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Digital Literacy, Fintech Adoption, and Sustainable Performance among MSMEs

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Abstract

Purpose – This study examines how digital literacy enables fintech adoption and how fintech adoption relates to environmental and economic sustainability performance through circular economy practices and green innovation among MSMEs in Surabaya, Indonesia.
Design/Methodology/Approach – A cross-sectional survey of 150 fintech-using MSME owner-managers was analyzed using PLS-SEM with bootstrapping and PLSpredict.
Results – Digital literacy is positively associated with fintech adoption. Fintech adoption is associated with circular economy practices, green innovation, and economic sustainability, but not directly with environmental sustainability. Its environmental association operates only through circular economy practices, whereas green innovation transmits its economic association.
Originality – The study explains how a digital capability is translated into sustainable performance, showing that the environmental value of fintech is contingent on operational circular routines.
Research limitations/Implications – The cross-sectional, single-city, self-reported design limits causal inference. MSME digitalization programs should couple fintech access with circular operating capabilities.

Keywords: Circular Economy, Digital Literacy, Fintech Adoption, Green Innovation, MSMEs Sustainable Performance

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Introduction

Digital transformation has changed the financial architecture of small businesses, as payment, financing, record-keeping, and customer transactions increasingly move through digital platforms. For micro, small, and medium enterprises (MSMEs), where financial administration is often concentrated in the owner or a small management team, fintech services such as mobile payments, digital banking, marketplace settlements, and online financing can reduce transaction frictions and broaden access to formal finance. These benefits are not automatic, because small firms differ substantially in their capacity to evaluate digital services, manage cyber and financial risks, and integrate technology into routine decisions. Digital literacy is therefore a central organizational issue rather than a peripheral individual skill (Ng, 2012; Ollerenshaw et al., 2021).

Digitalization now intersects with sustainability pressure. MSMEs are expected to control costs, improve resource productivity, reduce waste, and remain economically resilient despite limited capital, managerial time, and expertise. Digital technologies can improve visibility, coordination, and resource efficiency, but the pathway from adoption to sustainability performance remains uneven across firm types and performance dimensions (Guandalini, 2022; Philbin et al., 2022). Because a technology may improve transactions without changing material use or waste, it is unclear whether fintech is merely a financial efficiency tool or part of a broader sustainability capability. Indonesian evidence supports this concern: Noah Archer and Mardiana (2025) find that although most MSMEs recognize the importance of sustainability, their practices remain confined to basic actions such as energy efficiency and waste management, constrained by limited resources, unfamiliarity with reporting standards, and cost pressure.

Fintech is a relevant entry point because it affects both financing and operating decisions: digital payment records improve cash-flow visibility, digital credit relaxes short-term financing constraints, and platform-based services support procurement and sales. Pizzi et al. (2021) conceptualize fintech as an enabler of sustainable SME business models and circular economy practices, and Croutzet and Dabbous (2021) provide macro-level evidence that financial technology development is associated with renewable energy use. At the firm level, Siddik et al. (2023) link fintech adoption to corporate sustainability performance and show that circular economy practices are an important channel through which fintech may improve sustainability. These studies indicate that fintech matters beyond payment convenience, but they raise a question about the organizational mechanisms through which that value is realized.

Two mechanisms are particularly relevant. Circular economy practices retain the value of materials and products through reduction, reuse, repair, recovery, and recycling, which can lower resource consumption, waste, and input and disposal costs (Dey et al., 2020; Kirchherr et al., 2017). Green innovation involves changes in products, processes, technologies, or organizational methods intended to reduce environmental harm while supporting competitive value, and eco-innovation can strengthen circular capability and SME performance (Bag et al., 2022). Fintech can support both mechanisms by improving access to finance, traceability, and transaction information (Guang-Wen & Siddik, 2023; Tian et al., 2023), although the evidence of Guang-Wen and Siddik (2023) is drawn from banking institutions rather than MSMEs, so its transferability to small firms should be treated with caution.

Recent literature requires a precise formulation of the research gap. Waqar et al. (2025) examined circular economy practices and green innovation simultaneously as mediators between fintech adoption and aggregate sustainable performance in Pakistani SMEs, and Waqar et al. (2026) extended this stream by incorporating sustainable supply chain management. The novelty of the present study therefore lies not in combining these variables but in explaining how a digital capability is translated into sustainable performance. It proposes a capability-translation logic in which (1) digital literacy is the upstream capability that makes fintech usable, (2) fintech is an enabling financial and informational resource rather than an environmental technology, and (3) sustainable performance materializes only when this resource is converted into operating routines that change resource use. This logic yields a testable prediction that aggregate models cannot examine: fintech should relate directly to economic sustainability, because its core functions are financial, but to environmental sustainability mainly indirectly, through circular economy practices and green innovation.

Separating the two outcomes is theoretically important. Economic effects of fintech may appear quickly through transaction efficiency, cash-flow control, and financing flexibility, whereas environmental effects require changes in production, sourcing, energy use, waste handling, and product design. A positive fintech-economic relationship can therefore coexist with a weak fintech-environmental relationship, an asymmetry that aggregation would obscure. This is consistent with the Natural-Resource-Based View (NRBV), in which environmental advantage arises from capabilities that alter resource use rather than from generic technology ownership (Hart, 1995). The upstream role of digital literacy adds a further layer. Fintech adoption is frequently modeled as an initial explanatory variable, yet it depends on whether decision-makers

can understand digital interfaces, assess usefulness, recognize security risks, and integrate digital information into decisions. In owner-managed MSMEs, where individual and organizational capability overlap, this logic is compatible with the Technology Acceptance Model (Davis, 1989) and the Resource-Based View (Barney, 1991).

