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DIGITAL PAYMENT SYSTEMS AND FINANCIAL INCLUSION IN DEVELOPING COUNTRIES: PANEL EVIDENCE FROM 24 EMERGING ECONOMIES, 2010–2023

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Abstract
We investigate the effect of digital payments on financial inclusion in 24 developing economies between 2010 and 2023. Using a balanced panel data from the World Bank Global Findex Database, World Development Indicators, and IMF Financial Access Survey, the study estimates Pooled OLS, Fixed Effects and Random Effects models to investigate the effects of mobile money adoption and digital payments on total account ownership, female account ownership and account ownership for the poorest 40% of the population. The Hausman specification test is used to inform model choice. The empirical results show that digital payments have a statistically and economically significant positive impact on overall account ownership ($\beta = 0.927$, $p < 0.001$) and financial inclusion of women ($\beta = 0.876$, $p < 0.001$), and mobile money adoption has a significant impact on the reduction of exclusion gaps among the poorest income quintile ($\beta = 0.653$, $p < 0.00$ The gender financial inclusion gap is largely driven by country-specific effects. The Friedman non-parametric tests validate the highly significant improvement across all Global Findex surveys (2011-2021) within countries. This research extends the burgeoning research on fintech-inclusion by offering panel evidence and policy insights for policymakers, regulators and development practitioners in the Global South.

Keywords: Digital payments, financial inclusion, mobile money, panel data, developing countries, gender gap, fintech

1. Introduction

The explosive growth of digital financial services has transformed financial services in developing countries. In the last ten years, mobile money services, e-wallets and agent banking have pushed the envelope on financial inclusion to segments of the population previously denied access to traditional financial institutions (Demirgüç-Kunt et al., 2022; Klapper & Singer, 2023). Universal financial inclusion, in the sense of universal access to and use of affordable,

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appropriate financial products and services, remains a high priority development goal reflected in the Sustainable Development Goals (SDGs), specifically SDG 8 (decent work and economic growth) and SDG 10 (reduced inequalities) (World Bank, 2022; United

While significant headway has been made, the 2021 edition of the Global Findex Database reported that 1.4 billion adults globally are still unbanked, most of them in Sub-Saharan Africa, South Asia and some parts of Latin America and East Asia (Demirgüç-Kunt et The roots of financial exclusion lie in structural factors such as geographical distance, high transaction costs, insufficient documentation systems, limited In this context, digital payments - especially mobile money - have emerged as a potentially game-changing instrument to promote financial inclusion by overcoming the need for brick-and-mortar branch-based operations (Suri & Jack

The evidence on digital payments and financial inclusion is rapidly growing but also fragmented at multiple levels. First, much of the current evidence is cross-sectional or based on a single country, limiting the scope for generalizing findings and uncovering causal relationships over time (Asongu & Nwachukwu, 2022; Akileng et al., 2021). Second, there is scant empirical evidence on subgroup differences across gender and income, which are key targets for financial inclusion (Allen et al., 2021; Laha & Kuri, 2022). Third, the lack of a consistent approach to variable measurement and model building makes comparative analyses difficult (Ozili, 2021; Evans & Adeoye, 2021).

Our study overcomes these limitations by using a balanced panel data set for 24 developing countries from Sub-Saharan Africa, South Asia, Southeast Asia, the Middle East and North Africa, and Latin America for 2010-2023. Our database combines data from the World Bank Global Findex Database, World Development Indicators, and IMF Financial Access Survey. We use Pooled OLS, Fixed Effects (FE) and Random Effects (RE) panel regression models for five different dependent variables that represent various aspects of financial inclusion: overall account ownership, female account ownership, account ownership for the poorest 40%, gender gap in account ownership and income gap in account ownership. We choose between the former and latter based on the Hausman specification test, and use Friedman non-parametric tests and paired t-tests to analyse the evolution of results across the waves of the Global Findex survey.

Our contributions are three-fold. First, we offer a wide range of panel evidence on the impact of digital payments on financial inclusion across a variety of developing countries, allowing for within-country identification of effects that are not identified in cross-sectional analysis. Second, we report differential effects of digital payments and mobile money across gender and

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income groups, providing policy insights to the fintech-for-inclusion agenda. Third, we adopt a robust multi-model estimation approach with formal tests of specification, to ensure the validity of our findings. The rest of the paper is structured as follows: Section 2 is a review of existing literature; Section 3 is on the data and methodology; Section 4 exhibits the empirical findings; Section 5 discusses our results and its policy implications; and Section 6 is the conclusion.

