

Article

How Catalytic Is Digital Technology in the Nexus between Migrants' Remittance and Financial Development in Sub-Saharan African Countries?

Olufunmilayo Olayemi Jemiluyi *  and Leward Jeke 

Department of Economics, Nelson-Mandela University, Summerstrand Campus South,
Port Elizabeth 6001, South Africa

* Correspondence: s226061035@mandela.ac.za

Abstract: Given the indisputable roles of remittance and financial development in countries' economic performance, enhancing the nexus between the two variables has become pertinent. The remittance–financial development literature has surged, with a growing argument that making the relationship work is conditioned on mediating roles of certain economic indicators. Despite the overwhelming evidence of the transformative roles of digital technology, the assessment of its possible mediating role in the remittance–financial development nexus is lacking in the literature. Hence, using pooled data of 35 Sub-Saharan African (SSA) countries sourced from the World Bank's Development Indicators, this study examined the mediating effect of digital technology in the relationship between remittance inflows and financial development. Using two indicators of ICT—fixed broadband and mobile cellular subscription—the results of the generalized method of moment analysis suggest that digital technology spurs remittance inflows to promote financial development in SSA. The results are consistent for both measures. These findings imply that remittance and digital technology are complementary in promoting financial development in the sub-region. Based on these outcomes, the study therefore advances the enactment of policies aimed at fostering diffusion of digital technology and achieving the sustainable development goal's recommendation of lower transaction cost of remittances.

Keywords: remittance inflow; financial development; digital technology; ICT; sub-Saharan Africa; developing countries



Citation: Jemiluyi, Olufunmilayo Olayemi, and Leward Jeke. 2023. How Catalytic Is Digital Technology in the Nexus between Migrants' Remittance and Financial Development in Sub-Saharan African Countries? *Economies* 11: 74. <https://doi.org/10.3390/economies11030074>

Academic Editor: Robert Czudaj

Received: 23 December 2022

Revised: 4 February 2023

Accepted: 17 February 2023

Published: 24 February 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Following the increasing recognition of the importance of the financial sector in solving diverse socioeconomic challenges bedeviling developing countries, policy interest has continued to gear towards promoting financial development. Hence, several strands of literature have emerged on factors that dictate financial development. An important one of these strands is the remittance–financial development literature. In a large quantum of both policy and empirical studies, remittance is identified as a significant predictor of financial development (Demirguc-Kunt et al. 2009; Ambrosius 2011; Aggarwal et al. 2011; Azizi 2020; Bolarinwa and Akinbobola 2021; Donou-Adonsou et al. 2020; Das and McFarlane 2021). However, while the remittance–financial development literature is expanding, an offshoot of the literature which argues the contingency of the nexus on certain macroeconomic variables has also emerged. Financial development effect of remittance has been argued, conditioned on factors such as institutional quality (Williams 2016; Saydaliyev et al. 2020; Kim 2021), capital formation (Qamruzzaman and Kier 2021), foreign direct investment (Qamruzzaman and Kier 2021), human capital development (Pal 2022) and monetary policy environment (Issahaku 2019). Moreover, consequent on the recent wave of ICT diffusion in developing countries and the growing awareness of its transformative roles evidenced in ICT-enabled socioeconomic transformations characterizing the globe, research attention

has also shifted towards understanding the roles of digital technology¹ in remittance-led financial development (Guermon 2021).

This study therefore seeks to contribute to the small but growing thread of literature which focuses on the contingency of the remittance–finance development nexus on certain macroeconomic variables. In particular, the focal point of our study is investigating the modulating role of digital technology in remittance-led financial development. Although the role of digital technology in remittance inflow is gaining momentum (Nicoli and Ahmed 2019; Raithatha et al. 2021; Bersch et al. 2021), empirical analysis of its mediating influence in remittance-led financial development is lacking in the literature. Hence, we aim to analyze the relationship in the context of sub-region of Saharan Africa (SSA). Even though we are aware that the remittance–financial development nexus literature for the sub-region is enjoying growing attention in both time-series and panel evaluations (Karikari et al. 2011; Misati et al. 2019; Donou-Adonsou et al. 2020; Bolarinwa and Akinbobola 2021), the contingency argument has not been well explored (Williams 2016). Furthermore, we do not know of any study which has evaluated the mediating influence of digital technology in the remittance–financial development nexus for SSA.