Accordingly, this study asks how digital literacy influences fintech adoption and through which operational mechanisms fintech adoption translates into environmental and economic sustainability performance among MSMEs in Surabaya, Indonesia. It aims (1) to examine digital literacy as an antecedent of fintech adoption and to test whether fintech has distinct direct relationships with the two sustainability dimensions, and (2) to assess circular economy practices and green innovation as parallel yet potentially outcome-specific mediators. By linking an upstream digital capability with operating routines and disaggregated outcomes, the study offers a more diagnostic explanation of fintech-enabled sustainability in an urban developing-economy MSME context.

Literature Review and Hypothesis Development

Theoretical Integration

The framework integrates the Technology Acceptance Model (TAM), Resource-Based View (RBV), and Natural-Resource-Based View (NRBV). TAM positions digital literacy as a managerial capability that enhances the perceived usefulness and ease of fintech use. RBV suggests that adoption creates value only when digital financial resources are embedded in operational and investment routines, and NRBV links this capability to environmental value creation through circular economy practices and green innovation. Together, these perspectives support a sequential mechanism from digital literacy to fintech adoption, capability deployment, and sustainability performance.

The framework distinguishes two types of relationships. Direct paths (H4, H5, H7, and H9) capture what a resource or routine generates by virtue of its core function, whereas mediated paths (H10-H13) capture the extent to which the value of an enabling resource depends on a complementary operating routine. Following the RBV argument on resource complementarity, fintech is expected to create value directly in the domain its core function addresses, namely financial and transactional efficiency, but only indirectly in domains requiring substantive operational change, namely resource use and pollution. The direct and indirect hypotheses together establish whether the contribution of fintech to each sustainability dimension is autonomous, complementary, or contingent on operating routines (Zhao et al., 2010).

Digital Literacy and Fintech Adoption

Digital literacy refers to the ability to access, understand, evaluate, use, create, and communicate information through digital technologies (Ng, 2012). For MSMEs, it has a practical financial dimension: owner-managers must understand platform interfaces, payment flows, account security, transaction fees, financing terms, and data-based reporting. Infrastructure access yields stronger SME outcomes when accompanied by capability development, because effective adoption remains low if users lack the confidence or competence to operate them (Ollerenshaw et al., 2021). In this study, digital literacy is conceptualized as the individual capability of the owner-manager, which in owner-managed MSMEs functions as the channel through which digital capability enters the firm (Rengganis et al., 2025).

Under TAM, higher digital literacy makes fintech easier to use and helps owner-managers recognize concrete benefits, such as faster settlement, better transaction records, easier reconciliation, and broader financing options, while reducing perceived risk related to authentication, privacy, fraud, and platform credibility. SME evidence supports the role of technology acceptance mechanisms and managerial capability in fintech adoption (Krah et al., 2024). In Indonesia, a digital financial recording application enables MSME owners to record daily transactions and obtain financial statements more quickly (Rachman & Andriani, 2024), but owners must first possess basic financial knowledge before such an application can be used effectively (Sofian et al., 2024). Thus, the capability of the user, rather than the availability of the platform, determines the depth of adoption.

H1: Digital literacy positively affects fintech adoption.

Fintech Adoption and Circular Economy Practices

Circular economy practices seek to maintain the utility and value of products, components, and materials for as long as possible through reduction, reuse, repair, remanufacturing, and recycling (Kirchherr et al., 2017). The circular economy is a set of production and consumption principles that can contribute to, but are not identical with, sustainability (Kirchherr et al., 2017; Siddik et al., 2023). For MSMEs, adopting these

principles requires information about material flows, spending patterns, supplier options, and the economic consequences of waste and recovery activities.

Theoretically, the relationship rests on the RBV and organizational slack theory. The RBV views fintech as a financial and informational resource whose value depends on deployment, while slack theory holds that uncommitted financial resources give firms latitude to experiment with non-routine practices that day-to-day pressures would otherwise crowd out (Bourgeois, 1981; Purwanto & Rahmawati, 2025). Fintech lowers several barriers to circular practices: digital records make purchasing patterns and recurring material costs traceable, digital financing provides working capital for equipment modification, recycling, reusable packaging, or procurement changes, and documented platform transactions ease coordination with suppliers and customers. Pizzi et al. (2021) argue that fintech supports sustainable and circular SME business models, and Siddik et al. (2023) provide evidence that circular economy practices are an important mechanism of fintech-enabled sustainability.

H2: Fintech adoption positively affects circular economy practices.

Fintech Adoption and Green Innovation

Bag et al. (2022) show that eco-innovation is closely connected to circular economy capability and SME performance, Tian et al. (2023) find that fintech innovation strengthens green innovation in manufacturing SMEs, and Siddik et al. (2023) identify a relationship between fintech adoption, green-oriented financial activity, and environmental performance. Under the RBV, fintech increases a firm's capacity to mobilize and allocate financial resources; when managers use that capacity to redesign products or processes, fintech becomes an enabling capability for green innovation rather than an end in itself.

H3: Fintech adoption positively affects green innovation.

