DOI: https://doi.org/10.62985/j.huit_ojs.vol26.no3E.492

DOES CIRCULAR INFRASTRUCTURE ACTUALLY GENERATE RESILIENCE? EVIDENCE ON THE FULL MEDIATING ROLE OF DYNAMIC CAPABILITIES

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Received: 1 April 2026; Revised: 24 April 2026; Accepted: 16 May 2026

ABSTRACT

Amid global supply chain disruptions, Circular Economy Practices and Industrial Symbiosis (CEP/IS) have emerged as main strategies for achieving sustainable development. However, the actual impact of CEP/IS on Supply Chain Resilience (SCRES) remains highly debated: on the one hand, CEP/IS diversifies resource supplies; on the other hand, its tight physical interconnectedness poses a risk of triggering cascading failures when a single node is disrupted. To decode this paradox, this study integrates the Natural Resource-Based View (NRBV) and Dynamic Capability Theory (DCT) to propose and empirically test the mediating roles of Supply Chain Flexibility (F) and Supply Chain Cooperation (C). Applying the PLS-SEM algorithm to a survey dataset of 326 small and medium-sized manufacturing enterprises (SMEs) in Vietnam, the results indicate that CEP/IS alone exerts no statistically significant direct impact on SCRES. Instead, F and C serve as full mediators in this relationship. This finding yields a vital theoretical contribution: CEP/IS is merely a prerequisite; a CEP/IS network only exerts an effective defensive mechanism when organizations actively utilize it as a springboard to cultivate core capabilities of flexibility and cooperation. Practically, this study provides strategic directions for SMEs in emerging economies to shift their focus from investing solely in physical assets to building intangible capabilities for business continuity during crises.

Keywords: Circular economy practices, industrial symbiosis, supply chain resilience, supply chain flexibility, supply chain cooperation, dynamic capability theory.

1. INTRODUCTION

In the context of global supply chains continuously facing systemic disruptions due to macroeconomic uncertainties [1], building SCRES has become a survival imperative for all organizations [2]. Simultaneously, resource depletion pressures are driving a profound shift towards sustainable management systems, wherein CEP/IS have emerged as strategic solutions [3]. Drawing on NRBV [4], industrial symbiosis (IS) allows traditionally independent firms to collaborate in exchanging waste, by-products, and energy [5], thereby diversifying supply sources and reducing reliance on linear raw material supply chains.

However, the intersection between CEP/IS and SCRES poses a complexity theoretical [6], [7]. Through the lens of supply chain risk management, scholars warn that tight physical interconnectedness and shared infrastructure within a symbiotic network can easily create a "lock-in effect." This rigid reliance on byproduct supplies amplifies the network's vulnerability, whereby a localized disruption at a single node can propagate and trigger cascading failures that collapse the entire system. This complexity highlights a significant research gap: CEP/IS does not inherently generate SCRES; rather, it requires accompanying intangible capabilities and governance mechanisms for effective coordination [6], [7].

Based on DCT [8], this study argues that CEP/IS must be integrated and reconfigured through dynamic capabilities to be transformed into SCRES. The process of managing non-traditional and highly volatile material flows forces organizations to continuously reshape their operational processes and enhance transparency with their partners. This progression enables firms to cultivate two core dynamic capabilities: F and C. The internal transformation process—explaining how CEP/IS translates into F and C to ultimately forge SCRES—remains a complex "black box" that demands empirical validation.

To fill this void, this study poses two primary research questions:

RQ1: How do CEP/IS impact dynamic capabilities (F and C) within the supply chain?

RQ2: How do F and C mediate from CEP/IS to SCRES?

To answer these questions, the PLS-SEM approach is applied to a survey dataset of 326 manufacturing SMEs in Vietnam. Vietnam is a highly appropriate empirical context, as it is a deeply integrated emerging economy where SMEs play a pivotal role but often lack redundant resources [9]. Furthermore, Vietnam is currently striving to transform traditional industrial zones into eco-industrial park models [10], creating an ideal environment for assessing the true efficacy of CEP/IS.