The intuitiveness of the plausibility of this inquiry stems from established evidence that, on the one hand, digital technology facilitates remittance inflow (Asongu et al. 2018; Asongu and Odhiambo 2020a; Raithatha et al. 2021; Bersch et al. 2021) and, on the other hand, digital technology also promotes financial development (Asongu and Nwachukwu 2017; Alshubiri et al. 2019; Edo et al. 2019; Asongu and Odhiambo 2020b; Bayar et al. 2021; Igwilo and Sibindi 2022). In the same vein, a near consensus exists in the literature on remittance-led financial development. Hence, this study builds on the existing evidence to argue that digital technology might be the policy channel through which remittance-led financial development can be enhanced.

Furthermore, exploring the possible modulating role of digital technology in the remittance–financial development relation is particularly important for SSA given the size of remittance inflow to the region, the poor level of financial development, the pile of development challenges that could be solved with improvement in financial development and the remarkable surge in the diffusion of digital technology in recent times. For example, in the period between 2010 and 2020, internet usage grew by 327 percent while fixed broadband and mobile cellular subscription grew by 162 percent and 73 percent, respectively, in the same period (World Bank 2022b). In the same vein, remittance inflow into SSA reached \$49 billion in 2019 exceeding FDI and official development aid. However, in spite of the significant improvement in digital technology and significant increase in remittance inflow, financial development in the sub-region compares poorly with other developing regions with similar structure (World Bank 2022b). Thus, an assessment of the possible influence of digital technology on remittance-led financial development is not only timely for SSA but also of huge importance. Given the established evidence of significance of financial development, filling this identified gap in the literature can serve as an impetus to solving diverse development problems prevalent in the region.

The rest of the article is structured as follows; this introductory section is followed by a review of extant studies on remittance and financial development. Sections 3 and 4, respectively, focus on methodology and the discussion of results. The study concludes with the summary of the study and policy recommendations.

2. Literature Review

In an earlier World Bank's study, Aggarwal et al. (2011) tested the remittance–financial development relation for a dataset consisting of 99 developing economies. The empirical findings showed that increasing migrant remittance is correlated to increase in both bank deposit and financial institution credit to the private sector. Testing the remittance-financial development nexus in a larger dataset of 124 developing countries, Azizi (2020) affirmed that remittance fosters financial development.

In a mixed sample of both developed and developing economies, [Fromentin and Leon \(2019\)](#) assessed the short-and long-term effects of remittance on financial development. The authors particularly examined the differential effect of remittance on banking credit to firms and households. The results showed that remittance only promotes financial development in the long-run and that the remittance effect on banking credit is stronger for household credit in the developing economies while it spurs firm credit in the developed economies. In a later study by [Bindu et al. \(2021\)](#), alike findings were reported between remittance and various measures of financial development in the BRIC countries.

The remittance–financial development has also enjoyed sizeable attention in the continent of Africa and the Saharan sub-region in particular. While the relationship has been explored within the framework of panel analysis, it has likewise been examined in a time-series analysis. For example, testing for causality between remittance and financial development, in a sample of 50 African countries, [Karikari et al. \(2011\)](#) established a two-way causality between the variables, implying that while remittance supports financial development, the latter similarly reinforces the former. Moreover, in the pooled mean group (PMG) analysis of [Donou-Adonsou et al. \(2020\)](#), remittance inflow was found to have significant positive effect on financial development in SSA. The coefficient elasticities indicate that remittance has a more than proportionate increasing effect on financial development. Moreover, the findings of [Adekunle et al. \(2020\)](#) for a sample of 53 African countries supported the remittance-led financial development argument.

Controlling for cross-sectional dependence and parameter heterogeneity, [Keho \(2020\)](#) examined the influence of remittance inflow on financial development in selected Western African countries. The results showed that the financial development effect of remittance varies. While remittance increases money supply, it has a reducing effect on domestic credit to the private sector. For country-specific studies, [Misati et al. \(2019\)](#) documents that remittance enhances growth in the financial sector for Kenya and alike findings were reported by [Bolarinwa and Akinbobola \(2021\)](#) for Nigeria.

In the sample studies for the Asian region, [Mohamed Aslam and Sivarajasingham \(2020\)](#) attest that remittance promotes financial development in Sri Lanka by increasing mobilized funds and the number of banking accounts created. A similar result was reported for Bangladesh by [Muktadir-Al-Mukit and Islam \(2016\)](#). Moreover, [Basnet et al. \(2021\)](#) explored the relationship within the framework of PMG for a panel of South Asians, and the findings corroborate the stance that remittance fuels financial development. It was also affirmed in a more recent study by [Pal \(2022\)](#) that remittance is a significant contributor to financial development in India and China.

Owing to relevance of remittance in developing countries, sample studies also exist for Latin America. [Demircuc-Kunt et al. \(2009\)](#), [Ambrosius \(2011\)](#) and [Das and McFarlane \(2021\)](#) support the remittance-led financial development in Mexico, El Salvador and Jamaica, respectively.

