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International Remittances, Financial Technology, and Financial Inclusion in Africa

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Abstract

This study examines the interrelationship between international remittances and financial technology (fintech) on financial inclusion in Africa. The argument hinges on the lack of consideration of fintech as a shaper of the effect of remittances on financial inclusion Using various panel estimation techniques and data on 32 African economies between 1999 and 2018, the study makes two findings. First, remittances and fintech individually have a positive effect on financial inclusion. Second, remittances and fintech together have a positive effect on financial inclusion after controlling for other factors that influence financial inclusion. These results have two implications. First, policymakers should be mindful of the interplay of remittances and fintech, given that it significantly affects financial inclusion in Africa. Although fintech may not exist in a very mature form on the continent, its adoption and use reinforce remittances inflows, increasing financial inclusion. Second, regulators and technologists should identify the electronic payment systems within the financial technology space that enables access to financial services.

Keywords: remittance; financial technology; financial inclusion; economic development

JEL Classification: F24; G21; F65

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International Remittances, Financial Technology, and Financial Inclusion in Africa

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Abstract

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I. Introduction

Financial inclusion in Africa continues to gain global attention from policymakers and development finance institutions due to its potential to alleviate poverty, reduce economic hardships and external shocks, and promote economic growth and development (Demirguc-Kunt et. al. 2017; Bhanot et al. 2012; Hasnol et al. 2013). Financial inclusion involves access to useful and affordable financial products and services—responsibly and sustainably delivered—that meet individuals' needs through transactions, payments, savings, credit, and insurance. Financial inclusion is usually measured across three main dimensions: access, use, and affordability. Most poor people worldwide are financially excluded because they lack access to formal financial services that can give them access to bank accounts and to credit and digital payment systems. Their reliance mainly on cash, which is unsafe and hard to manage (Demirguc-Kunt et. al. 2017), reduces their ability to smooth savings and consumption over time.

African countries tend to have low levels of financial inclusion compared with the rest of the world, particularly the developed economies (Demirguc-Kunt et. al. 2021; Triki and Faye 2013). The Global Findex database shows that though increasing efforts are being made to improve financial inclusion in developing countries, progress has been slow. In developed countries, income levels are very high, and 90.6 percent of adults have bank accounts with a formal financial institution. In low- and middle-income developing economies, only 69 percent of adults have such accounts (Demirguc-Kunt et al. 2021).

Studies have shown that remittances and financial technology (fintech) individually promote financial inclusion (Ajefu and Ogebe 2019; Anzoategui et al. 2014; Stratan and Chistruga 2012). However, these studies have not considered the interactive effects of the two on financial inclusion. The intuition underpinning the interaction is that an increase in the use of fintech is likely to ease the flow of remittances, and an increase in the flow of remittances can cause households to open bank accounts. In recent times, development finance institutions such as the International Monetary Fund and the World Bank have shown interest in the potential effects of remittances and fintech in promoting financial inclusion, especially in low-income countries.

The cost of sending remittances remains high worldwide and is likely to increase. Fintech presents unique opportunities to reduce this cost. The average cost across the world is 7 percent of the total amount sent. This cost is even higher for developing countries such as Africa: about 10 percent on average and more than three times the cost (3 percent) that the Sustainable Development Goals envisage as affordable (IFAD 2017; World Bank 2020).

An increasing volume of remittances are channeled through fintech platforms and applications, which are popular because transactions are faster—in many cases, instantaneous—and cheaper than on the platforms and applications they replace. A reduction in transaction costs means that households can channel more remittances into productive investments and consumption, thus promoting financial inclusion, economic growth, and development (see Ajefu and Ogebe 2019; Barberis et al. 2015; AFI 2018). Consequently, examining the relationship between financial inclusion, fintech, and remittances is important. One of the major contributions of this paper is that we examine how remittances and fintech together impact financial inclusion.

This paper provides insights for financial institutions, policymakers, regulatory authorities, central banks, and interested stakeholders on the complex interrelationship of financial inclusion, remittances, and fintech. It helps policymakers craft the regulatory framework for financial inclusion in Africa by answering three questions: Do remittances independently affect financial inclusion? Does fintech independently lead to financial inclusion? To what extent does the presence of fintech strengthen the effect of remittances on financial development? The paper also investigates the causal relations of the three.

The rest of the paper is structured as follows: Section 2 provides stylised facts, Section 3 reviews the theoretical and empirical literature, Section 4 presents the data and methodology employed, Section 5 presents the regression results, and Section 6 presents conclusions and recommendations.

2.Trends and Stylised Facts

There are about 200 million migrant workers across the globe. In 2018, these migrant workers sent remittances totaling $689 billion, of which $529 billion went to remittance-dependent emerging economies. In 2019, world remittances increased to $714 billion, equivalent to about 1 percent of the world's total output. Remittances flow to low- and middle-income countries also continue to increase to even higher levels and in amounts greater than foreign direct investment in nominal terms and in percentage of GDP (World Bank 2020). In Sub-Saharan Africa, remittances increased by 9.6 percent from $42 billion in 2017 to $46 billion in 2018; by 2019, they increased to $48 billion, although at a lower rate. Remittances through official channels grew sturdily to 7.3 percent to reach $589 billion in 2021 in low- and middle-income countries. This figure seems far-fetched due to the high cost of sending money, which increased with the advent of the COVID-19 pandemic. Africa alone harnessed $82.7 billion in migrants' remittances in 2019, almost twice as much as the foreign direct investment flow of $46 billion. The COVID-19 crisis remains the most crucial downside risk to the outlook for remittances flows to low- and middle-income countries.

The contribution of remittances from migrants to the achievement of the Sustainable Development Agenda for 2030 cannot be over emphasized. Remittances make up a substantial amount of GDP in developing countries. On average, migrants send between $200 and $300 in remittances back home every one to two months, about 15 percent of their earnings; the remaining 85 percent is reserved in the migrants' host countries as savings (IFAD 2019). The 15 percent of migrant income sent back home makes up to 60 percent of the receiving households' disposable income (World Bank 2020).

The high cost of sending remittances through formal channels, coupled with regulatory reform since the global financial crisis in 2008, has encouraged fintech firms to venture into the remittances space. Barberis et al. (2015) argue that the collapse of trust and regulatory reform has had the unintended consequence of stimulating new technological players and limiting the capacity of banks to compete. Fintech has a positive influence on access to cross-border payments.

