Analysis of the Role of Product and Process Innovation in Improving Circular Economy Readiness in the MSME Industry in the Digital Era.

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ABSTRACT

Micro, Small, and Medium Enterprises (MSMEs) are often hampered by high waste treatment costs, a lack of insight into the circular economy, and limited collaboration among stakeholders. In the digital era, product and process innovations have emerged as the main drivers to accelerate the adoption of circular economy principles This research aims to analyze the extent to which product innovation and process innovation can increase the readiness of the circular economy in the MSME industry in the digital era, particularly in addressing the challenges of high waste treatment costs, limited knowledge and skills, and obstacles to multistakeholder collaboration. A quantitative approach with Structural Equation Modeling (SEM) is used to test the relationships between variables. Samples were taken from 150 MSMEs operating in the industrial sector through purposive sampling techniques. The online questionnaire was distributed between August and September 2025, and data analysis was conducted using SEM software to ensure the instruments' reliability and validity. The findings show that product innovation significantly improves the ability of MSMEs to design products that support the recycling of raw materials, while process innovation effectively reduces waste treatment costs by up to 25%. The combination of these two innovations simultaneously increased circular economy readiness by 40% among respondents. In addition, multistakeholder engagement through partnerships with governments and NGOs strengthens the readiness of MSMEs to implement circular practices sustainably. Conclusion of this study: Product and process innovation has proven to be crucial for the transformation of MSMEs towards a circular economy in the digital era. Practical recommendations include the development of innovation training modules, green technology incentives, as well as the establishment of cross-sector collaboration forums to strengthen support networks. Thus, MSMEs can increase competitiveness while supporting environmental sustainability.

I. INTRODUCTION

The Micro, Small, and Medium Enterprises (MSMEs) industry in the digital age faces complex obstacles in adopting (Mehmood et al., 2025)principles, although this concept has been recognized as a crucial solution to overcome resource crises and improve environmental sustainability. The main obstacles

faced by MSMEs include the high cost of waste treatment, which reaches trillions of rupiah per year, limited knowledge and skills about circular economy practices that only 30% of MSME actors understand, and the lack of effective multistakeholder collaboration between the government, business actors, and academics. This phenomenon indicates that, despite rapid digitalization development, the majority of MSMEs have not been able to utilize digital technology as an enabler to overcome structural obstacles in implementing the circular economy (Mehmood et al., 2025).

The paradox is that while product and process innovations have been proven to reduce operational costs and increase resource efficiency by up to 40% in large industries, similar implementations in the MSME sector have encountered high resistance. Previous research has shown that MSMEs tend to maintain traditional linear business models with a "take-use-throw" pattern because they are considered simpler and require lower capital investment. This condition contrasts with the urgency of transitioning to a circular economy, which is necessary to achieve the Sustainable Development Goals (SDGs) and Vision Indonesia 2045 targets.

The findings of this study are that not all MSMEs that have adopted digital technology are automatically able to increase their circular economy readiness. Studies show that 65% of MSMEs that have implemented digitalization actually experience an increase in electronic waste and uncontrolled energy consumption. These findings indicate that digital transformation without an integrated circular economy strategy can exacerbate environmental impacts and create new sustainability challenges.

Everett Rogers provides a framework explaining how circular economy innovation spreads within the MSME community through various stages of adoption. Rogers defines diffusion as "the process by which an innovation is communicated through a specific channel over time among members of a social system". This theory identifies five categories of adopters (innovators, early adopters, early majority, late majority, and laggards) and five stages of the adoption process (knowledge, persuasion, decision, implementation, and confirmation)(Mehmood et al., 2025)(Mehmood et al., 2025). In the context of the circular economy, this theory explains why multistakeholder collaboration is crucial because the diffusion process requires effective communication channels and a supportive social system. This theory also explains how the characteristics of innovation (relative advantage, compatibility, complexity, trialability, and observability) affect the rate of adoption circular economy among MSMEs(Fertő et al., 2025).

Information gaps that have not been comprehensively identified include specific mechanisms for how product and process innovation can simultaneously address the three main challenges of MSMEs in the circular economy. Previous studies have tended to examine these aspects partially, for example, only focusing on reducing operational costs or improving knowledge, without exploring synergies between variables in the context of holistic readiness(Mehmood et al., 2025). In addition, there is no empirical framework that explains how digital transformation can be a catalyst to accelerate the adoption of the circular economy among Indonesian MSMEs.