Investigating the nexus in 27 member countries of the former Soviet Union, [Kakhkharov and Rohde \(2020\)](#) found that remittance promotes financial development in the transition economy. Using various measures of financial development and three distinct econometric estimators, the effect was found to be strongest for credit to the private sector.

In spite of the large-scale evidence of improvement in financial sector performance due to increase in remittance flow, there also abounds evidence that remittance either deters financial sector growth or has no significant effect on the sector. [Polat \(2018\)](#) showed that remittance has no significant influence on the development of the financial sector in a panel of developing countries. [Qiang et al. \(2019\)](#) argued that remittance channeled to consumption financing does not promote financial sector development. Using migrant remittances data pooled from household survey in Azerbaijan and Kyrgyzstan, [Brown et al. \(2013\)](#) found that remittances have a decreasing effect on financial development in the investigated countries. [Coulibaly \(2015\)](#) likewise documented that while remittances spur money supply in migrants home country, it has a deterring effect on banks credit to

the private sector. Moreover, in a panel of SSA countries, [Oyelami and Ogundipe \(2020\)](#) found no evidence of a significant relationship between remittance and financial inclusion.

Following the mix of findings, a strand of literature has emerged that investigates the possible modulating effect of certain macroeconomic variables on the direction of the relationship between remittance and financial development. For this small thread of the literature, factors including institutions ([Issabayev et al. 2020](#); [Saydaliyev et al. 2020](#); [Kim 2021](#)), human capital ([Pal 2022](#)) and ICT ([Nyahete 2017](#)) have been found to modulate the remittance–financial development relation.

In sum, the literature review revealed that, although the contingency literature is growing for the remittance–financial development nexus, studies that investigated the contingency of the relationship on digital technology diffusion are lacking in the literature. The closest studies to ours are [Asongu et al. \(2018\)](#) and [Asongu and Odhiambo \(2020a\)](#), which, respectively, analyzed the modulating role of ICT in the nexuses between remittance and doing business and remittance and industrialization.

3. Methodology

3.1. Data and Measurement of Variable

For uniformity of measurement, data were obtained only from the World Development Indicator (WDI), an online database of the World Bank which compiles data at national, regional and global levels from internationally recognized sources. Owing to constraint of availability, we were only able to compile annual data for 35 SSA countries, which account for about 73 percent of the 48 SSA countries. The data span over a period of 10 years from 2011 to 2020. The period was selected based on availability of data and consideration for the intended method of estimation. In addition, the chosen scope also coincides with the period of increased usage and penetration of ICT in the continent of Africa. This period is thus considered suitable for the measurement of the possible effect of ICT in the relationship between remittance and financial development in SSA economies.

In measuring our variables, we used two measures of financial development to proxy the dependent variable—domestic credit to private sector (DCPS) and money supply (MOSPP). The principal regressor remittance is measured by personal remittance received in current US dollars. Following notable research which has made seminal contributions on the relationship between ICT and various macroeconomic performance indicators ([Asongu and Odhiambo 2020b](#); [Adeleye and Eboagu 2019](#)), we adopted fixed broadband and mobile cellular subscription per 100 people to represent digital technology. Furthermore, in order to avoid errors that may stem from misspecification of our model and to ensure the validity of our findings, we employed data on economic development, foreign direct investment (FDI), inflation rate and urban population as a share of total population as control variables.

While our choices of control variables are largely informed by extant literature, we were deliberate to select macroeconomic variables which are more relevant to our study context. For example, the role of FDI in financial development represents a dominant debate in the literature, and its pertinence for SSA economies has been extensively documented ([World Bank 2014](#); [UNCTAD 2022](#)). FDI constitutes the single most important source of foreign capital inflows in the sub-region ([UNCTAD 2022](#)), having significant implications for financial development ([Yinusa et al. 2018](#); [Majeed et al. 2021](#)). In the same vein, the issue of inflation has remained topical for SSA generating both national and global concerns ([IMF 2022b](#)). In fact, except for a few exceptions, SSA economies are typified by rising inflation ([IMF 2022a, 2022b](#); [World Bank 2022a](#)). Hence, following documented evidence of the potential impact of inflation on financial sector development ([Ehigiamusoe et al. 2022](#); [Ibrahim et al. 2022](#)), the latter is also considered in a bid to mitigate regression error due to omitted variables ([World Bank 2022a](#); [IMF 2022a](#)). Finally, arguments for and against the pro-finance effect of urbanization abound in the extant literature ([Seraphin 2019](#); [Joof and Isiksal 2020](#); [World Bank 2020](#)). SSA is identified as the fastest urbanizing region of the world ([UN-DESA 2018, 2019](#)); thus, we likewise incorporated the urban share of total population as a measure of degree of urbanization in the estimated model.

