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DIGITAL FINANCIAL INCLUSION AND THE TRANSMISSION OF MONETARY POLICY IN SUB-SAHARAN AFRICA

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Abstract

Monetary policy is an important tool of economic stabilization in modern economies. In recent years, the growth of fintech in Africa has seen Sub-Saharan African countries have one of the highest adoption rates of mobile money. Hence, this study seeks to examine whether the high adoption rate of mobile money has added complexity to the financial system structure and thus influences the effectiveness of monetary policy in these countries by using local projection and panel data analysis. The empirical evidence suggests that while digital financial inclusion (more adoption of mobile money) has transformed financial access in Sub-Saharan Africa, it has also introduced new complexities into the monetary transmission process - it appears to weaken the effectiveness of monetary policy in controlling inflation, having limited influence on output dynamics. The results reinforce need for a modernized monetary policy framework that reflects the realities of a rapidly evolving digital financial landscape.

Keywords*:*

Digital Financial Inclusion, Mobile Money, Sub-Saharan Africa, Monetary Policy, Inflation, Output.

Contribution/ Originality: This study uniquely explores whether the high adoption rate of mobile money has added complexity to the financial system structure and thus influences the effectiveness of monetary policy in the Sub-Saharan Africa. Using local projection and panel data analysis, it offers new insights into how digital financial inclusion has transformed financial access in the sub-region, and how that has influenced the transmission of monetary policy in the sub-region.

1.0 INTRODUCTION

Monetary policy is the primary tool of economic stabilisation in modern economies because of its ability to regulate money supply and interest rates. Yet in many Sub-Saharan African economies, its effectiveness is weak and inconsistent. This is seen in the persistent volatility of inflation despite policy rate adjustments. For example, despite the Central Bank of Nigeria's increase in monetary policy rates from 11.5% to 13.67% in 2022 and to 18.35% in 2023, the inflation rate still rose from 16.95% to 18.85% in 2022, to 24.65% in 2023, and to 33.24% in 2024. Kenya also recorded similar

volatility in the inflation rate from 2021 to 2023, despite the Central Bank of Kenya increasing central bank rates from 7% to 9.5% in 2022 and to 13.59 in 2023. Specifically, Kenya experienced a rise in the inflation rate from 6.11% in 2021 to 7.66% in 2022, and to 7.67% in 2023 (Central Bank of Nigeria, 2025; Central Bank of Kenya, 2025). This raises concerns about the effectiveness of the traditional monetary transmission mechanism in developing economies.

The standard framework for monetary policy transmission encompasses several key channels through which central bank actions, particularly adjustments to short-term interest rates, influence aggregate demand, output, and inflation. The interest rate channel, often regarded as the primary or traditional mechanism, operates by altering borrowing costs. Here, a monetary tightening raises real interest rates, which discourages investment by firms due to higher financing costs for capital projects, and reduces consumption by households, via elevated costs for durable goods, thereby dampening aggregate demand. The bank lending channel, a component of the broader credit channel, focuses on the supply side of credit, where policy-induced changes in bank reserves or funding costs constrain banks' ability or willingness to extend loans, particularly to borrowers reliant on bank financing, thus amplifying restrictions on investment and spending when credit availability tightens independently of interest rate effects. The exchange rate channel is especially relevant in open economies, as monetary tightening appreciates the domestic currency by attracting capital inflows through higher interest rates, which curbs imported inflation by lowering the domestic currency price of foreign goods and services while potentially reducing net exports through diminished competitiveness, contributing to overall disinflationary pressure. These channels interact dynamically, with their relative potency varying by economic structure, financial development, and openness. (Mishkin, 1995; Mishkin, 1996; Bernanke, 1995). These mechanisms assume a well-developed and bank-centred financial system.

According to the World Bank (2021), Sub-Saharan Africa is the global leader in mobile money adoption. The rapid increase in new Fintech startups and the advantage of convenience and accessibility mean that the rate of mobile money adoption can only grow. With the rapid growth of mobile money and digital financial services, financial access is no longer dependent on traditional banks. Millions of people now transact outside traditional banking systems. This transformation raises important questions about whether traditional monetary transmission channels remain relevant.

Existing studies focus on the relationship between mobile money and financial inclusion, financial inclusion and economic growth, monetary policy and inflation, and monetary policy and output growth. Little is known about how digital financial inclusion interacts with the effectiveness of monetary policy. For example, Joseph et al (2026) studied how mobile money adoption matters in financial inclusion in Sub-Saharan Africa without touching on the macro transmission. Jima & Makoni (2023) studied the relationship between financial inclusion and economic growth in Sub-Saharan Africa. Even when Huang et al. (2024) studied the relationship between E-money and monetary policy transmission, it was not specific to Africa or focused on mobile money, which has a high adoption rate in Sub-Saharan Africa. Hence, no clear empirical consensus on whether digital finance amplifies or weakens monetary policy transmission in Sub-Saharan Africa.

Hence, this paper examines whether mobile money penetration alters the effectiveness of the interest rate channel of monetary policy in Sub-Saharan Africa. To do this, the work answers questions such as, does it weaken or strengthen the transmission channel of monetary policy? It is expected to weaken transmission if it leads to many people bypassing banks, and thus make policy rates matter less. On the contrary, it may strengthen transmission if an increase in financial access leads to more mobile money agents responding to policy rates.

This paper contributes to the literature in conceptual, empirical and methodological ways. Conceptually, it contributes to literature by linking digital financial inclusion with monetary transmission. Empirically, it uses panel data across African economies and introduces interaction between the policy rate and mobile money penetration. Methodologically, it applies the Local Projections model to estimate how the response of inflation or output to monetary policy shocks varies with the level of digital financial inclusion.

The study adopts panel data for the period of 2005 – 2023 from Sub-Saharan African economies for key variables like policy rate, inflation rate, output, and mobile money indicators. The data is sourced from the World Development Indicators of the World Bank and the Central Banks of respective countries.

The results show that while digital financial inclusion has transformed financial access in Sub-Saharan Africa, it has also introduced new complexities into the monetary transmission process. Specifically, it appears to weaken the effectiveness of monetary policy in controlling inflation, while having a limited influence on output dynamics.

By implication, this means that there is a need for a modernised monetary policy framework that reflects the realities of a rapidly evolving digital financial landscape.

The remainder of the paper is organised as follows: review of relevant literature, research methodology, presentation and analysis of results, summary, conclusion and recommendations.

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 The Conventional Monetary Transmission Mechanism

The theoretical foundation of this study is anchored in the traditional monetary transmission mechanism, which explains how central bank policy actions influence real economic activity and prices. In standard macroeconomic theory, monetary policy operates primarily through adjustments in the policy interest rate, which affects borrowing costs, consumption, investment, and ultimately inflation and output. This is achieved through the following channels:

I. The Interest Rate Channel: This works through intertemporal substitution; higher interest rates increase the incentive to save and reduce consumption and investment.
II. The bank lending channel emphasises the role of financial intermediaries, where monetary tightening reduces bank reserves and deposits, thereby constraining credit supply.