This study makes two main theoretical contributions. First, it integrates NRBV and DCT to bridge the gap in the relationship between the circular economy and risk management by revealing the full mediating role of dynamic capabilities, thereby resolving the risk of cascading failures that are common in symbiotic networks. Second, it provides quantitative evidence affirming that establishing physical linkages is merely a "necessary condition," whereas flexibility and cooperation constitute the "sufficient condition" for building SCRES.

2. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

2.1. Theoretical background

The research model of this study is built upon the integration of two key theoretical foundations: the NRBV and DCT.

The NRBV argues that an organization's competitive advantage depends on its ability to manage and promote economic activities linked to the natural environment [4]. The NRBV provides a solid foundation for explaining why firms proactively engage in IS networks to alter their resource base (e.g., utilizing partners' waste to replace raw materials), thereby achieving a long-term sustainable competitive advantage [11]. Complementing the NRBV, the DCT explains an organization's capability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments [8]. The DCT offers a highly suitable theoretical grounding for elucidating the configuration and integration of static physical resources (derived from circular practices) into flexible operational capabilities, which subsequently enables organizations and their supply chains to effectively respond to exogenous shocks and disruptions [11].

2.2. Hypothesis development

2.2.1. The impact of CEP/IS on F and C

In this study, CEP/IS is defined as the collaborative exchange of energy, utilities, materials, services, and knowledge among traditionally independent firms to generate competitive advantages, where one organization's waste or by-products become another's input

[2], [12]. When adopting CEP/IS, firms establish new resource flows, leading to the development of two core dynamic capabilities: F and C.

F is the system's capacity to rapidly adapt to changes in customer demand, adjust production lead times, and ensure delivery reliability when facing disruptions [13]. Utilizing waste and by-products as alternative resources helps firms diversify their supply sources and reduce their reliance on a single linear supplier, thereby increasing F in reconfiguring production [11]. Simultaneously, C is the extent to which partners within the network share information, allocate risks, and build mutual trust to achieve common goals [14], [15]. Because the essence of IS relies on a high degree of interdependence among independent entities, this activity compels firms to engage in deep cross-sectoral integration, which strongly fosters C.

Based on the NRBV, the natural environment and ecological factors are not barriers but rather the basis for creating new, strategic resources. By adopting CEP/IS, firms begin integrating waste streams into their production processes. According to the DCT, managing non-traditional and highly volatile material flows (such as waste) dictates that organizations cannot maintain rigid structures. Instead, CEP/IS force firms to continuously reconfigure their internal operational processes to adapt, thereby cultivating F, that is, the capability to adjust timing and production configurations to handle alternative materials. Simultaneously, the exchange process under the NRBV necessitates physical and technical interdependence. The DCT also elaborates that to effectively integrate these exogenous resources, firms must develop the capability to sense and share information with cross-sectoral partners, thereby consolidating C, the level of risk-sharing and trust within the network. Therefore, the following hypotheses are proposed:

H1a: CEP/IS positively impact F.

H1b: CEP/IS positively impact C.

2.2.2. The impact of F and C on SCRES

SCRES is defined as the capability of a supply chain to prepare for, anticipate, withstand, adapt to, and rapidly recover from unforeseen disruptive events to maintain stable operational performance [13]. The dynamic capability of F enables an organization to adjust its logistics network and source alternative local materials in a timely manner when global supply chains are disrupted. Robust C within the symbiotic network helps firms provide early warnings of supply disruption risks, reallocate shared resources, and offer mutual financial or technical support to navigate crises [11]. Organizations that possess both capabilities exhibit superior SCRES.

According to the DCT, in highly volatile environments, the survival advantage lies not in static assets but in "core capabilities" that allow organizations to adapt swiftly. Specifically, F allows firms to react instantly to supply disruptions by switching to secondary suppliers or local recycled materials without interrupting their assembly lines. In contrast, trust-based C enables firms to share risks, receive early warnings of fluctuations, and cross-support logistics capacities during a crisis. Possessing these two "dynamic capabilities" provides organizations with substantial redundant strength, directly impacting their SCRES. Thus, the following hypotheses are proposed:

H2a: F positively impacts SCRES.

H2b: C positively impacts SCRES.

2.2.3. The mediating role of F and C

CEP/IS does not automatically construct SCRES; rather, it acts as a defense mechanism by cultivating dynamic capabilities [11]. Specifically, CEP/IS triggers the redesign of organizational production processes, generating flexibility and a solid collaborative foundation. These dynamic capabilities (F and C) directly absorb shocks and reinforce the SCRES [13].

