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Impact of Digital Payment Adoption through AI-ML on Micro-Business Performance

Ralphy Joseph C J

Research Scholar

Kerala University Of Fisheries and Ocean Studies

ORCID: https://orcid.org/0000-0003-1342-4833

Abstract—This study examines how the adoption and intensity of digital payment usage affect the operational and financial performance of micro-businesses. Primary data were collected from 468 micro-enterprises operating in retail trade, food and beverage services, personal and repair services, and artisanal micro-manufacturing. Enterprises were classified into four adoption tiers based on the share of monthly receipts settled digitally, and performance was measured through annual sales growth, customer base expansion, working capital cycle length, access to formal credit, and net profit margin. One-way ANOVA, chi-square tests, ordinary least squares regression with sector fixed effects, mediation analysis, and propensity score matching were applied. Results show that enterprises in the highest adoption tier recorded mean annual sales growth of 19.6 per cent against 4.1 per cent for non-adopters, with adoption intensity emerging as the strongest predictor of growth ($\beta = 0.283$, $p < 0.001$) in a model explaining 41.2 per cent of variance. Shortening of the working capital cycle partially mediated the relationship, accounting for 15.4 per cent of the total effect. Propensity score matching reduced but did not eliminate the estimated advantage, yielding an average treatment effect of 9.42 percentage points. Settlement charges and apprehension about tax scrutiny were the most binding barriers to deeper adoption.

Keywords—digital payments, micro-enterprises, business performance, financial inclusion, working capital, technology adoption

Introduction

Micro-businesses — owner-operated units with minimal capital, few or no paid employees, and limited formal record-keeping — form the numerical majority of enterprises in most developing economies and absorb a substantial share of non-farm employment. Their performance is constrained less by product-market demand than by transaction frictions: cash handling costs, unverifiable revenue histories that block formal credit, and working capital locked in receivables and inventory.

Digital payment infrastructure has expanded rapidly at the retail interface, with interoperable mobile money, unified payment interfaces, and low-cost QR acceptance reducing the fixed cost of acceptance to near zero. Global account-ownership and digital-payment usage figures rose sharply through the pandemic period, with two-thirds of adults worldwide making or receiving a digital payment (Demirgüç-Kunt, Klapper, Singer & Ansar, 2022). Yet the translation of payment digitalisation into measurable micro-business performance gains remains contested. Acceptance may simply substitute for cash without altering sales volume, and the digital trail may impose formalisation costs that offset efficiency gains.

This study addresses that question directly. It asks whether adoption intensity — not merely binary adoption — is associated with superior performance across five dimensions, whether the association survives correction for selection into adoption, and through which mechanism the effect operates. The contribution is threefold: it treats adoption as a graded construct rather than a dichotomy; it tests a specific transmission channel through the working capital cycle; and it quantifies the selection component using matched comparison.

Literature Review

The foundational evidence on digital payments and household or enterprise outcomes originates in mobile money research. Jack and Suri (2014) demonstrated that reduced transaction costs under Kenya's M-PESA system allowed households to smooth consumption against negative shocks, with remittance flows adjusting where non-users' consumption fell. Extending the analysis over eight years, Suri and Jack (2016) found that mobile money access lifted approximately 194,000 households out of poverty and induced occupational shifts from agriculture into business, particularly among female-headed households — the first large-scale demonstration that payment infrastructure alters enterprise formation itself.

Mechanism-level work has isolated the finance channel. Beck, Pamuk, Ramrattan and Uras (2018) showed that payment instrument choice affects enterprise credit and investment by mitigating theft risk and improving the enforceability of transactions, with firms using mobile money reporting higher investment and sales. Islam, Muzi and Rodriguez Meza (2018) used World Bank Enterprise Survey data from Kenya, Uganda and Tanzania and found that

mobile financial service use raised fixed asset purchases, with the effect concentrated among small and medium firms and attributable to lower transaction costs, greater liquidity and improved creditworthiness. Islam and Muzi (2022), analysing sixteen Sub-Saharan economies, reported that the investment effect was significant for women-owned firms but not for male-owned firms, operating through supplier payments and customer credit provision.

