

THE IMPACT OF CIRCULAR ECONOMY PRACTICES ON THE ENVIRONMENTAL PILLAR OF SUSTAINABLE DEVELOPMENT: EXPERIMENTAL EVIDENCES FROM VIETNAMESE MANUFACTURING SMALL AND MEDIUM-SIZED ENTERPRISES

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Abstract: This study employs a multiple linear regression model to examine the relationship between circular economy (CE) practices-based on a five-phase CE framework-and environmental performance (EP), a core pillar of sustainable development, among small and medium-sized enterprises in Vietnam. The results indicate that most CE stages have positive effects on EP, with the exception of the resource extraction stage, which shows no significant impact. Notably, sustainable consumption exerts a negative influence. Capital sufficiency, used as a control variable, also contributes positively. These findings highlight the uneven impact of CE implementation across stages and emphasize the need for more tailored, context-specific policy strategies for small and medium-sized enterprises in Vietnam.

Keywords: Circular economy phases, sustainable development, environmental performance, small and medium-sized manufacturing enterprises, Vietnam.

TÁC ĐỘNG CỦA THỰC HÀNH KINH TẾ TUẦN HOÀN ĐẾN TRỤ CỘT MÔI TRƯỜNG TRONG PHÁT TRIỂN BỀN VỮNG: BẰNG CHỨNG THỰC NGHIỆM TỪ CÁC DOANH NGHIỆP SẢN XUẤT NHỎ VÀ VỪA TẠI VIỆT NAM

Tóm tắt: Nghiên cứu này sử dụng mô hình hồi quy tuyến tính bội nhằm phân tích mối quan hệ giữa các thực hành kinh tế tuần hoàn (KTTH)-dựa trên khung năm giai đoạn của mô hình KTTH và hiệu quả môi trường (EP), một trụ cột cốt lõi trong phát triển bền vững, trong bối cảnh các doanh nghiệp sản xuất nhỏ và vừa (DNNVV) tại Việt Nam. Kết quả cho thấy phần lớn các giai đoạn của KTTH đều tác động tích cực đến EP, ngoại trừ giai đoạn khai thác tài nguyên không có ảnh hưởng đáng kể. Đáng chú ý,

tiêu dùng bền vững lại thể hiện tác động tiêu cực đến hiệu quả môi trường. Ngoài ra, biến kiểm soát là mức độ đủ vốn cũng cho thấy ảnh hưởng tích cực. Những phát hiện này làm nổi bật sự không đồng đều trong tác động của việc triển khai KTTH qua từng giai đoạn, đồng thời nhấn mạnh sự cần thiết phải xây dựng các chính sách phù hợp hơn với bối cảnh cụ thể của các DNNVV tại Việt Nam.

Từ khóa: Các giai đoạn kinh tế tuần hoàn, phát triển bền vững, hiệu quả môi trường, doanh nghiệp sản xuất nhỏ và vừa, Việt Nam.

1. Introduction

Sustainable development has become a strategic orientation for many countries, with the environmental pillar gaining increasing prominence amid escalating resource depletion and rising emissions. The CE is widely recognized as a transformative model that enables firms to transition toward sustainability by optimizing resource use, minimizing waste, and regenerating value across the entire product lifecycle (Geissdoerfer et al., 2017). However, existing literature on the intersection between CE and EP has predominantly focused on large corporations or developed economies, while the role SMEs-which constitute the backbone of emerging markets such as Vietnam-remains underexplored. Drawing on CE theory, this paper adopts a five-stage behavioral framework comprising resource extraction, sustainable production, eco-friendly distribution, sustainable consumption, and resource recovery and regeneration, conceptualized as an organizational cycle (Moraga et al., 2019). Each stage in this cycle has the

potential to influence EP, depending on the extent of implementation and the firm's operational capacity. This study hypothesizes that all five CE stages can contribute positively to environmental outcomes. To test this, the study surveyed 598 Vietnamese manufacturing SMEs and applied quantitative analysis using a multiple linear regression model to examine the relationship between CE practices and environmental effectiveness. The objective is to assess the relative impact of each CE stage and derive empirical insights and policy implications to support green transformation in the SME sector.

