DOI: https://doi.org/10.62985/j.huit_ojs.vol26.no3E.483

DIGITAL CAPABILITY AS AN ENABLER OF CIRCULAR ECONOMY READINESS: EVIDENCE FROM VIETNAMESE FIRMS WITH MODERATING EFFECT OF INSTITUTIONAL SUPPORT

Nguyen Nguyen Phuong, Nguyen Duc Cuong*

Industrial University of Ho Chi Minh City, Vietnam

*Email: *nguyenduccuong@iuh.edu.vn*

Received: 7 March 2026; Revised: 16 April 2026; Accepted: 9 May 2026

ABSTRACT

This study examines the role of digital capability in enabling circular economy readiness within the Technology–Organization–Environment (TOE) framework. While prior research has emphasized the importance of external drivers, limited attention has been paid to the internal mechanisms through which these factors translate into circular economy outcomes. Using survey data from 516 Vietnamese firms, this study employs partial least squares structural equation modelling (PLS-SEM) to test the proposed model. The results indicate that technological, organizational, and environmental factors significantly influence digital capability, which in turn exerts a strong positive effect on circular economy readiness. Digital capability also plays a significant mediating role, highlighting its function as a key mechanism that transforms external drivers into actionable circular practices. In contrast, although institutional support has a direct positive effect on circular economy readiness, its moderating role is not supported. This suggests that institutional conditions act as enabling environments rather than contingent factors shaping firm-level capabilities. This study contributes to the literature by extending the TOE framework through the integration of digital capability as a central mediating construct and by offering a political economy perspective that conceptualizes digital capability as a form of productive infrastructure. The findings provide important implications for firms and policymakers in emerging economies seeking to advance circular economy transitions.

Keywords: Circular economy readiness, digital capability, TOE framework, institutional support, emerging economies.

1. INTRODUCTION

Over the past decade, the global economy has witnessed the rapid convergence of digital transformation and sustainability-oriented development, forming what is widely referred to as the “twin transition” [1]. Within this paradigm, the Circular Economy (CE) has emerged as a central strategic approach to decouple economic growth from resource depletion and environmental degradation [2]. However, operationalizing circular business models requires firms to manage complex material flows, ensure product traceability across life cycles, optimize reverse logistics, and coordinate information sharing among value-chain partners. These requirements increasingly depend on advanced digital technologies and data-driven organizational capabilities [3]. Consequently, digital transformation is no longer a supportive tool but a fundamental enabler of circular transition.

Recognizing this interdependence, prior research has increasingly explored how digital technologies enable circular strategies. Studies show that Industry 4.0, big data analytics, cloud computing, and Internet of Things (IoT) applications facilitate product life-cycle monitoring, predictive maintenance, and resource recovery [4], [5]. Beyond technology adoption, recent literature emphasizes Digital Capability as a higher-order organizational competence integrating digital infrastructure, data governance, process digitalization, human digital skills, and digital culture to generate sustained performance outcomes [6]. In parallel, the Technology–Organization–Environment (TOE) framework has been widely employed to explain firms' adoption of technological and sustainability-related innovations by considering technological readiness, organizational resources, and environmental pressures [7].

Despite growing scholarly attention, several critical gaps remain in the extant literature. First, most empirical evidence on digital transformation and circular economy originates from developed economies, while studies in emerging markets-where institutional constraints, limited resources, and rising sustainability pressures coexist-remain scarce [8]. Second, existing research often examines digital technologies as isolated tools rather than conceptualizing Digital Capability as an integrated organizational mechanism driving circular readiness. Third, although the TOE framework has been extensively applied to explain technology adoption, limited empirical research has investigated how TOE conditions are transformed into Circular Economy Readiness through the mediating role of Digital Capability. Fourth, the role of institutional support has received insufficient attention, especially as a boundary condition that may strengthen or weaken the effect of digital capability on firms' circular economy readiness. This gap is particularly relevant in emerging economies, where policy support, regulatory clarity, and institutional incentives may significantly influence firms' transition pathways.

In Vietnam, this dual imperative is reinforced by a robust institutional landscape. The Vietnamese government has committed to the National Green Growth Strategy for 2021–2030, which emphasizes circular economy as a key solution for sustainable development [9]. The issuance of Decree No. 147/2024/ND-CP establishes a new legal corridor for data management and digital identity, directly influencing how enterprises collect and govern the data required for transparent circular practices [10]. Despite these strategic pushes, many Vietnamese firms face a "productivity paradox," in which substantial investments in digital technology fail to immediately translate into improved circular economy outcomes. This paradox arises when the organizational, human, and governance complements necessary to actualize digital investments remain underdeveloped, creating a gap between technological endowment and operational circular readiness. To the best of our knowledge, no prior study has empirically tested the integrated TOE–Digital Capability–CE Readiness mechanism in emerging-market enterprises, representing a significant theoretical and empirical gap.

To bridge these gaps, this study designs and empirically tests an integrated framework linking TOE factors, Digital Capability, and Circular Economy Readiness in the context of Vietnamese enterprises. Specifically, this research aims to: (i) examine the effects of Technology, Organization, and Environment factors on Digital Capability; (ii) investigate the impact of Digital Capability on Circular Economy Readiness; (iii) test the mediating role of Digital Capability in transforming TOE conditions into circular readiness; and (iv) evaluate the moderating role of Institutional Support on the DC–CERE relationship. Using survey data from 516 firms and PLS-SEM, this study offers robust empirical evidence on how digital transformation enables circular transition in emerging markets.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Technology-Organization-Environment (TOE) Framework in the Context of Twin Transition

The TOE framework is a widely utilized theoretical model for understanding the adoption and implementation of technology within organizations, offering a comprehensive lens through which technological, organizational, and environmental cues can be analysed to assess their impact on technology adoption.

Technological Factors: Technological factors within the TOE framework include the availability and characteristics of technology that influence its adoption. In the context of blockchain adoption in education, technological challenges such as scalability, integration complexities, and security concerns are predominant barriers [11]. In digital transformation, technological advancements are crucial for SMEs in the Asia Pacific region to enhance digital trade capabilities [12]. The adoption of AI also highlights the need for technological readiness within a TOE lens [13].

Organizational Factors: Organizational readiness and internal capabilities are critical for technology adoption. In the context of ERP systems in Industry 4.0, organizational agility and top management support are emphasized as key factors [14]. In e-commerce adoption, firm size, senior management support, and IT skills of SME owners are significant determinants [15], [16].

Environmental Factors: Environmental factors encompass external conditions such as market dynamics, regulatory environments, and competitive pressures. Regulatory complexities and alignment with international trade rules are vital for SMEs' digital trade success [12]. The environmental aspect of the TOE framework is less explored in digital transformation research, indicating a gap that needs addressing [17]. In Vietnam, the environmental context is being reshaped by the National Green Growth Strategy 2021-2030 and Decree No. 147/2024/ND-CP, which serve as institutional “nudges” for firms to align digital trade with environmental responsibility.