The NRBV indicates that CEP/IS creates redundant physical resources (e.g., recycled waste); however, the mere availability of waste does not automatically translate into a buffering mechanism that protects the system when a global crisis occurs. Instead, according to DCT, it is the continuous interaction and adjustment within the symbiotic environment that forges adaptive mechanisms. In other words, the CEP/IS activates the transformation of organizational structures, forming F and C. Organizations possessing high levels of flexibility and cooperation are the ones capable of effectively absorbing shocks. CEP/IS serves as the premise for creating dynamic capabilities, which are the direct vehicles for generating SCRES. Therefore, Hypothesis H3 is proposed as follows:

H3: F and C mediate the relationship between CEP/IS and SCRES.

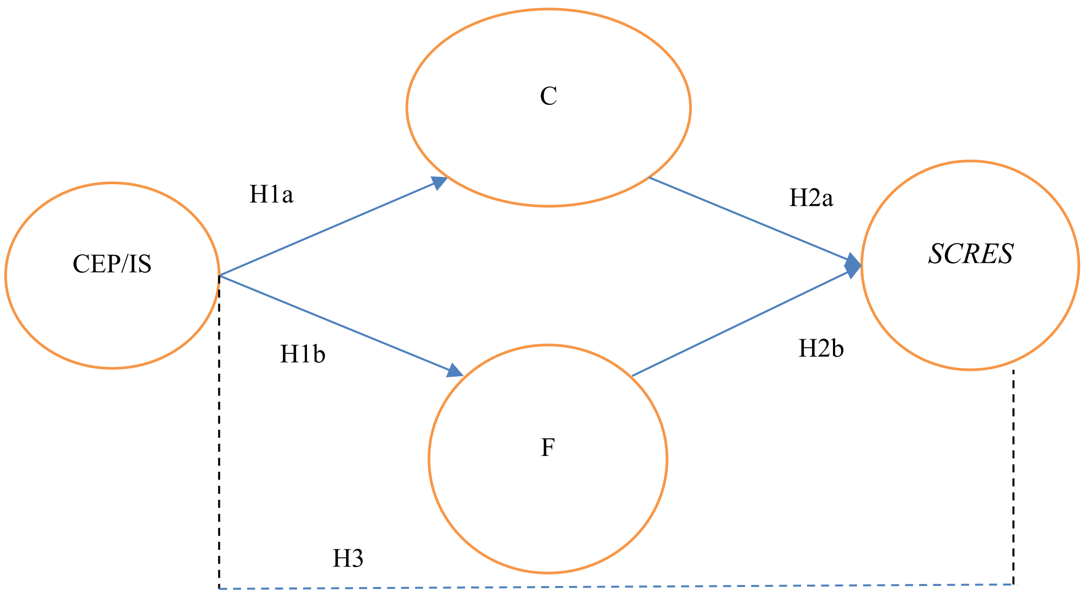

Figure 1. Research model

Source: Authors' elaboration

3. METHODOLOGY

3.1. Research design and data collection

This study adopted a mixed-methods research design to comprehensively address the research objectives. First, a qualitative approach was used to refine the conceptual measurement scales, ensuring their appropriateness for the practical context. Subsequently, a quantitative method employing PLS-SEM was used to empirically test the hypothesized relationships within the structural model. The unit of analysis is manufacturing enterprises located within industrial zones in Vietnam, with particular priority given to organizations currently transitioning towards the eco-industrial park (EIP) model.

Data were collected using a purposive sampling technique via an online survey. The target respondents were senior managers with comprehensive knowledge of corporate strategy and supply chain operations [16]. After a rigorous data screening process, 326 valid observations were retained, which adequately satisfied the sample size requirements for the PLS-SEM analysis [17]. To address potential non-response bias, early and late respondents were compared, and no statistically significant differences were found. Furthermore, common method bias (CMB) was controlled through careful questionnaire design and ex post statistical checks, ensuring the robustness and validity of the dataset.

3.2. Measurement of variables

All theoretical constructs in the research model were measured using a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The measurement items were adapted from well-established scales in top-tier literature and carefully refined for this study.