Experimental evidence has sharpened causal claims. Dalton, Pamuk, Ramrattan, van Soest and Uras (2024) conducted a randomised controlled trial encouraging mobile money adoption among Kenyan enterprises and found that treated firms increased business bank account use and access to formal credit, with the payment technology functioning as a gateway to broader financial services rather than a standalone efficiency tool. Hassan (2024), using an instrumental variable bivariate probit on 914 informal Zambian firms, found that mobile money use significantly improved informal business performance, attributing the gain to lower transaction costs and improved liquidity.

Adoption-side research qualifies these findings. Ligon, Malick, Sheth and Trachtman (2019), surveying small-scale merchants in Jaipur, India, found that despite near-universal awareness, adoption remained low; the dominant deterrents were the perceived risk of tax exposure and the absence of customer demand, not technological unfamiliarity. Crouzet, Gupta and Mezzanotti (2023) exploited India's demonetisation as a natural experiment and showed that adoption rose persistently in districts most exposed to the cash shortage, estimating that adoption would have been 45 per cent lower absent complementarities — evidence that coordination failure, rather than intrinsic unprofitability, suppresses take-up. Higgins (2024) documented the supply-side counterpart in Mexico: when small retailers adopted point-of-sale terminals, sales and profits rose as wealthier consumers redirected expenditure from supermarkets to small retailers, with card usage by other consumers increasing 21 per cent.

Adjacent literature establishes that the underlying constraint is liquidity management rather than capital scarcity alone. Dupas and Robinson (2013) showed that simply providing micro-entrepreneurs with a savings device raised business investment and expenditure, while Bachas, Gertler, Higgins and Seira (2021) found that debit card access raised savings by two per cent of annual income within two years through reduced transaction and monitoring costs. Johri, Asif, Tarkar, Khan, Rahisha and Wasiq (2024), examining 998 micro-enterprises, identified internet access, owner education and managerial experience as determinants of digital financial inclusion and found that digitally included enterprises perceived significantly lower regulatory and tax administration obstacles. Theoretically, adoption behaviour in this study is framed using the unified model of technology acceptance, in which performance expectancy, effort expectancy, social influence and facilitating conditions determine usage intention and behaviour (Venkatesh, Morris, Davis & Davis, 2003).

Across this body of work, three gaps persist. First, most enterprise studies treat adoption as binary, obscuring dose-response effects. Second, the working capital channel is frequently asserted but rarely tested as a formal mediator. Third, selection into adoption is seldom quantified, leaving associational estimates inflated. This study addresses all three.

Four hypotheses follow:

H1: Annual sales growth differs significantly across digital payment adoption tiers.
H2: Higher adoption intensity is associated with a shorter working capital cycle.
H3: Adoption intensity is positively associated with access to formal credit.
H4: The working capital cycle mediates the relationship between adoption intensity and sales growth.

Methodology

Research design. A cross-sectional survey design with retrospective twelve-month performance recall was employed, supplemented by matched-comparison estimation to address self-selection.

Population and sampling. The sampling frame comprised registered and unregistered micro-enterprises with fewer than ten workers operating from a fixed premises. Stratified random sampling was applied across four sector strata with proportional allocation. Minimum sample size was determined using Cochran's formula at 95 per cent confidence and a 5 per cent margin of error, yielding 384, inflated for anticipated non-response. Of 540 enterprises approached, 468 provided usable responses, a response rate of 86.7 per cent.

Instrument. A structured schedule was administered through face-to-face interview in the local language. Section A captured enterprise and owner attributes. Section B recorded objective transaction data: total monthly receipts, receipts settled digitally, average daily customer footfall, days receivable and days inventory. Section C measured perceptual constructs on a five-point Likert scale. Adoption intensity was operationalised as the share of monthly receipt value settled through digital channels, verified where possible against the owner's payment application transaction history.

Reliability and validity. Content validity was established through expert review by three subject specialists and a pilot on 35 enterprises excluded from the final sample. Cronbach's alpha was 0.871 for the adoption construct, 0.843 for perceived performance and 0.798 for the barriers construct. Sampling adequacy was confirmed with a Kaiser–Meyer–Olkin value of 0.862 and Bartlett's test of sphericity, $\chi^2(171) = 3{,}412.7$, $p < 0.001$.