The World Bank's payment aspect of financial inclusion admits that fintech's capacity to increase financial inclusion cannot be overemphasised. Fintech developments focus on payments and help remove the difficulties of universal access and everyday use of transaction accounts. Fintech has a comparative advantage in lowering overhead costs, and it offers smarter and more efficient systems and processes for sending and receiving money as well as new approaches to data-led credit scoring and risk profiling. Ideally, remittances have the potential to augment access to and use of transaction accounts by both senders and recipients. However, this potential remains unexploited

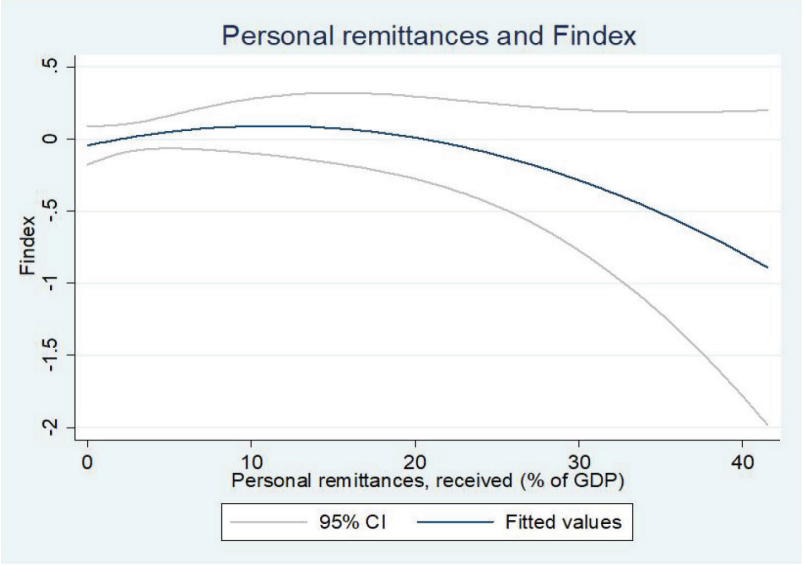
due to remittance service users who generally opt for cash-based methods over transaction accounts. The higher cost of remittances sent through bank transactions significantly discourages the sending of remittances through transaction accounts and invariably gives credence to the use of fintech. Fintech supports international remittances, smartly at a lower cost, thus substantially contributing to financial inclusion. Now the question is: will the multiplicative effect of remittances and fintech augment financial inclusion, thereby reducing poverty in Africa?

2.1 Relationship of Financial Inclusion, Financial Technology, and Migrants' Personal Remittances

This study presents the relationship between (1) financial inclusion and remittances, (2) financial inclusion and fintech, and (3) financial inclusion and remittances. It also presents the relationship between financial inclusion, fintech, and remittances.

Figure 1 shows that the relationship between financial inclusion and remittance inflows is U-shaped, suggesting that, initially, remittances can decrease financial inclusion by replacing formal financial services, but at higher inflow levels, they can increase financial inclusion by fostering financial development and access. Households might use remittances to cover their immediate needs rather than saving or investing them, therefore reducing the demand for financial products. However, high levels of remittances increase recipient households' income, potentially leading to savings and investments, which in turn contribute to greater financial inclusion.

Figure 1

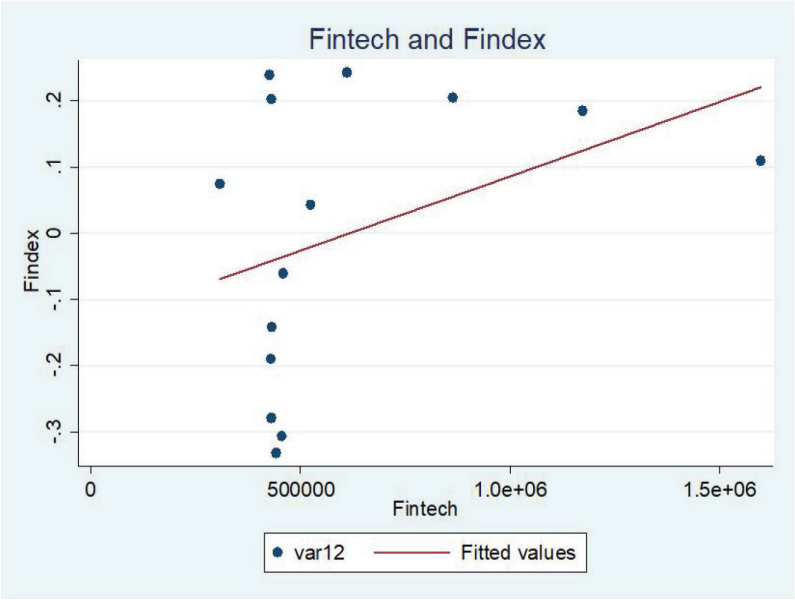


Source: Authors' compilation from WDI and the International Financial Statistics database.

Note: WDI = World Development Indicators.

Figure 2 shows that financial inclusion positively correlates with fintech. Thus, countries that facilitate fintech can increase financial inclusion. In figure 3, remittances and fintech are positively correlated. In figure 4, fintech and remittances jointly enhance financial inclusion (Findex) in Africa.

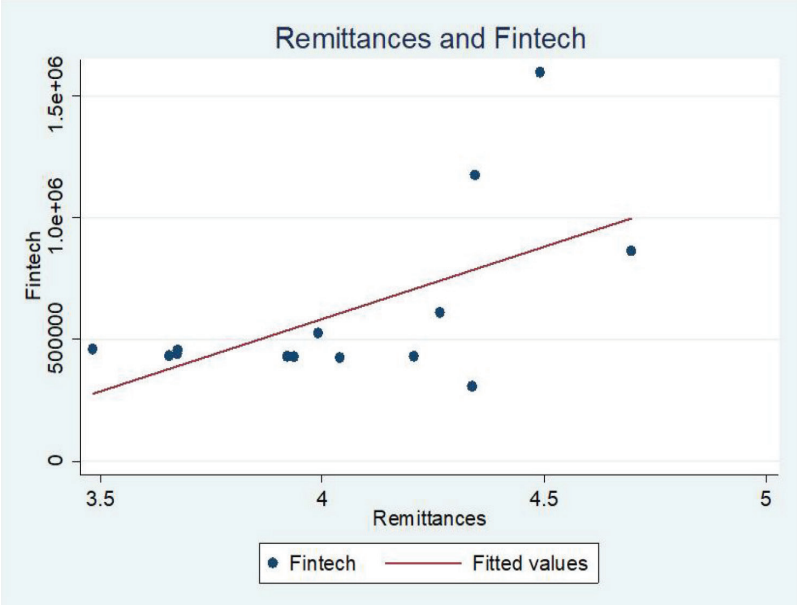
Figure 2



Source: Authors' compilation from WDI and the International Financial Statistics database.