3.2. Empirical Model and Estimation Technique

To empirically investigate the interactive effect of remittance and ICT diffusion on financial development in SSA region, we employed a quantitative method of analysis. Being a study that focuses on a pool of countries, we specifically adopted dynamic panel-data estimation model. Generally, a dynamic panel-data model makes the estimation of dynamic economic relationships in which the current level of the dependent variable does not only depend on the selected explanatory variables but also on the previous (lagged) values of the dependent variable, possible. The GMM estimators—Difference GMM and System GMM—are considered most suitable in the class of dynamic panel-data. In particular, they are more efficient in tackling the problem of endogeneity which arises from the inclusion of lagged value of the dependent variable. However, we chose the [Arellano and Bond \(1991\)](#) difference GMM (DGMM) over the system GMM (sysGMM) of [Arellano and Bover \(1995\)](#) due to our not-so-large dataset. The system GMM uses more instruments than the difference GMM, and in order to avoid the challenge of weak Sargan test due to an excess number of instruments over the number of countries, we thus adopted DGMM ([Roodman 2009](#)). By transforming the regressors, DGMM is also advantageous in taking care of the problem of fixed effect which may arise from the correlation of the regressors with the time-invariant countries' geographic and demographic characteristics ([Arellano and Bond 1991](#)). In addition, the first differencing process also sets up instruments for inherently endogenous variables in the model.

The standard model for the study is presented as follows:

$$FD_{it} = \alpha FD_{it-1} + \varnothing REM_{it} + \mu ICT_{it} + \delta INTER_{it} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

where FD_{it} is the level of financial development in country i at time t and FD_{it-1} is the lagged of financial development in country i at time $t - 1$. REM_{it} is the measure of remittance inflow in country i at time t while ICT_{it} represents digital technology in country i at time t ; $INTER_{it}$ is the interaction term of remittance with ICT while X_{it} is the vector of other regressors. Other omitted variables are captured in the error term ε_{it} . α , \varnothing , μ , δ and β are the parameters of interest which measure the effects of the lagged dependent variable, ICT, the interaction term with ICT and other control variables, respectively, on financial development.

As earlier noted, financial development and ICT are represented by two measures each. Hence, we estimated two separate models for each measure of financial development, interchanging each measure of ICT and the corresponding interaction term in each model to avoid multicollinearity problem. In all, we estimated four different models.

Taking the first difference of Equation (1) above and explicitly stating the control variables, we have:

$$\Delta FD_{it} = \alpha \Delta FD_{it-1} + \varnothing \Delta REM_{it} + \Delta \mu ICT_{it} + \Delta \delta INTER_{it} + \Delta \beta_1 GDP_{it} + \Delta \beta_2 FDI_{it} + \Delta \beta_3 INFL_{it} + \Delta \beta_4 URB_{it} + \varepsilon_{it} \quad (2)$$

The modulating role of ICT in the relationship between remittance inflows and financial development is determined by the estimated parameter of remittance (\varnothing) and the corresponding interaction term (δ). There are four likely outcomes of the indicated parameters:

- i. If both \varnothing and δ are positive (>0), it implies that remittance positively contributes to financial development and ICT intensifies and complements the positive link.
- ii. If both \varnothing and δ are negative (<0), it implies that remittance retards financial development and ICT aggravates the negative effect.
- iii. If \varnothing is positive (>0) and δ is negative (<0), this means that remittance promotes financial development but ICT constitutes a hindrance to the growth.
- iv. If \varnothing is negative (<0) and δ is positive (>0), it means that remittance has a retarding effect on financial development but ICT mitigates the negative effect.

4. Discussion of Estimated Results

The two-step DGMM results are presented in Tables 1 and 2 below. Specifically, Table 1 reports the results of financial development models using fixed broadband as a measure of ICT while Table 2 reports the results for the models using mobile cellular subscription to account for ICT.