Analytical strategy. Enterprises were grouped into four adoption tiers. Group differences were tested using one-way ANOVA with Tukey HSD post hoc comparison for

continuous outcomes and chi-square with Cramér's V for categorical outcomes. Determinants of sales growth were estimated by ordinary least squares with heteroscedasticity-robust standard errors and sector fixed effects. Mediation was assessed using the Sobel test with 5,000 bootstrap resamples. Selection was addressed through one-to-one nearest-neighbour propensity score matching with a 0.05 caliper, using enterprise age, owner education, owner age, gender, baseline turnover, registration status and sector as matching covariates.

Results

Sample profile. Mean owner age was 38.4 years (SD = 9.7) and mean enterprise age 7.6 years (SD = 5.2). Female-owned enterprises numbered 131 (28.0 per cent), 61.3 per cent held formal registration, and 94.4 per cent of owners owned a smartphone. Mean monthly turnover was ₹1.62 lakh (SD = ₹0.94 lakh). The overall mean digital share of receipts was 34.7 per cent (SD = 26.4).

Table 1. Distribution of sampled enterprises by adoption tier and sector (N = 468)

Adoption tier (digital share of receipts)	Retail trade	Food & beverage	Personal & repair	Micro-manufacturing	Total	%
Non-adopter (< 5%)	31	18	22	25	96	20.5
Low (5–25%)	44	27	28	23	122	26.1
Moderate (25–50%)	56	35	29	21	141	30.1
High (> 50%)	47	32	17	13	109	23.3
Total	**178**	**112**	**96**	**82**	**468**	**100.0**

Table 2. Performance outcomes by adoption tier

Outcome	Non-adopter (n = 96)	Low (n = 122)	Moderate (n = 141)	High (n = 109)	Test statistic	p
Annual sales growth (%), mean (SD)	4.1 (6.8)	8.7 (7.4)	13.9 (8.1)	19.6 (9.3)	F(3, 464) = 62.48	< 0.001
Customer base growth (%), mean (SD)	3.2 (5.9)	7.1 (6.4)	11.4 (7.2)	16.2 (8.0)	F(3, 464) = 48.16	< 0.001
Average daily footfall, mean	41.3	48.6	57.2	66.9	F(3, 464) = 37.92	< 0.001
Working capital cycle (days), mean (SD)	28.6 (11.2)	24.9 (10.4)	21.3 (9.8)	17.8 (9.1)	F(3, 464) = 29.77	< 0.001
Net profit margin (%), mean (SD)	9.4 (4.1)	10.8 (4.3)	12.1 (4.6)	13.6 (4.9)	F(3, 464) = 14.83	< 0.001
Formal credit accessed in 24 months (%)	14.6	23.0	34.0	45.9	$\chi^2(3) = 31.42$	< 0.001
Maintains business records (%)	31.3	45.9	62.4	78.0	$\chi^2(3) = 53.71$	< 0.001

Effect sizes were large for sales growth ($\eta^2 = 0.288$), moderate for the working capital cycle ($\eta^2 = 0.161$) and small to moderate for profit margin ($\eta^2 = 0.087$). Cramér's V for credit access was 0.259. Tukey HSD comparisons confirmed that all six pairwise differences in sales growth were significant at $p < 0.01$. H1, H2 and H3 are therefore supported.

Table 3. OLS regression predicting annual sales growth (N = 468)

Predictor	b	Robust SE	β	t	p
Digital adoption	1.412	0.187	0.283	7.55	< 0.001

intensity (per 10 pp)					
Access to formal credit (1 = yes)	2.914	0.856	0.151	3.40	0.001
Baseline turnover (log)	1.947	0.612	0.142	3.18	0.002
Owner education (years)	0.402	0.145	0.121	2.77	0.006
Formal registration (1 = yes)	2.186	0.803	0.115	2.72	0.007
Enterprise age (years)	−0.118	0.081	−0.061	−1.46	0.146
Female-owned (1 = yes)	−0.731	0.884	−0.034	−0.83	0.409
Constant	−4.220	3.910	—	−1.08	0.281

Sector fixed effects included. $R^2 = 0.412$; adjusted $R^2 = 0.399$; $F(10, 457) = 32.04$, $p < 0.001$; Durbin–Watson = 1.94; maximum VIF = 2.31.

Adoption intensity was the strongest single predictor: each ten-percentage-point increase in the digital share of receipts corresponded to a 1.41-percentage-point increase in annual sales growth, holding other factors constant. Enterprise age and owner gender were not significant.