Note: WDI = World Development Indicators.

Figure 3



Source: Authors compilation from WDI and the International Financial Statistics database.

Note: WDI = World Development Indicators.

Figure 4

Source: Authors' compilation from WDI and the International Financial Statistics database.

Note: WDI = World Development Indicators.

3. Extant Literature

3.1 Theoretical Literature

From the theoretical standpoint, the altruistic motive of sending money posits that migrants derive positive utility from the well-being and the consumption level of their families left behind, especially in vulnerable times (Becker 1974; Stark 1991), suggesting that migrant workers will continue to send remittances to their relatives back home in increasing amounts in times of vulnerability and economic hardships to enhance their well-being (Yang and Choi 2007; Yang 2008a). Therefore, migrant workers will likely seek cheaper means to send monies back home to relations during crises such as the recent COVID-19 pandemic.

Dilip (2023) indicates that the potential of fintech applications and companies is much larger than has been achieved. Governments of low- and middle-income countries took advantage of fintech to swiftly reach their vulnerable population with cash transfers in the form of financial assistance during the COVID-19 pandemic. Fintech permits businesses with a liquidity crisis to access alternative sources of funds through remittances, encouraging cross-border remittances, which are very much needed to pay bills from home as well as to secure payments with limited physical exchange. The pandemic highlighted fintech applications' vital role in achieving financial inclusion and the Sustainable Development Goals in general.

3.2 Empirical Literature

The relationship between international migrants' remittances, fintech, and financial inclusion has eluded development in the mainstream empirical literature, which emphasises the three separately.

Some studies look at remittance sand financial inclusion (Anarfo et al. 2020; Anzoategui et al. 2011; Chibba 2009); others look at financial inclusion and fintech (Feyen et al. 2020) and remittances and fintech (Dzeha et. al. 2018; Feeny et al. 2014; Freund and Spatafora 2008; Leonard 2012).

Several studies, not in peer-reviewed journals, look at the classifications of financial technologies in the provision of financial services. Fintech enhances the provision of bank services (Al Ajlouni 2018; Phan et al. 2020). Fintech has given birth to mobile money (Suri and Jack 2016; Yermack 2018). It enables the use of smartphone financial apps for easy access to financial services (Gelman et al. 2014; Carlin et al. 2019). The difficulties associated with payments are obviated by fintech through using the card for payments (Einav et al. 2017) and online lending (Buchak et al. 2018; Hertzberg et al. 2018). Admittedly, fintech is pivotal not only in increasing the accessibility and diversity of services but also in stimulating financial inclusion (Gabor and Brooks 2017; Haddad and Hornuf 2018; Swartz 2017). Patrons of financial technologies benefit from lower transaction costs, such as the costs of travelling to a bank branch or ATM to withdraw cash (Bachas et al. 2018), the crime risks of carrying cash (Economides and Jeziorski 2017), and the large fees to send remittance payments (Jack and Suri 2014).

Remittances have negative cost-elasticity to transaction costs, meaning the lower the costs of remitting money, the larger the number of transfers. Gibson et al. (2006) indicate that this negative price-elasticity is approximately 22 percent; Freund and Spatafora (2008) show that it will be about 16 percent. By running a randomised control trial, Aycinena et al. (2010) concluded that a US$1 lower fee would boost remittances by US$25 a month in the United States–El Salvador corridor. Meanwhile, the benefits of remittances at the micro level (Adams and Page 2005; Adams and Cuechuecha 2010a; Ratha 2013) and the macro level (Solimano 2003; World Bank 2006) cannot be overemphasised.

Remittances supplement households' income and alleviate poverty by boosting expenditure on nutrition, health, and education (Wadood and Hossain 2017; Kamal and Rana 2019). Remittances enhance labor productivity and capital accumulation (Dzeha et. al. 2017). Broadly, remittances encourage financial inclusion, enhance investment, impact financial development, and reduce macroeconomic volatility and increase economic growth (Adams 2007; Barajas et al 2009; Adams and Cuechuecha 2010a). Remittances flow to the poor, low-income earners, and the vulnerable in society, who are generally marginalised with regard to access to financial products and services, support the overarching goals of financial inclusion (Sinclair 2013). Remittances alleviate the poverty of households by increasing disposable income. Remittances are a vital source of foreign exchange for the correction of most countries' trade balances. Cumulatively, they increase global development finance and enhance economic growth (World Bank 2006, 2018b). The financial inclusion of the poor and vulnerable in societies is enhanced by the remittances they receive from their migrant relatives. Indeed, the various channels through which remittances are delivered lead to enhanced access to finance and financial services by those who are financially excluded (Stratan and Chistruga 2012).

Alliance for Financial Inclusion argues that international remittances to the poor through the numerous business models created by fintech increase financial inclusion (AFI 2018). These models reduce the cost of sending remittances. Barberis et al. (2015) find that the collapse of consumer interest and loss of trust in banking services after the global financial crisis increased banks' forex spread. This crisis led to migrant workers' interest in adopting fintech for remittances services. A

knowledge gap in literature is how fintech drives remittances to influence financial inclusion and, thus, access to financial products and services.

4. Data and Methodology

This study employed panel estimation methods to study the dynamic relations among international migrant remittances, fintech, financial inclusion, and economic growth. Holtz-Eakin et al. (1988) were the first to develop and use the panel vector autoregression (pVAR) method, and since then, it has been used in finance and economics studies (Love and Ariss 2014; Love and Ziccino 2006; Anarfo et al. 2020).

This study contributes to the existing literature by investigating the endogenous interaction among remittances, fintech, financial inclusion, and economic growth in African economies using the pVAR estimation technique. In econometric modelling, panel data analysis is encumbered by serious endogeneity problems. The pVAR technique solves these problems by considering all variables in the system of endogenous equations. Additionally, the methodology makes it possible to produce impulse response functions and to forecast error variance decomposition (FEVD) of the variables.

