] Pettit, T. J., K. L. Croxton, and J. Fiksel. 2013. "Ensuring Supply Chain Resilience: Development and Implementation of an Assessment Tool." *Journal of Business Logistics* 34 (1): 46–76. <https://doi.org/10.1111/jbl.12009>.
- [29] Podsakoff, P. M., S. B. MacKenzie, J.-Y. Lee, and N. P. Podsakoff. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." *Journal of Applied Psychology* 88 (5): 879–903. <https://doi.org/10.1037/0021-9010.88.5.879>.
- [30] Ponomarev, S. Y., and M. C. Holcomb. 2009. "Understanding the Concept of Supply Chain Resilience." *International Journal of Logistics Management* 20 (1): 124–143. <https://doi.org/10.1108/09574090910954873>.
- [31] Ragin, C. C. 2008. *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. University of Chicago Press.
- [32] Schneider, C. Q., and C. Wagemann. 2012. *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*. Cambridge University Press.
- [33] Sirmon, D. G., M. A. Hitt, and R. D. Ireland. 2007. "Managing Firm Resources in Dynamic Environments to Create Value: Looking inside the Black Box." *Academy of Management Review* 32 (1): 273–292. <https://doi.org/10.5465/amr.2007.23466005>.
- [34] Sirmon, D. G., M. A. Hitt, R. D. Ireland, and B. A. Gilbert. 2011. "Resource Orchestration to Create Competitive Advantage: Breadth, Depth, and Life Cycle Effects." *Journal of Management* 37 (5): 1390–1412. <https://doi.org/10.1177/0149206310385695>.
- [35] Tang, C. S. 2006. "Robust Strategies for Mitigating Supply Chain Disruptions." *International Journal of Logistics Research and Applications* 9 (1): 33–45. <https://doi.org/10.1080/13675560500405584>.
- [36] Teece, D. J. 2007. "Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance." *Strategic Management Journal* 28 (13): 1319–1350. <https://doi.org/10.1002/smj.640>.
- [37] Teece, D. J., G. Pisano, and A. Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18 (7): 509–533. [https://doi.org/10.1002/\(SICI\)1097-0266\(199708\)18:7<509::AID-SMJ882>3.0.CO;2-Z](https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z).
- [38] Tomlin, B. 2006. "On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks." *Management Science* 52 (5): 639–657. <https://doi.org/10.1287/mnsc.1060.0515>.
- [39] Wieland, A., and C. F. Durach. 2021. "Two Perspectives on Supply Chain Resilience." *Journal of Business Logistics* 42 (3): 315–322. <https://doi.org/10.1111/jbl.12271>.
- [40] Ye, F., K. Liu, L. Li, K.-H. Lai, Y. Zhan, and A. Kumar. 2022. "Digital Supply Chain Management in the COVID-19 Crisis: An Asset Orchestration Perspective." *International Journal of Production Economics* 245: Article 108396. <https://doi.org/10.1016/j.ijpe.2021.108396>.
- [41] Zhao, N., J. Hong, and K. H. Lau. 2023. "Impact of Supply Chain Digitalization on Supply Chain Resilience and Performance: A Multi-Mediation Model." *International Journal of Production Economics* 259: Article 108817. <https://doi.org/10.1016/j.ijpe.2023.108817>.

Appendix A

Complete Indicator Loadings

Table 15
Complete Outer Loadings

Indicator	Construct	Outer loading
CD1	CPD	0.829
CD2	CPD	0.804
CD3	CPD	0.789
CD4	CPD	0.791
CD5	CPD	0.803
CD6	CPD	0.863
DTA1	DTA	0.776
DTA2	DTA	0.783
DTA3	DTA	0.852
DTA4	DTA	0.815
DTA5	DTA	0.828
DTA6	DTA	0.836
SCR1	SCR	0.815
SCR2	SCR	0.831
SCR3	SCR	0.857
SCR4	SCR	0.873
SCR5	SCR	0.876
SCR6	SCR	0.883
SD1	SPD	0.814
SD2	SPD	0.823
SD3	SPD	0.814
SD4	SPD	0.838
SD5	SPD	0.859
SD6	SPD	0.879
SSCP1	SSCP	0.897
SSCP2	SSCP	0.914
SSCP3	SSCP	0.922
SSCP4	SSCP	0.934

Indicator	Construct	Outer loading
SSCP5	SSCP	0.927
SSCP6	SSCP	0.927
TMS1	TMS	0.790
TMS2	TMS	0.808
TMS3	TMS	0.831
TMS4	TMS	0.839
TMS5	TMS	0.816
TMS6	TMS	0.795

Note. All loadings exceeded .70.

Appendix B

Complete Truth Table for High SSCP

Table 16

Complete 32 Row Truth Table

TMS	DTA	SPD	CPD	SCR	Frequency	Raw consistency	PRI consistency	OUT
1	1	1	1	1	17	0.949	0.857	1
1	0	1	1	1	12	0.937	0.781	1
1	1	1	0	1	16	0.928	0.775	1
0	1	1	1	1	12	0.925	0.745	1
1	0	1	0	1	16	0.920	0.710	1
1	1	0	1	1	16	0.910	0.669	0
1	1	1	1	0	7	0.909	0.386	0
1	0	0	1	1	11	0.903	0.547	0
1	0	1	1	0	3	0.903	0.261	0
1	1	1	0	0	6	0.903	0.269	0
1	1	0	0	1	14	0.892	0.534	0
0	1	0	1	1	6	0.892	0.380	0
0	1	1	0	1	12	0.890	0.573	0
1	0	0	0	1	3	0.886	0.358	0
0	0	1	1	1	15	0.886	0.508	0
0	0	0	1	1	1	0.879	0.143	0

TMS	DTA	SPD	CPD	SCR	Frequency	Raw consistency	PRI consistency	OUT
1	1	0	1	0	7	0.874	-0.021	0
0	1	0	0	1	8	0.873	0.279	0
0	0	1	0	1	11	0.863	0.289	0
0	1	1	1	0	9	0.857	0.065	0
0	0	0	0	1	3	0.841	-0.411	0
1	1	0	0	0	7	0.836	-0.548	0
1	0	1	0	0	12	0.829	-0.601	0
0	1	1	0	0	5	0.823	-0.604	0
1	0	0	1	0	14	0.801	-1.208	0
0	0	1	1	0	10	0.793	-0.743	0
0	1	0	1	0	15	0.756	-1.546	0
0	0	1	0	0	12	0.750	-1.939	0
1	0	0	0	0	12	0.747	-2.977	0
0	1	0	0	0	16	0.724	-1.842	0
0	0	0	1	0	19	0.704	-2.884	0
0	0	0	0	0	18	0.653	-5.772	0

Note. Thresholds: frequency ≥ 2 , raw consistency $\geq .85$, and PRI consistency $\geq .70$. OUT = 1 identifies rows meeting all three criteria.