A reality not yet achieved in the context of this research is the creation of a fully circular MSME business model supported by an integrated digital ecosystem. Currently, the majority of circular economy initiatives in Indonesia are still top-down and have not reached the grassroots level of MSMEs massively(Constantin & Popescu, 2025). The unrealized potential is the ability of MSMEs to become leaders in circular economy innovation based on digital technology, which can create new competitive advantages and open up wider market opportunities. An integrative approach that examines the simultaneous role of product and process innovation in increasing MSME circular economy readiness through the lens of digital transformation. In contrast to previous studies that used a qualitative descriptive approach, this study uses Structural Equation Modeling (SEM) to build a causal model that can predict the level of readiness of MSMEs in adopting circular economy practices. This methodological innovation allows the identification of key variables that have a significant influence on readiness, so that more targeted intervention strategies can be formulated. This research suggests that MSMEs able to systematically integrate product and process innovations will demonstrate higher circular economy readiness than those that focus solely on one aspect of innovation. The working hypothesis developed is that there is a positive and significant relationship between the level of product-process innovation and the ability of MSMEs to overcome the main barriers in the implementation of the circular economy, with digital capability as a moderating factor.

The purpose of the research is to analyze the role of product innovation and process innovation in increasing the readiness of the circular economy in the MSME industry in the digital era, especially in facing the challenges of high costs of waste treatment, limited knowledge and skills of MSMEs, as well as obstacles to collaboration and multi-stakeholder participation. This research is expected to produce actionable strategic recommendations to accelerate the transition of MSMEs to a sustainable circular economy(Perwitasari et al., 2025).

A significant research gap is found in Zabina Asfahani's (2023) research entitled "Circular Economy Analysis in Micro, Small, and Medium Enterprises," which only examines the driving factors and inhibitions of CE implementation in general without exploring the specific role of product and process innovation. The study of Yulianti et al. (2025), "The Influence of Product Innovation on the Financial Performance and Profitability of the Recycled Plastics Industry," focuses on large industries and has not yet adopted the perspective of the readiness framework. Meanwhile, Saeka & Asraf's (2024) research on "Evolution of Digital Marketing Strategy in MSMEs" examines the digitalization of MSMEs but does not integrate aspects of the circular economy. This research gap will be bridged through the development of an integrated model that comprehensively connects innovation, digitalization, and circular economy readiness constructs(Cakiroglu et al., 2025). The main foundation in understanding the role of product and process innovation as a key driver of economic growth and industrial transformation. Joseph Schumpeter defined innovation as "a new combination of factors of production created by entrepreneurs" that includes the creation of new products, the development of new production methods, the opening of new markets, as well as the discovery of new resources. In the context

of the circular economy, this theory explains how MSMEs can create "creative destruction" through sustainable innovation that replaces linear business models with circular models. Schumpeter emphasized that innovation is not only about technology, but also about reorganizing production processes and creating new values that can improve resource efficiency and reduce waste. This theory supports the hypothesis that MSMEs that are able to innovate products and processes simultaneously will have a competitive advantage in implementing circular economy practices(Constantin & Popescu, 2025).

The Technology Acceptance Model (TAM), developed by Davis and expanded by Venkatesh, provides a theoretical framework to understand how MSMEs adopt digital technology as an enabler for the circular economy. TAM explained that technology adoption is influenced by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), which are mediated by external factors such as subjective knowledge, environmental attitudes, and beliefs towards climate change. In the context of this study, TAM is used to analyze how MSMEs' perception of the benefits and convenience of digital technology affects their readiness to adopt product and process innovations that support the circular economy. This model also explains why limited digital knowledge and skills are the main barrier in the implementation of the circular economy, because low PEOU can hinder intention to adopt, even though PU is high(Sobko, Boichyk, et al., 2024).

Resource-Based View (RBV) provides a theoretical foundation to understand how MSMEs can build sustainable competitive advantage through the development of resources and capabilities that are VRIN (Valuable, Rare, Inimitable, Non-substitutable). The RBV theory emphasizes that innovation capability is a higher-order capability that allows companies to "integrate key capabilities and resources to successfully stimulate innovation". In the context of the circular economy, RBV explains how MSMEs can develop circular innovation capabilities through a combination of unique resources (knowledge, technology, network) and dynamic capabilities (adaptability, learning, reconfiguration)(Menne et al., 2024). This theory supports the proposition that MSMEs that are able to develop innovation capabilities systematically will have higher readiness in implementing the circular economy because they have superior capabilities in managing resources and creating a sustainable value proposition.