2. Literature Review

2.1 Digital Payment Systems and the Fintech Revolution

Notions of digital payment systems have transformed over the last two decades. Initial research examined internet banking and card payment systems in developed countries (Beck et al., 2022; Demirgüç-Kunt & Klapper, 2021). The game-changing moment for developing economies came with the advent of mobile money, led by M-Pesa in Kenya in 2007, which showed that telecommunication networks can be used to substitute for banking branches to offer payment and savings services to the poor (Suri, 2021; Suri & Jack, 2023). The subsequent rollout of mobile money services across Sub-Saharan Africa - such as MTN Mobile Money, Airtel Money, Orange Money - and in Asia - such as bKash in Bangladesh and GCash in the Philippines - established a new paradigm for financial services (Islam et al., 2022; Banna et al., 2021).

Researchers have theorised a number of pathways through which digital payments can increase financial inclusion. The transaction cost reduction hypothesis suggests that digital channels reduce the fixed and variable costs of financial transactions, allowing small-value transactions to become profitable for financial service providers and their low-income customers (Batiz-Lazo et al., 2021; Murendo & Wollni, 2021). The reduction of information asymmetry hypothesis posits that digital transaction data creates credit information that allows financial service providers to score credit for unscored groups (Ozili & Arun, 2023; Anarfo & Abor, 2021). The network externality hypothesis suggests that the use of digital payment systems create positive externalities that drive the diffusion of the system and enhance financial intermediation (Evans & Adeoye, 2021; Kauffman et al., 2022).

2.2 Empirical Evidence on Financial Inclusion

The evidence on factors driving financial inclusion is found in both macro and micro studies using panel data and household and firm surveys. At the macro level, Beck et al. (2022) using a panel of 140 countries, found that ATMs and mobile subscriptions have a positive impact on financial account ownership, and it is more pronounced in low-income countries. Demirgüç-Kunt et al. (2022) using the 2021 Global Findex data found that globally 76% of the population had an account but less than 50% in Sub-Saharan Africa and South

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Asia. Ozili (2022) highlighted the importance of internet usage for financial inclusion with differential effects by income. Rasheed et al. (2021) for Pakistan reported substantial contributions of mobile banking and e-wallets to enhancing financial inclusion in rural Pakistan.

A recent focus is on mobile money. Suri and Jack (2023) now have an updated version of their pioneering Kenyan study showing that in the long run, poverty was reduced through savings and investment mechanisms facilitated by M-Pesa. Munyegera and Matsumoto (2021) for Uganda found mobile money use increased welfare via remittances and savings channels. Akileng et al. (2021) found that mobile money was positively associated with the use of formal financial services in Uganda. For Sub-Saharan Africa more generally, Asongu and Nwachukwu (2022) showed that mobile money penetration was associated with lower income inequality and increased financial inclusion in panel data of 48 African countries. Mwangi et al. (2021) highlighted the importance of mobile money agent network density.

2.3 Gender and Income Dimensions of Digital Financial Inclusion

Developing country financial systems suffer from a gender gap in financial inclusion. Allen et al. (2021) reported that women are 9 percentage points less likely to have a formal account than men globally; the gender gap exceeds 20 percentage points in some South Asian and Middle Eastern countries. The reasons for the gender gap in financial inclusion include discriminatory legal and social norms that limit women's ability to independently participate in financial markets; lower women's education; and lower access to mobile phones and internet (Demirgüç-Kunt et al., 2022; Klapper & Singer, 2023).

Research on the impact of digital payments on the gender gap is mixed. Laha and Kuri (2022) found that the rollout of mobile money in Sub-Saharan Africa decreased the gender gap in financial account ownership by allowing women to use a shared mobile network for transactions. Yiing et al. (2023) for Southeast Asia found positive but small effects of digital payments on women's financial inclusion, with effects mitigated by education levels and household income. On the other hand, Damle et al. (2022) argued that digital financial inclusion doesn't necessarily lead to women's economic empowerment if structural gender inequalities in asset holdings and income persist. For income, Quartey et al. (2022) and Anyanwu and Erhijakpor (2021) found that mobile money disproportionately helps the poor by removing the price premium attributed to bank proximity.

2.4 Infrastructure and Macroeconomic Determinants

The literature points to a range of structural factors that impact financial inclusion, beyond digital technologies. Banking infrastructure (proxied by ATM density and bank branch density) still has strong positive impacts on

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financial account holding in the developing world, in regions where digital technologies are less widely adopted (Fungáčová & Weill, 2022; Kim et al., 2021). GDP per capita shows positive association with financial inclusion, capturing the two-way determination of income and financial development (Ahamed & Mallick, 2021; Zins & Weill, 2022). Inflation and macroeconomic stability is reported as a negative factor for financial inclusion, especially with regards to savings, as it erodes the purchasing power of savings deposits and reduces trust in the financial sector (Ozili, 2021; Neaime & Gaysset, 2021). The share of the rural population is negatively associated with financial inclusion as the cost of providing financial services in rural areas is higher (Amponsah et al., 2021). Poverty rates are more ambiguous as large values proxy exclusion, but reducing poverty can lead to increased demand for financial services (Laha & Kuri, 2022).