Fintech Adoption and Environmental Sustainability Performance

Environmental sustainability performance reflects outcomes such as reduced waste, lower emissions, improved energy efficiency, and greater use of environmentally preferable resources. Although fintech is not an environmental technology, three channels suggest a direct association. These are (1) dematerialization, as digital payments and statements replace paper records, cash handling, and branch visits; (2) monitoring, as digital records make spending on energy, materials, and disposal visible, which the NRBV treats as a precondition for pollution prevention (Hart, 1995); and (3) green-finance access, as slack resources enable discretionary investments in energy-efficient equipment (Bourgeois, 1981). Consistent with these arguments, fintech development is associated with renewable energy use (Croutzet & Dabbous, 2021) and with firm-level environmental and sustainability performance (Siddik et al., 2023; Tian et al., 2023).

A direct environmental effect is, however, less certain than a direct economic effect, because digital payments or financing do not automatically reduce material use or emissions. If MSMEs use fintech mainly for sales collection, liquidity, or ordinary working capital, environmental improvement may not occur without complementary routines. Testing this path therefore determines whether fintech has an autonomous environmental effect or depends on circular economy practices and green innovation.

H4: Fintech adoption positively affects environmental sustainability performance.

Fintech Adoption and Economic Sustainability Performance

Economic sustainability performance refers to the firm's ability to maintain viable outcomes through cost control, productivity, stable profitability, and efficient resource use. Fintech has a more immediate connection with this dimension because its core functions address financial and transaction processes: digital payments shorten settlement time and reduce manual handling costs, digital banking and platform records support reconciliation and monitoring, and digital financing provides liquidity for business opportunities or temporary cash-flow pressures. Consistent with the RBV, fintech becomes a valuable resource when integrated into routine financial management. It is associated with sustainability performance and improved access to finance (Siddik et al., 2023) and with viable SME business models (Pizzi et al., 2021), so the relationship should be evident in the economic dimension even before firms change their environmental processes.

H5: Fintech adoption positively affects economic sustainability performance.

Circular Economy Practices and Environmental Sustainability Performance

Circular economy practices are directly oriented toward resource loops and waste prevention. Reduction lowers material inputs, reuse and repair extend product and component life, and recycling and recovery reduce the material sent to disposal, while also prompting firms to reconsider packaging, inventory, sourcing, and product design. Circular economy fields of action improve SME sustainability (Dey et al., 2020), and circular capability is linked with performance (Bag et al., 2022). From an NRBV perspective, these routines represent pollution-prevention and stewardship capabilities because they change how resources are used rather than how transactions are financed.

H6: Circular economy practices positively affect environmental sustainability performance.

Circular Economy Practices and Economic Sustainability Performance

The NRBV holds that pollution prevention lowers the input, waste-handling, and compliance costs associated with inefficient resource use (Hart, 1995), and the Porter hypothesis argues that environmental improvements can offset their own costs by revealing resource inefficiencies (Porter & van der Linde, 1995). In MSMEs, material efficiency, reuse, repair, and waste reduction lower input, replacement, and disposal costs, and by-products may create secondary revenue. These benefits are conditional: circular practices are expected to generate economic sustainability mainly when (a) they rely on low-capital routines such as reducing, reusing, and repairing rather than capital-intensive recycling technology, (b) the firm is sufficiently material-intensive for savings to be meaningful relative to implementation costs, and (c) the savings are visible in the firm's records so that owner-managers can capture and reinvest them. Empirically, all circular economy fields of action are associated with SME economic performance (Dey et al., 2020), circularity contributes to sustainable performance when embedded in viable business models (Waqar et al., 2026), and Indonesian evidence shows that sustainability-oriented performance is associated with higher profitability regardless of financial constraints (Wulandari et al., 2026).

H7: Circular economy practices positively affect economic sustainability performance.

Green Innovation and Environmental Sustainability Performance

Green innovation is designed to reduce the environmental burden of products and processes: cleaner production lowers energy and material consumption, product redesign reduces resource intensity, and process changes limit emissions or waste. When innovations are genuinely green, environmental performance should improve as they are implemented and scaled. Green innovation is an important determinant of sustainable business performance among SMEs (Baeshen et al., 2021) and is connected with corporate environmental performance (Tian et al., 2023). The NRBV views it as a capability that differentiates the firm while reducing ecological impact.

H8: Green innovation positively affects environmental sustainability performance.

Green Innovation and Economic Sustainability Performance

Green innovation can produce economic benefits through efficiency, market differentiation, and risk reduction. The Porter hypothesis holds that well-designed environmental innovation triggers offsets that lower costs or raise product value by more than the innovation's cost (Porter & van der Linde, 1995), and the NRBV adds that product-stewardship and pollution-prevention capabilities are socially complex and difficult to imitate, securing cost or differentiation advantages (Hart, 1995). Process innovations may reduce energy or material costs, product innovations may respond to customers who value environmental attributes, and cleaner processes may reduce future regulatory or resource cost pressures. Although the size and timing of these benefits depend on implementation costs faced by smaller firms, green or eco-innovation contributes to organizational performance (Baeshen et al., 2021; Bag et al., 2022).

H9: Green innovation positively affects economic sustainability performance.