This study considers a system of linear equations with a k-variate pVAR of order p with the panel-specific fixed effects, as indicated in Equation (1).

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \ldots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + u_{it} + e_{it}$$

$$i \in \{1,2,\ldots,N\}, t \in \{1,2,\ldots K_i\} \quad (1)$$

where Y_{it} is an *(1 x k)* dependent variable vector, X_{it} is a *(1 x l)* exogenous covariate vector, and U_{it} and e_{it} are *(1 x k)* vectors of dependent-variable-specific fixed effects and the error term, respectively. The *(1 x k)* matrices $A_1; A_2; \ldots; A_{p-1}, A_p$ and the (*1 x k)* matrix *B's* are coefficients to be estimated. The study assumes that the innovations have the following features:

$$E[e_{it}] = 0, E[e_{it}^{'} e_{it}] = 0 \; for \; all \; t > 0 \quad (2)$$

Specification of the general pVAR model is as follows:

$$Y_{it} = \beta_{0i}(t) + \sum_{k=1}^{p} \alpha_{it} Y_{it-k} + u_{it} \quad (3)$$

where Y_{it} is a vector of *K* endogenous variables for each country, *i = 1, ... N* over *t = 1, ... T* time periods while Y_{it} is stated as

$$Y_{it} = \begin{bmatrix} RemGDP_{it} \\ FinTech_{it} \\ Findex_{it} \\ GDPPC_{it} \end{bmatrix} \quad (4)$$

These variables are defined in Table 1. All-time dummies and constants are taken care of by $\beta_{\alpha i}(t)$ which are the deterministic components.

Y_{it-k} are the lagged values of the endogenous variables, and U_{it} is a $k\ x\ 1$ vector of random errors given by

$$U_{it} = [U_{1t}, U_{2t} \ldots U_{Nt}] \sim iid(0, \delta) \quad (5)$$

α_{it} and $\beta_{\alpha i}(t)$ are permitted to be cross-sectionally dependent. If exogenous variables are present, equation (8) becomes:

$$Y_{it} = \beta_{it}(t) + \sum_{k-1}^{p} \alpha_{it} Y_{it-k} + D_{ij} R_t + U_{it} \quad (6)$$

where D_{ij} are $K\ x\ M$ matrices for each lag $J = 1,...p$ and R_t is an $M\ X\ 1$ vector of exogenous variables common to all countries i. Similarly, following Love and Zicchino (2006), the study specifies the panel VAR in a reduced form as follows:

$$Y_{it} = \beta_{0i}(t) + \sum_{k-1}^{p} \alpha_{it} Y_{it-k} + \tau_2 R_{it} + \lambda_i + \gamma_t + \varepsilon_{it} \quad (7)$$

The specification of Equation (7) shows the inclusion of exogenous variables (R_{it}) making it different from the specification by Love and Zicchino (2006), where Y_{it-k} is a three-variable vector [*Findex, Rem, FinTech*] The exogenous variables are , therefore, captured in and the endogenous variables are [*Rem.FinTech; GDPPC*]. Additionally, λ_i is country-specific fixed effects, which capture the unobserved time-invariant factors; γ is time dummies and accounts for prolonged economic shocks, and ε_{it} is white noise.

Table 1 Data Sources and Descriptions of Variable

Variation	Variable Description	Variable Notation	Source
Financial Inclusion Index	International Financial Statistics describes financial inclusion as an index of six main variables, including ATMs per 100,000 adults, commercial bank branches per 1,000 adults, number of borrowers and depositors with commercial banks per 100 adults, and bank branches.	Findex	A constructed index
Financial Inclusion	ATMs per 100,000 adults	ATMs	IFS
Financial Inclusion	Borrowers from commercial banks per 100 adults	BRSCB	IFS
Financial Inclusion	Bank branches per 100,000 adults	BBRS	IFS
Financial Inclusion	Bank accounts per 1,000 adults	BACS	IFS
Financial inclusion	Depositors with commercial banks per thousand adults	DEPCBS	IFS
Financial Inclusion	Commercial bank branches per 100,000 adults	CBBRS	IFS
Remittance	Personal remittances as a ratio of GDP	REM	WDI
Fintech	Mobile money transactions per 100,000 adults	Fintech	G20 Financial Inclusion Indicators
Economic Growth	GDP per capita (annual percent)	GDPPC	WDI

Sources: Authors compilation from WDI and the International Financial Statistics database.
Note: WDI = World Development Indicators.

4.1 Specification of Empirical Model

The specification of the empirical equation follows from equations (3) and (6) and involves the Financial Inclusion Index, remittances, fintech, and economic growth. Thus, three empirical equations are specified according to the pVAR estimation framework. The Financial Inclusion Index, remittances, fintech, and economic growth are specified as a function of their own lags and the lag of the exogenous variables, while controlling for country-specific fixed and time-specific effects, as follows:

$$Findex_{it} = \sum_{j=1}^{p} \emptyset_{1j} Findex_{it-j} + \sum_{j=1}^{p} \emptyset_{2j} Rem_{it-j} + \sum_{j=1}^{p} \emptyset_{3j} FinTec_{it-j} + \sum_{j=1}^{p} \emptyset_{4j} GDPPC_{it-j} + \sum_{j=1}^{p} \emptyset_{5j} Rem.FinTec_{it-j} + \lambda_i + \gamma_t + \varepsilon_{it} \quad (8)$$

$$Rem_{it} = \sum_{j=1}^{p} \emptyset_{1j} Rem_{it-j} + \sum_{j=1}^{p} \emptyset_{2j} Findex_{it-j} + \sum_{j=1}^{p} \emptyset_{3j} FinTec_{it-j} + \sum_{j=1}^{p} \emptyset_{4j} GDPPC_{it-j} + \sum_{j=1}^{p} \emptyset_{5j} Rem.FinTec_{it-j} + \lambda_i + \gamma_t + \varepsilon_{it} \quad (9)$$

$$FinTec_{it} = \sum_{j=1}^{p} \emptyset_{1j} FinTec_{it-j} + \sum_{i=1}^{p} \emptyset_{2j} Findex_{it-j} + \sum_{j=1}^{p} \emptyset_{3j} Rem_{it-j} + \sum_{j=1}^{p} \emptyset_{4j} GDPPC_{it-j} + \sum_{j=1}^{p} \emptyset_{5j} Rem.FinTec_{it-j} + \lambda_i + \gamma_t + \varepsilon_{it} \quad (10)$$

$$GDPPC_{it} = \sum_{j=1}^{p} \emptyset_{1j} GDPPC_{it-j} + \sum_{j=1}^{p} \emptyset_{2j} Findex_{it-j} + \sum_{j=1}^{p} \emptyset_{3j} Fintec_{it-j} + \sum_{j=1}^{p} \emptyset_{4j} Remit_{it-j} + \sum_{j=1}^{p} \emptyset_{5j} Rem.FinTec_{it-j} + \lambda_i + \gamma_\tau + \varepsilon_{it} \quad (11)$$