2.5 Research Gaps and Positioning of the Present Study

Our review of the above literature suggests the following gaps. First, although macro-level panel studies have addressed financial inclusion, few use the suite of three estimators (Pooled OLS, FE, RE) with formal Hausman testing in the context of multiple aspects of financial inclusion. Second, the simultaneous analysis of digital payments and mobile money in the same panel (allowing for comparisons of relative magnitudes) is rare. Third, the study of dynamical trends of inclusion using non-parametric Friedman tests and Wilcoxon signed-rank tests across Global Findex waves offers a complementary perspective to regression-based studies. The current paper fills these three gaps using a large, cross-country panel for 2010-2023.

3. Data and Methodology

3.1 Sample and Data Sources

The research uses an unbalanced panel data set with 24 developing nations for the years 2010-2023 (up to 336 country-year observations for infrastructure and macroeconomic variables). The sample includes countries from Sub-Saharan Africa (Ethiopia, Ghana, Kenya, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda, Zambia, Zimbabwe), South and Southeast Asia (Bangladesh, China, India, Indonesia, Philippines, Thailand, Vietnam), the Middle East and North Africa (Egypt) and Latin America (Brazil, Colombia, Mexico, Peru). The sample's countries were chosen based on data availability from several indicator sources and to represent different regions.

The financial inclusion indicators are sourced from the World Bank Global Findex Database, which offers nationally representative survey data on financial inclusion collected in 2011, 2014, 2017, and 2021 for 96 observations for account ownership variables. Control variables for digital infrastructure and macroeconomic indicators are sourced from the World Development

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Indicators (WDI) for all years 2010-2023. Mobile money accounts for the years when data are available for Findex surveys provide additional information to the account ownership indicators. Variable definitions and sources are in Table 1.

Table 1: ***Variable Definitions and Data Sources***

Variable	Definition	Source
Account Ownership – Total (%)	Adults with a formal financial account (%)	Global Findex
Account Ownership – Female (%)	Female adults with a formal account (%)	Global Findex
Account Ownership – Poorest 40% (%)	Poorest 40% adults with formal account (%)	Global Findex
Mobile Money Account (%)	Adults with a mobile money account (%)	Global Findex
Digital Payments Made/Received (%)	Adults making/receiving digital payments (%)	Global Findex
Internet Users (%)	Individuals using the Internet (% of population)	WDI
Mobile Subscriptions per 100	Mobile cellular subscriptions per 100 people	WDI
ATMs per 100k Adults	Automated teller machines per 100,000 adults	IMF FAS / WDI
Bank Branches per 100k Adults	Commercial bank branches per 100,000 adults	IMF FAS / WDI
GDP per Capita (USD)	GDP per capita, current US dollars	WDI
Poverty Rate (%)	Poverty headcount at national poverty line (%)	WDI
Inflation (%)	Inflation, consumer prices (annual %)	WDI
Rural Population (%)	Rural population (% of total)	WDI
Total Population (Millions)	Total population in millions	WDI

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Note. WDI = World Development Indicators; IMF FAS = IMF Financial Access Survey. Global Findex data available for 2011, 2014, 2017, and 2021 waves.

3.2 Descriptive Statistics

Summary statistics are in Table 2. Average account ownership (total) across countries was 46.57% (SD = 21.39%, range: 9.7-96.0%). Account ownership by women averaged 43.25% with a gender gap consistent with the literature. The rate of account ownership among the bottom 40% of the population averaged 35.74%, showing the stratification of account ownership by income. Mobile money account ownership was highly variable (mean = 18.48%, SD = 19.84%) due to the concentration of mobile money services in Sub-Saharan Africa and South Asia. Making or receiving digital payments averaged 46.46% for countries surveyed for the Findex in 2017 and 2021.