Mediating Roles of Circular Economy Practices and Green Innovation

Both mediation arguments rest on the distinction between enabling and operating capability. Fintech supplies financial access, transaction visibility, and cash-flow information, but these advantages do not by themselves close material loops or reduce environmental burden. Combining RBV and NRBV, fintech expands resource-deployment capability, whereas circular economy practices and green innovation apply it to routines that alter resource use. Both pathways have empirical support (Dey et al., 2020; Guang-Wen & Siddik, 2023; Siddik et al., 2023; Tian et al., 2023; Waqar et al., 2025). Fintech should therefore have limited

value for either outcome unless the capacity it creates is redirected toward circular and green-oriented operations, although each of the four indirect paths rests on a distinct rationale.

The first path, through circular economy practices to environmental sustainability, is the most direct test of the capability-translation logic. Fintech does not alter material flows by itself, whereas circular routines are, by definition, the activities that reduce, reuse, repair, and recycle materials. Following the NRBV (Hart, 1995), fintech is expected to be associated with environmental sustainability mainly because it enables the financing, traceability, and coordination that circular routines require (Siddik et al., 2023).

H10: Circular economy practices mediate the effect of fintech adoption on environmental sustainability performance.

The second path, through circular economy practices to economic sustainability, follows a cost-saving rather than a pollution-prevention logic. Fintech makes recurring material, energy, and disposal expenses visible and provides working capital for low-cost circular changes, while circular routines convert this visibility into realized input savings and extended asset life (Dey et al., 2020; Porter & van der Linde, 1995). Because this path operates alongside the direct economic effect of fintech (H5), it tests whether part of fintech's economic value is realized through operational resource efficiency rather than only through transactional efficiency.

H11: Circular economy practices mediate the effect of fintech adoption on economic sustainability performance.

The third path concerns green innovation as an innovation-based route to environmental outcomes. Innovation requires up-front investment and tolerance of uncertain payoffs, which small firms often lack; slack financial resources provided by fintech can relax these constraints (Bourgeois, 1981), and the resulting cleaner products and processes lower environmental impact (Tian et al., 2023). Unlike H10, this path relies on new products and processes rather than on reorganizing existing material flows.

H12: Green innovation mediates the effect of fintech adoption on environmental sustainability performance.

The fourth path proposes that green innovation transmits the value of fintech to economic sustainability through innovation offsets and differentiation (Porter & van der Linde, 1995). The financing and payment functions of fintech allow MSMEs to acquire cleaner technology and reach customers who value green attributes, while the innovation itself generates cost savings or price premiums (Waqar et al., 2025). This path captures whether fintech-enabled green innovation is appropriated economically, the outcome that resource-constrained MSMEs typically prioritize.

H13: Green innovation mediates the effect of fintech adoption on economic sustainability performance.

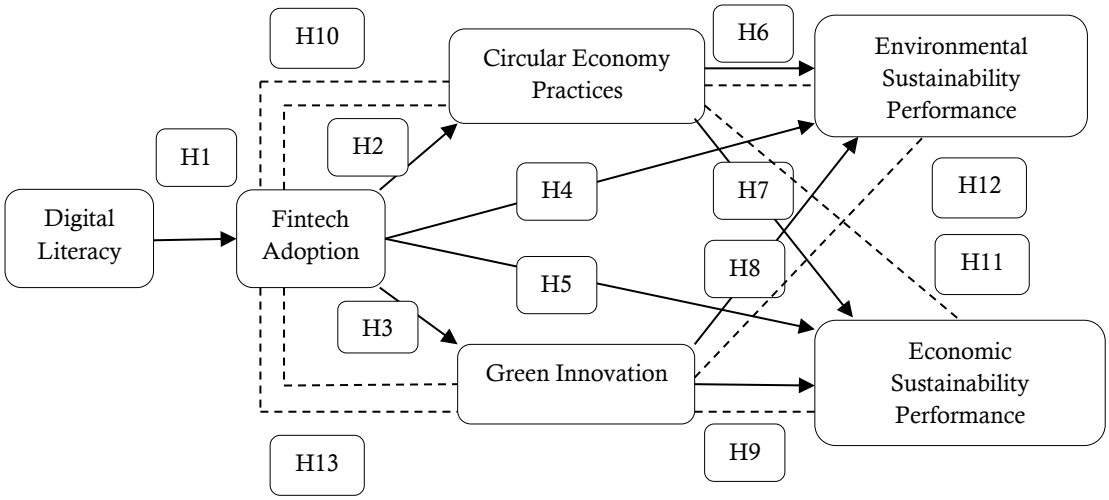


Figure 1
Research Model
Source: Author

Methods

This study adopted a quantitative cross-sectional survey design, with the MSME as the unit of analysis and owners or managers involved in business decision-making as respondents. The population comprises fintech-using MSMEs in Surabaya, East Java, Indonesia. Due to the lack of comprehensive list of such firms exists, a sampling frame of 170 MSMEs was used, and purposive sampling ensured fintech experience: eligible firms had operated for at least two years and used at least one fintech-related service, such as digital payments, mobile banking, marketplace transactions, or digital financing. Of the 170 questionnaires distributed online and offline, 165 were returned and 15 were excluded as ineligible or incomplete, yielding 150 valid responses (a usable response rate of 88.2%).