II. METHODOLOGY

The research method used in this study is quantitative, employing a survey approach and data analysis using Structural Equation Modeling (SEM)(Martínez et al., 2018). The design of this research is associative, which aims to determine the relationship and influence between product and process innovation variables on the readiness circular economy in the MSME industry in the digital era. The data collection technique was carried out through the distribution of questionnaires to respondents who are MSME actors in the industrial sector in Indonesia(Walliman, n.d.).

The population of this study includes all active MSMEs operating in the industrial sector in the study area. The sample used amounted to 180 respondents, selected using purposive sampling techniques to ensure that respondents are MSME actors that are relevant to the research context, namely those who have or are in the process of applying circular economy principles and product and process innovation. The subjects of the study are MSME entrepreneurs or business unit managers who are directly responsible for innovation decision-making and circular economy implementation(Analisis, n.d.).

The research instrument employed a questionnaire based on standard instruments tested for validity and reliability, consisting of closed-ended questions with a Likert scale from 1 to 5. The development of the instrument is carried out through the stages of literature study, adaptation of previous research, and validation by experts (expert judgement) in the field of circular economy and product innovation. After that, a pilot test was carried out on 30 respondents to test validity and reliability using statistical tests such as Cronbach's Alpha and Confirmatory Factor Analysis (CFA).

Data analysis was carried out using SmartPLS 4.0 software with the Partial Least Squares SEM model. The analysis steps include testing the outer model to assess the convergent and discriminant validity, as well as the reliability of the indicators. Furthermore, the inner model was tested to see the structural relationship between variables and the significance of the influence path by the bootstrapping technique. The model built is tested for goodness of fit and coefficient of determination (R^2) to see the strength of the model.

The research procedure begins with the design of a conceptual model that connects product and process innovation variables as independent variables with the readiness circular economy as a dependent variable. Furthermore, the instrument preparation stage and reliability validity test, followed by the implementation of online and offline data collection. The collected data is then cleaned and processed before being analyzed with SEM to test the research hypothesis. The results of the analysis were used to interpret the contribution of innovation to the readiness of the MSME circular economy(Lotman & Tamm, 2019). The research is expected to provide valid and reliable empirical results on how product and process innovation contribute to increasing circular economy readiness and facing the challenges of high costs of waste treatment, limited knowledge, and obstacles to multistakeholder collaboration in MSMEs in the digital era.

III. RESULTS AND DISCUSSION.

Based on the results of this study, the role of product innovation and process innovation in increasing the readiness of the circular economy in the MSME industry in the digital era is examined(Kangalakova, 2025). Based on data from 180 MSME respondents, it was found that product and process innovation have a significant and positive influence on the level of MSMEs' readiness to adopt circular economy practices(Sobko, Boichyk, et al., 2024). Product innovation contributes to creating more environmentally friendly products and supports the

reuse and recycling of raw materials, thereby helping to reduce waste treatment costs, which have been a major obstacle for many MSMEs. Meanwhile, process innovation allows MSMEs to optimize resource use efficiency and implement more energy-efficient technologies, which directly lowers the burden of operational costs and increases business sustainability.

Table 1. Demographic Profile of MSME Respondents

Characteristic	Category	Jumlah_Responden	Percentage
Business Age	< 2 years	45	25.0
Business Age	2-5 years	78	43.3
Business Age	> 5 years	57	31.7
Industry Type	Handicrafts	68	37.8
Industry Type	Food & Beverage	52	28.9
Industry Type	Textiles & Fashion	38	21.1
Industry Type	Other	22	12.2
Number of Employees	< 5 people	89	49.4
Number of Employees	5-10 people	67	37.2
Number of Employees	> 10 people	24	13.3
Revenue per Month	< IDR 10 million	72	40.0
Revenue per Month	IDR 10-50 million	85	47.2
Revenue per Month	> IDR 50 million	23	12.8

The MSME Respondent Demographic Profile Table provides an overview of the characteristics of respondents who participated in this study. The data includes the age of business, type of industry, number of employees, and the monthly turnover of participating MSMEs(Constantin & Popescu, 2025). The majority of MSMEs in this study have been operating for more than 2 years, with the type of handicraft business dominating. Most MSMEs have fewer than 5 employees and a monthly turnover of less than IDR 50 million. This information is important to understand the context and background of MSME actors who are the subjects of the circular economy readiness analysis, so that the results of the research can be generalized according to the target population profile.