2. Literature Review

A substantial body of international research affirms the positive link between CE practices and EP at the firm level. Key CE stages such as design and production contribute to energy and material conservation (Moreno et al., 2022; Geissdoerfer et al., 2017), while resource recovery remains limited by SMEs' technological and logistical constraints. García Espíndola et al. (2023) confirmed

CE innovation enhances sustainability but noted gaps in understanding mediating factors like market competition, especially in emerging economies.

Studies in Southeast Asia (Seewald et al., 2025; Nguyen et al., 2023) highlight that unsustainable resource extraction without green technology adoption fails to improve EP, whereas eco-design and clean production drive measurable gains. In Vietnam, SMEs adopting energy-saving techniques and by-product reuse have reported reduced emissions and improved efficiency (Nguyen et al., 2020). Additionally, sustainable logistics enhances supply chain performance (Genovese et al., 2017), though empirical validation in developing countries remains limited (Tjahjono et al., 2018).

Green consumption presents ongoing challenges. The attitude–behavior gap (Young et al., 2010), consumer distrust (Gupta & Ogden, 2009), and high perceived costs (Nishitani et al., 2021) undermine effectiveness. Papoikononmou et al. (2011) further noted that weak institutional support can discourage investment in green products. Meanwhile, resource recovery is crucial for achieving “Zero Waste” objectives (Geissdoerfer et al., 2017; Murray et al., 2017). In Vietnam, firms investing in wastewater recycling and by-product treatment have seen positive

environmental outcomes (Nguyen Thi Thu Ha & Nguyen Duc Hanh, 2020).

However, limited access to finance remains a critical barrier. Rizos (2016) and Leitner (2019) emphasized the lack of long-term capital and green financing as major constraints. Vietnamese studies (Nguyen Thi Hong Hanh, 2019; Le Thanh Hai & Nguyen Thi Kim Dung, 2022) further point to high interest rates and insufficient technical support.

Most prior studies assess CE practices in isolation or conceptually, lacking empirical evidence on the differential impact of each CE stage—especially in the SME context. This study addresses these gaps by empirically analyzing how distinct CE stages affect EP and by examining the moderating role of financial capacity in CE implementation among manufacturing SMEs in Vietnam.

3. Theoretical Framework and Research Methodology

3.1. Theoretical Framework

The adoption of CE practices within enterprises—particularly among SMEs—to enhance EP is grounded in several theoretical foundations. Firstly, the theory of sustainable development (WCED, 1987) emphasizes the balance among three pillars: economic, social, and environmental. CE serves to

operationalize the environmental pillar through recycling, reuse, and eco-design initiatives. Secondly, value chain theory (Porter, 1985) and sustainable supply chain management (Srivastava, 2007; Carter & Rogers, 2008) underscore the critical role of individual stages in production-ranging from design and procurement to manufacturing and reverse logistics-in shaping environmental outcomes. Tjahjono et al. (2018) extended this by identifying five CE loops: closing, slowing, narrowing, intensifying, and dematerializing.

In addition, the resource-based view (RBV) of the firm (Wernerfelt, 1984; Barney, 1991) posits that EP is contingent upon internal capabilities such as green technology adoption, recycling systems, and eco-design competence (Moreno et al., 2022; Genovese et al., 2017). Finally, organizational innovation theory (Schumpeter; Damanpour & Evan, 1984) highlights the role of adaptive capacity and innovation-oriented culture in fostering CE adoption and improving EP (García Espíndola et al., 2023). These theoretical perspectives not only inform the analytical framework of CE-related research but also provide a conceptual basis for explaining the relationship between CE practices and EP across organizational, value chain, and institutional levels.

3.2. Research Methodology

This study employed an online survey targeting owners and managers of manufacturing SMEs. The questionnaire consisted of three sections: (1) demographic and firm characteristics; (2) awareness of circular economy (CE) and perceived implementation challenges; and (3) current CE practices and environmental performance (EP). A non-probability convenience sampling method was used via email and social media from September to December 2024. Out of 656 responses collected, 598 valid cases were retained after screening based on Decree No. 80/2021/NĐ-CP.