CEP/IS: adapted from [11] and comprised 10 observation items. However, during the scale purification process, five items relating to "employee training" and "packaging redesign" exhibited low outer loadings (below 0.500), reflecting that Vietnamese SMEs have not yet fully synchronized these activities into their IS strategies. These items were systematically excluded. The final scale retained five core items measuring infrastructure sharing, resource exchange, and waste reuse capabilities; F: adapted from [11], [18] to measure the capacity to adapt to and maintain performance amidst disruptions. The initial scale included five items; however, one item was eliminated because of cross-loading issues with the SCRES construct. Thus, four valid items were retained; C: adapted from [1], [19]. All four items demonstrated robust quality and were retained; SCRES: This measures a system's capability to withstand exogenous shocks and recover revenue and operational performance. The construct was evaluated using three items derived from [11], [18], all of which yielded highly satisfactory factor loadings (> 0.800) and were kept unchanged.

3.3. Data analysis technique

Data analysis was performed using variance-based PLS-SEM via SmartPLS 3.0 software. The PLS-SEM algorithm is highly recommended for exploratory research, complex structural models, relatively small sample sizes, and data that do not strictly adhere to normal distribution [17]. Following standard methodological guidelines, the analytical procedure was conducted in two stages.

Step 1: Measurement Model Assessment: The reliability and internal consistency of the scales were evaluated using Cronbach's Alpha and Composite Reliability (CR). Convergent validity was established by ensuring that the outer loadings of each indicator exceeded the 0.700 threshold, and the Average Variance Extracted (AVE) for each construct was 0.500 or higher [17] Discriminant validity was rigorously verified using the criterion proposed by Fornell and Larcker [20], which dictates that the square root of the AVE for a specific construct must be greater than its correlation coefficient with any other construct in the model. Simultaneously, discriminant validity was thoroughly established using the Heterotrait-Monotrait (HTMT) ratio of correlations, with all values meeting the recommended criteria below 0.85 [17].

Step 2: Structural Model Assessment: The structural paths were estimated using ordinary least squares (OLS) [17]. To assess the statistical significance of the hypothesized relationships—including the direct impacts and the full mediating roles of F and C—a non-parametric bootstrapping procedure with 5,000 subsamples was performed [17]. This technique provides robust standard errors and 95% confidence intervals for evaluating both the direct and indirect effects.

4. RESULTS

4.1. Demographic characteristics of the sample

Although awareness of sustainable development is growing, the widespread implementation of CEP/IS in Vietnam remains in its early stages. The transition from traditional industrial zones to eco-industrial parks encounters various barriers, including a lack of shared infrastructure and limited financial resources. Consequently, the sampling procedure was not conducted randomly across all enterprise types but rather employed a purposive sampling strategy targeting "focal firms" and pioneers operating within industrial parks with high potential for waste and by-product exchanges. Following a rigorous data screening process, 326 valid observations from SMEs were retained for the final analysis. The sample accurately represents the targeted population, encompassing key manufacturing sectors such as Textiles & Apparel (25.15%), Food & Beverage (19.94%), Electronics & Electrical (18.10%), and Chemicals & Plastics (15.03%). Furthermore, the respondents predominantly comprised top-level executives, supply chain managers, and sustainability directors possessing comprehensive knowledge of their organizations' strategic operations and environmental initiatives.

Table 1. Demographic characteristics of the sample (N = 326)

Characteristics	Classifications	Frequency (n)	Percentage (%)
Industry sector	Textiles & Apparel	82	25.15
	Food & Beverage	65	19.94
	Electronics & Electrical	59	18.1
	Chemicals & Plastics	49	15.03
	Metal & Machinery	39	11.96
	Others	32	9.82
Firm size	< 50 employees	81	24.85
	50 - 200 employees	245	75.15
Years of operation	< 5 years	33	10.12
	5 - 10 years	114	34.97
	11 - 15 years	98	30.06
	> 15 years	81	24.85
Respondent's position	Top management/CEO	65	19.94
	SCM/Logistics Manager	114	34.97
	Production/Operations Manager	98	30.06
	Sustainability Manager	49	15.03
Working experience	< 5 years	49	15.03
	5 - 10 years	130	39.88
	11 - 15 years	98	30.06
	> 15 years	49	15.03
Total		326	100

Source: Authors' elaboration

4.2. Measurement model assessment

Reliability and convergent validity: The first step in the PLS-SEM analysis was to evaluate the quality of the measurement scales using Outer Loadings, Composite Reliability (CR), and Average Variance Extracted (AVE) [17].