Sample adequacy was assessed using three criteria. First, under the ten-times rule, the largest number of structural paths directed at any construct is three (environmental and economic sustainability performance), requiring at least 30 observations. Second, a power analysis for three predictors ($\alpha = .05$, power = .80) indicates that 77 observations are required to detect a medium effect ($f^2 = .15$) (Faul et al., 2009); with 150 observations, power is .985. Third, the inverse square root method indicates that 150 observations can detect path coefficients of approximately .20 or larger at the 5% level with 80% power (Kock & Hadaya, 2018). The mediating paths add no sample-size requirement because each partial regression involves at most three predictors and indirect effects are tested by bootstrapping. However, paths smaller than approximately .20 may be underpowered, so non-significant small coefficients are interpreted as effects not detected rather than as evidence of no effect. All constructs were operationalized as reflective measures with three indicators on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree), adapted from prior research (Table 2) and translated into Indonesian. Digital literacy captured confidence, knowledge, and capability in managing business finances through digital platforms; fintech adoption, the use of digital financial services, payment systems, and financing; circular economy practices, recycling, reuse, repair, and reduce-reuse-recycle principles; green innovation, environmentally oriented products, cleaner production, and resource efficiency; environmental sustainability performance, waste reduction, lower emissions, and renewable-resource use; and economic sustainability performance, cost efficiency, profitability, and operating cost reduction. Digital literacy is conceptualized as the individual capability of the owner-manager rather than an aggregated organizational capability. This follows a key-informant logic: in MSMEs, financial and technology decisions are concentrated in the owner-manager, who is the channel through which digital capability enters the firm (Ollerenshaw et al., 2021; Rengganis et al., 2025). The other constructs refer to firm-level practices and outcomes reported by the owner-manager as the most knowledgeable informant, so the model links an individual-level capability to firm-level practices and outcomes, and the findings are interpreted accordingly. Before estimation, four descriptive rows appended to the survey data were excluded, leaving 150 respondent records. Partial least squares structural equation modeling was applied using SmartPLS 4 (Hair et al., 2019) because the study emphasizes prediction, estimates direct and indirect effects, accommodates moderate samples, and does not require multivariate normality. The measurement model was evaluated through indicator loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), and HTMT. The structural model was assessed using VIF, R^2, effect sizes (f^2; Cohen, 1988), predictive relevance (Q^2predict from PLSpredict; Shmueli et al., 2019), path coefficients, bootstrapping, and specific indirect effects.

Table 1
Selected Respondent Characteristics

Characteristic	Dominant Category	n	%
Gender	Male	83	55.3
Gender	Female	67	44.7
Age	25-44 years	124	82.7
Education	Bachelor/Master	102	68.0
Business scale	Micro/Small	132	88.0
Sector	Trade	36	24.0
Sector	Food and beverage	28	18.7
Sector	Manufacturing	26	17.3
Fintech platform	QRIS/e-wallet	43	28.7
Fintech platform	Mobile banking	39	26.0

Table Source: Processed Data

The respondent profile indicates a digitally engaged sample that still reflects the dominance of smaller firms: micro and small enterprises account for most observations, most respondents are of productive working age, and a majority hold undergraduate or postgraduate degrees. Trade, food and beverage, and manufacturing are the most visible sectors, and QRIS/e-wallet and mobile banking are the most frequently reported platforms. The model therefore explains fintech-enabled sustainability among firms already exposed to digital finance, across heterogeneous sectors and scales.

Table 2
Measurement Items and Sources

Construct	Code	Item	Source
Digital literacy (DL)	DL1	I am confident managing business finances through digital platforms.	Adapted from Ng (2012); Ollerenshaw et al. (2021)
	DL2	I have adequate knowledge of digital financial applications.	
	DL3	I am capable of using digital platforms to manage business transactions and records.	
Fintech adoption (FA)	FA1	My business uses digital financial services in daily operations.	Adapted from Siddik et al. (2023); Krah et al. (2024)
	FA2	My business uses digital payment systems (e.g., QRIS, e-wallets).	
	FA3	My business uses digital financing services.	
Circular economy practices (CEP)	CEP1	My business recycles materials or waste.	Adapted from Siddik et al. (2023); Dey et al. (2020)
	CEP2	My business reuses and repairs materials, products, or equipment.	
	CEP3	My business applies reduce-reuse-recycle principles.	
Green innovation (GI)	GI1	My business develops environmentally friendly products.	Adapted from Tian et al. (2023); Baeshen et al. (2021)
	GI2	My business uses cleaner production processes.	
	GI3	My business improves resource efficiency.	
Environmental sustainability performance (ENSP)	ENSP1	My business has reduced waste.	Adapted from Siddik et al. (2023); Waqar et al. (2025)
	ENSP2	My business has reduced emissions.	
	ENSP3	My business has increased the use of renewable resources.	
Economic sustainability performance (ESP)	ESP1	My business has improved cost efficiency.	Adapted from Siddik et al. (2023); Waqar et al. (2025)
	ESP2	My business has improved profitability.	
	ESP3	My business has reduced operating costs.	

Research Results

The measurement model demonstrates satisfactory reliability and validity (Table 3). Indicator loadings range from .865 to .933, Cronbach's alpha from .864 to .899, composite reliability from .917 to .937, and AVE from .786 to .832. The highest HTMT ratio (.557) remains below the conservative .85 criterion, and inner variance inflation factors (1.000–1.432) indicate that multicollinearity is not a material concern. All six constructs are therefore retained for hypothesis testing.