$Findex_{it}$ is the financial inclusion index for country i at time t; Rem_{it} is the ratio of international migrant remittances received to gross domestic product for country i at time t; $FinTech_{it}$ is the level of fintech adoption for country i at time t; $GDPPC_{it}$ is the GDP per capita (economic growth) for country i at time t; $Findex_{it-j}$ is the lag of financial inclusion index; Rem_{it-j} is the lag of remittances; $FinTech_{it-j}$ is the lag of fintech adoption; $GDPPC_{it-j}$ is the lag of economic growth proxied by GDP per capita; and $Rem.FinTech_{it-j}$ is an interaction term between remittances and fintech adoption.

The impulse response functions (IRFs) are generated after estimating all the coefficients of the pVAR. The IRFs enable the study to explain the response of endogenous variables over time to a shock in another variable in the system. The Cholesky decomposition procedure is employed to compute the forecast error variance decompositions, which indicate the sources of shocks and their contributions to the variance of each endogenous variable during a given forecast period.

4.2 Data Source and Description of Variables

Table 1 presents a detailed description of the data sources for all the key variables. All the variables used to construct the financial inclusion index are obtained from the International Financial Statistics (IFS); the other variables are pooled from the database of the World Development Indicators (WDI). The study employed unbalanced panel data, with a sample of 48 African

countries and data spanning from 1999 to 2018, reflecting data availability. The panel data are unbalanced because some of the variables have missing data.

Financial inclusion is the key variable of interest. The study uses the panel Principal Component Analysis (PCA) to construct the Financial Inclusion Index (Findex), which is specified as a function of six components:

$$Findex = f(\text{ATMs; CBBRS; BBRS; BACS; DEPCBS; BRCBS}) \quad (12)$$

Following PCA methodology, the study specifies the factor index as

$$Findex = \sum_{j-1}^{p} W_j X_j \quad (13)$$

thus *Findex* represents the Financial Inclusion Index, *W* is the weight of the individual components, *X* is the value of the various components, and *p* is the total number of the components. The index has two main dimensions (Wang and Guan, 2017). The first dimension is the category that indicates demand or use: borrowers from commercial banks per 100 adults (BRCBs), bank accounts per 1,000 adults (BACs), and depositors with commercial banks per 1,000 adults (DEPCBs). The second dimension indicates supply or access: ATMs per 100,000 adults (ATMs), commercial banks branch per 100,000 adults (CBBRs), and bank branches per 100,000 adults (BBRs). Table 1 describes these variables.

4.3 Empirical Results

Table 2 presents the descriptive statistics of the variables used based on true values in the model estimate for 32 African countries to show their mean, median, standard deviation, and skewness. Each variable shows positive means and medians except GDP per capita, which has a negative median. This result is to be expected, given the nature of the series. The average FINDEX is around 5.6 per 1,000 adults, GDP per capita (GDPPC) is around 1765.11, and the average personal remittances received (percent of GDP) is 40.4 percent. The fintech record is 609,613. Again, the standard deviation shows the modest changes in the variables in the study. Furthermore, all variables are positive in terms of skewness, implying that the average values are greater than their median. In the descriptive summary statistics, outliers are displayed to enable the reduction of their biased effect and their potential to influence the reliability, consistency, and accuracy. The results do not indicate biasedness in the coefficients. The maximum and minimum values of the variables provide no evidence of outliers in the dataset. Interestingly, the skewness and kurtosis values suggest or confirm evidence of normality in the data, implying that the variables are normally distributed around their mean.

Table 2 Descriptive Statistics

	FINDEX	FINTECH	REMITTANCES	GDPPC
Mean	0.00005	609613	4.0424	1765.1070
Median	-0.2306	156853.2	1.8702	1001.34
Variance	0.9955	10700000	32.9124	4266225.748
Std. Dev.	0.9977	1033230.782	5.7369	2065.4844
Skewness	3.2988	2.9144	3.1182	2.3311
Kurtosis	12.9862	10.3523	12.6837	4.9165
Obs.	448	448	448	448

Source: Authors' compilation from WDI and the International Financial Statistics database.
Note: WDI = World Development Indicators, FINDEX = Financial inclusion index; Fintech = migrants' personal remittances received (percent of GDP); GDP per capita; Std. Dev. = standard deviation; Obs = observation.

Table 3 reports the Pearson Correlation Coefficient matrix to check for possible multicollinearity between the explanatory variables. For multicollinearity to occur, the correlation coefficient between two variables should be 0.7 or more (Kennedy 2008; Wooldridge 2009). The study proceeds to analyse the interactions, observing that the correlation between the variables is generally low at below 0.5. The study finds a positive correlation between each of the three variables (fintech, remittances, and GDP per capita) and financial inclusion, meaning that all three variables move individually in tandem with financial inclusion. Conversely, it finds that remittances and fintech are negatively correlated. This result indicates that an increase in the flow of remittances will decrease participation in fintech. In the same manner, GDP per capita has a negative correlation with remittances.

Table 3 Ordinary Correlation Matrix

	FINDEX	FINTECH	REMIT	GDPPC
FINDEX	1.000000			
FINTECH	0.382656	1.000000		
REMIT	0.020377	-0.004803	1.000000	
GDPPC	0.411093	0.332398	-0.218900	1.000000

Source: Authors' compilation from WDI and the International Financial Statistics database.
Note: WDI = World Development Indicators, FINDEX = Financial inclusion index; Fintech = migrants' personal remittances received (percent of GDP); GDPPC = GDP per capita.

In deciding the appropriate lags to use for the estimations, the study relied on the following: the sequential modified LR test, the final prediction error, the Akaike Information Criterion, the Schwarz Criterion, and the Hannan Quinn Criterion. Based on the traditional approach of selecting the model that has the lowest number of lags (see Table 4), this study uses the Schwarz Criterion. Thus, it adopts a first-order pVAR model for the estimation.