The TOE framework's application across various domains underscores its robustness. The proposal to expand the TOE framework to include a human factor-transforming it into a TOEH model-suggests a need for a more holistic approach that considers human elements such as critical thinking skills [18]. The Twin Transition represents a powerful synergy where digital transformation acts as the “engine” driving businesses toward the green growth “destination”, with the three TOE pillars providing the essential lenses for analysis.

2.2. Digital Capability

Digital competence refers to the ICT-related knowledge and attitudes of individual employees, where human digital skills and digital culture are equally essential [6]. Digital capability is increasingly recognized as a higher-order organizational competence that integrates digital infrastructure, data governance, process digitalization, human digital skills, and digital culture to generate sustained performance outcomes [19]. Digital infrastructure provides the technological backbone for this capability by establishing data architectures and connectivity [20]. Effective data governance ensures data quality, security, and compliance, allowing organizations to utilize data as a strategic asset [21]. Process digitalization enhances operational efficiency, agility, and customer experience [22].

2.3. Integration of Institutional Support and TOE under Political Economy Perspective

Institutional support plays a crucial role in shaping firms' digital and sustainability transformation. Institutional frameworks, including formal regulations, policies, and incentives, significantly influence how firms adopt digital technologies for circular economy practices [23]. Institutional environments have been identified as key drivers of digital transformation when firms face increasing pressure to align with market expectations and regulatory requirements [24], [25].

This study integrates a political economy perspective into the TOE framework by reconceptualizing digital capability as a form of productive infrastructure [26]. Rather than treating technology as a supporting tool, digital capability is positioned as an organizational mechanism through which TOE factors are transformed into circular economy readiness. From this perspective, technological, organizational, and environmental conditions collectively shape digital capability, which enables firms to reorganize resource flows and implement circular practices.

In the Vietnamese context, institutional support functions as a dual-purpose mechanism: first, providing legal certainty for digital trade and data traceability through Decree No. 147/2024/ND-CP; and second, offering financial incentives such as green credit to mitigate initial costs of the twin transition. However, the prevalence of “regulatory lag” and “institutional inertia” in emerging markets suggests that such support acts more as a direct enabler than a moderating force, establishing a baseline environment for all firms regardless of digital maturity.

2.4. Circular Economy and Circular Economy Readiness

The Circular Economy (CE) has achieved significant traction as a sustainable development model, aiming to minimize waste and make the most of resources [27]. The CE has emerged as a strategic approach to sustainable development by decoupling economic growth from resource consumption and environmental degradation. Recent studies highlight CE as a key mechanism for advancing the Sustainable Development Goals [28]. Empirical evidence shows that circular strategies enhance sustainable business performance by optimizing material flows and extending product life cycles [29].

CE Readiness reflects a firm's strategic and operational preparedness to shift from linear to restorative models. This readiness is deeply tied to “Lifecycle Intelligence”-the ability to utilize IoT for real-time tracking and AI for predictive maintenance to maintain product value across cycles [30], [31]. CE Readiness refers to the extent to which an organization is capable of embracing and executing the strategic, operational, and cultural transformations necessary for shifting toward circular economy models [32].

2.5. Research Gaps and Previous Studies

A growing body of literature has highlighted the pivotal role of digital technologies in enabling circular economy (CE) practices. Digital technologies such as IoT, AI, blockchain, and digital twins significantly enhance resource efficiency, lifecycle monitoring, and supply chain transparency [33], [34]. These technologies enable real-time data collection, predictive analytics, and traceability, facilitating more efficient resource allocation [35]. Digital platforms enable new value propositions such as product-as-a-service and sharing-based models [36], [37]. In construction, technologies like Building Information Modeling (BIM) and digital twins facilitate lifecycle management and resource optimization [38].

Despite these advancements, the literature remains largely technology-centric. Recent studies have begun to emphasize digital capability as a higher-order competence, but the process through which it is translated into circular economy readiness remains insufficiently understood. Firms often face challenges including high investment costs, lack of digital infrastructure, and integration difficulties [33]-challenges particularly acute in emerging markets.

Three critical gaps emerge: first, prior studies adopt a technology-oriented perspective, overlooking digital capability as a dynamic organizational mechanism; second, there is limited understanding of the mechanism through which digital capability enables circular economy readiness; and third, empirical evidence from emerging markets remains limited. This study constructs an integrated framework to address these gaps.

2.6. Construct Identification, Research Hypotheses and Research Model

2.6.1. Construct Identification

Expanding upon the TOE framework, this study identifies three key dimensions-technological, organizational, and environmental factors-as the primary antecedents of digital capability. Unlike prior studies that focus on technology adoption, this study conceptualizes TOE dimensions as drivers of digital capability, a higher-order organizational competence enabling firms to leverage digital technologies for circular transformation. This perspective aligns with the dynamic capability view, which emphasizes firms' ability to integrate, build, and realign resources in response to environmental changes.

Technological factors refer to the readiness, infrastructure, and compatibility of digital technologies within the organization. Advanced digital infrastructure facilitates the integration of digital systems and enhances firms' ability to utilize IoT, AI, big data, and blockchain [39], [40]. Technological readiness is a critical determinant of digital transformation in emerging economies [41].

Organizational factors capture internal capabilities, including top management support, organizational capacity, and digital culture. Leadership commitment plays a crucial role in allocating resources and driving digital transformation [42], [43]. Organizational culture fosters dynamic capabilities that enhance firms' ability to innovate and achieve sustainability goals [44].

Environmental factors encompass external pressures including competitive pressure, market forces, and regulatory frameworks. Competitive pressure drives digital technology adoption, while regulatory environments influence the strategic convergence of digital advancement and circularity goals [24], [45]. Market demand and consumer acceptance further shape firms' incentives [46].

2.6.2. Research Hypotheses and Research Model

2.6.2.1. Technological Factors and Digital Capability

Technological factors play a foundational role in shaping firms' digital capability by determining the extent to which digital technologies can be effectively adopted and integrated. The availability of robust digital infrastructure, the stability of enterprise systems such as ERP or CRM, and the compatibility between technological platforms collectively establish technological readiness. When firms experience tangible benefits from digital technology adoption-such as improved efficiency and cost reduction-they are more likely to further invest in digital capabilities. Prior studies consistently emphasize that technological readiness and infrastructure are critical enablers of digital transformation [24], [39].

H1: Technological factors positively influence digital capability.

2.6.2.2. Organizational Factors and Digital Capability

Organizational factors reflect firms' internal readiness to develop and deploy digital capabilities. Leadership commitment shapes strategic direction and resource allocation for digital transformation. Employees' willingness to adapt to new technologies and the availability of financial and human resources further determine the extent to which firms can sustain digital initiatives. Previous studies have shown that top management support, organizational capacity, and digital culture are key drivers [42], [43], [44].