Table 3
Measurement Model Assessment

Construct	Loading Range	α	CR	AVE
Digital literacy	.887-.916	.881	.926	.808
Fintech adoption	.899-.920	.899	.937	.832
Circular economy practices	.889-.902	.879	.925	.805
Green innovation	.866-.915	.872	.921	.795
Environmental sustainability	.889-.933	.895	.934	.825
Economic sustainability	.865-.909	.864	.917	.786

Table Source: Processed Data

The structural model shows modest but meaningful explanatory power (Table 4). Digital literacy explains 22.8% of the variance in fintech adoption; fintech adoption explains 24.0% of circular economy practices and 18.1% of green innovation, and the combined predictors explain 25.9% of environmental and 22.7% of economic sustainability performance. Using thresholds of .02, .15, and .35 for small, medium, and large effects (Cohen, 1988), digital literacy has a medium effect on fintech adoption (f^2 = .295), and fintech adoption has medium effects on circular economy practices (f^2 = .316) and green innovation (f^2 = .221). Downstream effects fall in the small range: the strongest is circular economy practices on environmental sustainability (f^2 = .106), followed by the direct effect of fintech adoption on economic sustainability (f^2 = .051), whereas the direct effect of fintech adoption on environmental sustainability (f^2 = .018) is below the small-effect threshold, consistent with the non-significant H4. The model thus explains capability formation better than final outcomes, which are likely shaped by additional strategic, sectoral, and market factors. PLSpredict (10-fold cross-validation, 10 repetitions) yields positive Q^2predict values for all endogenous constructs, ranging from .056 for environmental sustainability to .217 for fintech adoption, with circular economy practices (.122), green innovation (.116), and economic sustainability (.077) in between; all indicator-level Q^2predict values are also positive (Shmueli et al., 2019). Predictive relevance diminishes along the longer chain from digital literacy, so the model is better suited to explaining than to forecasting sustainability performance.

Table 4
Explanatory Power, Effect Size, and Predictive Relevance

Endogenous Construct	R^2	Q^2predict	Predictor	f^2
Fintech adoption	.228	.217	Digital literacy	.295
Circular economy practices	.240	.122	Fintech adoption	.316
Green innovation	.181	.116	Fintech adoption	.221
Environmental sustainability	.259	.056	Fintech adoption	.018
			Circular economy practices	.106
			Green innovation	.022
Economic sustainability	.227	.077	Fintech adoption	.051
			Circular economy practices	.027
			Green innovation	.034

Table Source: Processed Data
Note. Effect sizes (f^2): .02 = small, .15 = medium, .35 = large (Cohen, 1988). Q^2predict from PLSpredict (10 folds, 10 repetitions); Q^2predict > 0 indicates predictive relevance (Shmueli et al., 2019).

Table 5
Structural Path and Mediation Results

Hyp.	Relationship	β	t	p	Decision
H1	DL -> FA	.477	8.313	< .001	Supported
H2	FA -> CEP	.490	7.647	< .001	Supported
H3	FA -> GI	.425	6.439	< .001	Supported
H4	FA -> ENSP	.138	1.778	.075	Not supported
H5	FA -> ESP	.237	2.887	.004	Supported
H6	CEP -> ENSP	.336	4.867	< .001	Supported
H7	CEP -> ESP	.174	2.037	.042	Supported
H8	GI -> ENSP	.148	1.782	.075	Not supported
H9	GI -> ESP	.187	2.440	.015	Supported
H10	FA -> CEP -> ENSP	.165	3.889	< .001	Supported
H11	FA -> CEP -> ESP	.085	1.912	.056	Not supported*
H12	FA -> GI -> ENSP	.063	1.686	.092	Not supported
H13	FA -> GI -> ESP	.080	2.235	.025	Supported

Table Source: Processed Data
Note. DL = digital literacy; FA = fintech adoption; CEP = circular economy practices; GI = green innovation; ENSP = environmental sustainability performance; ESP = economic sustainability performance. *H11 is marginal (p = .056) but does not meet the 5% criterion.

Nine of the thirteen hypotheses meet the 5% significance criterion (Table 5). Digital literacy positively affects fintech adoption (H1), and fintech adoption positively affects circular economy practices (H2) and green innovation (H3). The direct effect of fintech on environmental sustainability is positive but not significant (H4 not supported), whereas its effect on economic sustainability is significant (H5). Circular economy practices positively affect both environmental and economic sustainability (H6 and H7). Green innovation does not significantly affect environmental sustainability (H8 not supported) but positively affects economic sustainability (H9). For mediation, the fintech–circular economy–environmental pathway is supported (H10); the circular economy pathway to economic sustainability is marginal and does not meet the formal criterion (H11); the green innovation pathway to environmental sustainability is not supported (H12); and the green innovation pathway to economic sustainability is supported (H13). The results therefore reject a uniform dual-mediation interpretation and show outcome-specific mechanisms. Following Zhao et al. (2010), H10 represents indirect-only (full) mediation because the direct path to environmental sustainability is not significant, whereas H13 represents complementary (partial) mediation because the direct path to economic sustainability is also significant.