Table 2: ***Descriptive Statistics***

Variable	N	Mean	Std Dev	Min	Median	Max	Missing
Account Ownership – Total (%)	96	46.57	21.39	9.7	43.55	96.0	240
Account Ownership – Female (%)	96	43.25	22.83	2.9	38.75	97.0	240
Account Ownership – Poorest 40% (%)	96	35.74	21.79	3.0	31.50	93.0	240
Mobile Money Account (%)	73	18.48	19.84	0.7	10.00	85.0	263
Digital Payments Made/Received (%)	48	46.46	18.66	17.0	45.00	89.0	288
Internet Users (%)	336	42.09	22.20	0.7	41.65	87.0	0
Mobile Subscriptions per 100	336	96.67	27.41	20.1	99.00	164.9	0
ATMs per 100k	336	32.43	26.89	0.9	25.10	138.0	0

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Variable	N	Mean	Std Dev	Min	Median	Max	Missing
Adults							
Bank Branches per 100k Adults	336	11.74	8.62	1.8	9.90	53.4	0
GDP per Capita (USD)	336	3,821	3,289	380	2,851	12,810	0
Poverty Rate (%)	336	28.92	14.56	2.3	27.40	71.9	0
Inflation (%)	336	6.82	5.61	-1.2	5.50	44.4	0
Rural Population (%)	336	49.55	17.32	12.4	51.00	83.7	0

Note. N = number of non-missing observations. Missing = total missing observations across 336 country-year observations (24 countries × 14 years). Financial inclusion variables (Global Findex) are available only for survey years 2011, 2014, 2017, and 2021.

3.3 Empirical Strategy

3.3.1 Panel Model Specification

The baseline empirical model takes the following form:

$$FI\_it = \alpha + \beta_1 DPAY\_it + \beta_2 X\_it + \mu\_i + \lambda\_t + \varepsilon\_it \quad (1)$$

where FI_it is a measure of financial inclusion for country i in period t; DPAY_it is a measure of digital payments (digital payments penetration or mobile money adoption); X_it is a set of time-varying control variables such as internet penetration, mobile subscriptions, ATM density, bank branch density, GDP per capita, poverty rate, inflation and rural population share; μ_i is the unobserved country-specific time-invariant effect (Fixed Effects); λ_t is the time-specific fixed effect (

Three estimation models are used: Pooled OLS (which ignores country specific effects and is used as a benchmark), Fixed Effects (which demeans the dependent variable to remove all time-invariant country specific effects) and Random Effects (which assumes random country specific effects are uncorrelated with regressors, allowing more efficient estimation). In Fixed Effects models, standard errors are clustered at the country level to allow for within-cluster serial correlation. Random Effects and Pooled OLS use robust standard errors. Year dummies are also included to account for common shocks.

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3.3.2 Model Selection: Hausman Test

The Hausman (1978) specification test is used to determine which of the Fixed Effects (FE) and Random Effects (RE) estimators is preferred. This is a test of whether the coefficient vectors of the FE and RE models differ systematically. If the null hypothesis of no systematic difference between estimators is rejected, Fixed Effects is preferred as it indicates country differences are correlated with regressors. Not rejecting implies Random Effects is consistent and efficient.

3.3.3 Temporal Dynamics: Non-Parametric Tests

To supplement the panel regression results, we investigate the dynamics over time across the Global Findex surveys with two non-parametric tests. The Friedman non-parametric test for repeated measures assesses whether distributions of account ownership differ across the four waves of the survey (2011, 2014, 2017, 2021). Comparisons of distributions of account ownership between consecutive and non-consecutive waves use paired t-tests (normality assumption) and Wilcoxon signed-rank tests (distribution-free). This analysis is performed on 24 matching country observations over the four survey years.

3.3.4 Multicollinearity Assessment

Variance Inflation Factors (VIF) are calculated for all independent variables in the model. Using the convention, VIF > 10 is taken as a sign of severe multicollinearity, which needs to be addressed, while 5 ≤ VIF ≤ 10 indicates moderate collinearity for which the modeler needs to be aware (Hair et al., 2019; O'Brien, 2021).

4. Empirical Results

4.1 Multicollinearity Diagnostics

Table 3 shows results from the full set of predictors. ATMs per 100k adults (VIF = 12.16) and GDP per capita (VIF = 10.44) are slightly above 10, as the relationship between economic growth and financial development is well documented. Adoption of mobile money accounts (VIF = 7.16), digital payments (VIF = 5.44), and share of rural population (VIF = 7.95) are moderately correlated. Since ATMs and GDP per capita are theoretically relevant controls and are included in alternative model specifications with mobile money and digital payments, we do not view severe multicollinearity as a serious concern. The other predictors have VIF below 5, suggesting no multicollinearity.

Table 3: ***Variance Inflation Factor Results***

Variable	VIF	Assessment
Constant	217.11	Structural (not interpretable)
Mobile Money Account (%)	7.16	Moderate

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Variable	VIF	Assessment
Digital Payments Made/Received (%)	5.44	Moderate
Internet Users (%)	2.56	No Issue
Mobile Subscriptions per 100	2.77	No Issue
ATMs per 100k Adults	12.16	High – monitor
Bank Branches per 100k Adults	3.07	No Issue
GDP per Capita (USD)	10.44	High – monitor
Poverty Rate (%)	2.44	No Issue
Inflation (%)	1.33	No Issue
Rural Population (%)	7.95	Moderate
Total Population (Millions)	1.77	No Issue

Note. VIF < 5: no concern; 5 ≤ VIF < 10: moderate (review); VIF ≥ 10: high (use caution). Constants are routinely excluded from VIF interpretation.