III. The exchange rate channel operates through capital flows and currency appreciation, affecting net exports and imported inflation.

These frameworks assume a well-developed, bank-centred financial system, which is critical for effective transmission (Mishkin 1995; Bernanke and Blinder, 1992).

2.1.2 Financial Frictions and Structural Weaknesses in Developing Economies

The effectiveness of monetary policy depends crucially on the structure of the financial system. The financial accelerator theory highlights how information asymmetries and credit constraints amplify or dampen policy effects (Bernanke et al, 1999).

In many developing economies, particularly in Sub-Saharan Africa, limited access to formal banking weakens the bank lending channel. A large proportion of households and firms operate outside the formal financial system, reducing the sensitivity of aggregate demand to policy rate changes (International Monetary Fund (IMF), 2016). Thus, when financial inclusion is low, monetary transmission is often weak, shallow, and inconsistent.

2.1.3 Digital Financial Inclusion as a Structural Transformation

Recent advances in financial technology have transformed financial intermediation in developing economies. Digital financial inclusion, particularly mobile money, has expanded access to financial services beyond traditional banking institutions. Sub-Saharan Africa is the global leader in mobile money adoption, with countries such as Kenya, Ghana, and Nigeria experiencing rapid growth in digital financial services. (Klapper et al, 2025; Suri and Jack, 2016). This transformation challenges the traditional assumption of a bank-dominated financial system and introduces alternative financial channels.

2.1.4 Competing Theoretical Channels: Amplification vs Attenuation

Digital financial inclusion introduces ambiguous theoretical effects on monetary transmission. The effects are:

I. **Attenuation Hypothesis (Weakening Effect)**
Digital finance may weaken monetary transmission through disintermediation, where reduced reliance on traditional banks weakens the bank lending channel; through decoupling from interest rates, where Mobile money transactions are not always directly linked to interest-bearing assets; and through reduced policy control over liquidity (Bank for International Settlements, 2019; IMF, 2020). These studies suggest that digital finance may reduce the effectiveness of traditional policy tools.

II. **Amplification Hypothesis (Strengthening Effect)**
Conversely to the attenuation hypothesis, digital financial inclusion may enhance transmission in different ways. Broader financial participation increases responsiveness to policy signals; faster transaction speeds improve the propagation of monetary shocks; and financial deepening increases integration into the macroeconomy (Demirguc-Kunt et al. 2018).

Collectively, the theoretical ambiguity implies that the effectiveness of monetary policy is conditional on the level of digital financial inclusion. Thus, digital financial inclusion acts as a moderating factor in the transmission mechanism. The theoretical framework directly motivates the empirical approach adopted in this study. Specifically, the interaction between monetary policy and digital financial inclusion is incorporated into a dynamic panel framework using Jorda's (2005) local projections. This approach allows the estimation of how the response of inflation or output to monetary policy shocks varies with the level of digital financial inclusion.

2.2 Empirical Literature

2.2.1 Mobile Money and Financial Inclusion

A growing body of empirical literature has examined the role of mobile money as a driver of financial inclusion, particularly in developing economies. Early contributions, such as Donovan (2012), highlight the transformative potential of mobile money as a platform capable of extending financial services to previously unbanked populations. This view is reinforced by Aron (2018), who provides a comprehensive review of the microeconomic and macroeconomic channels through which mobile money operates, emphasising its role in facilitating transactions and improving risk-sharing, although evidence on savings and welfare effects remains less conclusive.

Recent empirical studies provide more robust quantitative evidence. Using panel data for 50 African countries, Avom et al. (2023) find that mobile money adoption significantly improves financial inclusion, with estimated effects ranging between 12 and 14 percent. Their results, which are robust across multiple estimation techniques, suggest that mobile money effectively aligns financial services with the needs of underserved populations. Similarly, Khan (2025) shows that mobile money enhances both deposit-based and credit-based financial inclusion among informal enterprises, particularly by improving profitability and access to trade credit.

At the macro level, global evidence from Klapper et al (2025) identifies mobile money as a key driver of financial inclusion, especially in regions where traditional banking infrastructure is limited. Complementary findings by Asongu and Le Roux (2023) indicate that mobile money not only promotes inclusion but also moderates the adverse effects of income inequality on poverty, suggesting broader developmental implications.

Despite these positive findings, the literature also highlights important limitations. Osabutey and Jackson (2024), in a critical review, argue that the benefits of mobile money are not uniformly distributed, with weaker impacts observed among the poorest segments of society. They further emphasise challenges related to infrastructure, security, and inclusiveness, suggesting that the mobile money–financial inclusion nexus remains incomplete.

Overall, the evidence supports the view that mobile money is a significant enabler of financial inclusion, although its impact is heterogeneous and context-dependent.

2.2.2 Financial Inclusion and Economic Growth

The relationship between financial inclusion and economic growth has received considerable attention in the empirical literature. Major argument is that improved access to financial services enhances savings mobilisation, investment, and resource allocation, thereby promoting economic growth.

Empirical evidence largely supports this view, Jima and Makoni (2023), using a panel ARDL framework for 26 Sub-Saharan African countries, find a strong long-run relationship between financial inclusion and economic growth, with evidence of bi-directional causality. This suggests a reinforcing cycle in which financial inclusion and economic growth mutually enhance each other. Similarly, Kim et al. (2018), employing dynamic panel techniques and panel VAR analysis, document a positive and statistically significant effect of financial inclusion on economic growth in OIC countries.

From a broader perspective, Sahay et al. (2015) provide cross-country evidence that financial inclusion contributes to economic growth, although the marginal benefits diminish beyond certain thresholds. Their findings also highlight potential trade-offs, particularly with financial stability when credit expansion is not properly regulated. Complementing this, Andrianaivo and Kpodar (2012) show that mobile phone development contributes to economic growth partly through its impact on financial inclusion, thereby linking digital technology, inclusion, and macroeconomic performance.

However, the literature also cautions against a linear interpretation of this relationship. Cecchetti and Kharroubi (2012) argue that excessive financial development can become detrimental to productivity growth, suggesting that the growth effects of financial inclusion may be nonlinear.

Taken together, these studies indicate that financial inclusion plays a significant role in promoting economic growth, although its effects depend on institutional quality, financial depth, and regulatory frameworks.

2.2.3 Monetary Policy and Macroeconomic Outcomes

The empirical analysis of monetary policy transmission has traditionally focused on its effects on inflation and output. The foundational work by Mishkin (1996) outlines the key transmission channels, including the interest rate, bank lending, and exchange rate channels.

Empirical evidence using structural and reduced-form models has largely confirmed these mechanisms. Christiano, Eichenbaum, and Evans (1999), employing vector autoregression (VAR) techniques, show that exogenous monetary policy shocks have systematic and persistent effects on key macroeconomic variables such as output and inflation. Their findings highlight the importance of identifying policy shocks in understanding the dynamics of monetary transmission.

While this literature provides strong evidence for advanced economies, its applicability to developing economies is less clear. Structural weaknesses, including shallow financial systems and limited access to banking services, often weaken the effectiveness of these transmission channels.