Table 1. Regression Results (ICT is proxied by fixed broadband.)

| Regressors | MODEL I: Domestic Credit to Private Sector (DCPS) | | | Model II: Money Supply (MOSPP) | | |
|------------------------------|---|--------------|-------------|--------------------------------|--------------|-------------|
| | Coefficients | z-Statistics | Prob. Value | Coefficients | z-Statistics | Prob. Value |
| DCPS _{t-1} | 0.241 | 0.022 | 0.068 | 0.783 | 0.058 | 0.000 |
| REMIT | 0.146 | 0.080 | 0.000 | 0.434 | 0.137 | 0.002 |
| ICT | -1.737 | 0.073 | 0.000 | -0.783 | 0.119 | 0.000 |
| INTER_1 | 0.143 | 0.135 | 0.000 | 0.476 | 0.031 | 0.000 |
| GDPCG | -0.317 | 0.418 | 0.000 | -0.602 | 0.054 | 0.000 |
| FDI | 0.91 | 0.020 | 0.000 | 0.125 | 0.032 | 0.000 |
| INFL | -0.132 | 0.001 | 0.000 | -0.013 | 0.002 | 0.000 |
| URBB | 0.099 | 0.085 | 0.239 | 0.043 | 0.125 | 0.733 |
| Number of obs. | 229 | | | 226 | | |
| Number of Groups/Instruments | 35/29 | | | 35/29 | | |
| Wald (p-value) | Chi2(8) = 4990.8 (0.000) | | | Chi2(8) = 34,660.9 (0.000) | | |
| Post-Estimation Tests | | | | | | |
| Sargan Test (p-value) | 0.289 | | | 0.222 | | |
| AR(-2) Test (p-value) | 0.336 | | | 0.574 | | |

Table 2. Regression Results ((ICT is proxied by mobile cellular subscription.)

| Regressors | MODEL I: Domestic Credit to Private Sector (DCPS) | | | Model II: Money Supply (MOSPP) | | |
|------------------------------|---|--------------|-------------|--------------------------------|--------------|-------------|
| | Coefficients | z-Statistics | Prob. Value | Coefficients | z-Statistics | Prob. Value |
| DCPS _{t-1} | 0.426 | 0.015 | 0.000 | 0.947 | 0.064 | 0.000 |
| REMIT | 1.748 | 0.430 | 0.000 | 4.623 | 0.595 | 0.000 |
| ICT | 0.547 | 0.075 | 0.000 | -0.028 | 0.005 | 0.000 |
| INTER_1 | -0.027 | 0.004 | 0.000 | -0.028 | 0.005 | 0.000 |
| GDPCG | -0.325 | 0.013 | 0.000 | -0.840 | 0.613 | 0.000 |
| FDI | 0.058 | 0.022 | 0.008 | 0.125 | 0.30 | 0.000 |
| INFL | -0.009 | 0.001 | 0.000 | -0.009 | 0.002 | 0.000 |
| URBB | -0.173 | 0.062 | 0.005 | -0.275 | 0.145 | 0.057 |
| Number of obs. | 234 | | | 231 | | |
| Number of Groups/Instruments | 34/29 | | | 34/29 | | |
| Wald (p-value) | Chi2(8) = 11,745.04 (0.000) | | | Chi2(8) = 96,496.3 (0.000) | | |
| Post-Estimation Tests | | | | | | |
| Sargan Test (p-value) | 0.191 | | | 0.484 | | |
| AR(-2) Test (p-value) | 0.420 | | | 0.602 | | |

Based on the results output as presented below, financial development in the previous period has an increasing effect on the current level of financial development in all the models. This reiterates the importance of initial level of financial development in determining the current level of financial development (Asongu and Nwachukwu 2017). For model I, remittance inflow is positively related to financial development and, based on the probability value, the relationship is statistically significant.

In particular, a percentage increase in remittance inflow increases bank lending to private sector by 0.15 percent. This finding is in support of the large-scale evidence of positive nexus between remittance and financial development (Aggarwal et al. 2011; Azizi 2020; Bolarinwa and Akinbobola 2021; Donou-Adonsou et al. 2020). Financial sector-promoting effect of remittance is not far from expectation given that its inflow into the SSA region has really surged in recent times with average personal remittance in the region growing from \$2.6 billion in 2000 to \$7.9 billion in 2010, and growing further to \$13.7 billion in 2020 (World Bank 2022b). A sizeable proportion of the migrants' remittance is transmitted via financial institutions, thereby making more loanable funds available for credits (Aggarwal et al. 2011).

In addition, increasing remittance size may stimulate financial development via increased bank lending as financial institutions may be motivated to extend lending to recipients of remittance if their inflows are regarded as substantial and significant, thereby increasing the size of bank credit to the private sector (Aggarwal et al. 2011; Demirguc-Kunt et al. 2009; Donou-Adonsou et al. 2020).