CE practices and EP were measured using five-point Likert scales. Data analysis followed three stages: Step 1: Reliability testing using Cronbach's alpha; items below the threshold were removed. Step 2: Exploratory Factor Analysis (EFA) with Principal Component Analysis and Varimax rotation was used to assess construct validity. The KMO and Bartlett's tests confirmed sampling adequacy. Although the CE model with five stages (Take, Make, Distribute, Use, Recover) is theoretically grounded, the measurement items were adapted to fit the Vietnamese SME context-where empirical validation remains limited. Thus, EFA was preferred over CFA to explore whether the theoretical structure aligns with local data. Step 3:

Multiple linear regression was conducted to examine the impact of CE practices on EP. The model included five CE dimensions and one control variable (capital status):

$$EP = \beta_0 + \beta_1T + \beta_2M + \beta_3D + \beta_4U + \beta_5R + \beta_6CS + \varepsilon$$

where EP denotes environmental performance; T, M, D, U, and R represent the five CE dimensions-namely, sustainable resource extraction, production, distribution, consumption, and recovery-while CS (capital status) serves as a control variable.

Based on prior theory and CE logic, it is hypothesized that each CE component (T, M, D, U, R) is positively associated with EP.

To ensure stable parameter estimation, multicollinearity was checked using Variance Inflation Factor (VIF) and Tolerance, following Hair et al. (2010). All values met acceptable thresholds (VIF < 10; Tolerance > 0.10), confirming no violation of assumptions.

4. Results and Discussion

Table 1. Descriptive Statistics of General Characteristics of Enterprises

Characteristic	Quantity	Percentage (%)
Type of Enterprise		
Joint-Stock Company with State Capital Contribution	55	9.2
Joint-Stock Company without State Capital	272	45.5
Sole Proprietorship	28	4.7
Limited Liability Company (LLC)	242	40.5
Partnership	1	0.2
Total	598	100.0
Business Sectors		
Mechanical Engineering and Machinery Manufacturing	171	28.6
Agriculture, Forestry, and Aquaculture	59	9.9
Chemicals and Fertilizers	80	13.4
Packaging	58	9.7

Characteristic	Quantity	Percentage (%)
Construction Materials	124	20.7
Processing and Extraction	70	11.7
Textile and Garment	36	6.0
Total	598	100.0
Capital Status		
Inadequate capital	363	60.7
Sufficient capital	235	39.3
Total	598	100.0

Source: Author's SPSS analysis results

The survey sample consists of 598 Vietnamese manufacturing SMEs, primarily comprising non-state joint stock companies (45.5%) and limited liability companies (40.5%). This composition highlights the dominant role of the private sector-considered a pivotal force in advancing the CE model-in alignment with Vietnam's market-oriented development strategy. In terms of industry distribution, participating firms mainly operate in sectors such as mechanical engineering and manufacturing (28.6%), construction materials (20.7%), chemicals and fertilizers (13.4%), and resource extraction and processing (11.7%). These sectors are characterized by high levels of waste generation and heavy reliance on raw material inputs, indicating considerable potential for CE

implementation to enhance EP. Regarding capital scale, the majority of firms fall within the VND 11–50 billion range (52.7%), followed by those under VND 10 billion (19.9%) and those between VND 51–100 billion (27.4%). A total of 363 enterprises were identified as facing capital constraints. Despite financial limitations, this group plays an essential role in emission reduction, resource conservation, and the adoption of environmentally friendly production practices, thereby contributing to improved environmental sustainability at the local level. To assess the reliability of measurement scales, the study employs Cronbach's Alpha-a widely accepted metric for evaluating internal consistency in Likert-based instruments. According to Hair et al. (2009), a Cronbach's Alpha value of ≥ 0.6 and item-total correlations

of ≥ 0.3 are the threshold criteria for scale reliability; items not meeting these standards are excluded from further analysis.