H2: Organizational factors positively influence digital capability.

2.6.2.3. Environmental Factors and Digital Capability

Environmental factors represent external pressures that influence firms' digital transformation. Increasing customer demand for product transparency, supply chain collaboration requirements, and regulatory frameworks related to environmental protection collectively create institutional pressure for digital adoption. Prior research has demonstrated that regulatory support, market dynamics, and competitive forces significantly influence digital capability development [24], [45].

H3: Environmental factors positively influence digital capability.

2.6.2.4. Digital Capability and Circular Economy Readiness

Digital capability serves as a key enabler of circular economy readiness by allowing firms to integrate digital technologies into their operations and strategic decision-making. Through digital infrastructure, data governance, process digitalization, human digital skills, and digital culture, firms can enhance resource efficiency, improve lifecycle management, and facilitate information sharing across value chains-all essential for implementing circular economy practices such as reverse logistics, recycling, and service-based business models. Prior studies highlight that digital technologies and capabilities significantly contribute to circular economy implementation [33], [34].

H4: Digital capability positively influences circular economy readiness.

2.6.2.5. Institutional Support as Moderator

From an institutional theory perspective, regulatory pressure and environmental governance mechanisms can drive firms to align digital transformation with sustainability goals [42]. Institutional environments characterized by strong regulatory support and competitive pressure can amplify the effectiveness of digital transformation in promoting circular economy performance [47]. However, institutional support may function as a boundary condition: in supportive institutional environments, firms are more likely to translate digital capability into circular practices, while weak institutional frameworks may limit this effectiveness [48].

H5: Institutional support positively influences circular economy readiness.

H6: Institutional support positively moderates the relationship between digital capability and circular economy readiness, such that the positive effect of digital capability on circular economy readiness is stronger under higher levels of institutional support.

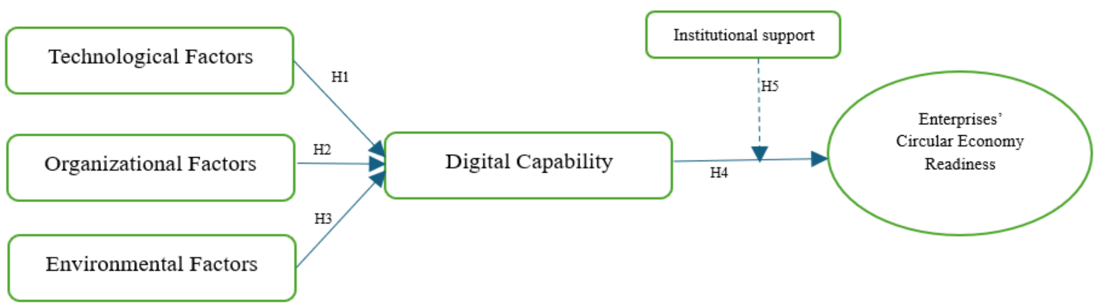

Figure 1. Research model (Source: Developed by the authors)

3. RESEARCH METHODOLOGY

3.1. Research Design

This study adopts a mixed-method approach using a sequential exploratory design [49]. The research was conducted in two phases. In the first phase, qualitative data were collected through semi-structured interviews with experts to refine constructs and measurement items. In the second phase, a quantitative survey was conducted to empirically test the proposed research model and hypotheses. This design is particularly suitable for emerging research contexts such as digital transformation and circular economy, where theoretical constructs require contextual adaptation and empirical validation.

3.2. Data Collection

Data were collected through an online structured questionnaire administered to firms operating in Vietnam. Target respondents were managers and decision-makers with experience in digital transformation or sustainability-related initiatives. A total of 516 valid responses were obtained after data screening. The sample includes firms across manufacturing, logistics, and e-commerce, with small and medium-sized enterprises (SMEs) accounting for approximately 62% of the sample.

3.3. Measurement

Before analysis, the dataset was screened for completeness, missing values, and outliers. To address potential common method bias, procedural remedies were applied, including ensuring respondent anonymity and improving questionnaire clarity. Harman's single-factor test was conducted to assess the presence of common method variance. The data were then coded and prepared for statistical analysis using SmartPLS 3.0.

3.4. Data Analysis

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 3.0. This method is appropriate for complex models, prediction-oriented research, and studies conducted in emerging research contexts. The analysis followed a two-step approach. First, the measurement model was evaluated by assessing internal consistency reliability (Cronbach's Alpha and Composite Reliability), convergent validity (AVE), and discriminant validity (HTMT ratio). Second, the structural model was assessed by examining R^2, effect sizes (f^2), and predictive relevance. Hypotheses were tested using bootstrapping with 5,000 resamples. The moderating effect was tested using the interaction term approach with the two-stage method recommended for reflective constructs.

3.5. Ethical Considerations

Ethical considerations were strictly observed throughout the research process. Respondents' participation was voluntary, and they were informed about the purpose of the study. Confidentiality and anonymity were ensured, and no personally identifiable information was collected. Data were used exclusively for academic research purposes.

4. RESEARCH FINDINGS

4.1. Descriptive Statistics and Sample Profile

Table 1 presents the characteristics of the sample. The majority of firms are small and medium-sized enterprises (62%), reflecting the structure of the Vietnamese business landscape. Regarding industry distribution, manufacturing firms account for the largest proportion (34.9%), followed by logistics (21.3%) and e-commerce (18.4%) sectors, which are highly relevant to digital transformation and circular economy practices. Most respondents hold managerial positions (top management: 40.7%; middle management: 36.8%), ensuring the reliability of responses. In terms of digital transformation experience, most firms have between 2 and 5 years of experience (44.6%), indicating a relatively mature stage of digital adoption.

Table 1. Descriptive Statistics of Sample

Category	Group	Frequency (n)	Percentage (%)
Firm size	SMEs	320	62.0
	Large firms	196	38.0
Industry	Manufacturing	180	34.9
	Logistics	110	21.3
	E-commerce	95	18.4
	Others	131	25.4
Position of respondent	Top management	210	40.7
	Middle management	190	36.8
	Operational management	116	22.5
Experience in digital transformation	< 2 years	140	27.1
	2-5 years	230	44.6
	> 5 years	146	28.3

Source: Authors' compilation based on survey data

4.2. Results of PLS-SEM Analysis

4.2.1. Measurement Model Assessment

Table 2. Results of Reliability and Convergent Validity Assessment

Construct	Outer Loadings	Cronbach's α	ρ_A	CR	AVE	VIF range
Circular Economy Readiness (CERE)	0.783–0.854	0.901	0.903	0.924	0.669	1.838–2.534
Digital Capability (DC)	0.658–0.850	0.807	0.820	0.867	0.568	1.425–2.252
Environmental Factors (ENV)	0.707–0.854	0.795	0.807	0.867	0.621	1.444–1.939
Organizational Factors (ORG)	0.660–0.818	0.790	0.800	0.856	0.545	1.442–1.784
Technological Factors (TECH)	0.643–0.847	0.814	0.829	0.871	0.576	1.469–2.158
Institutional Support (IS)	0.751–0.859	0.840	0.858	0.892	0.675	1.633–1.998