Table 4 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3210.395	NA	3.81e+10	35.71550	35.78646	35.74427
1	-2296.449	1777.117	1770680.	25.73833	26.09310*	25.88217*
2	-2276.430	38.03616	1693817.	25.69367	26.33226	25.95259
3	-2252.360	44.66282	1549596.	25.60401	26.52642	25.97800
4	-2234.336	32.64495	1517019.	25.58151	26.78774	26.07058
5	-2202.129	56.89897	1269573.	25.40143	26.89148	26.00558
6	-2171.677	52.44535	1084436.*	25.24085	27.01472	25.96008
7	-2155.432	27.25433*	1085940.	25.23814*	27.29582	26.07244
8	-2141.700	22.42928	1119729.	25.26333	27.60484	26.21271

Source: Authors' compilation from WDI and the International Financial Statistics database.
Note: WDI = World Development Indicator, * indicates lag order selected by the criterion; LR = sequential modified LR test statistic (each test at the 5 percent level); FPE = final prediction error; AIC = Akaike information criterion; SC = Schwarz information criterion; HQ = Hannan-Quinn information criterion.

4.4 Regression Results

Table 5 presents the results from the estimations of all four models using the pVAR methodology.

Table 5 Panel Vector Autoregression Results

	Model 1 FINDEX	Model 2 FINTECH	Model 3 REMIT	Model 4 GDPPC
FINDEX(-1)	1.0160***	-0.2930**	-0.0606	-6.0028
	(0.0081)	(0.1428)	(0.0384)	(13.3919)
	[124.951]	[-2.0516]	[-1.5777]	[-0.4483]
FINTECH(-1)	0.0037***	0.9868***	-0.0068*	1.4674
	(0.0008)	(0.0132)	(0.0036)	(1.2395)
	[4.9571]	[74.6404]	[-1.9089]	[1.1839]
REMIT(-1)	0.0132**	-0.1809*	0.6311***	5.4672
	(0.0053)	(0.0927)	(0.0249)	(8.6908)
	[2.5054]	[-1.9510]	[25.3463]	[0.6291]
GDPPC(-1)	0.0000	0.0004***	0.0008**	1.0040***
	(0.0000)	(0.0002)	(0.0000)	(0.0137)
	[1.2975]	[2.7786]	[2.1724]	[73.4210]

	Model 1 FINDEX	Model 2 FINTECH	Model 3 REMIT	Model 4 GDPPC
REMIT#FINTECH	-0.0004**	0.0100***	0.0115***	-0.2055
	(0.0002)	(0.0032)	(0.0009)	(0.2960)
	[-2.4692]	[3.1552]	[13.5060]	[-0.6943]
R-squared	0.9785	0.8960	0.9463	0.9490
Adj. R-squared	0.9783	0.8950	0.9458	0.9486
Sum sq. resids	31.0952	9595.767	692.3069	84353530
S.E. equation	0.2778	4.8796	1.3107	457.5084
F-statistic	4586.300	867.8323	1776.055	1873.832
Log likelihood	-53.7875	-1223.120	-686.7944	-3075.736
Akaike AIC	0.2882	6.0202	3.3911	15.1017
Schwarz SC	0.3373	6.0694	3.4403	15.1508
Mean dependent	0.0621	29.9312	4.0935	1736.422
S.D. dependent	1.8853	15.0552	5.6291	2015.438

Source: Authors' compilation from WDI and the International Financial Statistics database.
*Standard errors in () and T-statistics in [] ***, **, * represent significance at 1 percent, 5 percent, and 10 percent, respectively.*

Model 1—FINDEX results: Financial inclusion has a significantly positive relationship with its first lag, showing that FINDEX exhibits a random walk as it explains itself and indicates that current levels of financial inclusion are composed of the previous index of financial inclusion. Adoption of fintech in the previous year significantly impacts financial inclusion in a positive way at a 1 percent level of significance, suggesting that an increase in the adoption of fintech will significantly raise the level of financial inclusion. An increase in the flow of personal remittances has a significantly positive effect on financial inclusion, indicating that as remittances continue to flow in large amounts, many more people will open bank accounts and sign onto banking products and services. On the other hand, the interaction between remittances and fintech (REMIT#FINTECH) has a significantly negatively affects financial inclusion. Thus, the results suggest that the multiplicative effect of personal remittances and fintech significantly dampens the level of financial inclusion in Africa. The interaction's negative effect suggests that remittances and fintech are substitutes rather than complements in promoting financial inclusion.

Model 2—Fintech results: The previous level of financial inclusion has a significantly negative impact on fintech at a 5 percent significance level, indicating that the level of the previous year's financial inclusion reduces the use of fintech in Africa. Thus, people who have opened accounts and who are using formal banking products and services shun adoption of fintech. Again, fintech exhibits a random walk, in that previous levels of fintech explain the current level of fintech with a positive effect. The results also show that migrants' personal remittances, although significant for fintech, have a negative effect on fintech while the previous GDP per capita has a significantly

positive effect on fintech. Interestingly, the effect of the interaction between the flow of remittances and fintech (REMIT#FINTECH) increases the adoption of fintech.

Although the first lag of fintech has a significantly positive effect on financial inclusion in Model 1, the first lag of the level of financial inclusion has a negative effect on fintech in Model 2. In Model 1, the multiplicative effect of the flow of remittances and fintech decreases the level of financial inclusion, but in Model 2, the effect on fintech is positive, indicating that fintech adoption expands in the presence of remittances and fintech.

Model 3—Personal remittances results: The results show that the main determinants of the flow of personal remittances include fintech, which negatively impacts remittances. This finding signifies that an increase in the adoption of fintech reduces remittance flows. Again, previous remittance flows significantly and positively impact current levels of remittance flows. Moreover, gross domestic product per capita influences these flows. As it increases, remittances increase. The interactive effect of personal remittances and fintech (Remit#Fintech) significantly and positively impacts remittance flows.

Model 4—GDP per capita results: The results indicate that only the previous GDP per capita levels impact current GDP per capita.