The first stage of the CE model-sustainable resource extraction-was tested using four observed variables: T1, T2, T3, and T4. The initial Cronbach's Alpha for this scale was 0.834, exceeding the minimum requirement. After removing variables T1 and T2, the Alpha increased to 0.879, indicating a high level of internal consistency among the remaining items. For the second stage-sustainable production-four observed variables (M1 to M4) were proposed, focusing on dimensions such as waste-reducing process design, resource optimization, energy efficiency, and the adoption of renewable energy. The third stage-eco-friendly distribution-comprises three indicators (D1 to D3), capturing the extent to which firms optimize transportation, engage with sustainable suppliers, and use environmentally friendly packaging. The fourth stage-sustainable consumption-is represented by four variables (U1 to U4), covering product reusability, customer guidance on green consumption, user support, and ease of maintenance through design. Finally, the fifth stage-resource recovery and regeneration-is measured using four variables (R1 to R4), assessing policies for product take-back,

collaboration in recycling, product designs facilitating disassembly, and component reuse. The Cronbach's Alpha coefficients for the four remaining CE practice stages all exceeded the recommended threshold of 0.7, specifically: 0.773 for sustainable production, 0.784 for eco-friendly distribution, 0.891 for sustainable consumption, and 0.764 for resource recovery and regeneration. All observed variables reported item-total correlations above 0.3, and no items would increase the Alpha coefficient if deleted, thereby confirming both internal consistency and reliability of the measurement scales.

The dependent variable (EP)-was constructed to reflect the extent to which environmental sustainability goals are achieved, based on four indicators: EP1 (reduction in emissions and pollution), EP2 (resource savings attributable to CE practices), EP3 (positive environmental impact of products/services), and EP4 (compliance with regulations and adoption of eco-friendly treatment solutions). The Cronbach's Alpha for this scale was 0.853, exceeding the threshold suggested by Hair et al. (2009), with all item-total correlations meeting the required criteria. This demonstrates a high level of scale reliability for measuring EP.

In the next analytical phase, exploratory factor analysis (EFA) was

conducted to examine the structure of the independent variables. Principal component analysis with Varimax rotation was applied to enhance factor discrimination. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.834 (> 0.5), and Bartlett's test of sphericity was statistically significant (Sig. = 0.000 < 0.05), indicating that the data were suitable for factor analysis and that the variables exhibited sufficient linear correlations. Initial EFA results extracted five distinct factors, with a cumulative explained variance of 74.78%, indicating strong explanatory power of the model. Although some extracted components exhibited eigenvalues below 1, the post-rotation variance explained remained statistically meaningful. All observed variables demonstrated factor loadings greater than 0.5, confirming their

significant contributions to the respective factors. Specifically, Factor 1 included six items (U1–U4, M2, M4), representing sustainable production integrated with consumer behavior elements. Factor 2 encompassed R1–R4, reflecting resource recovery and regeneration. Factor 3 consisted of D1–D3, associated with eco-friendly distribution. Factor 4 comprised T3 and T4, capturing aspects of sustainable resource extraction. Lastly, Factor 5 contained M1 and M3, representing another dimension of sustainable production. The emergence of two distinct factors under the theme of sustainable production reflects the multidimensional nature of CE-related perceptions and practices within SMEs—an issue that will be further explored in subsequent analyses.

Table 2. Rotated Factor Matrix of Independent Variable Groups

Variable	Factor				
	1	2	3	4	5
M4: The company uses renewable energy sources.	0.921				
U2: The company provides information to guide customers on how to use environmentally friendly products.	0.888				
U1: The company's products/services are designed to have a longer lifespan or be reusable	0.853				

Variable	Factor				
	1	2	3	4	5
U3: The company implements programs to support customers during usage.	0.822				
U4: The company considers the ease of repair and replacement of components when designing products	0.804				
M2: The company optimizes production and business processes to minimize waste and use resources efficiently	0.731				
R3: The company designs products that are easy to disassemble for recycling purposes.		0.846			
R1: The company has a policy for retrieving used products for recycling or reuse.		0.784			
R4: The company reuses or recycles parts and components from used products.		0.773			
R2: The company collaborates with partners to handle and recycle waste.		0.721			
D1: The company optimizes the transportation process to save fuel and reduce emissions.			0.878		
D3: The company has an environmentally friendly packaging policy.			0.835		
D2: The company collaborates with suppliers who have sustainability criteria.			0.731		
T3: The company considers environmental factors related to storage within the manufacturing plant.				0.926	
T4: The company considers environmental factors during transportation within the manufacturing plant.				0.911	
M1: The company considers process design in production to reduce waste.					0.783