Source: Authors' calculations based on survey data using SmartPLS 3.0

As shown in Table 2, the measurement model was evaluated for indicator reliability, internal consistency reliability, convergent validity, and multicollinearity. All constructs meet the recommended thresholds. Indicator reliability was assessed through outer loadings; most indicators exceed 0.70, while a few items show slightly lower loadings but remain above the acceptable level of 0.60, retained to preserve content validity. Cronbach's Alpha values range from 0.790 to 0.901 (threshold: > 0.70); Composite Reliability (CR) values range from 0.856 to 0.924. Convergent validity is confirmed as all AVE values exceed 0.50, ranging from 0.545 to 0.675. All VIF values are below 5.0, ruling out multicollinearity concerns.

Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio. As presented in Table 3, all HTMT values fall below the conservative threshold of 0.85. The highest HTMT value is observed between DC and CERE (0.764), which remains well within the acceptable range, confirming empirical distinction despite theoretical relatedness. The interaction term (DC × IS) shows consistently low HTMT values (0.076–0.181), confirming it does not introduce multicollinearity or measurement redundancy.

Table 3. HTMT Ratio Results (Discriminant Validity Assessment)

	CERE	DC	DC×IS	ENV	IS	ORG	TECH
CERE	0.818						
DC	0.764	0.753					
DC×IS	0.108	0.137	-				
ENV	0.522	0.563	0.081	0.788			
IS	0.376	0.359	0.181	0.295	0.821		
ORG	0.581	0.584	0.076	0.505	0.286	0.738	
TECH	0.535	0.506	0.096	0.478	0.318	0.479	0.759

Source: Authors' calculations based on survey data using SmartPLS 3.0

4.2.2. Structural Model Assessment

Table 4. Model Fit Assessment

Index	Saturated Model	Estimated Model	Threshold
SRMR	0.054	0.064	< 0.08
d_ULS	1.267	1.805	-
d_G	0.391	0.411	-
Chi-Square	1186.937	1214.735	-
NFI	0.840	0.836	> 0.80

Source: Authors' calculations based on survey data using SmartPLS 3.0

As shown in Table 4, SRMR values for the saturated model (0.054) and the estimated model (0.064) are both below the recommended threshold of 0.08, indicating a good model fit. NFI values of 0.840 and 0.836, respectively, exceed the acceptable threshold of 0.80, further supporting the adequacy of the model.

Table 5. Explanatory Power of the Structural Model (R^2)

Endogenous Construct	R^2	R^2 Adjusted	Interpretation
Digital Capability (DC)	0.467	0.464	Moderate
Circular Economy Readiness (CERE)	0.595	0.593	Moderate–Substantial

Source: Authors' calculations based on survey data using SmartPLS 3.0

Table 5 shows that TOE factors collectively explain 46.7% of the variance in Digital Capability ($R^2 = 0.467$), indicating moderate explanatory power. The model explains 59.5% of variance in Circular Economy Readiness ($R^2 = 0.595$), which is substantial given the complexity of the phenomenon and is consistent with prior PLS-SEM studies in the sustainability domain.

4.2.3. Hypothesis Testing: Direct Effects

Table 6. Structural Model Results - Direct Effects and Effect Sizes

Hypothesis	Relationship	β	t-value	p-value	f^2	Decision
H1	TECH → DC	0.203	5.320	0.000	0.054	Supported
H2	ORG → DC	0.338	8.450	0.000	0.144	Supported
H3	ENV → DC	0.296	6.880	0.000	0.110	Supported
H4	DC → CERE	0.723	30.216	0.000	1.118	Supported
H5	IS → CERE	0.119	3.748	0.000	0.030	Supported
H6	DC × IS → CERE	-0.014	0.460	0.646	0.000	Not supported

Source: Authors' calculations based on survey data using SmartPLS 3.0; bootstrapping with 5,000 resamples

Table 6 presents the path coefficients, t-values, p-values, and effect sizes (f^2) for all hypothesized relationships. H1 (TECH → DC: $\beta = 0.203$, $t = 5.320$, $p < 0.001$), H2 (ORG → DC: $\beta = 0.338$, $t = 8.450$, $p < 0.001$), and H3 (ENV → DC: $\beta = 0.296$, $t = 6.880$, $p < 0.001$) are all supported, confirming that TOE factors are significant antecedents of digital capability. H4 (DC → CERE: $\beta = 0.723$, $t = 30.216$, $p < 0.001$) receives the strongest support, with a large effect size ($f^2 = 1.118$), underscoring digital capability's dominant role as an enabler of circular economy readiness. H5 (IS → CERE: $\beta = 0.119$, $t = 3.748$, $p < 0.001$) is supported with a small effect size ($f^2 = 0.030$), confirming that institutional support exerts a significant direct effect on CERE. H6 (DC × IS → CERE: $\beta = -0.014$, $t = 0.460$, $p = 0.646$) is not supported ($f^2 = 0.000$), indicating that institutional support does not moderate the DC–CERE relationship.

4.2.4. Mediation Analysis

To assess the mediating role of Digital Capability (DC) in the TOE–CERE relationship, indirect effects were estimated via bootstrapping with 5,000 resamples. As presented in Table 7, all three indirect paths are statistically significant, with 95% bias-corrected confidence intervals that exclude zero.

Table 7. Mediation Analysis - Indirect Effects via Digital Capability

Indirect Path	Indirect Effect (β_ind)	Boot SE	Boot t	95% CI (LL, UL)	Decision
TECH → DC → CERE	0.147	0.029	5.069	[0.095, 0.207]	Supported (H_med1)
ORG → DC → CERE	0.244	0.033	7.394	[0.182, 0.313]	Supported (H_med2)
ENV → DC → CERE	0.214	0.033	6.485	[0.151, 0.281]	Supported (H_med3)

Source: Authors' calculations based on survey data using SmartPLS 3.0; bootstrapping with 5,000 resamples; 95% bias-corrected CI

The indirect effect of Organizational Factors on CERE via DC is the largest (β_{ind} = 0.244, 95% CI [0.182, 0.313]), followed by Environmental Factors (β_{ind} = 0.214, 95% CI [0.151, 0.281]) and Technological Factors (β_{ind} = 0.147, 95% CI [0.095, 0.207]). These results confirm that Digital Capability serves as a full mediating mechanism: TOE conditions do not directly translate into circular economy readiness but are channelled entirely through the development and deployment of digital capability within the firm. This finding is consistent with a process-oriented view of circular economy transformation and contributes to resolving the "productivity paradox" by demonstrating that digital investments produce circular outcomes only when they are embedded in broader organizational capability development.