2.2.4 Financial Inclusion and Monetary Policy Effectiveness

More recent studies have begun to explore the interaction between financial inclusion and monetary policy effectiveness. Arshad et al. (2021), using a structural VAR framework across developed and developing countries, find that financial inclusion and monetary policy effectiveness are interrelated, although the direction of causality differs across country groups. In developed economies, financial inclusion enhances monetary policy effectiveness, while in developing economies, the relationship appears weaker and less immediate.

Similarly, Biswas and Ahamed (2023) provide mixed evidence, showing that different dimensions of financial inclusion have varying effects on monetary policy outcomes. While some indicators, such as ATM penetration, appear to weaken policy effectiveness, others show insignificant or positive effects. This suggests that the relationship between financial inclusion and monetary policy is complex and dependent on how inclusion is measured.

From a theoretical and empirical standpoint, Mehrotra and Yetman (2015) demonstrate that higher levels of financial inclusion influence inflation dynamics and the optimal conduct of monetary policy. Their findings indicate that economies with greater financial inclusion tend to exhibit different trade-offs between inflation and output volatility.

Although primarily focused on growth, studies such as Lenka and Sharma (2017) indirectly reinforce this link by showing that improvements in financial inclusion are associated with broader macroeconomic stability and efficiency.

Overall, the literature suggests that financial inclusion has important implications for monetary policy, but the nature and magnitude of its effects remain ambiguous.

2.2.5 Digital Finance and Monetary Policy Transmission

The intersection of digital finance and monetary policy transmission remains relatively underexplored but is gaining increasing attention. A key contribution in this area is Huang et al. (2024), who provide cross-country evidence that the development of e-money strengthens monetary policy transmission. Their results indicate that digital financial systems can enhance the responsiveness of market interest rates to policy rates, increase bank deposits and credit, and improve financial intermediation efficiency. Notably, these effects are more pronounced in countries with initially low levels of financial inclusion.

Complementary insights are provided by the Bank for International Settlements (2019) that highlights that the rise of digital finance and big technology firms may fundamentally alter financial intermediation, with important consequences for monetary control and financial stability. The IMF (2020) further underscores the macro-financial implications of digital money, particularly in the context of cross-border transactions and the evolving role of central banks.

Despite these emerging contributions, empirical evidence on how digital financial inclusion, particularly mobile money, modifies the transmission of monetary policy remains limited.

Table 2.1: Summary of Selected Empirical Studies on the Relationship between Digital Financial Inclusion and Transmission of Monetary Policy.

Author(s)	Region/Countries	Methodology	Key Findings	Key Limitations
Avom et al. (2023)	50 African countries	Panel data (parametric & non-parametric, PSM)	Mobile money significantly improves financial inclusion (12–14%)	Focuses only on inclusion; no macro transmission analysis.
Osabutey & Jackson (2024)	Africa (review-based)	Systematic literature review	Mobile money benefits exist but are uneven; the poorest groups benefit less	Lacks quantitative empirical testing
Khan (2025)	SSA & Asia	IV Probit + non-parametric methods	Mobile money improves access to deposits and credit for informal firms	Firm-level focus; limited macro implications
Aron (2018)	Developing countries	Literature review	Strong evidence for risk-sharing; weaker for savings and welfare.	Mostly descriptive; lacks causal macro evidence.
Klapper et al (2025)	Global	Descriptive & survey-based (Findex)	Mobile money is a key driver of global financial inclusion	Limited causal identification
Asongu & le Roux (2023)	42 SSA countries	Interactive quantile regression	Mobile money mitigates the effects of poverty and inequality	Indirect link to financial inclusion and no monetary policy focus
Donovan (2012)	Developing countries	Conceptual + descriptive	Mobile money expands access to financial services	Early-stage evidence; limited empirical rigour
Jima & Makoni (2023)	26 SSA countries	Panel ARDL, GMM, Granger causality	Financial inclusion and growth have a bi-	Does not consider digital finance specifically

			directional relationship	
Kim et al. (2018)	55 OIC countries	Dynamic panel + VAR + IRFs	Financial inclusion positively affects economic growth	Regional focus outside Africa
Sahay et al. (2015)	Cross-country	IMF analytical framework	Inclusion promotes growth, but with diminishing returns and stability risks	Not focused on mobile money
Andrianaivo & Kpodar (2012)	African countries	System GMM	ICT (mobile phones) boosts growth via financial inclusion	An ICT proxy may not capture digital finance fully
Cecchetti & Kharroubi (2012)	Global	Cross-country regression	Financial development has nonlinear (sometimes negative) growth effects	Focuses on financial depth, not inclusion
Mishkin (1996)	Advanced economies	Theoretical + empirical synthesis	Identifies key transmission channels (interest rate, credit, exchange rate)	Limited relevance to weak financial systems
Christiano et al. (1999)	Advanced economies	VAR analysis	Monetary policy shocks significantly affect output and inflation	Evidence largely from developed economies
Arshad et al. (2021)	40 countries (developed & developing)	SVAR	Financial inclusion and monetary policy effectiveness are interrelated	Weak contemporaneous effects; mixed causality
Biswas & Ahamed (2023)	10 developing countries	Panel regression	Mixed effects: some inclusion measures weaken policy effectiveness	Measurement sensitivity of inclusion variables

Mehrotra & Yetman (2015)	Cross-country	Theoretical + empirical	Inclusion affects inflation-output trade-offs and policy design	Focuses on formal inclusion, not digital finance
Lenka & Sharma (2017)	India	ARDL + ECM	Financial inclusion promotes growth and stability	Country-specific; indirect link to monetary policy
Huang et al. (2024)	21–47 countries	Panel fixed effects	E-money strengthens monetary policy transmission	Focus on e-money broadly, not specifically mobile money
BIS (2019)	Global	Policy analysis	Digital finance may weaken traditional monetary control mechanisms	Not empirically tested
IMF (2020)	Global	Policy framework	Digital currencies have complex macro-financial implications	Focus on CBDCs, not mobile money directly

Source: Authors' Selected Empirical Summary

Table 2.1 summarises selected empirical studies on mobile money, financial inclusion, and monetary policy transmission. The evidence shows that while mobile money significantly promotes financial inclusion, and financial inclusion is linked to macroeconomic outcomes, limited empirical work directly examines how digital financial inclusion interacts with monetary policy transmission mechanisms.

2.3 Identified Gaps in the Literature

From the foregoing review, it was observed that there is substantial evidence that mobile money promotes financial inclusion; financial inclusion is generally associated with improved macroeconomic outcomes, including economic growth. While a growing literature examines the relationship between financial inclusion and monetary policy effectiveness, the findings remain mixed and inconclusive.

Importantly, existing studies have largely treated these relationships in isolation. Very few studies explicitly examine how digital financial inclusion interacts with monetary policy transmission, particularly in the context of Sub-Saharan Africa, where mobile money adoption is most advanced.

This study addresses this gap by investigating whether digital financial inclusion alters the effectiveness of the interest rate channel of monetary policy, thereby contributing to the emerging literature at the intersection of monetary economics, financial development, and digital finance.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study adopts a quantitative research design based on panel data analysis to examine how digital financial inclusion influences the effectiveness of monetary policy transmission in Sub-Saharan Africa. The choice of a panel design is motivated by its ability to capture both cross-country heterogeneity and time dynamics, which are essential in understanding monetary policy effectiveness across different institutional and financial environments.