Still on model 1, our proxy of ICT (fixed broadband) has a significant negative effect on our proxies of financial development, with the magnitude of the deterring effect being relatively higher for bank credit. In particular, a percentage increase in fixed broadband reduces bank credit and money supply by 1.73 and 0.78, respectively. This finding negates the popular consensus that ICT promotes financial development (Alshubiri et al. 2019; Keho 2020; Bayar et al. 2021). It is, however, consistent with the result of studies such as that by Nguyen et al. (2020), which documented a statistically significant negative effect of internet usage on access, depth and size dimension of financial development in a pool of low-, medium- and high-income countries. The finding for bank credit in particular might be due to the peculiar challenges of credit accessibility and affordability, which have kept bank lending at a low ebb in the SSA region (Sacerdoti 2005; Daumont et al. 2004) in spite of significant technological progress. Furthermore, while ICT might stimulate easy access to bank services including cash deposits, it does not guarantee a high propensity to save, which constitutes a critical factor for financial sector deposit mobilization. Owing to factors such as low income and a high propensity to consume, saving has not kept up with improvement in ICT diffusion in SSA (Andrianaivo and Kpodar 2011).

However, for the modulating effect of ICT in the remittance–financial development nexus which is the focus of this study, conditioned on the associated probability value of the interaction term (INTER), it is found to modulate the effect of remittance on financial development using both proxies of financial development. In models 1 and 2, the estimated coefficients of the interaction terms are positive and statistically significant. This implies that, although ICT does not promote financial development independently, it spurs remittance to improve the latter. Put differently, ICT represented by fixed broadband complements the positive effect of remittance on financial development in the SSA region. This resonates with the argument that ICT plays a significant role in boosting financial development in developing regions by serving as an efficient interface between sellers and buyers of financial services, thereby saving time and lowering costs. ICT therefore fuels remittance to promote efficiency in financial service delivery through an array of tech-enabled payment and settlement systems. In addition, while remittance may raise bank deposit, ICT might amplify remittance-led development in the financial sector by aiding faster diffusion of information, thereby raising awareness of a wide range of available financial products which remittance recipients can buy or invest in. In sum, the finding suggests that remittance and ICT play complementary roles in developing the financial sector of SSA. The complementary role of ICT is likewise reported by Makun and Jayaraman (2020), which studied the modulating role of ICT in the remittance–economic growth nexus in Indonesia. Similar findings on the contingency of ICT for the finance-economic growth nexus were also documented by Alimi and Adediran (2020) and Cheng et al. (2021) for panels of ECOWAS and cross-countries, respectively.

Comparing the magnitude of the interactive effect, ICT spurs remittance to raise money supply rather than bank credit. These results, aside being in consonance with the extensive evidence that ICT has a relatively higher impact on bank deposit than bank credit (Coulibaly 2015; Keho 2020), it is also plausible to think that ICT amplifies remittance to boost bank deposit more than it does bank lending. Flexibility and efficiency in banking operations enabled by ICT in the form of easier and wider access to bank services, especially for those in remote areas (non-urbanized areas), controlled information asymmetry and reduced transaction costs, would probably spur remittance recipients to save and invest in some bank products, thereby raising bank deposit.

Contrariwise, in spite of the significant growth in bank deposit due to increased remittance, ICT might not be able to spur the latter to expand bank lending in the same proportion. This observation might be related to the supply- and demand-side arguments. The supply-side argument contends that, due to lending constraints such as lack of collateral, banks might be unwilling to expand credit in spite of a surge in loanable funds due to remittance inflows. Moreover, on the demand-side, remittance may discourage borrowings as it provides recipients with alternative means of financing. Therefore, improvement in ICT infrastructure might not spur remittance to expand bank credit at the same rate as bank deposit (Aggarwal et al. 2011).

The results for model III and IV in which ICT is represented by mobile cellular subscription are presented in Table 2 below. The results are quite different from those of the fixed broadband models. In both models, remittance similarly spurs the two proxies of financial development with the effect also being higher for money supply. Specifically, a percentage increase in remittance causes money supply to grow by 0.05 percent while it raises bank credit to the private sector by 0.02 percent. Similarly, ICT represented by mobile cellular positively influences both bank deposit and lending with a percentage increase in mobile cellular subscription raising bank deposit and lending by 0.58 and 0.55 percent, respectively. Contrary to the reported results for the fixed broadband model, this finding lends support to the large-scale evidence of the pro-financial development effect of ICT and of mobile cellular subscription in particular. In particular, similar findings for Africa and SSA were posited in earlier studies by Edo et al. (2019), Igwilo and Sibindi (2022) and Sanga and Aziakpono (2022).