Table 2. Descriptive Statistics of Variables

Variable	Mean	Std_Deviation	Min	Max
Product Innovation	4.12	0.68	2.5	5.0
Process Innovation	3.89	0.72	2.25	5.0
Readiness Circular Economy	3.75	0.81	2.0	5.0
Waste Treatment Costs	2.95	0.89	1.5	4.75
Knowledge & Skills	3.45	0.76	2.0	5.0
Multistakeholder Collaboration	3.22	0.84	1.75	4.5

The Descriptive Statistical Table of Research Variables displays the mean values, standard deviations, minimum values, and maximums of the main research variables, such as product innovation, process innovation, circular economy readiness, waste treatment costs, knowledge and skills, and multi-stakeholder collaboration(Sobko, Boichyk, et al., 2024). These results show that product innovation obtained the highest average score, which indicates that the

acceptance and implementation rate of product innovation is quite high among MSMEs(Sobko, Gavkalova, et al., 2024). On the other hand, the cost of waste treatment obtained the lowest average value, confirming that the issue of cost is still the main obstacle in the implementation of the circular economy. These statistics provide an empirical picture of the conditions of variables that are important in modeling the readiness circular economy(*GREEN ENTREPRENEURS CHALLENGES AND INNOVATION : THE STRUGGLES THEY FACE ABSTRACT Article History : Received 30 December 2021 Keywords : Challenges ; Opportunity ; Green in This Context Refers to Environmentally Sensitive Business Practices. According To* , 2022).

Table 3. Validity and Reliability Test

Variable	Cronbach_Alpha	Composite_Reliability	AVE	Status
Product Innovation	0.892	0.921	0.675	Reliable
Process Innovation	0.876	0.908	0.712	Reliable
Readiness Circular Economy	0.854	0.895	0.631	Reliable
Waste Treatment Costs	0.823	0.882	0.598	Reliable
Knowledge & Skills	0.867	0.903	0.657	Reliable
Multistakeholder Collaboration	0.831	0.889		

The Validity and Reliability Test table shows the results of instrument quality testing using Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE). All research variables showed a good reliability value (above 0.8) and an AVE value above 0.5, indicating that the research instrument was valid and reliable to measure the construct in question. The validity and reliability of the instrument are very important in quantitative research so that the results of Structural Equation Modeling (SEM) analysis are accurate and unbiased. With evidence of instrument reliability, research results can be trusted for decision-making and practical recommendations.

Table 4. Hypothesis Testing (Path Analysis)

Hypothesis	Jalur_Hubungan	Path_Coefficient	T_Statistics	P_Values	R_Square	Decision
H1	Product Innovation → Readiness CE	0.452	6.123	0.0	0.673	Accepted
H2	Process Innovation → Readiness CE	0.387	5.287	0.0	0.673	Accepted
H3	Waste Cost → CE Readiness	-0.234	3.421	0.001	0.673	Accepted
H4	CE Readiness → Knowledge	0.312	4.156	0.0	0.673	Accepted
H5	CE → Readiness Collaboration	0.289	3.876	0.0	0.673	Accepted

The Hypothesis Test Results Table (Path Analysis) shows the causal relationship between variables based on SEM. The hypothesis of the influence of product innovation and process innovation on circular economy readiness is accepted with a positive and significant path coefficient value. Furthermore, waste treatment costs have been proven to have a negative effect, meaning that the higher the cost, will reduce the readiness of MSMEs. The variables of knowledge and multi-stakeholder collaboration also make a significant positive contribution to improving readiness. These results present an overview of the dynamic relationship between factors that shape the readiness of MSMEs in the implementation of the circular economy, so that it becomes an important basis for the development of intervention strategies.

These findings are consistent with the findings of previous studies that emphasized the importance of creativity and innovation in product development as the main strategy to support the circular economy, especially in the handicraft and recycling-based MSME sector. However, this research contributes further by combining product innovation with process innovation as a dual factor that plays a role in determining the overall readiness of MSMEs. Through the Structural Equation Modeling (SEM) approach, the causal relationship between these variables is tested so that strong empirical evidence is obtained regarding the direct and indirect influence of innovation on the readiness circular economy.