Given the dynamic nature of monetary transmission, the study employs the Local Projections (LP) approach developed by Oscar Jordà (2005). This approach allows the estimation of impulse response functions without imposing strong structural assumptions, making it particularly suitable for economies characterised by structural differences and data limitations, as is common in Sub-Saharan Africa.

The research design is therefore structured to estimate the response of inflation and output to monetary policy shocks, examine how these responses vary with the level of digital financial inclusion, and capture both short-run and medium-run dynamics.

3.2 Model Specification

The model used in this study is grounded in the monetary transmission mechanism theoretical framework, augmented to incorporate the role of digital financial inclusion as a structural factor influencing policy effectiveness. The conventional monetary transmission mechanism, as articulated by Frederic Mishkin (1995, 1996) and Ben Bernanke and Alan Blinder (1992), posits that monetary policy affects macroeconomic outcomes through key channels such as the interest rate channel, the bank lending channel, and the exchange rate channel. In its simplest form, this relationship can be expressed as:

$Y_t = f(MP_t)$ - - - - - - - - (1)

Where:

Y_t = macroeconomic outcomes (inflation or output)

MP_t = monetary policy stance (policy rate)

However, the financial accelerator framework developed by Ben Bernanke, Mark Gertler and Simon Gilchrist (1999) highlights that the effectiveness of monetary policy depends on financial structure, including access to credit and the depth of financial intermediation. In economies with limited financial inclusion, the transmission mechanism is weakened because a large share of economic agents are excluded from formal financial systems.

This modifies the relationship in equation (1) to become:

$Y_t = f(MP_t, FI_t)$ - - - - - - - (2)

Where:

FI = financial inclusion

Here, financial inclusion affects the strength of the transmission process.

Building on this, recent developments in digital finance suggest that financial inclusion is no longer solely determined by traditional banking systems. As discussed in the theoretical framework, digital financial inclusion (proxied by mobile money) introduces new channels that may either enhance or weaken monetary transmission.

Thus, financial inclusion becomes:

$FI_t = g(DFI_t)$ - - - - - - (3)

Substituting equation (3) into equation (2) becomes:

$Y_t = f(MP_t, DFI_t)$ - - - - - - - (4)

However, the amplification hypothesis and attenuation hypothesis establish that digital financial inclusion does not merely affect outcomes directly; rather, it modifies the strength of the relationship between monetary policy and macroeconomic outcomes. These competing hypotheses (attenuation vs amplification) imply that the marginal effect of monetary policy depends on the level of digital financial inclusion. Hence, formally:

$$\frac{\partial Y}{\partial MP} = \beta + \theta \cdot DFI \quad - - - - - (5)$$

This leads to the interaction specification:

$$Y_t = \beta MP_t + \theta(MP_t \times DFI_t) + \delta DFI_t + \gamma X_t + \epsilon_t \quad - - (6)$$

Where:

$MP_t \times DFI_t$ captures the moderating effect

X_t represents control variables

This formulation directly reflects the theoretical ambiguity that:

$\theta > 0$ = amplification effect

$\theta < 0$ = attenuation effect

Monetary policy effects are inherently dynamic, unfolding over time. To capture these dynamics, the study adopts the Local Projection approach proposed by Oscar Jordà (2005), which allows the estimation of impulse responses across different horizons without imposing restrictive assumptions. Thus, from equation (6), the empirical model is specified as:

$$Y_{i,t+h} - Y_{i,t-1} = \alpha_i + \gamma_t + \beta_h MP_{i,t} + \theta_h\left(MP_{i,t} \times DFI_{i,t}\right) + \delta X_{i,t} + \epsilon_{i,t+h}$$

Where:

$Y_{i,t+h}$ = Dependent variable (inflation or output) at horizon h.

$MP_{i,t}$ = Monetary policy indicator (policy rate or its change).

$DFI_{i,t}$ = Digital financial inclusion (mobile money penetration).

$MP_{i,t}$ x $DFI_{i,t}$ = Interaction term capturing moderating effect.

$X_{i,t}$ = Vector of control variables.

h = the forecast horizon.

α_i = country fixed effects.

γ_t = time fixed effects.

β_h = baseline effect of monetary policy on macroeconomic outcomes.

θ_h = moderating effect of digital financial inclusion. This coefficient is of primary interest. A positive value suggests that digital financial inclusion strengthens monetary policy transmission, while a negative value implies attenuation.

$\epsilon i,t+h$ = Error term.

To allow the study to test whether digital financial inclusion strengthens monetary policy transmission (amplification) or weakens it (attenuation), the total marginal effect of monetary policy is therefore expressed as:

Total Effect $= \beta_h + \theta_h \cdot DFI$

The model is estimated twice using both inflation and Output (GDP growth) as the dependent variable separately.

3.2 Data Description and Data Sources

The study employs annual panel data covering the period 2005 – 2024 for selected Sub-Saharan African countries. The choice of this period is guided by the increasing availability of data on mobile money and digital financial services.

The dataset includes key variables such as the monetary policy rate, inflation rate (Consumer Price Index), output (GDP growth rate), mobile money indicator (proxy for digital financial inclusion), and other macroeconomic control variables like exchange rate and trade openness.

Data are sourced from reputable international and national databases, including the World Development Indicators of the World Bank, the Central Banks of Nigeria, Central Bank of Kenya, the Bank of Ghana, and the Bank for International Settlements.

3.3 Country Selection

The study focuses on selected Sub-Saharan African economies. The criteria for inclusion are the availability of consistent data on policy rates, inflation and GDP, and mobile money indicators; the presence of active mobile money ecosystems given the focus on digital financial inclusion; the operation of a monetary policy regime where policy rates are used as a primary instrument; and no significant data gaps over the study period to maintain robustness.

Based on these criteria, the final sample consists of Kenya, Nigeria, Ghana, and Uganda. These countries are among the leaders in mobile money adoption, and as such, provide a suitable context for analysis (World Bank, 2021).

3.4 Data Transformation

To ensure consistency and econometric validity, some of the data that are not measured in rates are log-transformed where necessary to reduce skewness. Lag structures are introduced to capture dynamic effects during the estimation process. The interactive term (MPR×DFI) variable is computed to arrive at the data.

Table 3.1 presents each variable, its symbol, measurement, data source, and theoretical linkage.