4.2.5. Moderation Analysis

The moderating role of Institutional Support (IS) on the DC–CERE relationship was tested using the two-stage interaction term approach in SmartPLS 3.0. Table 8 presents the results.

Table 8. Moderation Analysis - Moderating Effect of Institutional Support on DC → CERE

	Coefficient (β)	t-value	p-value	f^2	95% CI
Direct: DC → CERE	0.723	30.216	0.000	1.118	[0.657, 0.788]
Direct: IS → CERE	0.119	3.748	0.000	0.030	[0.057, 0.181]
Interaction: DC × IS → CERE	-0.014	0.460	0.646	0.000	[-0.073, 0.045]

Source: Authors' calculations based on survey data using SmartPLS 3.0; bootstrapping with 5,000 resamples; 95% bias-corrected CI

The interaction term DC × IS yields a non-significant negative coefficient ($\beta = -0.014$, $t = 0.460$, $p = 0.646$), with a 95% confidence interval of [-0.073, 0.045] that spans zero, and a negligible effect size ($f^2 = 0.000$). H6 is therefore rejected. Critically, the direct effect of IS on CERE remains significant and positive ($\beta = 0.119$, $p < 0.001$), establishing that institutional support functions as a direct driver rather than a contingent moderator. This distinction has important theoretical implications: institutional frameworks in Vietnam appear to create baseline enabling conditions for all firms-regardless of their digital maturity-rather than amplifying the conversion of digital capability into circular practices among high-capability firms specifically.

Table 9. Effect Size (f^2) Summary

Predictor	Outcome	f^2	Interpretation
DC	CERE	1.118	Large
IS	CERE	0.030	Small
DC × IS	CERE	0.000	Negligible
ORG	DC	0.144	Medium
ENV	DC	0.110	Small–Medium
TECH	DC	0.054	Small

Note: f^2 < 0.02 = negligible; 0.02–0.15 = small; 0.15–0.35 = medium; > 0.35 = large [50]

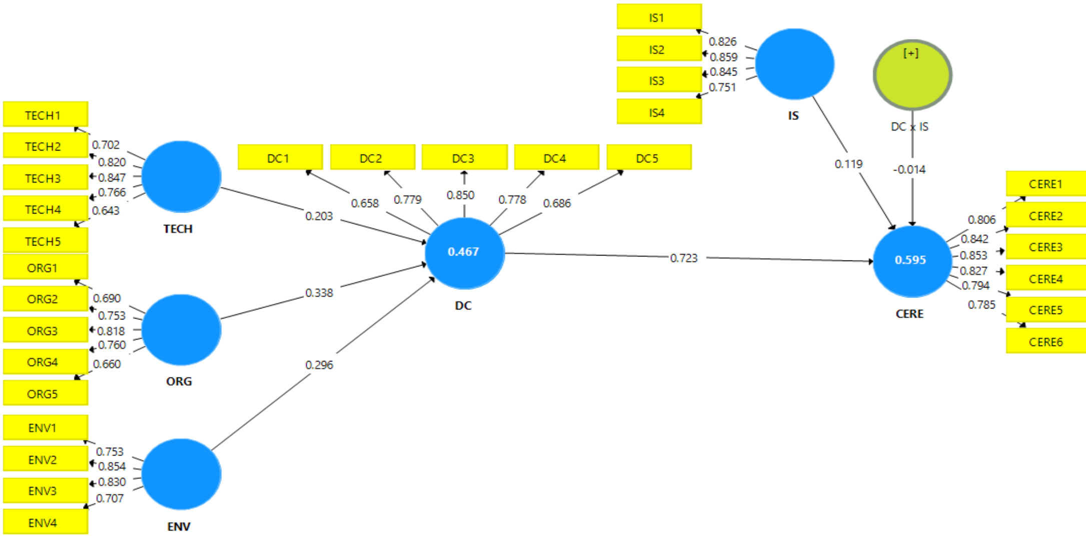

Figure 2. Results of the Structural Model (PLS-SEM Analysis)
(Source: Authors' analysis using SmartPLS 3.0)

5. DISCUSSION

5.1. Summary of Findings

This study investigates the role of digital capability as an enabler of circular economy readiness within the TOE framework, using data from 516 Vietnamese firms and PLS-SEM. The findings reveal four key results: (1) technological, organizational, and environmental factors all significantly and positively influence digital capability (H1–H3 supported); (2) digital capability exerts a strong positive effect on circular economy readiness (H4 supported, $f^2 = 1.118$); (3) digital capability fully mediates the TOE–CERE relationships (all indirect effects significant); and (4) institutional support has a significant direct positive effect on CERE (H5 supported) but does not moderate the DC–CERE relationship (H6 not supported). These results collectively advance a process-oriented understanding of circular economy transformation in emerging market contexts.

5.2. Interpretation and Theoretical Discussion

The significant effects of TOE factors on digital capability (H1–H3) are consistent with prior studies grounded in the TOE framework, confirming that technological readiness, organizational resources, and environmental pressures collectively drive firms' digital transformation [24], [43]. However, this study advances beyond existing work by demonstrating that these factors do not directly translate into circular economy readiness. Instead, they operate exclusively through the development of digital capability, as confirmed by the full mediation results.

The dominant effect of digital capability on circular economy readiness (H4: $\beta = 0.723$, $f^2 = 1.118$) aligns with and extends prior research emphasizing the enabling role of digital technologies in sustainability transitions [47], [51], [52]. The large effect size is theoretically significant: it indicates that digital capability is not merely one among several drivers of circular readiness but the primary mechanism through which firms operationalize circular practices. This finding resolves an important empirical ambiguity in the literature, where prior studies have alternately positioned digital technologies as tools, capabilities, or outcomes rather than as integrated organizational mechanisms.

The full mediation finding also provides a theoretically important resolution to the "productivity paradox" identified in the Vietnamese context. Many Vietnamese firms invest substantially in digital infrastructure yet fail to achieve corresponding improvements in circular economy performance-a gap attributable to the underdevelopment of complementary organizational capabilities. The mediation results demonstrate that technology alone is insufficient; it is the firm-level integration of digital infrastructure, data governance, human digital skills, and digital culture-constituting digital capability-that bridges the gap between technological endowment and circular outcome. Firms stuck in the paradox are, in effect, firms that have acquired technological inputs without developing the capability to deploy them for circular purposes.

Interestingly, the moderating effect of institutional support is not supported (H6: $\beta = -0.014$, $p = 0.646$, $f^2 \approx 0.000$), which stands in contrast to some prior studies suggesting that strong institutional environments can amplify the effect of digital transformation on sustainability outcomes [23], [47]. Instead, the findings indicate that institutional support exerts a direct, universally positive influence on CERE (H5 supported), consistent with the view that institutional frameworks function as enabling conditions for all firms rather than as contingent moderators for high-capability firms specifically.