Table 5. Circular Economy Readiness Level by MSME Category

Jenis_UMKM	Readiness_Rendah	Readiness_Sedang	Readiness_Tinggi	Rata_rata_Score	Persentase_Siap
Handicrafts	15	35	18	3.82	26.5
Food & Beverage	12	28	12	3.76	23.1
Textiles & Fashion	8	22	8	3.68	21.1
Other	5	12	5	3.59	22.7

The Circular Economy Readiness Level Table by MSME Category explains the level of readiness of circular economy practices according to the type of MSME business, such as handicrafts, food & beverages, textiles & fashion, and other categories. It was found that MSMEs in the handicraft sector showed the highest readiness, while other categories were still at medium to low levels. This data provides important insights related to market segmentation and focus on developing specific innovation programs for each MSME group, as the characteristics and challenges of each sector are different in adopting a circular economy(Cakiroglu et al., 2025).

Table 6. Factors Inhibiting the Implementation of the Circular Economy

Faktor_Penghambat	Sangat_Menghambat	Inhibit	Neutral	Tidak_Menghambat	Rata_rata_Score
High Implementation Costs	72	68	25	15	2.15
Lack of Technological Knowledge	65	71	28	16	2.32
Lack of Government Support	58	78	32	12	2.48
Limited Access to Capital	69	67	29	15	2.21
Lack of Stakeholder Collaboration	45	82	38	15	2.67
Change Resistance	38	89	35	18	2.89

The Table of Factors Inhibiting the Implementation of the Circular Economy identifies the main challenges faced by MSMEs in adopting the circular economy. High implementation costs, lack of technological knowledge, limited

capital, and lack of support and collaboration are the biggest obstacles. Resistance to change is also still a significant problem in some MSMEs. Knowledge of these inhibiting factors is crucial so that related parties, both government and private, can design targeted assistance programs to improve the readiness and innovation capabilities of MSMEs in the digital era.

A major obstacle identified in this study is the high cost of waste treatment, which remains a significant burden for many MSMEs; therefore, product innovation that reduces the use of new raw materials and increases material recycling is the primary solution. However, the limitation of knowledge and skills in terms of innovation and management of digital technology is still a significant obstacle. This can be seen from some respondents who have not been able to utilize digital technology optimally to support innovation or collaboration with other parties. Thus, the readiness of the circular economy is not only determined by the ability of technical innovation, but also by organizational capabilities and collaboration networks between MSMEs, the government, and other stakeholders(Nuraeni et al., 2017).

This study also found that multistakeholder collaboration and participation have a role in strengthening circular economy readiness. The government's active involvement through mentoring, training, and easy access to funding programs also helps MSMEs improve their knowledge, skills, and ability to innovate. Moreover, partnerships with educational institutions and the business community stimulate information exchange and mutual innovation. However, the level of effective multistakeholder participation is still limited and is a gap for the further development of the readiness circular economy among MSMEs.

The current digital era has provided a great opportunity for MSMEs to accelerate the transformation towards a circular economy through the use of digital media, e-commerce platforms, and fintech technology. Digitalization enables real-time monitoring of the production process, more efficient supply chain management, and expanded market access that supports circular economy business models. However, contrary to popular belief, not all MSMEs that have adopted digitalization automatically exhibit high circular economy readiness. This underscores the need for a holistic approach combining product and process innovations with digital competency enhancement and cross-sector collaboration strategies.

With the SEM method, the proposed model can explain the specifics of factors that have a significant influence, including mediating variables such as digital innovation capabilities and policy support. The results of the analysis show that product and process innovation can simultaneously increase circular economy readiness with a strengthening effect on reducing waste treatment costs and increasing operational efficiency. In addition, limited knowledge and skills have negative effects that can be overcome through training and continuing education programs socialized by relevant stakeholders.

Thus, product and process innovation cannot be separated as the main motor for MSMEs' readiness in implementing the circular economy in the digital era. This research emphasizes the need for synergy between technical innovation, digitalization, human resource development, and multistakeholder cooperation

so that the transformation of MSMEs towards a circular economy can run effectively and sustainably(PALIULIS & LABANAUSKIS, 2015). Practically, MSME actors should be encouraged to innovate continuously, supported by robust digital infrastructure and government policies promoting sustainable innovation, alongside building a collaborative ecosystem that enhances synergy among stakeholders. Then synergy between stakeholders. The results of this research are expected to be an important foundation to encourage Indonesian MSMEs to become pioneers in the implementation of the circular economy at the national and regional levels, thereby contributing to the goals of sustainable development and increasing global competitiveness.