Table 3.1 Variable Definition and Transformation Table

Variable	Acronym	Measurement	Expected Sign	Data Transformation	Data Source	Theoretical Basis
Inflation Rate	INF	CPI annual % change	-	Level	World Bank	Monetary transmission outcome
Output Growth	GDPG	Annual GDP growth (%)	-	Level	World Bank	Aggregate demand response
Monetary Policy Rate	MPR	Central bank policy rate (%)	-	Level	Central Bank of Nigeria, Central bank of Kenya, Bank of Ghana, and BIS	Interest rate channel
Digital Financial Inclusion	DFI	Mobile cellular subscriptions (per 100 people)	±	Log/normalised	World Bank	Financial inclusion theory

Interaction Term	MPR×DFI	Product of MPR and DFI	±	Constructed by multiplying MPR by DFI	Author	Moderation hypothesis
Exchange Rate	EXR	Local currency per USD	+	Log difference	World Bank	Exchange rate channel
Trade Openness	TOP	(Exports + Imports)/GDP	+	Level	World Bank,	Open economy transmission

Source: The Researchers (2026)

3.6 Method of Data Analysis

The study employs the Local Projection (LP) estimation technique to analyse the dynamic effects of monetary policy shocks on macroeconomic outcomes. This method involves estimating separate regressions for different forecast horizons, allowing for flexible modelling of impulse response functions. The LP approach is preferred because it does not impose restrictive assumptions inherent in VAR models; it accommodates nonlinearities and interaction effects, which are central to this study; and it is robust to model misspecification and suitable for panel data with heterogeneity (Jordà, 2005).

The estimation includes country fixed effects to control for unobserved heterogeneity, time fixed effects to account for global shocks, and robust standard errors to address heteroskedasticity. Impulse response functions are then constructed to trace the effect of monetary policy shocks on inflation and output across different levels of digital financial inclusion.

The estimation and test procedures are performed using R programming language version 4.5.2 on RStudio via the Posit Cloud.

4.0 Presentation and Analysis of Results

4.1 Monetary Policy and Inflation (IFN Model).

Table 4.1: Summary of Local Projection Estimates of Monetary Policy Transmission with Digital Financial Inclusion (Dependent Variable: Inflation)

Horizon	MPR	MPRxDFI (Interactive Term)
h = 0	0.434 (0.177)	-0.002 (0.361)
h = 1	-0.494 (0.551)	-0.003 (0.660)
h = 2	-0.769 (0.597)	-0.006 (0.572)
h = 3	0.021 (0.983)	-0.014 (0.140)
h = 4	0.694 (0.433)	-0.018* (0.059)

Researchers' Summary from RStudio Output (2026)

Note: p-values in parentheses.

* indicates significance at 10% level.

The results for the inflation model, as presented in Table 4.1, show that the coefficient of the monetary policy rate (MPR) is inconsistent in sign and statistically insignificant across most horizons. While the expected theoretical relationship suggests that higher policy rates should reduce inflation, the estimates do not provide strong empirical support for this channel in the short to medium term.

This finding aligns with the earlier argument in the study that monetary policy transmission in Sub-Saharan Africa is weak and unstable, likely due to structural constraints such as shallow financial systems and limited banking penetration.

Importantly, the interaction term (MPR×DFI), which captures the role of digital financial inclusion, is negative across all horizons and becomes marginally significant at horizon 4 (with p-value = 0.059). This suggests that digital financial inclusion weakens the effectiveness of monetary policy in controlling inflation over time. This provides empirical support for the attenuation hypothesis. As mobile money usage increases, a larger share of economic transactions may occur outside the traditional banking system, thereby reducing the sensitivity of aggregate demand to policy rate changes. In other words, the means of economic stabilisation, which is monetary policy, no longer has the effectiveness to achieve its ends because the transmission mechanism of this policy has become ineffective as more people perform economic transactions outside the traditional banks because of the increased adoption rate of mobile money.

4.2 Monetary Policy and Output (GDPG Model)

Table 4.2: Summary of Local Projection Estimates of Monetary Policy Transmission with Digital Financial Inclusion (Dependent Variable: GDPG)

Horizon	MPR	MPRxDFI (Interactive Term)
h = 0	0.007 (0.874)	0.001 (0.117)
h = 1	0.156 (0.547)	0.001 (0.306)
h = 2	0.457 (0.379)	0.000 (0.991)
h = 3	0.369 (0.362)	0.001 (0.659)
h = 4	0.388 (0.443)	0.001 (0.842)

Researchers' Summary from RStudio Output (2026)

Note: p-values in parentheses.

For the output model, the results in Table 4.2 show that the coefficient of the monetary policy rate is positive but statistically insignificant across all horizons. This is contrary to standard theory, which predicts that monetary tightening should reduce output. The absence of a significant

relationship suggests that the interest rate channel has a weak influence on real economic activity in the selected Sub-Saharan African economies.

Similarly, the interaction term (MPR×DFI) is positive but consistently insignificant, indicating that digital financial inclusion does not play a meaningful role in modifying the output response to monetary policy. This implies that, unlike inflation, the effect of digital financial inclusion on the output channel of monetary policy is limited or negligible.

4.3 Impulse Response Analysis

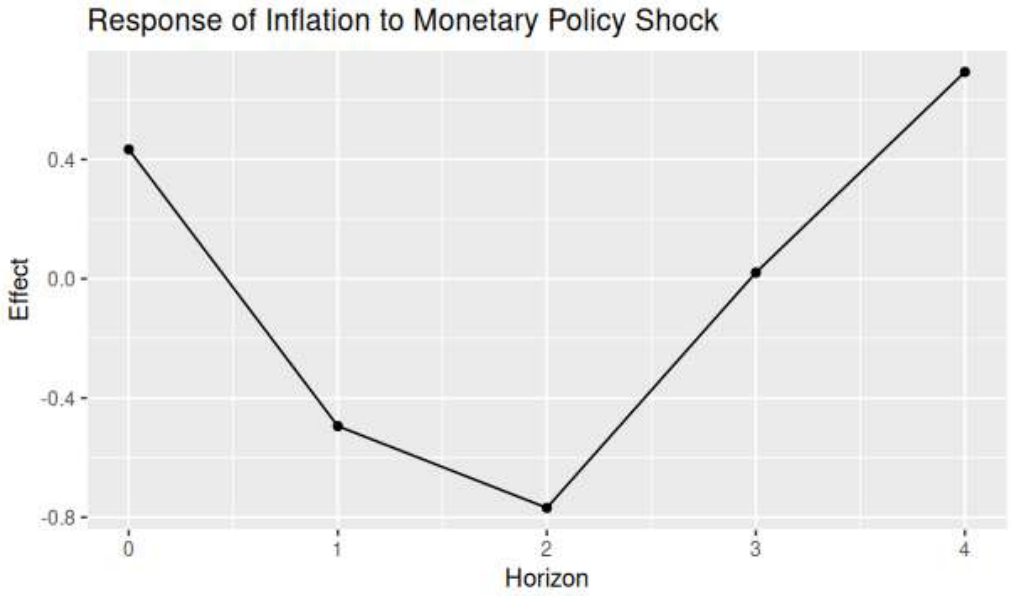

Figure 4.1: Response of Inflation (IFN) to Monetary Policy Shock

Source: Authors' computation (2026)

Figure 4.1 presents the dynamic response of inflation to a monetary policy shock across different horizons. At horizon 0, inflation responds positively to a monetary policy tightening. This initial increase is contrary to standard theoretical expectations, where a contractionary policy is expected to reduce inflation. This outcome may reflect short-run rigidities, including price stickiness, supply-side constraints, or delayed transmission of policy signals. From horizon 1 to horizon 2, the response of inflation turns negative and reaches its lowest point, indicating a delayed disinflationary effect of monetary policy. This suggests that the transmission mechanism operates with a lag, which is consistent with the conventional view that monetary policy effects are not instantaneous. However, this disinflationary effect is not sustained. From horizon 3 onwards, inflation begins to rise again, eventually turning positive by horizon 4. This reversal indicates that the effect of monetary policy on inflation is unstable and short-lived.