Discussion & Conclusion

Discussion

Digital Literacy as an Upstream Fintech Capability

The support for H1 indicates that digital literacy is an important antecedent of fintech adoption. Consistent with TAM, digitally competent owner-managers perceive less effort and uncertainty when evaluating financial applications (Davis, 1989). The result reinforces that infrastructure access does not guarantee effective digitalization (Ollerenshaw et al., 2021) and that technology acceptance factors shape SME fintech adoption (Krah et al., 2024). Digital literacy thus functions as an upstream business capability that helps owner-managers interpret platform features, assess risks, and integrate fintech into daily decisions. This extends fintech-sustainability research, which often treats adoption as an exogenous starting point, and is compatible with the RBV view that a technological resource generates value only when complementary capabilities exist (Siddik et al., 2023). Fintech inclusion programs should therefore go beyond platform access and account ownership to build digital capability, security awareness, financial application skills, and the ability to interpret digital transaction information.

Fintech as an Enabler of Circular and Green Operating Practices

The support for H2 and H3, with medium effect sizes, suggests that the strongest role of fintech occurs before final sustainability outcomes: fintech may expand the financial and informational capacity from which operational changes develop. This supports the RBV interpretation of fintech as an enabling capability rather than a stand-alone performance solution, consistent with studies explaining how digital finance facilitates circular business arrangements (Pizzi et al., 2021; Siddik et al., 2023) and linking fintech to green innovation in SMEs (Tian et al., 2023; Waqar et al., 2025). Both require resources to be reallocated, for example to sourcing, packaging, repairing, cleaner equipment, or process redesign, a burden that financial flexibility and clearer records can ease. The finding is therefore consistent with a sequential interpretation: fintech may create capacity, but sustainability appears to depend on what managers do with it. Because the data are cross-sectional, this sequence is inferred from theory and the pattern of associations rather than observed over time, and access to fintech should not be treated as synonymous with sustainability performance.

Asymmetric Direct Effects on Sustainability Performance

The direct sustainability results are asymmetric: fintech adoption has a significant positive relationship with economic sustainability (H5) but no significant direct relationship with environmental sustainability (H4). Fintech directly addresses payment, liquidity, financing, and transaction information, functions plausibly associated with economic outcomes through reduced transaction friction, better cash-flow management, and improved cost control (Pizzi et al., 2021; Siddik et al., 2023).

The non-significant H4 should not be read merely as a departure from studies reporting a direct fintech-environmental relationship (Siddik et al., 2023; Tian et al., 2023). Together with the significant indirect path through circular economy practices (H10), it constitutes the central theoretical insight of this study: the association between fintech and environmental sustainability takes the form of indirect-only (full) mediation (Zhao et al., 2010), consistent with fintech being an enabling resource whose environmental value is contingent on a complementary operating capability. Prior studies reported a direct effect used aggregate measures or did not model operating routines, so value transmitted through such routines may have been attributed to fintech itself. Once circular routines are modeled, the dematerialization and monitoring channels proposed for H4 appear too weak to produce a detectable autonomous effect among MSMEs, whose environmental footprint is driven mainly by materials, energy, and waste rather than financial administration. This refines RBV and NRBV: the RBV explains the direct economic value of fintech, whereas the NRBV explains why environmental value requires a routine that changes resource use (Hart, 1995), establishing the boundary condition that fintech is not an environmental resource per se. Because the design is cross-sectional, this pattern indicates a statistical indirect association consistent with the proposed mechanism, not a demonstrated temporal causal sequence.

Circular Economy as the Main Environmental Translation Mechanism

The support for H6 and H7 indicates that circular economy practices are positively associated with both environmental and economic sustainability, with the environmental path being the strongest downstream relationship in the model. This accords with the operational content of circularity, as reduction, reuse, repair, and recycling directly alter material flows and waste generation, and is consistent with Dey et al. (2020) and Bag et al. (2022).

The support for H10, together with a non-significant direct path, suggests that the environmental value of fintech is realized primarily through an operating mechanism: fintech may facilitate financing and transaction visibility, but circular routines reduce resource loss. Encouraging MSMEs to adopt digital payments is therefore unlikely to yield environmental gains on their own; digital finance interventions should be connected with waste accounting, resource-use monitoring, supplier selection, reusable packaging, repair systems, and recycling arrangements.

The H11 mediation, however, is only marginal and formally unsupported. This is consistent with the distinction between enabling and operating value: the economic contribution of fintech is already captured largely by its direct transactional channel (H5), so the circular pathway adds relatively little economic value beyond it. For MSMEs, circularity thus functions primarily as an environmental rather than an economic conduit for fintech, which qualifies the win-win assumption common in circular economy research. Given the marginal p-value (.056) and the limited power for small indirect effects in a sample of 150, this conclusion should be treated as tentative.

Green Innovation Produces a Different Outcome Pattern

The green innovation results differ green innovation is associated with economic sustainability (H9) but not with environmental sustainability (H8). This departs from the NRBV expectation and from studies reporting a direct link (Guang-Wen & Siddik, 2023; Tian et al., 2023), suggesting that in MSMEs green innovation operates primarily as an economically appropriate capability. Consistent with the Porter hypothesis (Porter & van der Linde, 1995), resource-constrained MSMEs most likely adopt innovations with quick payoffs, such as energy- and material-efficient process adjustments, whose environmental gains may be too small to detect at the firm level or may be offset when efficiency gains expand output. In addition, the H8 coefficient ($\beta = .148$) is below the minimum effect the sample can reliably detect (approximately .20), indicating an undetected effect rather than a genuinely absent one. Indonesian evidence likewise shows that observable outcomes of green initiatives depend on how they are measured and documented (Purnomo & Santoso, 2025). The environmental effectiveness of green innovation in MSMEs therefore depends on its type and scale rather than its mere presence, and its win-win logic operates asymmetrically, with the economic side materializing more clearly.