4.2 Temporal Dynamics in Financial Inclusion

Table 4 shows the results of Friedman non-parametric tests of whether the distributions of account ownership changed in the four waves of the Global Findex survey. The Friedman statistics for all three measures of account ownership are highly significant: total ownership ($\chi^2 = 61.65$, $p < 0.001$), female ownership ($\chi^2 = 63.85$, $p < 0.001$) and poorest-40% account ownership ($\chi^2 = 64.76$, $p < 0.001$). There is also a highly significant trend for mobile money account ownership ($\chi^2 = 20.74$, $p < 0.001$). Importantly, the gender gap ($\chi^2 = 1.80$, $p = 0.616$) and income gap ($\chi^2 = 5.58$, $p = 0.134$) do not show a significant trend over time, so while the overall level of inclusion grew, inclusion gaps between groups were more resistant to change.

Table 4: *Friedman Non-Parametric Tests Across Global Findex Waves*

Variable	Countries (N)	Survey Years	Friedman χ^2	p-value	Significance
Account Ownership – Total (%)	24	2011, 2014, 2017, 2021	61.65	< 0.001	***

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Variable	Countries (N)	Survey Years	Friedman χ^2	p-value	Significance
Account Ownership – Female (%)	24	2011, 2014, 2017, 2021	63.85	< 0.001	***
Account Ownership – Poorest 40% (%)	24	2011, 2014, 2017, 2021	64.76	< 0.001	***
Mobile Money Account (%)	7	2011, 2014, 2017, 2021	20.74	< 0.001	***
Gender Gap (pp)	24	2011, 2014, 2017, 2021	1.80	0.616	n.s.
Income Gap (pp)	24	2011, 2014, 2017, 2021	5.58	0.134	n.s.

*Note. pp = percentage points; n.s. = not significant. *** $p < 0.001$. Friedman test requires ≥ 3 measurement occasions; Mobile Money available for 7 countries across all four waves.*

Table 5 shows results for pairwise comparisons between survey waves. Between 2011 and 2014, total account ownership improved by an average of 9.68 percentage points, between 2014 and 2017 by 10.68 points and between 2017 and 2021 by 11.11 points, with all differences significant at $p < 0.001$ by paired t-test and by Wilcoxon test. Total improvement between 2011 and 2021 was 31.48 percentage points. Account ownership among women showed an almost identical pattern, with 31.15 percentage points gain between 2011 and 2021. Account ownership of the bottom 40% improved by 31.42 points. These findings support a long-term, statistically significant improvement in financial inclusion in all subgroups of the population in the countries studied.

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Table 5: ***Pairwise Year Comparisons in Account Ownership (Paired t-test and Wilcoxon)***

Variable	Period	N	Mean Y1	Mean Y2	Change (pp)	t-stat	p-val (t)	W-stat	p-val (W)
AO – Total (%)	2011–2014	24	31.19	40.88	+9.68	-4.94	< .001***	24.0	< .001***
AO – Total (%)	2014–2017	24	40.88	51.56	+10.68	-5.11	< .001***	15.0	< .001***
AO – Total (%)	2017–2021	24	51.56	62.67	+11.11	-4.63	< .001***	9.0	< .001***
AO – Total (%)	2011–2021	24	31.19	62.67	+31.48	-12.88	< .001***	0.0	< .001***
AO – Female (%)	2011–2014	24	28.22	37.42	+9.20	-4.86	< .001***	25.0	< .001***
AO – Female (%)	2014–2017	24	37.42	47.96	+10.54	-4.68	< .001***	18.0	< .001***
AO – Female (%)	2017–2021	24	47.96	59.38	+11.41	-4.85	< .001***	10.0	< .001***
AO – Female (%)	2011–2021	24	28.22	59.38	+31.15	-12.07	< .001***	0.0	< .001***
AO – Poorest 40% (%)	2011–2014	24	20.79	29.62	+8.83	-4.80	< .001***	18.0	< .001***
AO – Poorest 40% (%)	2014–2017	24	29.62	40.33	+10.71	-5.42	< .001***	3.5	< .001***
AO – Poorest 40% (%)	2017–2021	24	40.33	52.21	+11.88	-4.68	< .001***	10.0	< .001***
AO – Poorest	2011–2021	24	20.79	52.21	+31.42	-11.95	< .001***	0.0	< .001***

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Variable	Period	N	Mean Y1	Mean Y2	Change (pp)	t-stat	p-val (t)	W-stat	p-val (W)
40% (%)									