Generally, the impulse response pattern reveals a delayed transmission mechanism, a temporary disinflationary effect, and a lack of persistence in policy impact. These findings reinforce the regression results, suggesting that the interest rate channel of monetary policy is weak and inconsistent in the selected Sub-Saharan African economies. The instability of the response further

supports the argument that structural factors, such as shallow financial systems and the growing role of digital financial platforms, may be limiting the effectiveness of monetary policy.

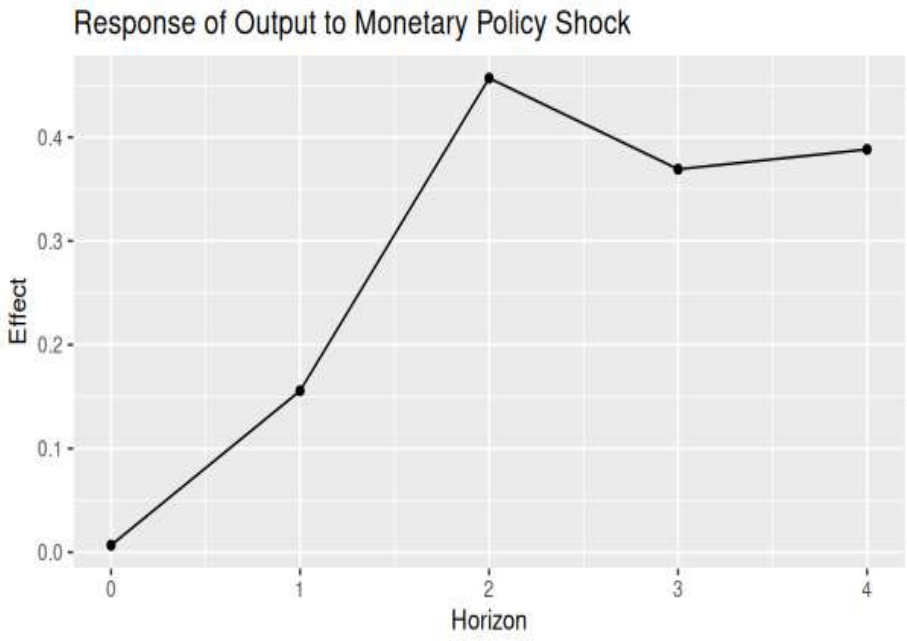

Figure 4.2: Response of Output (GDPG) to Monetary Policy Shock

Source: Authors' computation (2026)

Figure 4.2 illustrates the response of output growth to a monetary policy shock. The results show a consistently positive response of output across all horizons, with the effect increasing from horizon 0 and peaking around horizon 2, before stabilising slightly in subsequent periods. This result is counterintuitive from a theoretical perspective. Standard macroeconomic theory predicts that a contractionary monetary policy shock (increase in policy rate) should reduce output by increasing borrowing costs and dampening investment and consumption. However, the observed positive response suggests that output does not react in line with the traditional interest rate channel. Several reasons may be responsible for this outcome. For example, it could be due to the dominance of the informal sector, which is less sensitive to interest rates, weak credit transmission due to limited banking penetration, the possibility that policy rate changes are responding to economic conditions rather than driving them (endogeneity), or some structural rigidities in production and investment. Furthermore, the relatively smooth and persistent positive response suggests that output dynamics are largely insulated from monetary policy shocks.

In a nutshell, monetary policy does not exert a strong or predictable influence on real economic activity in the selected economies.

4.4 Synthesis of Impulse Response Findings

The impulse response analysis provides important support for our central argument. The unstable and short-lived response of inflation confirms that monetary policy transmission is weak. The

counterintuitive response of output further suggests that the real sector is not effectively influenced by policy rate changes.

When considered alongside the regression results, particularly the negative interaction between monetary policy and digital financial inclusion, the evidence suggests that the growing role of digital financial systems, especially mobile money, may be weakening the traditional bank-based transmission channels of monetary policy. This aligns with the attenuation hypothesis, which posits that as financial transactions increasingly occur outside the formal banking system, the effectiveness of conventional monetary policy tools declines.

4.5 Discussion of Results, Implications for Monetary Transmission, and Policy Implications

The results reveal some important insights that monetary policy has limited effectiveness in influencing both inflation and output, confirming structural weaknesses in the transmission mechanism. It also reveals that digital financial inclusion matters for inflation because the negative interaction effect suggests that mobile money and digital finance may dilute the effectiveness of policy tools, particularly in controlling inflation. Furthermore, it reveals that there is no strong effect on the output channel because the channel remains largely unaffected by both monetary policy and digital financial inclusion.

The findings of this study have important implications for monetary authorities in Sub-Saharan Africa, particularly institutions such as the Central Bank of Nigeria, Bank of Ghana, the Central Bank of Kenya, and the Bank of Uganda. For these institutions, there should be a rethinking of monetary policy effectiveness because the weak and insignificant impact of policy rates suggests that Central banks cannot rely solely on the interest rate channel for macroeconomic stabilisation. There is a need to strengthen financial intermediation, improve banking sector depth, and enhance transmission mechanisms.

Also, digital finance should be integrated into policy frameworks because the evidence that digital financial inclusion weakens inflation control implies that monetary authorities must incorporate mobile money systems into the monetary policy framework. This can be achieved by monitoring mobile money liquidity, including fintech indicators in policy decisions, and improving regulatory oversight of digital financial platforms.

Furthermore, there should be some strengthening of financial integration since digital finance may operate outside traditional banking channels; thus, policies should aim to integrate mobile money with the formal financial system and encourage interoperability between banks and fintech platforms. This will ensure that policy rate changes are transmitted across both traditional and digital financial sectors. Moreover, given the weak transmission observed, there should be policies beyond interest rate policy. Central banks should consider complementary tools, such as macroprudential policies, liquidity management tools, and targeted credit interventions.

5.0 SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary of the Study

This study examined the role of digital financial inclusion in shaping the effectiveness of monetary policy transmission in selected Sub-Saharan African economies. Specifically, it investigated whether mobile money penetration alters the strength of the interest rate channel in influencing inflation and output.

Given the observed weak and inconsistent response of inflation and output to monetary policy adjustments in countries such as Nigeria, Kenya, Ghana, and Uganda, the study extended the conventional monetary transmission framework by incorporating digital financial inclusion as a moderating factor.

Using annual panel data covering the period 2005-2024 and applying the Local Projection method developed by Jordà (2005), the study estimated the dynamic response of inflation and output to monetary policy shocks, while explicitly accounting for the interaction between policy rates and mobile money penetration.