Incremental innovations may also lower unit cost without changing the overall environmental footprint if production volume increases or other operations remain unchanged. Because the data are cross-sectional, the model cannot observe whether environmental benefits appear after a longer implementation period; this time-lag explanation remains a conjecture offered as an agenda for longitudinal research rather than as an explanation of the result.

The mediation findings reinforce this outcome-specific pattern. H13 is supported in the form of complementary mediation, because the direct path (H5) is also significant, whereas H12 is not supported, following from the non-significant H8. Fintech may help MSMEs mobilize resources for green-oriented changes associated with business value, but these changes do not yet show a statistically clear environmental association. This adds nuance to integrated fintech-sustainability studies such as Waqar et al. (2025): circular economy practices and green innovation do not operate uniformly within an aggregate sustainability construct, and their contributions differ once the outcome dimensions are disaggregated.

Theoretical Contribution

The study makes three theoretical contributions. First, it connects TAM, RBV, and NRBV in a staged capability model: TAM explains why digital literacy facilitates fintech adoption, RBV explains how fintech becomes a deployable organizational capability, and NRBV explains why environmental outcomes require routines that directly change resource use. Second, by separating environmental and economic sustainability, it shows that the same digital capability can be associated with different outcomes through different mechanisms. Third, it refines recent fintech-sustainability research: circular economy practices are the clearer environmental conduit, whereas green innovation contributes more consistently to economic sustainability, a distinction hidden by aggregate scores. Most importantly, fintech does not automatically generate environmental sustainability; it is an enabling but not sufficient resource whose environmental value is contingent on operational capability, particularly circular economy practices.

For MSME managers, the association between digital literacy and fintech adoption (H1, $\beta = .477$) suggests that owner-managers should first build their own digital financial skills. Because fintech relates to economic sustainability both directly (H5) and through green innovation (H13), managers can use transaction records to identify efficiency-oriented green innovations, such as energy- or material-saving process changes, whose cost effects are visible. Because fintech is associated with environmental sustainability only through circular economy practices (H4 not supported; H10 supported), managers seeking environmental improvement should link fintech data to circular operating targets, for example by tracking material purchases, waste, and repair costs through digital transaction records.

For policymakers, the absence of a direct fintech-environmental association (H4) suggests that digitalization programs that only expand fintech access are unlikely to be sufficient for environmental objectives. In Indonesia, three adjustments follow. First, QRIS/e-wallet services, promoted nationally through Bank Indonesia's Quick Response Code Indonesian Standard (QRIS), were the most frequently reported platform category (28.7%); QRIS merchant onboarding could therefore include simple modules on using transaction data for cost and resource monitoring. Second, given the upstream role of digital literacy (H1), the financial literacy agenda of the Financial Services Authority (OJK) under the National Strategy for Indonesian Financial Literacy (SNLKI) 2021–2025 could include digital financial capability for MSME owner-managers. Third, local initiatives such as the E-Peken digital marketplace of the Surabaya City Government could integrate simple circular-practice guidance, such as reusable packaging and waste reduction, into existing onboarding (H10). Financial institutions could also tie sustainability-linked financing to evidence of circular or green practices rather than fintech use alone.

Conclusion

This study concludes that digital literacy is an important upstream determinant of fintech adoption among MSMEs in Surabaya, Indonesia. Fintech adoption is positively associated with circular economy practices and green innovation, but its sustainability consequences are not uniform: it relates directly to economic but not to environmental sustainability. Circular economy practices are the clearest route to environmental improvement and also contribute to economic performance, whereas green innovation contributes more consistently to economic sustainability. The mediation pattern therefore rejects a uniform dual-mediation narrative: digital finance is associated with sustainability value when it is translated into specific operating capabilities, and different capabilities relate to distinct dimensions of sustainable performance. Theoretically, fintech does not automatically generate environmental sustainability; its environmental benefits are contingent on operational capability, particularly circular economy practices. Practically, MSME digitalization programs should not stop at increasing fintech access but should also develop the operating capabilities that support sustainability.

Limitation & Future Research

This study has three main limitations. First, the cross-sectional design captures associations at a single point in time, so the significant indirect effects are consistent with, but do not demonstrate, a temporal causal sequence, and reverse causality (e.g., more profitable firms adopting more fintech) cannot be ruled out. Second, purposive sampling of fintech-using MSMEs in a single city means that the estimates describe digitally engaged urban MSMEs, may overstate relationships relative to less digitally exposed MSMEs, and cannot be generalized to other regions, sectors, or firm sizes; moreover, with 150 observations, paths smaller than approximately .20 may not be detected, so the non-significant H4, H8, H11, and H12 indicate effects not detected rather than confirmed absence. Third, all constructs were self-reported by the owner-manager using three reflective indicators, which may introduce common methods and social desirability bias, particularly for environmental performance (Podsakoff et al., 2003). Future research should therefore use (1) longitudinal or panel designs to test the temporal sequence and the time-lag argument for green innovation; (2) probability sampling across multiple regions, including non-user comparison groups and larger samples; and (3) multi-source and objective data, such as transaction records, energy bills, waste volumes, or financial statements, combined with richer multi-item scales.

Declaration of Generative AI Use

AI was used to compile the state of the art and assist with grammar in the Discussion section.

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