*Note. AO = Account Ownership; pp = percentage points; N = number of matched country pairs; W-stat = Wilcoxon signed-rank test statistic. *** p < 0.001.*

4.3 Hausman Specification Test Results

Hausman test results for all 15 of the panel models estimated from the three sets of dependent variables and the three model specifications are summarized in Table 6. The Hausman test does not reject the null of no systematic difference for most account ownership models (Total, Female, Poorest 40%) in all three model sets (p values = 1.000), and Random Effects is recommended as the efficient estimator. Exceptions are the Gender Gap models: the Base model for gender gap ($\chi^2 = 27.55$, df = 9, p = 0.001) and the Mobile Money model for gender gap ($\chi^2 = 25.51$, df = 7, p < 0.001) reject the null, and recommend Fixed Effects. The null is also rejected for the Mobile Money model for the poorest-40% account ownership ($\chi^2 = 39.58$, df = 7, p < 0.001). This suggests that the gender gap is controlled by country-specific unobserved variables that are correlated with the regressors; this has policy implications.

Table 6: ***Hausman Specification Test Summary***

Model	Dep. Variable	N Obs	Hausman χ^2	df	p-value	Preferred
Total – Base	AO (%) Total	96	-13.67	9	1.000	Random Effects
Total – Mobile Money	AO (%) Total	73	9.35	7	0.228	Random Effects
Total – Digital Pay	AO (%) Total	48	-1.00	7	1.000	Random Effects
Female – Base	AO Female (%)	96	-16.46	9	1.000	Random Effects
Female – Mobile Money	AO Female (%)	73	7.15	7	0.414	Random Effects
Female –	AO Female	48	-2.03	7	1.000	Random

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Model	Dep. Variable	N Obs	Hausman χ^2	df	p-value	Preferred
Digital Pay	(%)					Effects
Poor40 – Base	AO Poorest 40%	96	-78.60	9	1.000	Random Effects
Poor40 – Mobile Money	AO Poorest 40%	73	39.58	7	< .001	Fixed Effects ***
Poor40 – Digital Pay	AO Poorest 40%	48	-316.09	7	1.000	Random Effects
Gender Gap – Base	Gender Gap (pp)	96	27.55	9	0.001	Fixed Effects **
Gender Gap – Mobile Mon	Gender Gap (pp)	73	25.51	7	< .001	Fixed Effects ***
Gender Gap – Digital Pay	Gender Gap (pp)	48	-1.67	7	1.000	Random Effects
Income Gap – Base	Income Gap (pp)	96	11.30	9	0.256	Random Effects
Income Gap – Mobile Mon	Income Gap (pp)	73	-602.03	7	1.000	Random Effects
Income Gap – Digital Pay	Income Gap (pp)	48	7.03	7	0.426	Random Effects

*Note. Negative Hausman statistics reflect near-singular difference matrices and indicate unambiguous preference for Random Effects. ** $p < 0.01$; *** $p < 0.001$.*

4.4 Panel Regression Results: Total Account Ownership

Table 7 shows the results for the panel regressions for total account ownership in the three models. The digital payments model (Random Effects, $R^2 = 0.940$) is the most accurate. The most important positive variable is digital payments made/received: in the Random Effects specification, a percentage point increase in digital payments is associated with a 0.922 percentage point increase in total account ownership ($\beta = 0.922$, standard error (SE) = 0.046, p

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< 0.001). The Fixed Effects estimate (β = 0.927, SE = 0.121, p < 0.001) is virtually identical, and this finding is robust. In the mobile money model, adoption of a mobile money account is significant in both Pooled OLS (β = 0.534, p < 0.001) and Random Effects (β = 0.503, p < 0.001) models; the GDP per capita coefficient is also significant in the Random Effects model (β = 0.003, p = 0.0 In the base model, branch density (β = 1.087, p = 0.036) and inflation (β = -0.175, p = 0.025) are significant in the Fixed Effects model, implying that within countries, changes in bank branch density and inflation impact inclusion.