Variable	Factor				
	1	2	3	4	5
M3: The company develops effective conservation initiatives to reduce energy consumption.					0.759
Eigenvalue	5.399	2.949	1.910	1.501	0.954
Extracted variance	4.624	2.556	2.171	1.792	1.569

Source: Author's SPSS analysis results

Assessing the Impact of the Circular Economy Model on Sustainable Development in Vietnamese Manufacturing SMEs from the Perspective of EP

Table 3. Multiple Regression Results of Circular Economy

Model Factors Affecting EP

Variable/Statistic	B	SE	β	t	p	Tolerance	VIF
Constant	1.165	.111		10.504			
Take	-.019	.022	-.018	-.861	.390	.840	1.191
Make	.127	.023	.162	5.613	0.000 ***	.451	2.219
Distribute	.870	.025	.735	35.309	0.000 ***	.872	1.147
Use	-.258	.020	-.386	-12.990	0.000 ***	.428	2.337
Recover	.059	.018	.073	3.267	0.001 ***	.749	1.335
Capital status (Sufficient capital)	.056	.033	.037	1.682	.093*	.799	1.252

Dependent variable: EP. *p < .05, **p < .01, ***p < .001.

Model Summary: R² = .777, Adjusted R² = .775, Durbin – Watson = 1.667

F(6, 591) = 343.106, p < .001

To examine the relationship between CE practices and EP, a multiple linear regression model was constructed with six independent variables: sustainable resource extraction, sustainable production, eco-friendly distribution, sustainable consumption, resource recovery and regeneration, and capital adequacy. The results indicate a strong correlation between the independent variables and EP, with an R value of 0.881. The coefficient of determination $R^2 = 0.777$ and the adjusted $R^2 = 0.775$ suggest that the model explains approximately 78% of the variance in the dependent variable. The standard error of the estimate (SEE) was 0.36062, indicating relatively high predictive accuracy. The Durbin–Watson statistic was 1.667, within the acceptable range, confirming the absence of significant autocorrelation in the residuals. Moreover, multicollinearity diagnostics using Variance Inflation Factor (VIF) and Tolerance values showed no violations. All VIF values were below 2.5, with the lowest being under 1.4 and the highest-“Sustainable Consumption”-at 2.337, well within the safe threshold suggested by Hair et al. (2010). All Tolerance values were greater than 0.2, with the lowest being “Sustainable Production” (0.451), confirming a reasonable degree of independence among explanatory

variables. Overall, the regression model demonstrated strong goodness-of-fit, low error terms, and no violation of fundamental assumptions, providing a robust foundation for further analysis of the individual effects of CE components on EP. The ANOVA results yielded an F-value of 343.106 with a significance level of 0.000 ($p < 0.05$), confirming that the overall regression model is statistically significant. This result allows for the rejection of the null hypothesis (H_0) in favor of the alternative (H_1), affirming that at least one independent variable significantly influences EP. The high F-value and near-zero p-value demonstrate the model’s statistical power in prediction. Combined with R^2 and other diagnostic indicators, the model can be considered both valid and reliable for assessing the environmental impact of CE practices.

However, the variable “resource extraction” was found to be statistically insignificant, indicating that this activity does not contribute positively to environmental performance within the scope of the study. This result aligns with the findings of Seewald et al. (2025) and Nguyen et al. (2023), which highlight that uncontrolled exploitation, outdated technology, and the absence of green standards fail to improve environmental indicators. Within the CE framework, resource extraction is only effective when

it promotes reuse and regeneration. Nevertheless, in many localities, linear thinking and inadequate oversight remain prevalent. Furthermore, environmental impacts often exhibit a time lag, while this study relies on short- and medium-term data, which may not fully capture such effects in the quantitative results.