4.4.1 Forecast-Error Variance Decomposition

Fundamental to the pVAR model of the Cholesky decomposition for the 32 African countries is the residual covariance matrix, to which the forecast error variance decomposition (FEVD) corresponds with the results. As reported in the FEVD estimates in Table 6, in the short run, the level of financial inclusion, the adoption of fintech, the flow of remittances, and GDP per capita do not explain variations in financial inclusion. However, in the long run, as much as 88.6 percent of the variations in financial inclusion are attributable to that inclusion, 8.3 percent to fintech, 1.1 percent to remittances, and 1.9 percent to GDP per capita.

In the short run, remittance flows and GDP per capita do not explain variations in fintech adoption and financial inclusion. Fintech explains about 0.098 percent of the variations and financial inclusion, 99.9 percent. In the long run, however, 0.45 percent and 95.14 percent of variations in fintech are attributed to financial inclusion and fintech separately. In addition, 1.03 percent, and 3.36 percent of the variations in fintech are explained by remittances and GDP per capita, respectively.

Additionally, the FEVD estimates show that, in the short run, 2.2 percent and 97.8 percent of variations in remittance flows are explained by the increase in the adoption of fintech and remittance. In the long run, 0.49 percent of the variations are explained by financial inclusion, 5 percent by fintech, and 1.7 percent by GDP per capita. Remittances account for 92.7 percent of the variations in the long run.

Furthermore, in the short run, GDP per capita explains about 99.9 percent of its own variation. Financial inclusion explains 0.01 percent of the variation of GDP per capita, and the level of financial inclusion and the flow of remittances explain 0.02 percent. In the long run, the level

of financial inclusion explains 0.12 percent of this variation; fintech adoption, 0.42 percent; and remittance flows, 0.16 percent. GDP per capita explains 99.3 percent of its own variation in the long run.

Table 6 Forecast Error Variance Decomposition

1. FINDEX:

Period	S.E.	FINDEX	FINTECH	REMIT	GDPPC
1	0.277776	100.0000	0.000000	0.000000	0.000000
2	0.397026	99.64231	0.154506	0.187782	0.015405
3	0.491893	98.97996	0.521802	0.436723	0.061514
4	0.574942	98.08882	1.100516	0.662353	0.148310
5	0.651069	96.99252	1.883257	0.839871	0.284349
6	0.722850	95.69730	2.858196	0.967641	0.476865
7	0.791879	94.20611	4.010107	1.051941	0.731843
8	0.859247	92.52391	5.321189	1.100838	1.054065
9	0.925753	90.65914	6.771786	1.121934	1.447136
10	0.992011	88.62376	8.341039	1.121684	1.913514

2. FINTECH:

Period	S.E.	FINDEX	FINTECH	REMIT	GDPPC
1	4.879635	0.098033	99.90197	0.000000	0.000000
2	6.884560	0.058917	99.75517	0.113400	0.072509
3	8.413523	0.039776	99.45195	0.276051	0.232224
4	9.694380	0.039984	99.04897	0.439071	0.471978
5	10.81573	0.059396	98.56874	0.585099	0.786762
6	11.82353	0.098176	98.01916	0.709943	1.172724
7	12.74552	0.156662	97.40226	0.814529	1.626547
8	13.60009	0.235284	96.71817	0.901456	2.145094
9	14.40025	0.334504	95.96670	0.973585	2.725206
10	15.15561	0.454778	95.14811	1.033513	3.363597

3. REMIT:

Period	S.E.	FINDEX	FINTECH	REMIT	GDPPC
1	1.310680	0.000568	2.195537	97.80390	0.000000
2	1.553729	0.017455	2.567724	97.35204	0.062784
3	1.644629	0.051033	2.933620	96.81673	0.198622
4	1.683462	0.098482	3.281225	96.23036	0.389934
5	1.702501	0.155922	3.607288	95.62146	0.615325
6	1.713657	0.219702	3.913979	95.01037	0.855946
7	1.721542	0.286963	4.205588	94.40956	1.097890
8	1.727981	0.355695	4.486517	93.82576	1.332029
9	1.733711	0.424559	4.760437	93.26211	1.552892
10	1.739038	0.492697	5.030122	92.71967	1.757506

4. GDPPC:

Period	S.E.	FINDEX	FINTECH	REMIT	GDPPC
1	457.5084	0.014484	0.001918	0.019314	99.96428
2	648.4558	0.018825	0.004920	0.052767	99.92349
3	796.2709	0.024492	0.019889	0.083608	99.87201
4	922.1464	0.031664	0.046662	0.108178	99.81350
5	1034.283	0.040520	0.084743	0.126194	99.74854
6	1136.883	0.051235	0.133431	0.138518	99.67682
7	1232.443	0.063986	0.191899	0.146266	99.59785
8	1322.590	0.078950	0.259246	0.150470	99.51133
9	1408.451	0.096304	0.334536	0.151990	99.41717
10	1490.848	0.116226	0.416816	0.151507	99.31545

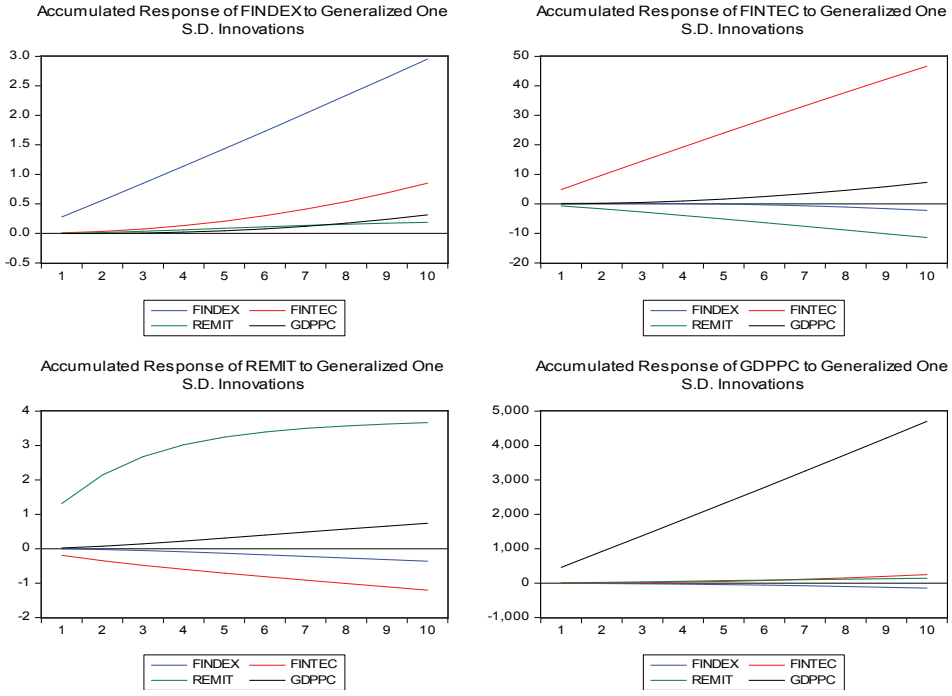
Source: Authors' compilation from WDI and the International Financial Statistics database.
Note: Cholesky Ordering: FINDEX, FINTECH, REMIT, GDPPC.