Table 7: ***Panel Regression — Total Account Ownership (Selected Results)***

Variable	Base: RE Coef (SE)	Mobile Money: RE Coef (SE)	Digital Pay: RE Coef (SE)
Digital Payments (%)	—	—	0.922*** (0.046)
Mobile Money (%)	—	0.503*** (0.099)	—
Internet Users (%)	0.039 (0.196)	0.064 (0.157)	-0.015 (0.065)
Mobile Subscriptions/100	0.014 (0.058)	0.029 (0.080)	0.038 (0.029)
ATMs per 100k Adults	0.104 (0.122)	—	—
Bank Branches per 100k	0.308 (0.333)	—	—
GDP per Capita (USD)	0.001 (0.001)	0.003** (0.001)	0.000 (0.001)
Poverty Rate (%)	0.239 (0.196)	0.075 (0.168)	-0.038 (0.075)
Inflation (%)	-0.108 (0.071)	-0.047 (0.042)	0.020 (0.016)
Rural Population (%)	0.147 (0.233)	0.140 (0.280)	0.068 (0.086)
Total Population (M)	0.019* (0.009)	—	—
N Observations	96	73	48
R^2	0.715	0.817	0.940

*Note. RE = Random Effects (Hausman-selected for all Total AO models). Robust standard errors in parentheses. * p < 0.10; ** p < 0.05; *** p < 0.001. — indicates variable not included in that model specification.*

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4.5 Panel Regression Results: Female Account Ownership and Gender Gap

Our results for female account ownership (Table 8, full results in Appendix) are very similar to those for total account ownership. In the digital payments Random Effects model (R^2 = 0.934), female account ownership is predicted by digital payments with β = 0.876 (SE = 0.048, p < 0.001), suggesting a close to one-for-one correspondence with broad-based rather than gender-targeted digital financial inclusion. In the Random Effects model, mobile money adoption is significant (β = 0.476, SE = 0.098, p < 0.001) as is GDP per capita (β = 0.004, p = 0.003).

For the gender gap models, Hausman tests require Fixed Effects for the Base and Mobile Money models. In the Base Fixed Effects model (R^2 = 0.175), only total population is significant (β = −0.060, SE = 0.026, p = 0.022), implying that the gender gap is higher in countries with smaller populations, perhaps due to the economies of scale of digital infrastructure roll-out. Mobile money adoption is not significant in Fixed Effects (β = -0.003, SE = 0.040, p = 0.950), suggesting that the adoption of mobile money, in the absence of other gender-focused interventions, does not reduce the gender financial inclusion gap within countries over time. This finding is in line with Damle et al. (2022) and more positive predictions in the literature.

4.6 Panel Regression Results: Poorest 40% Account Ownership

Inclusion of the poorest 40% is the component most affected by mobile money: the Fixed Effects coefficient for mobile money is 0.653 (SE = 0.140, p < 0.001) with R^2 = 0.526, much higher than other model specifications, confirming the effectiveness of mobile money to include the poor. In the Pooled OLS version, the coefficient for poverty rate (β = 0.876, p = 0.065) is marginally significant and positive, which implies that countries with higher headcounts of the poor have been catching up rapidly in extending inclusion to the poor, which is in line with the hypothesis of convergence. Electronic payments result in a significant Random Effects coefficient (β = 0.895, SE = 0.056, p < 0.001, R^2 = 0.940) for poorest-40% ownership as well.

Table 8: ***Panel Regression Summary — Mobile Money Models (Key Coefficients, RE/FE as Selected)***

Outcome	Estimator	Mobile Money β	SE	p-val	R^2	N
AO – Total (%)	RE	0.503	0.099	< .001***	0.817	73
AO – Female (%)	RE	0.476	0.098	< .001***	0.810	73

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Outcome	Estimator	Mobile Money β	SE	p-val	R^2	N
AO – Poorest 40% (%)	FE	0.653	0.140	< .001***	0.526	73
Gender Gap (pp)	FE	-0.003	0.040	0.950 (n.s.)	0.103	73
Income Gap (pp)	RE	-0.024	0.019	0.209 (n.s.)	0.190	73

*Note. RE = Random Effects; FE = Fixed Effects (Hausman-guided). AO = Account Ownership. n.s. = not statistically significant. *** $p < 0.001$.*

5. Discussion

The verdict is in. The uptake of digital payments is a major driver of financial inclusion in emerging markets. We find a close-to-one correlation between digital payments and account ownership ($\beta \approx 0.92$). This means that a 10 percentage point increase in the adoption of digital payments corresponds to a 9.2 percentage point increase in account ownership. This is consistent with the estimates in Demirgüç-Kunt et al. (2022) and Suri and Jack (2023). The fact that this finding holds for both Fixed Effects and Random Effects models suggests this is particularly reliable.

Why is this so? There are multiple reasons. First, digital payments necessarily require accounts - so the adoption of digital payments creates accounts (Ozili & Arun, 2023). But once they begin to use digital payments, they become familiar with digital finance. This makes it easier for them to take up other financial services such as credit, savings and insurance (Islam et al., 2022; Batiz-Lazo et al., 2021). And vendors in informal markets in South Asia and East Africa are adopting digital payments. This generates the need for accounts among those who have previously used cash only (Mwangi et al., 2021; Evans & Adeoye, 2021).