This pattern is consistent with the concept of "institutional inertia" and "regulatory lag" prevalent in emerging markets [48]. Vietnam's key institutional instruments-including the National Green Growth Strategy 2021-2030 and Decree No. 147/2024/ND-CP-provide broad regulatory direction and legal infrastructure for data governance. However, these frameworks are still insufficiently granular or operationally specific to differentially shape how firms leverage digital capability for circular practices. In other words, institutional support in Vietnam currently raises the floor for all firms' circular economy readiness (direct effect) without selectively strengthening the ceiling for those with advanced digital capabilities (no interaction effect). This represents a structural gap between policy orientation and the operational demands of firm-level digital-to-circular transformation.

From a political economy perspective, drawing on Harvey [26], digital capability functions not merely as a technological resource but as a form of productive infrastructure that enables firms to reorganize resource flows and extend value creation across the product lifecycle. The transition toward a circular economy can thus be understood not only as a sustainability shift but also as a structural reorganization of productive capacity-one in which digital capability serves as the central enabling mechanism, analogous to how physical infrastructure historically enabled the reorganization of industrial production.

5.3. Implications

Theoretical implications: This study extends the TOE framework by incorporating digital capability as a central mediating mechanism, demonstrating that external technological, organizational, and environmental drivers operate through internal capability development rather than directly driving circular economy readiness. It advances the digital transformation and sustainability literature by positioning digital capability as a structural enabler-a productive infrastructure-rather than a supporting factor. The full mediation finding also contributes a process-oriented resolution to the productivity paradox by identifying the organizational mechanism that bridges digital investment and circular outcome. Finally, the distinction between institutional support as a direct driver versus a non-significant moderator enriches institutional theory by highlighting the boundary conditions of institutional amplification in emerging markets.

Practical implications: For firm managers, the results underscore that achieving circular economy readiness requires building integrated digital capabilities-spanning data management, system integration, process digitalization, and digital talent-rather than merely acquiring digital tools. Firms experiencing the productivity paradox should audit their organizational complements to digital infrastructure, as technology without capability embedding will not yield circular outcomes. For policymakers, the significant direct effect of institutional support on CERE suggests that regulatory clarity, financial incentives, and infrastructure investment directly raise firms' circular readiness. However, the non-significant moderating effect indicates that generic institutional frameworks are currently insufficient to amplify capability-to-readiness conversion. Future policy should therefore shift from broad regulatory orientation toward capacity-building programmes that strengthen the link between digital capability development and circular business model implementation.

5.4. Limitations and Future Research

This study has several limitations. First, the cross-sectional design limits causal inference and the ability to capture dynamic changes over time; future research should adopt longitudinal designs to examine the temporal development of digital capability and its evolving relationship with circular economy readiness. Second, the study focuses exclusively on Vietnamese firms, limiting the generalizability of findings; comparative studies across ASEAN or other emerging market contexts would provide valuable insights. Third, the non-significant moderating effect of institutional support suggests that future research should explore alternative boundary conditions-such as firm size, industry clockspeed, or absorptive capacity-that may condition the DC–CERE relationship. Fourth, the study relies on self-reported perceptual measures; future research could complement survey data with objective firm-level performance indicators to enhance measurement validity.

5.5. Contributions

This study makes four substantive contributions. First, it extends the TOE framework into the circular economy domain by establishing digital capability as the central mediating mechanism, advancing a process-oriented understanding that moves beyond prior direct-effect models. Second, it enriches the digital transformation and sustainability literature by providing robust empirical evidence-including mediation and moderation analyses-for digital capability's role as productive infrastructure in enabling circular economy readiness in emerging markets. Third, by integrating a political economy perspective via Harvey [26], it conceptualizes circular economy transition as a structural reorganization of productive capacity, not merely a sustainability choice. Fourth, it clarifies the dual role of institutional support-as a direct driver of CERE but not as a moderator of the DC–CERE relationship-offering both theoretical precision and actionable policy guidance for emerging economies navigating the twin transition.

6. CONCLUSION

This study highlights the pivotal role of digital capability in enabling firms to transition toward a circular economy. Circular economy readiness does not emerge directly from external technological, organizational, and environmental conditions but depends fundamentally on firms' ability to develop and deploy integrated digital capabilities that transform those conditions into actionable circular practices. The full mediation of TOE effects through digital capability demonstrates that digital investment produces circular outcomes only when embedded within broader organizational capability-offering an empirically grounded resolution to the productivity paradox observed among Vietnamese firms. While institutional support contributes directly to creating a favourable enabling environment, it does not selectively amplify the conversion of digital capability into circular readiness, reflecting the current stage of institutional development in Vietnam. Overall, this study underscores that circular economy transformation requires a structural shift in productive capacity, with digital capability serving as the foundational enabling mechanism-particularly in emerging economies navigating the twin transition of digitalization and sustainability.

REFERENCES

[1] A. Costa, *Navigating the twin transition: digital transformation and sustainability in low-tech industries: a small and medium-sized companies' perspective.* Rome, Italy: Tab Edizioni, 2024. [Online]. Available: https://www.tabedizioni.it/shop/product/navigating-the-twin-transition-digital-transformation-and-sustainability-in-low-tech-industries-1599

[2] M. Geissdoerfer, P. Savaget, N. M. P. Bocken, and E. J. Hultink, "The Circular Economy – A new sustainability paradigm?," *J. Clean. Prod.*, vol. 143, pp. 757–768, Feb. 2017, doi: https://doi.org/10.1016/j.jclepro.2016.12.048

[3] M. Antikainen, T. Uusitalo, and P. Kivikytö-Reponen, "Digitalisation as an Enabler of Circular Economy," *Procedia CIRP*, vol. 73, pp. 45–49, 2018, doi: https://doi.org/10.1016/j.procir.2018.04.027

[4] A. Subagja, G. Watanto, and A. Mujadi, "Predictive Maintenance Strategies for Industry 4.0: A Modelling Approach," *International Journal of Technology and Modeling*, vol. 3, no. 3, pp. 121–128, Dec. 2024, doi: https://doi.org/10.63876/ijtm.v3i3.121

[5] A. Suthar, K. Kolhe, V. Gutte, and D. Patil, "Predictive Maintenance and Real Time Monitoring using IoT and Cloud Computing," in *2024 5th International Conference on Image Processing and Capsule Networks (ICIPCN)*, IEEE, Jul. 2024, pp. 814–820. doi: https://doi.org/10.1109/ICIPCN63822.2024.00141.

[6] F. Adedoyin, "Digital Competence and Operational Performance in Agile Organizations," in *Digital Competence in Agile and Hierarchical Organizations*, London: Routledge, 2025, pp. 1–16. doi: https://doi.org/10.4324/9781003535416-1.