The study finds that the direct effect of monetary policy on inflation is weak and statistically insignificant across most horizons. This suggests that the traditional interest rate channel of monetary policy is not sufficiently effective in stabilising prices in the selected Sub-Saharan African economies. The interaction between monetary policy and digital financial inclusion is negative and becomes marginally significant in the medium term. This indicates that higher levels of mobile money penetration tend to weaken the effectiveness of monetary policy in controlling inflation. This finding supports the attenuation hypothesis, which posits that digital finance may reduce the relevance of traditional bank-based transmission mechanisms. The results also show that monetary policy has no significant impact on output growth, and digital financial inclusion does not meaningfully alter this relationship. This implies that the output channel of monetary policy remains weak, regardless of the level of digital financial inclusion.

In a nutshell, the findings suggest that while digital financial inclusion has improved access to financial services, it has also introduced structural changes that may dilute the effectiveness of conventional monetary policy tools.

5.2 Conclusion

This study contributes to the growing literature at the intersection of monetary economics, financial development, and digital finance by demonstrating that the effectiveness of monetary policy is conditional on the structure of the financial system.

The evidence indicates that in economies where mobile money usage is widespread, a significant portion of financial transactions occurs outside the traditional banking system. As a result, policy rate adjustments may not fully transmit through the usual channels, particularly the bank lending channel and the interest rate channel. Thus, the study concludes that digital financial inclusion, while beneficial for expanding financial access, may weaken the effectiveness of monetary policy transmission in Sub-Saharan Africa, particularly with respect to inflation control. This finding

highlights the need for a rethinking of monetary policy frameworks in the context of rapidly evolving financial technologies.

5.3 Policy Recommendations

Based on the findings, the study offers the following policy recommendations:

1. **Integration of Digital Finance into Monetary Policy Frameworks:** Monetary authorities, such as the Central Bank of Nigeria, the Central Bank of Kenya, the Bank of Uganda, and the Bank of Ghana, should formally incorporate digital financial indicators into their policy frameworks. This includes monitoring mobile money transactions, liquidity flows, and fintech activity as part of monetary policy analysis. Such integration will improve the understanding of how liquidity circulates within the economy beyond the traditional banking sector.
2. **Strengthening Linkages Between Banks and Mobile Money Platforms:** To improve policy transmission, there is a need to enhance the integration between mobile money systems and formal banking institutions. Policies that promote interoperability between banks and fintech platforms will ensure that monetary policy signals are transmitted more effectively across the financial system. This will reduce the degree of financial fragmentation caused by the expansion of digital financial services.
3. **Deepening Financial Markets:** The weak response of both inflation and output to monetary policy suggests underlying structural deficiencies. Governments and central banks should implement reforms aimed at deepening financial markets, improving access to credit, and strengthening financial intermediation. A more developed financial system will enhance the responsiveness of economic agents to policy rate changes.
4. **Adoption of Complementary Policy Instruments:** Given the limitations of the interest rate channel, central banks should complement traditional monetary policy tools with alternative instruments, including macroprudential policies, targeted credit interventions, and liquidity management tools. These instruments can help address sector-specific constraints and improve overall policy effectiveness.
5. **Strengthening Regulatory Frameworks for Digital Finance:** The rapid growth of mobile money requires robust regulatory oversight to ensure financial stability and effective policy transmission. Regulatory authorities should develop frameworks that enhance transparency in digital financial transactions, improve data availability for policymaking, and ensure that fintech activities align with macroeconomic objectives.

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REFERENCES

Andrianaivo, M., & Kpodar, K. (2012). ICT, financial inclusion, and growth: Evidence from African countries (IMF Working Paper No. 11/73). International Monetary Fund.

Aron, J. (2018). Mobile money and the economy: A review of the evidence. The World Bank Research Observer, 33(2), 135–188.

Arshad, M. U., Ahmed, Z., Ramzan, A., Shabbir, M. N., Bashir, Z., & Khan, F. N. (2021). Financial inclusion and monetary policy effectiveness: A sustainable development approach of developed and under-developed countries. PLOS ONE, 16(12), e0261337. https://doi.org/10.1371/journal.pone.0261337

Asongu, S. A., & le Roux, S. (2024). The role of mobile money innovations in the effect of inequality on poverty and severity of poverty in Sub-Saharan Africa. Information Systems Frontiers, 26, 1565–1579. https://doi.org/10.1007/s10796-023-10427-0

Avom, D., Bangaké, C., & Ndoya, H. (2023). Do financial innovations improve financial inclusion? Evidence from mobile money adoption in Africa. Technological Forecasting and Social Change, 190, 122451. https://doi.org/10.1016/j.techfore.2023.122451

Bank for International Settlements. (2019). Big tech in finance: Opportunities and risks (Annual Economic Report). https://www.bis.org/publ/arpdf/ar2019e3.htm

Bank for International Settlements. (2026). Central bank policy rates. https://data.bis.org/topics/CBPOL

Bank of Ghana (2026). Policy Rate Trends. Accra https://www.bog.gov.gh/monetary-policy/policy-rate-trends/

Bernanke, B. S., & Blinder, A. S. (1992). The federal funds rate and the channels of monetary transmission. American Economic Review, 82(4), 901–921.

Bernanke, B. S., & Gertler, M. (1995). Inside the black box: The credit channel of monetary policy transmission. Journal of Economic Perspectives, 9(4), 27–48.

Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework (NBER Working Paper No. 6455). National Bureau of Economic Research.

Biswas, G. K., & Ahamed, F. (2023). Financial inclusion and monetary policy: A study on the relationship between financial inclusion and effectiveness of monetary policy in developing countries. arXiv. https://arxiv.org/abs/2308.12542

Cecchetti, S. G., & Kharroubi, E. (2012). Reassessing the impact of finance on growth (BIS Working Paper No. 381). Bank for International Settlements.

Central Bank of Kenya (2026). Central Bank Rate. Nairobi. https://www.centralbank.go.ke/rates/central-bank-rate/

Central Bank of Nigeria (2026). Money Market Indicators, Money and Credit Statistics. Abuja. https://www.cbn.gov.ng/rates/mnymktind.html

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). Monetary policy shocks: What have we learned and to what end? (NBER Working Paper No. 6400). National Bureau of Economic Research.

Demirgüç-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. R. (2018). The Global Findex database 2017: Measuring financial inclusion and the fintech revolution. World Bank.

Donovan, K. (2012). Mobile money for financial inclusion. Information and Communications for Development, 61, 61–73. http://hdl.handle.net/11427/19272

Huang, Z., Lahreche, A., Saito, M., & Wiriadinata, U. (2024). E-money and monetary policy transmission (IMF Working Paper No. 2024/069). International Monetary Fund. https://doi.org/10.5089/9798400270543.001

International Monetary Fund. (2016). Sub-Saharan Africa: Multispeed growth (Regional Economic Outlook).