4.4.2 Impulse Response Functions

Figure 5 shows the impulse response functions convenient for the display of interactions among the variables in the pVAR model. These functions, which are reported with a 95 percent confidence level, represent the reactions of the variables to system shocks. However, it is often unclear which shocks are relevant for studying specific economic problems. Therefore, structural information must be used to specify meaningful shocks. Structural vector autoregressive models and the estimation of impulse responses are discussed, and extensions to models with cointegrated variables or nonlinear features are considered below.

The impulse response functions in figure 5 report how shocks (standard deviations) of independent variables influence an outcome variable and how long the shocks will last. Fintech, remittances, and gross domestic product per capita report positive and significant effects on financial inclusion only within one standard deviation. These findings are consistent with the results of the regressions presented above. Interestingly, the stability of the effects of these variables (except gross domestic product per capita) on financial inclusion remains a major source of concern. Similar results are observed when fintech is employed as the dependent variable and the impulse response variable while financial inclusion, remittances, and gross domestic product per capita are employed as the shock variables. Gross domestic product growth rate is the only variable that remains stable during the first two periods, and remittances are the only variable that reports a negative and significant response to fintech, consistent with the regression outcomes. Financial inclusion and gross domestic product per capita report a positive and significant but unstable response to fintech. These findings are in line with the regression findings on fintech presented above. However, using remittances and gross domestic product per capita as outcome variables, the study largely finds negative and significant responses. Remittances are unstable only beyond the sixth period, and gross domestic product per capita remains stable for about seven periods. Financial inclusion as the outcome variable remains stable within one standard deviation for about four periods before becoming unstable.

Figure 5 Impulse Response Functions



Source: Authors' compilation from WDI and the International Financial Statistics database.
Note: FINDEX = Financial Inclusion Index; REMIT = remittances; GDPPC = GDP per capita.

4.4.3 Results from a Random- and Fixed-Effects Estimator

Given the generally non-intuitive nature of the results from the pVAR model, the study estimated a comparative model using the random- and fixed-effects estimator. Notably, the pVAR methodology could not ascertain whether remittance and fintech has a positive effect on financial inclusion. However, when relying on the random and fixed effects estimator (a Hausman test showed the former was more consistent with the data-generating process), the study finds that the remittances and fintech together positively affect financial inclusion. More specifically, it finds that remittances and the number of mobile money agent outlets together positively affect financial inclusion. This result has important implications for policy as much as it demonstrates, unlike the pVAR results, that accounting for other potential factors that are likely to influence financial inclusion leads to the positive interactive effect of remittances and fintech on financial inclusion.

Table 7 Random Effects Results of the Interactive Effect of Remittances and Fintech on Financial Inclusion

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Household Final Consumption Expenditure	0.272***	0.263***	0.261***	-0.000	-0.002	-0.001
	(0.021)	(0.020)	(0.021)	(0.002)	(0.002)	(0.002)
Access to electricity (percent of Popn)	1.456*	0.925	1.080	0.497***	0.395***	0.398***
	(0.749)	(0.727)	(0.772)	(0.059)	(0.055)	(0.059)
Proportion of female Popn	-63.714**	-58.439**	-59.913**	-3.641*	-5.142***	-3.988**
	(26.544)	(24.891)	(25.402)	(1.869)	(1.817)	(1.870)
Personal remittances	1.720	1.205	-0.075	-0.069	0.058	-0.163
	(2.937)	(1.572)	(1.798)	(0.237)	(0.121)	(0.140)
Mobile phone used to pay bills	1.429			0.882***		
	(2.284)			(0.172)		
Personal remittances # Mobile phone used to pay bills	0.002			-0.007		
	(0.105)			(0.008)		
Mobile money transactions		-0.000			0.000***	
		(0.000)			(0.000)	
Personal remittances received # Mobile money transactions		0.000***			-0.000	
		(0.000)			(0.000)	
Mobile agent outlets			-0.012			0.017***
			(0.052)			(0.004)
Personal remittances received # Mobile agent outlets			0.021**			0.001**
			(0.009)			(0.001)
Observations	349	348	347	348	347	346
Number of countries	28	28	28	28	28	28

*Source: Authors' compilation from WDI and the International Financial Statistics database. Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

5. Conclusion

This paper investigates the interrelationship of the flow of international remittances and the level of fintech on financial inclusion in Africa. Its argument hinges on the lack of consideration of fintech as a shaper of the effect of remittances on financial inclusion. Using the pVAR model as well as the random effects estimator and data from 32 African economies between 1999 and 2018, the paper reports two key results: (1) remittances and fintech positively affect financial inclusion, and (2) their interactive effect is positive when accounting for other variables that influence financial inclusion.

These results have implications for policymakers and academic researchers. Policymakers should be mindful of the interplay of remittances and fintech since they significantly increase financial inclusion in Africa. Researchers should explore potential nonlinear, or threshold, effects of these variables on financial inclusion. Fintech in Africa may not have developed to an advanced stage such that its adoption and use can reinforce or shape its relationship with the inflow of remittances in Africa to promote financial inclusion. It is also possible that fintech's effects may differ by income group or even location.

This paper's results also have implications for regulators and technologists. Both need to work together to identify the electronic payment systems within the fintech space that enable everyone to access financial services easily in Africa. For policy purposes, a proper regulatory structure is a must for remittances, fintech, and financial inclusion. The structure must guarantee the authenticity of all transactions by way of remittances using financial technologies. This will help ensure security, confidentiality, and stability to promote financial inclusion and increase overall value creation within the economies of Africa. Importantly, the value of fintech is enhanced by its credibility. Financial inclusion can be achieved effectively if the right policies are implemented to encompass remittances and fintech.

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