Regarding CEP/IS construct, the original scale inherited from [11] consisted of 10 observation variables. However, five observation variables related to "employee training" and "packaging redesign" had low factor loadings (below 0.500) because enterprises in Vietnam have not yet truly synchronized these activities into their IS strategies. Therefore, these variables were eliminated. The retained scale consists of 5 core variables measuring the sharing of infrastructure, resources, and waste reuse (Outer loadings: 0.818 - 0.886); Regarding F construct, the original scale consisted of five variables. One observation variable was eliminated because of the cross-loading phenomenon on the SCRES construct. Four variables were retained; Regarding C construct: The original scale of four variables from [11]. All four variables achieved good quality and remained unchanged; Regarding SCRES construct, the original scale consisted of three variables measuring the capability to withstand and recover revenue and performance. All three variables had very high factor loadings (below 0.800) and remained unchanged.

Table 2. Assessment of construct reliability and convergent validity

Constructs	Initial items	Retained items	Factor loadings	Cronbach's Alpha	CR	AVE
CEP/IS	10	5	0.818 - 0.886	0.903	0.928	0.721
F	5	4	0.839 - 0.912	0.905	0.934	0.779
C	4	4	0.825 - 0.909	0.902	0.932	0.773
SCRES	3	3	0.842 - 0.915	0.849	0.909	0.769

Source: Authors' elaboration

The results in Table 2 show that all observation variables have Factor Loadings greater than the standard threshold of 0.70. The Cronbach's Alpha and Composite Reliability (CR) indices of all constructs (CEP/IS, F, C, SCRES) exceeded the 0.800 level, indicating a very high internal consistency. Simultaneously, the AVE values of all constructs were greater than 0.500, ranging from 0.721 to 0.779, satisfying the convergent validity requirement of the measurement scales [17].

Table 3. Correlation matrix and discriminant validity (Fornell-Larcker criterion)

Constructs	C	CEP/IS	F	SCRES
C	0.879			
CEP/IS	0.578	0.849		
F	0.546	0.616	0.883	
SCRES	0.620	0.442	0.548	0.877

Source: Authors' elaboration

Discriminant validity: Evaluated using the criterion of Fornell and Larcker [20], which requires that the square root of the AVE of a construct must be greater than its correlation coefficient with any other construct in the model [11]. Table 3 shows that the bold values on the diagonal (the square root of AVEs) are all greater than the correlation values located below the diagonal, affirming that the constructs in the model have clear discriminant validity [17].

Table 4. Heterotrait-Monotrait (HTMT)

Constructs	C	CEP/IS	F	SCRES
C				
CEP/IS	0.637			
F	0.602	0.678		
SCRES	0.705	0.502	0.622	

Source: Authors' elaboration

Furthermore, to rigorously assess the discriminant validity of the measurement model, this study employed the Heterotrait-Monotrait (HTMT) ratio of correlations, which is currently recommended as a superior criterion in modern PLS-SEM guidelines [17]. As presented in Table 4, the HTMT values across all pairs of constructs range from a minimum of 0.502 (between SCRES and CEP/IS) to a maximum of 0.705 (between SCRES and C). Because all of these HTMT ratios are strictly below the conservative threshold of 0.85 established by [17], it is concluded that the latent constructs are empirically distinct from one another. Consequently, the discriminant validity of the proposed measurement model is firmly established, providing a solid foundation for the subsequent structural model assessment.

4.3. Structural model assessment and hypothesis testing

After the measurement model met the requirements, the structural model was analyzed using the PLS algorithm and bootstrapping technique with 5000 subsamples to evaluate the statistical significance level of the impact coefficients to test the hypotheses in the research model [17].

4.3.1. Direct impacts

The structural model assessment results (Table 5) show that the explanatory power of the model is quite good, with the R^2 of the SCRES variable reaching 0.447, which means that 44.7% of the variance of SCRES is explained by the variables in the model.