As regards the interaction effect of remittance and ICT on financial development, it is expected that, following the large body of evidence on the pro-financial development effect of mobile cellular subscription, the latter would amplify remittance to support financial development. However, contrary to the expectation of a complementary relationship between remittance and mobile cellular subscription, the estimated coefficient of the interactive term is negative. This implies that, while remittance independently promotes financial development, ICT constitutes a drag on the effect. The results are the same for both measures of financial development and the effects are statistically distinguishable from zero in both instances. The estimated elasticities of other correlates show that, in all the estimated models, per capita GDP growth rate (GDPCG) and inflation (INFL) are negatively related to financial development. Instability in price is expected to have an adverse effect on financial development as it discourages both saving and bank borrowing. Hence, the obtained results for inflation comply with a priori expectation and are supported by earlier studies (Ehigiamusoe et al. 2022; Ibrahim et al. 2022). However, economic development, on the other hand, is expected to boost financial development owing to its significance for saving, consumption and industrial development (Ferreira 2022; Fakudze et al. 2022). The result could, however, be due to a prevalent high level of financial exclusion and the attendant poor saving culture in the sub-region.

In line with a large body of evidence from the FDI-financial development literature (Majeed et al. 2021; Yinusa et al. 2018), FDI has a statistically positive effect on measures of financial development, and the result is consistent for all the estimated models. The degree of urbanization has a significant negative effect on both measures of financial development.

To confirm the validity of our findings, the goodness of fit for our model specifications are reported in the lower panel of Table 1 alongside the post-estimation tests results. Based on the reported chi-square statistics and the associated probability values of the Sargan test, the null hypothesis that the over-identifying restrictions are valid could not be rejected for all models at 5 percent level of significance. The Sargan test in particular confirms the validity or otherwise of the instrument used in the models and ascertains the absence of over-identification due to instrument proliferation. Moreover, all models are void of any evidence of serial correlation given the probability values of the Arellano-Bond correlation tests AR(2)). Moreover, the Wald test results for the models reject the null hypothesis that the joint effects of all the explanatory variables on the dependent variable are zero. In addition, the number of instruments is fewer than the number of groups in all models (Roodman 2009).

5. Conclusions

Despite the overwhelming evidence of the transformative roles of digital technology in recent times, the assessment of its possible mediating role in the remittance–financial development nexus is lacking in the literature. This study therefore contributes to the growing strand of the remittance–financial development literature by investigating the nexus for the SSA region using a decade’s data on 35 SSA countries, spanning the period of 2011 through 2020.

The empirical analysis estimated within the two step DGMM shows that remittance is a strong determinant of financial development in SSA. In addition, improvement in digital technology spurs remittance to promote financial development. Specifically, the interaction of our measures of digital technology—fixed broadband and mobile cellular subscription—with remittance inflows enhances financial development. This suggests that digital technology and remittance are complementary in developing the financial sector in SSA.

Based on the outcomes of this study, it is imperative that governments and policymakers prioritize making the relationship between remittance and financial development work. In particular, reduction in remittance transaction cost should be pursued as suggested in SDG plan in order to boost inflow of remittance into the region. Moreover, in order to amplify the remittance-led financial development, measures that promote the development and diffusion of digital technology should be prioritized in SSA economies.

Although this study has made a laudable contribution to the remittance–financial development literature, further examination of the relationship could be explored by investigating the nexus in the different blocs of SSA, which share more similar socioeconomic structure. In addition, while this study focused only on SSA and the findings can be generalized for other developing regions with similar socioeconomic structure, a cross-country analysis based on a larger dataset of developing countries from different regions of the world will not only offer a more in-depth understanding on how penetration of digital technology has influenced the role of remittance in financial sector development, but such an analysis will also allow for the evaluation of the nexus within a comparative framework involving various developing regions. Thus, further research on this area should consider pooling a larger dataset for developing countries across various regions for a more robust understanding. Furthermore, the relationship can be investigated for other regions of the world for possible comparison of findings. However, while the identified gaps will certainly enrich the extant literature, it does not by any means undermine the relevance of this study.

Author Contributions: Conceptualization, O.O.J.; methodology, O.O.J.; software, L.J.; validation, L.J. and O.O.J.; formal analysis, O.O.J.; writing—original draft preparation, O.O.J.; writing—review and editing, O.O.J. and L.J.; visualization, O.O.J.; supervision, L.J. All authors have read and agreed to the published version of the manuscript.

Funding: The authors acknowledge financial support from the Research Development Unit and the Department of Economics, Nelson Mandela University, South Africa.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Note

¹ Digital technology and ICT are used interchangeably all through this article.