Perhaps the most interesting finding is for the bottom 40% of the population. This is the population most strongly affected by mobile money (FE $\beta = 0.653$). This makes sense. Mobile money is targeted at the poor because it requires low balances, is intuitive to use and can be accessed through informal retail outlets (Suri, 2021; Munyegera & Matsumoto, 2021). The Fixed Effects estimate here is especially compelling because it accounts for country-level issues such as colonial banking and regulatory frameworks.

But the news is not good in terms of gender. Greater mobile money penetration is not associated with more equal account ownership. This is

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concerning. There are factors that hold women back, beyond the technology itself - lower mobile phone ownership, restrictive social norms and lack of financial knowledge (Laha & Kuri, 2022; Klapper & Singer, 2023). The gender gap can be closed. Women-focused digital literacy, phone subsidies, and legal reform to remove obstacles to women's financial independence are all needed. Our Friedman test findings paint a mixed picture. On the one hand, account ownership has improved dramatically on all three fronts from 2011 to 2021. On the other hand, the gender gap ($p = 0.616$) and income gap ($p = 0.134$) have not significantly decreased. We are making progress, but not for all. This pattern, what we might call "inclusion without equity", is a wake-up call. Overarching financial inclusion policies are not sufficient. Policies that reach the most excluded are needed.

Branch networks still matter. Even with digital finance, the number of bank branches is a significant predictor of bank account ownership ($\beta = 1.087$, $p = 0.036$). This indicates that digital and physical banking infrastructure are complementary. Where digital banking infrastructure is still nascent, branches play a key role (Kim et al., 2021; Fungáčová & Weill, 2022). However, inflation has a significant negative effect on financial inclusion ($\beta = -0.175$, FE). Uncertain prices erode trust in the financial system (Neaime & Gaysset, 2021; Ozili, 2021).

Our results suggest policymakers should do the following. First, policymakers should invest in digital payment systems - interoperable payment systems, fintech sandboxes, and agents. The near-unit coefficient makes this investment worthwhile. Second, mobile money policies should consider the needs of the poor. That includes limited documentation, no minimum balances, and flat fees. Third, technology is not a panacea for gender and income inequality. Digital technologies need to be complemented with financial literacy, gender-sensitive ID cards, digital payments-based social payments, and legal reforms. Finally, don't forget macroeconomic stability. Monetary and fiscal stability provide the environment for financial inclusion to flourish.

6. Conclusion

We investigated the association between digital payment systems and financial inclusion in 24 developing economies between 2010 and 2023 using a robust panel estimation approach that includes Pooled OLS, Fixed Effects and Random Effects models with Hausman test for model selection. Five financial inclusion measures (total account ownership, female account ownership, account ownership by the bottom 40% of the population, gender gap, and income gap) and two measures of digital payment systems (digital payments [any] penetration and mobile money adoption) were examined.

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The key findings are: First, digital payments adoption is a strong and robust predictor of total account ownership ($\beta \approx 0.92$, close to one), implying that a 10 percentage point increase in payments adoption is associated with about 9 percentage points increase in account ownership. Second, mobile money adoption is a powerful predictor of financial account ownership among the poorest 40% of the population (FE $\beta = 0.653$, $p < 0.001$), withstanding the identification of within-country changes in Fixed Effects models. Third, neither digital payments nor mobile money has a systematic impact on the gender gap in financial account ownership within countries over time, highlighting the need for additional targeted gender-sensitive policy. Fourth, Friedman tests reveal statistically significant increases in absolute financial inclusion across all waves of the Global Findex survey, with average total account ownership rising by 31.48 percentage points during 2011 to 2021. But both the gender and income gaps have not closed substantially, posing a policy challenge. Fifth, the Hausman tests indicate that unobserved country-level heterogeneity is correlated with regressors for gender gap models, requiring Fixed Effects and suggesting the significance of country-specific structural factors in determining the gender gap in financial inclusion.

The study has limitations. Findex data is available only in survey years, reducing sample size for financial inclusion outcomes, and reduces the power of panel estimations. The between-country panel approach, while allowing generalisation, may overlook within-country spatial heterogeneity. The endogeneity between digital payment uptake and financial inclusion cannot be fully addressed in observational panel data, although time fixed effects control for common shocks. Future work should investigate instrumental variable strategies, take advantage of the staggered timing of mobile money regulatory reforms as natural experiments, and apply the analyses to subnational and individual data to detect different impacts across population subgroups.

Notwithstanding these caveats, the results hold valuable lessons for policymakers, development practitioners and financial regulators in the Global South. Digital payment ecosystems offer a promising opportunity to scale financial inclusion. But equity concerns, particularly for women, require that inclusion strategies include technology-driven strategies alongside structural measures to overcome the underlying social and economic factors preventing the most disadvantaged groups from engaging in the digital financial economy

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