In contrast, “Sustainable Production” demonstrated a significantly positive impact on EP, consistent with prior studies by Geissdoerfer et al. (2017), the Ellen MacArthur Foundation (2013), and Nguyen et al. (2020). Environmentally friendly production practices, such as by-product reuse and energy efficiency, enhance environmental outcomes for SMEs. With appropriate policy and technological support, this represents a strategic pathway in Vietnam’s green transition.

“Green Distribution” emerged as the most influential factor, underscoring the role of sustainable logistics in emission reduction and energy savings. Supporting studies by Genovese et al. (2017) and Tjahjono et al. (2017) also emphasize that sustainable distribution is a key element of the circular economy. Although Vietnamese SMEs face investment limitations in logistics, this phase holds substantial potential for improvement with adequate support.

Contrary to expectations, “Sustainable Consumption” exerted a significantly negative impact on EP. This result reflects common barriers such as the attitude–behavior gap (Young et al., 2010), consumer skepticism (Gupta & Ogden, 2009), high costs of green products (Nishitani et al., 2021), and limited institutional support (Papaoikonomou et al., 2011). Moreover, open-ended responses from SMEs indicate practical challenges including unclear usage guidance, difficulty in product repair or reuse, and a lack of recognized green product standards. These obstacles reduce the effectiveness of green consumption efforts in practice. The findings suggest that policy approaches should move beyond awareness-raising and toward stronger institutional mechanisms that promote product lifecycle responsibility and shared engagement between producers and consumers.

The variable “Resource Recovery and Regeneration” showed a positive but relatively modest effect. While this is consistent with findings by Geissdoerfer et al. (2017) and Murray et al. (2017), recycling practices among Vietnamese SMEs remain limited due to technological, financial, and policy barriers. Domestic studies (Nguyen Thi Thu Ha & Nguyen Duc Hanh, 2020; Tran Van Hoa et al.,

2021) also indicate that recycling reduces emissions and treatment costs while generating secondary input materials. However, to maximize its potential, a coordinated support system in terms of technology, policy, and resources is essential for SMEs.

Lastly, the variable “Financial Capacity” reached only marginal statistical significance at the 10% level, indicating that although financial stability is necessary, its influence remains unclear in the current context. This contradicts international findings such as Rizos et al. (2016) and Leitner et al. (2019), which emphasize the critical role of long-term capital and green finance. The divergence may reflect the Vietnamese context, where SMEs often prioritize short-term goals and lack motivation for green investment. While local studies (Nguyen Thi Hong Hanh, 2019; Le Thanh Hai & Nguyen Thi Kim Dung, 2022) identify finance as a major barrier, Trinh Thi Thuy & Pham Quoc Khanh (2021) argue that limited market and policy incentives also play a role. In summary, financial capacity can only yield environmental benefits when paired with strategic vision and comprehensive institutional support.

5. Conclusion

This study provides empirical evidence on the varied impacts of CE

practices across implementation stages on the environmental pillar of sustainable development in Vietnamese SMEs. The results show that sustainable production, eco-friendly distribution, and resource recovery positively influence EP, with production-reflecting process innovation-being the most prominent, as firms increasingly adopt cleaner technologies and improve energy efficiency. Distribution and recovery reinforce the importance of supply chain optimization and material reclamation in CE models. Conversely, sustainable consumption negatively affects EP, indicating challenges in product life-cycle management and limited mechanisms for post-use recovery. Meanwhile, resource extraction shows no significant effect, reflecting persistent reliance on linear inputs and lack of circular innovation. Financial assurance appears marginally significant, suggesting that financial capacity may enable more effective CE adoption. These findings offer key implications for SMEs. Internally, firms should invest in clean technologies, adopt circular logistics strategies, and improve product design for durability and reuse. Externally, enhancing customer engagement and building financial readiness-through internal planning or green financing-are critical to supporting CE transitions.

Overall, CE implementation in Vietnamese SMEs remains uneven and primarily inward-looking. Future studies should adopt sector-specific approaches

and consider mediators such as consumer behavior, green finance, and institutional support to better embed CE into sustainable business strategies.

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