International Monetary Fund. (2020). Digital money across borders: Macro-financial implications (Policy Paper No. 2020/050). https://doi.org/10.5089/9781513559209.007

Jima, M. D., & Makoni, P. L. (2023). Financial inclusion and economic growth in Sub-Saharan Africa: A panel ARDL and Granger non-causality approach. Journal of Risk and Financial Management, 16(6), 299. https://doi.org/10.3390/jrfm16060299

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. American Economic Review, 95(1), 161–182. https://doi.org/10.1257/0002828053828518

Joseph, E. S., Chegere, M. J., & Mdadila, K. (2026). Financial inclusion in Sub-Saharan Africa: Does mobile money adoption matter? Scientific African, 32, e03282. https://doi.org/10.1016/j.sciaf.2026.e03282

Khan, S. U. (2025). Mobile money and financial inclusion: International evidence from informal sector enterprises in Asia and Africa. Journal of Asian Economics, 101, 102033. https://doi.org/10.1016/j.asieco.2025.102033

Kim, D., Yu, J., & Hassan, M. K. (2018). Financial inclusion and economic growth in OIC countries. Research in International Business and Finance, 43, 1–14. https://doi.org/10.1016/j.ribaf.2017.07.178

Klapper, L., Singer, D., Starita, L., & Norris, A. (2025). Connectivity and financial inclusion in the digital economy: The Global Findex database. World Bank. https://www.worldbank.org/en/publication/globalfindex

Lenka, S. K., & Sharma, R. (2017). Does financial inclusion spur economic growth in India? Journal of Developing Areas, 51(3), 215–228. https://doi.org/10.1353/jda.2017.0069

Mehrotra, A., & Yetman, J. (2015). Financial inclusion and optimal monetary policy (BIS Working Paper No. 476). Bank for International Settlements.

Mishkin, F. S. (1995). Symposium on the monetary transmission mechanism. Journal of Economic Perspectives, 9(4), 3–10.

Mishkin, F. S. (1996). The channels of monetary transmission: Lessons for monetary policy (NBER Working Paper No. 5464). National Bureau of Economic Research.

Osabutey, E. L. C., & Jackson, T. (2024). Mobile money and financial inclusion in Africa: Emerging themes, challenges and policy implications. Technological Forecasting and Social Change, 202, 123339. https://doi.org/10.1016/j.techfore.2024.123339

Sahay, R., Čihák, M., N'Diaye, P., Barajas, A., Mitra, S., Kyobe, A., Mooi, Y. N., & Yousefi, S. R. (2015). Financial inclusion: Can it meet multiple macroeconomic goals? (IMF Staff Discussion Note No. SDN/15/17). International Monetary Fund.

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. Science, 354(6317), 1288–1292. https://doi.org/10.1126/science.aah5309

World Bank. (2021). The impact of mobile money in Sub-Saharan Africa: Regional note (Global Findex 2021). https://thedocs.worldbank.org

World Bank. (2026). World Development Indicators. https://databank.worldbank.org/source/world-development-indicators

APPENDICES

Appendix I: R Studio Local Projection Estimation Output

term	estimate	std.error	t-statistic	p.value	horizon	model
MPR	0.433899	0.246941	1.757099	0.177153	h_0	IFN
MPRxDFI	-0.00152	0.00141	-1.07417	0.361455	h_0	IFN
DFI	0.074959	0.063856	1.17388	0.325153	h_0	IFN
EXR	0.003149	0.002002	1.572805	0.213817	h_0	IFN
TOP	7.018918	12.07103	0.581468	0.601733	h_0	IFN
MPR	-0.49428	0.738045	-0.66972	0.550974	h_1	IFN
MPRxDFI	-0.00289	0.005955	-0.4858	0.66038	h_1	IFN
DFI	0.151835	0.142016	1.069139	0.36339	h_1	IFN
EXR	-0.00027	0.002569	-0.10535	0.922748	h_1	IFN
TOP	7.986461	20.4813	0.389939	0.722618	h_1	IFN
MPR	-0.76853	1.30413	-0.5893	0.597093	h_2	IFN
MPRxDFI	-0.00586	0.009265	-0.63286	0.571771	h_2	IFN
DFI	0.179516	0.178619	1.005024	0.38893	h_2	IFN
EXR	-0.00214	0.000915	-2.33334	0.101838	h_2	IFN
TOP	18.85252	19.87711	0.948454	0.41287	h_2	IFN
MPR	0.020699	0.887523	0.023322	0.982858	h_3	IFN
MPRxDFI	-0.01388	0.00697	-1.99192	0.140422	h_3	IFN
DFI	0.323846	0.151154	2.142498	0.121566	h_3	IFN
EXR	-0.00309	0.001433	-2.15501	0.120139	h_3	IFN
TOP	40.65587	12.35842	3.28973	0.046087	h_3	IFN
MPR	0.693816	0.769079	0.902139	0.433477	h_4	IFN
MPRxDFI	-0.0184	0.00621	-2.96251	0.059424	h_4	IFN
DFI	0.465879	0.121932	3.820797	0.031556	h_4	IFN
EXR	-0.00329	0.002201	-1.49552	0.231662	h_4	IFN
TOP	45.09605	18.4193	2.448304	0.091818	h_4	IFN
MPR	0.006807	0.03957	0.172016	0.874375	h_0	GDPG
MPRxDFI	0.000921	0.000422	2.182512	0.117073	h_0	GDPG
DFI	-0.03114	0.013374	-2.32878	0.102261	h_0	GDPG
EXR	0.000362	0.000378	0.9569	0.409211	h_0	GDPG
TOP	-0.87369	7.491995	-0.11662	0.914533	h_0	GDPG
MPR	0.155602	0.229817	0.67707	0.546897	h_1	GDPG
MPRxDFI	0.001367	0.001112	1.229968	0.306367	h_1	GDPG
DFI	-0.0478	0.016708	-2.86069	0.06454	h_1	GDPG
EXR	0.000774	0.000902	0.858075	0.453939	h_1	GDPG
TOP	-3.58972	11.46808	-0.31302	0.774766	h_1	GDPG
MPR	0.456911	0.444221	1.028565	0.379358	h_2	GDPG
MPRxDFI	3.59E-05	0.00294	0.012217	0.99102	h_2	GDPG
DFI	-0.02259	0.055477	-0.4072	0.711171	h_2	GDPG
EXR	0.001856	0.001152	1.610926	0.205581	h_2	GDPG
TOP	-10.364	8.675661	-1.19461	0.318078	h_2	GDPG
MPR	0.369157	0.343805	1.073738	0.361621	h_3	GDPG
MPRxDFI	0.001198	0.002456	0.487673	0.659198	h_3	GDPG
DFI	-0.04446	0.059494	-0.74725	0.509148	h_3	GDPG
EXR	0.002157	0.001042	2.069481	0.130307	h_3	GDPG
TOP	-13.8972	4.271721	-3.2533	0.047371	h_3	GDPG
MPR	0.388272	0.44034	0.881755	0.442838	h_4	GDPG
MPRxDFI	0.00063	0.002894	0.217648	0.841666	h_4	GDPG
DFI	-0.0329	0.070679	-0.46546	0.673312	h_4	GDPG
EXR	0.002773	0.001568	1.768508	0.175129	h_4	GDPG
TOP	-13.7345	8.740024	-1.57145	0.214115	h_4	GDPG