[7] J. L. Chong and K. Olesen, "A Technology-Organization-Environment Perspective on Eco-effectiveness: A Meta-analysis," *Australasian Journal of Information Systems*, vol. 21, Mar. 2017, doi: https://doi.org/10.3127/ajis.v21i0.1441.

[8] E. Barteková and P. Börkey, "Digitalisation for the transition to a resource efficient and circular economy," *OECD Environment Working Papers*, no. 192, OECD Publishing, Paris, France, 2022, doi: https://doi.org/10.1787/6f6d18e7-en.

[9] Prime Minister of Vietnam, *National Green Growth Strategy*. Viet Nam, 2021.

[10] Government of Vietnam, *Decree 147/2024/ND-CP*. Viet Nam, 2024.

[11] L. Isiaku and A. Adalier, "Analyzing the barriers to blockchain adoption in educational sectors: a comprehensive literature review using the Technology-Organizational-Environment (TOE) framework," *On the Horizon: The International Journal of Learning Futures*, vol. 33, no. 1, pp. 32–60, Feb. 2025, doi: https://doi.org/10.1108/OTH-05-2024-0029.

[12] Q. Yang, A. B. Aman, H. O. Zaki, and R. Baharin, "Digital Trade Transformation for SMEs in Asia Pacific Using the Technology-Organization-Environment Framework: A Literature Review," *China and WTO Review*, vol. 11, no. 1, pp. 83–95, Apr. 2025, doi: https://doi.org/10.52152/cwr.2025.11.1.07

[13] S. Donmez, A. T. Celikel, Y. P. S. Sarica, and E. I. Develi, "Understanding AI adoption at organizations: Literature review of TOE framework," *Pressacademia*, Aug. 2025, doi: https://doi.org/10.17261/Pressacademia.2025.1994

[14] P. Morawiec and A. Sołtysik-Piorunkiewicz, "ERP system development for business agility in industry 4.0—A Literature review based on the TOE Framework," *Sustainability*, vol. 15, no. 5, p. 4646, Mar. 2023, doi: https://doi.org/10.3390/su15054646

[15] N. A. Halim, N. Ahmad, and M. H. Abu Yazid, "Exploring the Organizational Readiness for AI Automotive After-Sales Services: A Systematic Literature Review," *International Journal of Academic Research in Business and Social Sciences*, vol. 14, no. 12, pp. 1361-1373, Dec. 2024, doi: https://doi.org/10.6007/IJARBSS/v14-i12/24092

[16] O.-A. Chioma Herrieth and Dr. A. Rahman Abdul Rahim, "A Systematic Review and Proposition of an E-Commerce Framework for African SMES: Integrating TAM and TPB into TOE Framework," *International Journal of Business & Management Studies*, vol. 04, no. 07, pp. 15–37, Jul. 2023, doi: https://doi.org/10.56734/ijbms.v4n7a3

[17] J. Toscano Jara *et al*, "Digital transformation: A systematic literature review from the theoretical lenses of the TOE framework," *Innovar*, vol. 34, no. 93, Dec. 2023, doi: https://doi.org/10.15446/innovar.v34n93.98245

[18] A. S. Madaki *et al*, "Unleashing the Impact of IT Integration Implementation in Public Sector Organizations Through the Lens of TOE: A Review," in *2023 International Conference on Electrical Engineering and Informatics (ICEEI)*, IEEE, Oct. 2023, pp. 1–6, doi: https://doi.org/10.1109/ICEEI59426.2023.10346696

[19] S. Khin and T. C. Ho, "Digital technology, digital capability and organizational performance," *International Journal of Innovation Science*, vol. 11, no. 2, pp. 177–195, Jun. 2019, doi: https://doi.org/10.1108/IJIS-08-2018-0083.

[20] Z. Avtalion, I. Aviv, I. Hadar, G. Luria, and O. Bar-Gil, "Digital Infrastructure as a New Organizational Digital Climate Dimension," *Applied Sciences*, vol. 14, no. 19, p. 8592, Sep. 2024, doi: https://doi.org/10.3390/app14198592.

[21] X. Liu, R. Torres de Oliveira, M. Indulska, and M.-L. Verreynne, "Towards a Digital Capability Framework," *Academy of Management Proceedings*, vol. 2020, no. 1, p. 18505, Aug. 2020, doi: https://doi.org/10.5465/AMBPP.2020.18505abstract.

[22] Kiran Kumar Lekkala, "Digital Transformation: The Strategic Integration of Technology in Modern Business," *International Journal of Advanced Research in Science, Communication and Technology*, pp. 344–351, Mar. 2025, doi: https://doi.org/10.48175/IJARSCT-24443

[23] K. Bentkowska, "Institutional determinants of circular economy," *Ekonomia i Prawo*, vol. 23, no. 4, pp. 559–575, Dec. 2024, doi: https://doi.org/10.12775/EiP.2024.028

[24] G. Wang and H. Zhang, "FinTech-Driven Corporate Sustainability: A Technology–Organization–Environment Framework Analysis," *Sustainability*, vol. 17, no. 19, p. 8748, Sep. 2025, doi: https://doi.org/10.3390/su17198748

[25] A. Risqi Arifia, "Adoption of Digitalization in SMEs Using the TOE Framework and Advanced Analyses," *Journal Economic Business Innovation*, vol. 1, no. 2, pp. 180–194, Jul. 2024, doi: https://doi.org/10.69725/jebi.v1i2.174

[26] David Harvey, *The Enigma of Capital and the Crises of Capitalism*, vol. 22, no. 1. Oxford University Press, 2010. doi: https://doi.org/10.1177/103530461102200110

[27] Ellen MacArthur Foundation, *Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition,* 2013.

[28] E. V. Yaroson *et al*, "A systematic literature review exploring and linking circular economy and sustainable development goals in the past three decades (1991–2022)," *Int. J. Prod. Res.*, vol. 62, no. 4, pp. 1399–1433, Feb. 2024, doi: https://doi.org/10.1080/00207543.2023.2270586

[29] S. Nazir and A. Capocchi, “Systematic Literature Review of Circular Economy and Sustainable Development,” in *Sustainability Reporting Practices and the Circular Economy*, Cham: Springer Nature Switzerland, 2024, pp. 15–81. doi: https://doi.org/10.1007/978-3-031-51845-4_2

[30] E. N. da Silva, “Digital Circular Economy: Blockchain, IoT, and AI for Traceability and Efficiency,” *Revista ft*, vol. 29, no. 150, pp. 52–53, Sep. 2025, doi: https://doi.org/10.69849/revistaft/ra10202509071652