Table 5. Results of testing direct impact hypotheses

Hypothesis	Relationship	Path coefficient (β)	Standard deviation (STDEV)	T-value	P-value	Conclusion
H1a	CEP/IS → F	0.616	0.037	16.579	0.000	Accepted
H1b	CEP/IS → C	0.578	0.051	9.901	0.000	Accepted
H2a	F → SCRES	0.304	0.054	5.655	0.000	Accepted
H2b	C → SCRES	0.461	0.046	9.922	0.000	Accepted

Source: Authors' elaboration

Interpreting the results for hypotheses H1 and H2 Hypotheses H1a and H1b: CEP/IS has a positive and strong impact on F (β = 0.616, $p < 0.001$) and C (β = 0.578, $p < 0.001$). This implies that efforts to share waste increase F. Hypotheses H2a and H2b: F and C both positively affect SCRES with statistical significance, with coefficients of 0.304 and 0.461, respectively ($p < 0.001$).

Table 6. Effect sizes (f^2) of the structural model

Constructs	C	CEP/IS	F	SCRES
C				0.234
CEP/IS	0.501		0.612	0.000
F				0.094
SCRES				

Source: Authors' elaboration

Following the path analysis, both the statistical significance and substantive significance (Table 6), such as the effect size (f^2), were evaluated to determine the practical relevance of the exogenous variables [17]. The analysis revealed that CEP/IS exert a robust and large effect on both F (f^2=0.612) and C (f^2=0.501). Regarding the direct predictors of SCRES, C demonstrated a medium effect size (f^2=0.234), whereas F exhibited a small yet meaningful effect (f^2=0.094). Notably, the direct effect of CEP/IS on SCRES yielded an f^2 value of precisely 0.000. This near-zero effect size statistically corroborates the full mediation hypothesis, explicitly proving that CEP/IS do not independently generate SCRES without the transmission mechanism of dynamic capabilities.

Table 7. Constructs crossvalidated redundancy (Q^2)

Constructs	SSO	SSE	Q^2 (=1-SSE/SSO)
C	1304	972.572	0.254
CEP/IS	1630	1630	
F	1304	924.545	0.291
SCRES	978	648.304	0.337

Source: Authors' elaboration

Furthermore, the predictive relevance of the structural model was assessed using the blindfolding procedure to calculate Stone-Geisser's Q^2 (Table 7). Values of Q^2 greater than zero for specific endogenous latent constructs indicate that the path model can predict accurately and possesses robust predictive relevance [17]. The results demonstrate that all endogenous constructs possess highly satisfactory predictive power, with Q^2 values of 0.291 for F, 0.254 for C, and 0.337 for SCRES. These values substantially exceed zero, confirming that the proposed structural model exhibits strong out-of-sample predictive capabilities

4.3.2. Testing the mediating role

To test H3, this study evaluated the mediating roles of F and C in the relationship between CEP/IS and SCRES. The analysis was performed using the bootstrapping technique with 5000 subsamples to extract the standard deviation and 95% confidence intervals (Boot LLCI and Boot ULCI) for the indirect effects [17]. A mediating effect is considered statistically significant when the 95% confidence interval of the indirect effect coefficient does not contain the value 0 [17]. The results of the analysis are presented in Table 8.

Table 8. Results of testing the mediating effect (Bootstrapping with 95% confidence interval)

Indirect relationship	Indirect coefficient (β)	Standard deviation (STDEV)	T-value	P-value	Boot LLCI (2.5%)	Boot ULCI (97.5%)	Conclusion
H3a: CEP/IS → F → SCRES	0.187	0.035	3.363	0.000	0.120	0.257	Accepted
H3b: CEP/IS → C → SCRES	0.266	0.031	8.678	0.000	0.207	0.327	Accepted
Direct effect							
CEP/IS → SCRES	-0.011	0.055	0.190	0.849	-0.035	0.125	*Not significant*