Mediation. The working capital cycle partially mediated the adoption–growth relationship. The indirect effect was b = 0.218 (bootstrap 95 per cent CI [0.102, 0.357]; Sobel z = 3.94, $p < 0.001$), representing 15.4 per cent of the total effect of 1.412; the direct effect of 1.194 remained significant. H4 is supported in its partial form.

Correcting for selection. Propensity score matching compared high-adoption enterprises with observationally similar non- and low-adopters. The average treatment effect on the treated was 9.42 percentage points of sales growth (SE = 2.18; t = 4.32; $p < 0.001$) against an unadjusted difference of 15.5 percentage points, indicating that roughly two-fifths of the raw gap reflects selection on observables. The matched effect on formal credit access was 18.7 percentage points (SE = 5.4; p = 0.001).

Table 4. Perceived barriers to deeper digital payment adoption (five-point scale)

Barrier	Mean	SD	Rank
Transaction and settlement charges	3.92	0.96	1
Apprehension about tax scrutiny and formalisation cost	3.78	0.88	2
Network and connectivity failure	3.61	1.02	3
Low digital literacy of owner or staff	3.44	1.09	4
Customer preference for cash	3.37	1.11	5
Fraud and security concerns	3.21	1.05	6
Delayed settlement to bank account	2.98	0.97	7

Discussion

The dose-response pattern in Table 2 is the central finding: performance rises monotonically across adoption tiers rather than shifting discretely at the point of first adoption. This suggests that benefits accrue from displacement of cash as the dominant settlement medium, not from the mere availability of a digital option — consistent with the persistence of adoption in high-exposure districts documented by Crouzet et al. (2023), where sustained usage rather than one-time uptake drove outcomes.

The mediation result locates a concrete mechanism. A reduction of 10.8 days in the working capital cycle between the extreme tiers releases liquidity that would otherwise be immobilised, and this channel carries 15.4 per cent of the total growth effect. That the direct effect remains dominant implies additional pathways, most plausibly the customer-acquisition effect visible in footfall differences and the redirection of consumer expenditure toward acceptance-enabled small retailers reported by Higgins (2024).

The credit-access finding aligns closely with Dalton et al. (2024): digital payment usage functions as an entry point to formal finance, with matched estimation still yielding an 18.7-percentage-point advantage. The verifiable transaction record substitutes for the collateral and audited accounts that micro-enterprises cannot supply, echoing the creditworthiness mechanism identified by Islam et al. (2018).

The barrier profile is instructive and mirrors Ligon et al. (2019). The two highest-ranked constraints — settlement charges and tax apprehension — are institutional rather than technological, while digital literacy ranks only fourth. Policy aimed at deepening adoption should therefore prioritise merchant discount rate relief and credible ring-fencing of transaction data from punitive tax enforcement, rather than further awareness campaigns.

Finally, the absence of a significant gender coefficient warrants care. It indicates no growth penalty for female-owned enterprises conditional on adoption, but does not address differential adoption rates, which Islam and Muzi (2022) found to matter substantially for investment outcomes.

Conclusion

Digital payment adoption intensity is a robust and economically meaningful correlate of micro-business performance. Enterprises settling more than half their receipts digitally outperformed non-adopters by 15.5 percentage points of annual sales growth in raw terms and by 9.42 percentage points after matching on observable characteristics. The effect operates partly through a shortened working capital cycle and partly through improved access to formal credit and expanded customer reach. Because the binding constraints on deeper adoption are the cost of acceptance and fear of regulatory exposure rather than unfamiliarity with the technology, interventions that reduce merchant-side transaction costs and offer transitional tax certainty are likely to generate larger marginal gains than training-led approaches.

Limitations and Scope for Future Research

The cross-sectional design with retrospective recall limits causal inference; propensity score matching corrects only for selection on observed covariates, leaving unobserved owner ability or ambition uncontrolled. Performance measures rely partly on owner recall, which may be subject to reporting error in the absence of formal accounts, though verification against transaction histories mitigates this for the adoption variable. The sample is confined to fixed-premises enterprises and therefore excludes mobile vendors, among whom acceptance economics may differ. Longitudinal panel tracking, instrumental variable strategies exploiting network rollout timing, and randomised acceptance-cost subsidies represent productive extensions.

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