[31] A. Iqbal, S. Akhter, S. Mahmud, and L. M. Noyon, “Empowering the circular economy practices: Lifecycle assessment and machine learning-driven residual value prediction in IoT-enabled microwave oven,” *Heliyon*, vol. 10, no. 19, p. e38609, Oct. 2024, doi: https://doi.org/10.1016/j.heliyon.2024.e38609

[32] L. Fraccascia, I. Giannoccaro, A. Agarwal, and E. G. Hansen, “Business models for the circular economy: Opportunities and challenges,” *Bus. Strategy Environ.*, vol. 28, no. 2, pp. 430–432, Feb. 2019, doi: https://doi.org/10.1002/bse.2285

[33] M. Scholtysik, A. Rasor, L. Petzke, C. Koldewey, and R. Dumitrescu, “An integrative perspective on digital technologies and circular economy: a systematic literature review,” *Proceedings of the Design Society*, vol. 5, pp. 541–550, Aug. 2025, doi: https://doi.org/10.1017/pds.2025.10068

[34] D. Hariyani, P. Hariyani, S. Mishra, and M. Kumar Sharma, “Leveraging digital technologies for advancing circular economy practices and enhancing life cycle analysis: A systematic literature review,” *Waste Management Bulletin*, vol. 2, no. 3, pp. 69–83, Sep. 2024, doi: https://doi.org/10.1016/j.wmb.2024.06.007

[35] S. Supriadi *et al.*, “Analysis of Circular Supply Chain Management in Technology Industry to Support Circular Economy,” *Proceeding of International Conference on Science and Technology UISU*, pp. 209–214, Aug. 2025, doi: https://doi.org/10.30743/8vvcf741

[36] S. Banihashemi, S. Meskin, M. Sheikhkhoshkar, S. R. Mohandes, A. Hajirasouli, and K. LeNguyen, “Circular economy in construction: The digital transformation perspective,” *Clean. Eng. Technol.*, vol. 18, p. 100715, Feb. 2024, doi: https://doi.org/10.1016/j.clet.2023.100715

[37] B. Kısmet and M. B. Çolakoğlu, “Circular Built Environment During the Digital Age: A Systematic Review,” *Journal of Computational Design*, vol. 6, no. 2, pp. 365–390, Sep. 2025, doi: https://doi.org/10.53710/jcode.1618537.

[38] C. Keles, F. Cruz Rios, and S. Hoque, “Digital Technologies and Circular Economy in the Construction Sector: A Review of Lifecycle Applications, Integrations, Potential, and Limitations”, *Buildings* vol. 15, no. 4, art. no. 553, 2025, doi: https://doi.org/10.3390/buildings15040553

[39] S. Çetin, C. De Wolf, and N. Bocken, “Circular Digital Built Environment: An Emerging Framework,” *Sustainability*, vol. 13, no. 11, p. 6348, Jun. 2021, doi: https://doi.org/10.3390/su13116348

[40] Z. M. Oğuz and Ö. Eren, “The Potential of Digital Technologies as a Catalyst for the Transition to Circularity,” *Mimarlık Bilimleri ve Uygulamaları Dergisi (MBUD)*, vol. 10, no. 1, pp. 638–653, Jul. 2025, doi: https://doi.org/10.30785/mbud.1643270

[41] N. Thi, P. Lien, M. Thi, and C. Lan, “Factors Affecting Digital Transformation of Agriculture Enterprises in Vietnam: A TOE Framework Approach,” *International Journal of Research*, vol. 12, 2025, no. 7, pp. 266-273, doi: https://doi.org/10.5281/ZENODO.16571012

[42] X. Chen and Q. An, “Digital Transformation and Organizational Resilience in Bulk Commodity Supply Chains: A Synergistic Mechanism Study Based on the TOE Framework with Evidence from Xiamen Xiangyu Group,” *in Digitalization and Management Innovation IV: Proceedings of DMI 2025, Frontiers in Artificial Intelligence and Applications*, vol. 412, pp. 85-98, 2025, doi: https://doi.org/10.3233/FAIA250707.

[43] H. Mu’min, D. Bernardus, and T. S. Kaihatu, “Unlocking Digital Success: A TOE Framework Analysis of Digital Marketing Adoption for Enhanced SMEs Competitiveness,” *International Journal of Accounting and Economics Studies*, vol. 12, no. 5, pp. 303–319, Sep. 2025, doi: https://doi.org/10.14419/n81qcx19.

[44] P. Xiu, P. Yang, and X. Lin, “Digital transformation and environmental, social and governance performance: a technology–organization–environment framework,” *Management Decision*, pp. 1–31, Sep. 2025, doi: https://doi.org/10.1108/MD-11-2024-2503.

[45] M. de O. Gondak, C. Hluszko, V. Moretti, G. L. F. Zeni, and A. C. de Francisco, “Guide to digital technologies for circularity in the project lifecycle: perspective of the EN 15643-3:2012 standard,” *Construction Innovation*, Sep. 2025, doi: https://doi.org/10.1108/CI-01-2025-0021.

[46] C. W. Bücker and H. Hall, “Customer Behaviour in the Circular Economy: The Enabling Role of Digital Technologies,” 2024.

[47] S. Yin, M. Jiang, L. Chen, and F. Jia, “Digital transformation and the circular economy: an institutional theory perspective,” *Industrial Management & Data Systems*, vol. 124, no. 4, pp. 1627–1655, Apr. 2024, doi: https://doi.org/10.1108/IMDS-10-2023-0792.

[48] S. Sahoo *et al*, “Forging Circuits and Bytes: The Mediator with Moderating Effects of Digital Transformation on The Circular Economy and Sustainable Entrepreneurship,” *International Journal of Accounting and Economics Studies*, vol. 12, no. 5, pp. 397–410, Sep. 2025, doi: https://doi.org/10.14419/tv3wzg33.

[49] John W. Creswell and Vicki L. Plano Clark, *A Revision Process That Bridges Qualitative and Quantitative Assessment*. SAGE Publications, 2017.

[50] J. Cohen, *Statistical Power Analysis for the Behavioral Scien*ces, 2nd ed. Hillsdale, NJ, USA: Lawrence Erlbaum Associates, 1988. [Online]. Available: https://utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf.

[51] P. Centobelli, R. Cerchione, and E. Esposito, “Pursuing supply chain sustainable development goals through the adoption of green practices and enabling technologies: A cross-country analysis of LSPs,” *Technol. Forecast. Soc. Change*, vol. 153, p. 119920, Apr. 2020, doi: https://doi.org/10.1016/j.techfore.2020.119920

[52] H. Turkcan, S. Z. Imamoglu, H. Ince, and S. Erat, “Digital Capabilities and Circular Economy Practices to Enhance Environmental and Economic Performance: The Role of Digital Technology-Environmental Strategy Alignment,” *Corp. Soc. Responsib. Environ. Manag.*, vol. 32, no. 4, pp. 5069–5087, Jul. 2025, doi: https://doi.org/10.1002/csr.3230