Source: Authors' elaboration

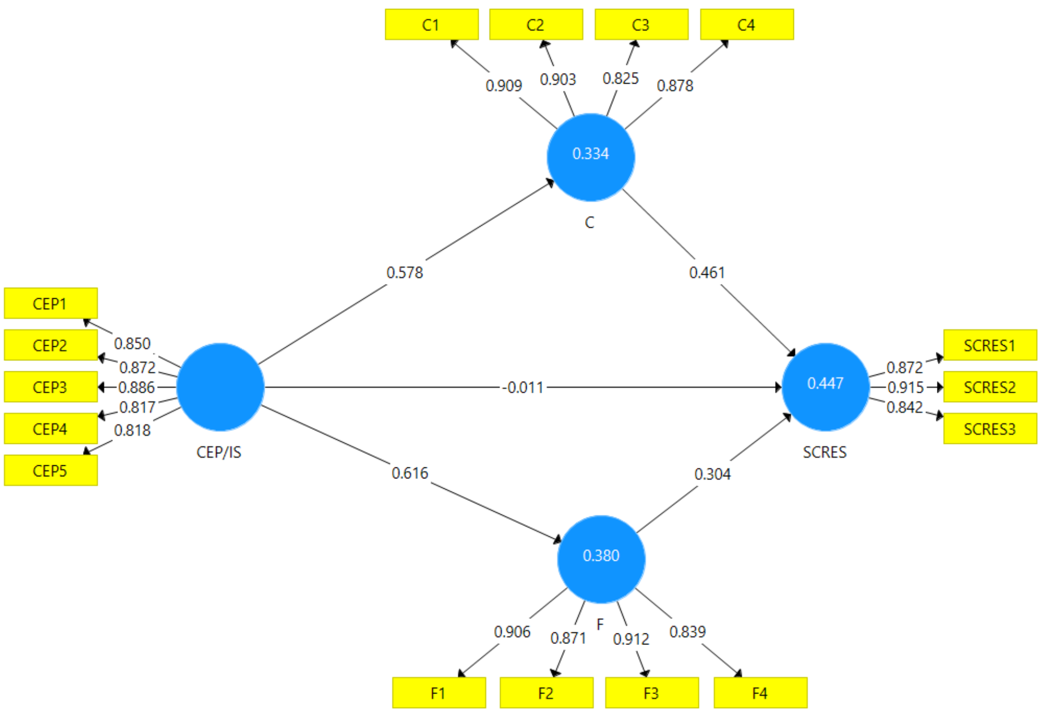

Figure 2. Assessing structural model result

Source: Authors' elaboration

Interpreting the results for hypothesis H3: For H3a: The indirect impact coefficient of the path CEP/IS -> F -> SCRES was 0.187, with a 95% confidence interval of [0.120; 0.257]. Because this interval is entirely positive and does not contain the value 0, we can conclude that F plays a statistically significant mediating role. This strongly supports H3a. For H3b: Similarly, the indirect impact coefficient of the path CEP/IS → C → SCRES is 0.266, and the 95% confidence interval [0.207; 0.327] does not contain the value 0. This confirms that C is a valid mediating variable, supporting H3b.

Nature of the mediating variable: The direct impact of CEP/IS on SCRES is not statistically significant (-0.011, $p > 0.05$) in the presence of the two mediating variables. Therefore, F and C play a full mediating role [17].

4.4. Common method bias and robustness checks

To ensure the rigorousness and stability of the PLS-SEM findings, advanced diagnostic procedures were conducted. *First*, to assess potential multicollinearity issues and rigorously control for Common Method Bias (CMB), the Variance Inflation Factor (VIF) values were examined.

Table 9. Variance Inflation Factor of the structural model

Indicator	VIF	Indicator	VIF	Indicator	VIF	Indicator	VIF
C1	3.149	CEP1	2.357	F1	3.119	SCRES1	2.072
C2	3.095	CEP2	2.637	F2	2.589	SCRES2	2.558
C3	2.029	CEP3	2.916	F3	3.286	SCRES3	1.904
C4	2.575	CEP4	2.158	F4	2.132		
		CEP5	2.052				

Source: Authors' elaboration

The analysis reveals that the VIF values for all indicators range from a minimum of 1.904 to a maximum of 3.286 (Table 9). Current literature suggests that if the full collinearity VIF value is smaller than the conservative threshold of 3.3, multicollinearity and common method bias are not problematic [21]. Given that all item-level VIFs are strictly below 3.3, it is concluded that the measurement model is free from significant common method bias, thereby ensuring the validity of the findings. *Second*, to further rule out potential endogeneity issues that could bias the path estimates, alternative model configurations were evaluated. Comparing the proposed mediated model against a direct-effects-only model demonstrated that the inclusion of dynamic capabilities as full mediators yielded a significantly superior explanatory power, validating the structural stability of the proposed framework."