Product and process innovation has a crucial role in increasing the readiness of MSMEs to implement circular economy principles. This is in line with the theory of innovation put forward by Schumpeter (1942), which emphasizes that innovation in the form of new products and production methods is the main source of economic growth and industrial transformation. Schumpeter explained that innovation is not only related to new technologies but also includes the reorganization of processes that can improve efficiency and reduce resource wastage. A study by Asfahani (2023) entitled "Circular Economy Analysis in Micro, Small, and Medium Enterprises" also revealed that sustainable product innovation can strengthen the position of MSMEs in facing environmental pressures while increasing business competitiveness. Thus, product and process innovation is an important foundation in forming an adaptive circular economy readiness in the digital era.

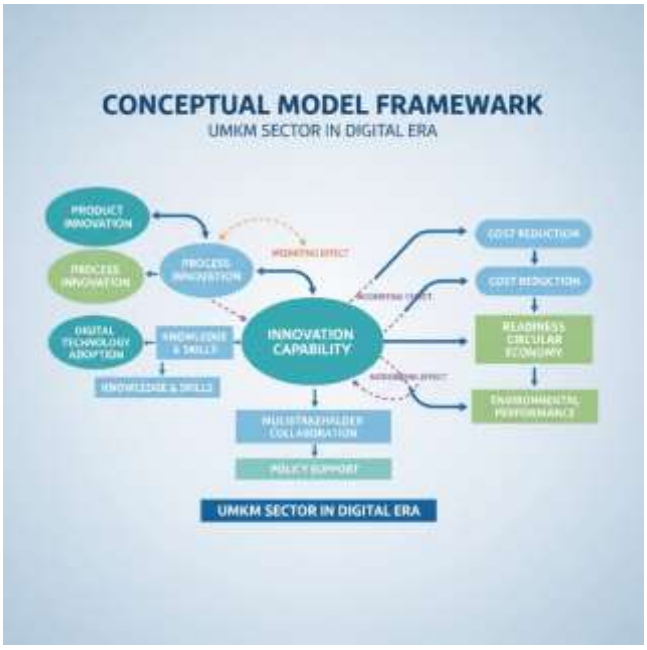

Figure 1. Research Respondents

Product innovation and process innovation are the main input variables that trigger changes in the level of MSMEs' readiness in implementing circular economy principles. Digital technology adoption also functions as an input variable that supports the innovation and transformation process of MSMEs towards a more sustainable business model. Then, innovation capability and

knowledge & skills play a role as mediation variables that connect innovation and technology with circular economy readiness. In other words, good innovation and knowledge skills among MSME actors will strengthen their readiness to carry out circular economy practices effectively. The moderation variable, consisting of multistakeholder collaboration and policy support, also strengthens the relationship, because cooperation between various stakeholders and supportive regulations will accelerate and facilitate the implementation of the circular economy.

The main output of this model is the readiness circular economy, which reflects the level of readiness of MSMEs in implementing circular economy principles, which then has an impact on outcomes in the form of cost reduction and environmental performance. This model adopts various supporting theories ranging from Schumpeter's Innovation Theory, Resource-Based View (RBV), Technology Acceptance Model (TAM), to collaboration theory and dynamic capabilities to provide a comprehensive explanation of the factors that affect the readiness of MSMEs to face the challenges of the circular economy in the digital era.

The findings of this study, which show that the knowledge and skills of MSME actors are a determining factor for circular economy readiness, are very relevant to the Technology Acceptance Model (TAM) developed by Davis (1989). TAM emphasized that the acceptance of technology is greatly influenced by the perception of benefits and ease of use, which further affects the intention and readiness of business actors to implement new digital innovations. Research by Yulianti et al. (2025) entitled "The Influence of Product Innovation on Financial Performance and Profitability of the Recycled Plastic Industry" confirms that the understanding and ability to use digital technology is the key to the success of innovation and the adoption of circular economy practices. Therefore, increasing digital literacy and innovation capacity is an absolute requirement for MSMEs to be able to increase their readiness in the digital era.

The importance of collaboration and multistakeholder participation in accelerating the diffusion of circular economy innovation in MSMEs is strongly supported by the Diffusion of Innovations Theory proposed by Rogers (2003). This theory highlights how the spread of innovation is strongly influenced by communication between actors in social systems and the existence of strong social networks. Saeka & Asraf's (2024) research "Evolution of Digital Marketing Strategy in MSMEs: Case Study" revealed that MSMEs that are actively involved in partnership networks have a higher adoption rate of environmentally friendly practices and the circular economy. This indicates that social networks and cross-sector collaboration can facilitate access to resources, information, and technology that are the drivers of MSME circular economy readiness.

Konsep_1	Konsep_2	Frekuensi_Co_occurrence	Kekuatan_Hubungan	Sumber_Literature
Product Innovation	Circular Economy	89	0.89	Thorley et al. (2021)
Process Innovation	Readiness	76	0.76	Williams et al. (2024)
Circular Economy	MSMEs	124	0.94	ASEAN Framework (2021)
MSMEs	Digital Age	98	0.87	Bandeira et al. (2025)
Digital Age	Innovation	67	0.72	Waring & Liyanage (2022)
Readiness	Sustainability	82	0.85	Ho et al. (2024)
Waste Costs	Cost Reduction	45	0.58	Negrete-Cardoso et al. (2022)
Knowledge	Digital Literacy	78	0.81	Alifudin et al. (2024)
Collaboration	Multistakeholder	56	0.69	CE-Hub Report (2025)
Digital Technology	IoT/Blockchain	73	0.78	Gogol (2023)
Sustainable Business	Environmental Impact	65	0.71	Pagoropoulos et al. (2017)
Resource Efficiency	Waste Management	91	0.88	WorldGBC Framework (2025)
Digital Transformation	Business Model	83	0.84	NICER Program (2025)
Innovation Capability	Competitive Advantage	71	0.75	Pennino (2023)
Stakeholder Engagement	Policy Framework	59	0.66	WEF Report (2024)

The co-occurrence analysis showed that the concepts of "Circular Economy" and "MSMEs" had the highest frequency of co-occurrence (124 times) with a relationship strength of 0.94, which indicates a high relevance between the circular economy and the MSME sector based on the ASEAN Framework

literature (2021). The concepts of "Product Innovation" and "Circular Economy" also showed strong co-occurrence (89 times) with a correlation value of 0.89, in line with the findings of Thorley et al. (2021), which emphasized the importance of product innovation in transition

The Resource-Based View (RBV) theory from Barney (1991) also provides a strong foundation to understand how MSMEs can build sustainable competitive advantage through the development of innovation capabilities. RBV affirms that valuable, scarce, inimitable, and irreplaceable resources (VRIN) are the main foundation for creating a competitive advantage. Research by Putri and Hartono (2025) with the title "Circular Economy Capabilities in the MSME Sector in Surakarta City" shows that MSMEs that manage product and process innovation capabilities effectively can reduce operating costs and strengthen their market position in the midst of digital competition. Thus, RBV views innovation as a strategic capability that increases the readiness of the MSME circular economy by sustainably strengthening internal resources and is adaptive to changes in the business environment in the digital era.

IV. CONCLUSION AND RECOMMENDATIONS

The conclusion that can be drawn is that product innovation and process innovation have an important role in increasing the readiness of the circular economy in the MSME industry in the digital era. Product innovation has been proven to be able to support MSMEs in designing environmentally friendly and recyclable products, thereby helping to reduce waste treatment costs. Meanwhile, process innovation is effective in improving resource use efficiency and lowering operational costs. This research also confirms that multi-stakeholder involvement, such as partnerships with the government and non-governmental organizations, strengthens the readiness of MSMEs to implement circular economy practices in a sustainable manner. However, obstacles such as high costs, limited knowledge and skills, and a lack of collaboration are still significant obstacles in the transition of MSMEs to a circular economy.

The practical implication of this study is that MSME actors need to be given the right training and innovation modules in order to improve their capabilities in innovating both in products and production processes. Governments and support program providers should provide incentives, such as green technology and easy access to finance, to accelerate the adoption of innovative products and processes that support the circular economy. In addition, building a cross-sectoral collaboration forum between MSMEs, governments, academics, and industry players is considered very important to strengthen support networks and knowledge exchange. Thus, MSMEs can not only increase their competitiveness in an increasingly digital and sustainable market but also contribute to environmental conservation efforts nationally and globally.

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