5. DISCUSSION AND CONCLUSIONS

5.1. Discussion of the Main Findings

The primary objective of this study was to unpack the underlying mechanisms through which CEP/IS influence SCRES. The empirical results, derived from PLS-SEM, provide robust support for the proposed framework and offer nuanced insights compared to previous literature.

First, regarding the impact of CEP/IS on dynamic capabilities (RQ1), the findings demonstrate a significant positive effect of CEP/IS on both F and C. This finding suggests that engaging in physical resource sharing and waste valorization acts as a catalyst for firms to synchronize their operations and enhance information sharing. This aligns with the recent findings of [11], who posited that circular practices force organizations to break traditional boundaries. However, while some previous studies argued that symbiotic networks might increase vulnerability due to tight physical coupling, our study provides empirical support that the continuous maintenance of CEP/IS actually triggers the proactive reconfiguration of internal processes, thereby actively building dynamic capabilities.

Second, addressing the mediating mechanisms (RQ2), the results reveal that F and C fully mediate the relationship between CEP/IS and SCRES. The direct impact of CEP/IS on SCRES becomes statistically non-significant in the presence of these mediators. This finding offers a meaningful extension to DCT [8] in the context of circular supply chains. Unlike prior assumptions that CEP/IS directly SCRES [22], this study demonstrates that CEP/IS serves merely as a static resource; it must be converted into intangible, dynamic capabilities (F and C) to absorb external shocks and prevent cascading failures effectively.

5.2. Theoretical Contributions

This study provides a meaningful incremental extension to the existing literature on supply chain risk management and sustainable operations by integrating the NRBV, DCT. Specifically, it offers three theoretical contributions.

First, the research provides empirical support for the underlying mechanisms that convert CEP/IS into SCRES. By integrating NRBV with DCT, this study confirms the full mediating roles of F and C [11], [21]. The findings suggest that the mere possession of CEP/IS acts as a static resource; it is the continuous reconfiguration of internal processes and inter-organizational alignment that effectively enhances SCRES.

Second, the study enriches the understanding of the "vulnerability versus resilience" debate in IS. While prior studies warn about the risk of cascading failures in tightly coupled symbiotic networks [22], our structural model demonstrates that such risks are mitigated when organizations cultivate dynamic capabilities. The full mediation effect underscores that CEP/IS only exerts a defensive mechanism when organizations actively utilize it as a springboard to cultivate collaborative and flexible capabilities.

Third, the study explicitly establishes the boundary conditions for its theoretical implications. Unlike universal theories often derived from multinational corporations in developed nations, the findings of this research are strictly bounded by the context of resource-constrained manufacturing SMEs operating in an emerging economy [9]. This contextualization highlights how localized constraints shape the trajectory of SCRES.

5.3. Managerial and Policy Implications

For managerial practice, the findings suggest that SMEs should shift their strategic focus from merely investing in CEP/IS assets to cultivating intangible dynamic capabilities. Managers must recognize that CEP/IS (e.g., shared energy grids or waste treatment facilities) does not automatically generate SCRES against disruptions. Instead, leadership should prioritize building an open organizational culture that encourages inter-organizational information sharing and flexible process redesign [9]. By leveraging physical connections to develop flexible capabilities and a collaborative foundation, SMEs can effectively absorb supply chain shocks and maintain business continuity during crises.

5.4. Limitations and Future Research

First, the study relies on a cross-sectional research design, which restricts the ability to draw strict causal inferences between circular economy practices, dynamic capabilities, and SCRES. While the structural model and robustness checks provide strong empirical support for the hypothesized relationships, future research should employ longitudinal or experimental designs to explicitly validate the causal mechanisms proposed in this framework. *Second*, the data were collected from single respondents within SMEs in Vietnam. Although advanced PLS-SEM diagnostic procedures confirmed that common method bias was not a significant issue, future studies could incorporate secondary operational data to further enhance objectivity and test this framework across different geographical contexts to assess external validity.

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