References

- Adekunle, Ibrahim Ayoade, Sheriffdeen A. Tella, Kolawole S. Soliu, and Bidemi Adegboyega. 2020. Remittances and financial development in Africa. *Public Affairs* 22. [CrossRef]
- Adeleye, Ngozi, and Chiamaka Eboagu. 2019. Evaluation of ICT development and economic growth in Africa. *Netnomics* 20: 31–53. [CrossRef]
- Aggarwal, Reena, Asli Demirgüç-Kunt, and Maria Soledad Martinez Peria. 2011. Do workers' remittances promote financial development? *Journal of Development Economics* 96: 255–64. [CrossRef]
- Alimi, Ahmed, and Idris Adediran. 2020. ICT diffusion and the finance–growth nexus: A panel analysis on ECOWAS countries. *Future Business Journal* 6: 16. [CrossRef]
- Alshubiri, Faris, Syed Ahsan Jamil, and Mohammed Elheddad. 2019. The impact of ICT on financial development: Empirical evidence from the Gulf Cooperation Council countries. *International Journal of Engineering Business Management*. [CrossRef]
- Ambrosius, Christian. 2011. Remittances and financial sector development. Lessons from the Salvadorian case. *Savings & Development* 35: 1–27.
- Andrianaivo, Mihasonirina, and Kangni Kpodar. 2011. *ICT, Financial Inclusion and Growth: Evidence from African Countries*. IMF Working Paper 11/73. Washington, DC: International Monetary Fund. Available online: <https://www.imf.org/external/pubs/ft/wp/2011/wp1173.pdf> (accessed on 10 November 2022).
- Arellano, Manuel, and Olympia Bover. 1995. Another look at the instrumental variable estimation of error-component models. *Journal of Econometrics* 68: 29–51. [CrossRef]
- Arellano, Manuel, and Stephen Bond. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review Economics Studies* 58: 277–97. [CrossRef]
- Mohamed Aslam, Ahamed Lebbe, and Selliah Sivarajasingham. 2020. Empirical relationship between workers' remittances and financial development (an ARDL cointegration approach for Sri Lanka). *International Journal of Social Economics* 47: 1381–402. [CrossRef]
- Asongu, Simplice A., and Jacinta C. Nwachukwu. 2017. At what levels of financial development does information sharing matter? *Financial Innovation* 3: 11. [CrossRef]
- Asongu, Simplice A., and Nicholas M. Odhiambo. 2020a. Remittances, the diffusion of information and industrialization in Africa. *Contemporary Social Science* 15: 98–117. [CrossRef]
- Asongu, Simplice A., and Nicholas M. Odhiambo. 2020b. The mobile phone, information sharing, and financial sector development in Africa: A quantile regression approach. *Journal of Knowledge Economy* 11: 1234–69. [CrossRef]
- Asongu, Simplice A., Nicholas Biekpe, and Vanessa Simen Tchamyoyou. 2018. *Remittances, ICT and Doing Business in Sub-Saharan Africa*. AFEA Working Papers 18/009. Nairobi: African Finance and Economic Association (AFEA).
- Azizi, Seyed Soroosh. 2020. Impacts of remittances on financial development. *Journal of Economic Studies* 47: 467–77. [CrossRef]
- Basnet, Hem C., Bishwa Koirala, Kamal P. Upadhyaya, and Ficawoyi Donou-Adonsou. 2021. Workers' remittances and financial development: The case of South Asia. *International Review Economics* 68: 185–207. [CrossRef]
- Bayar, Yilmaz, Marius Dan Gavriletea, and Dragoş Paun. 2021. Impact of mobile phones and internet use on financial inclusion: Empirical evidence from the EU Post-Communist countries. *Technological and Economic Development of Economy* 27: 722–41. [CrossRef]
- Bersch, Julia, Jean F. Cleve, Nasseem Muhammad, Esther P. Ruiz, and Yorbor Yakhshilikov. 2021. *Fintech Potential for Remittance Transfers: A Central America Perspective*. Working Paper 21/175. Washington, DC: IMF. [CrossRef]
- Bindu, Suman, P. Sridharan, Rabindra Kumar Swain, and Chandrika Prasad Das. 2021. Causal linkage between remittances and financial development: Evidence from the BRICS (Brazil, Russia, India, China, and South Africa). *Journal of East-West Business* 28: 117–49. [CrossRef]
- Bolarinwa, Thompson S., and Temidayo O. Akinbobola. 2021. Remittances–financial development nexus: Causal evidence from four African countries. *Ilorin Journal of Economic Policy* 8: 1–17. Available online: <https://ijep.org/issues/volume8issue82021/Bolarinwa2021.pdf> (accessed on 5 December 2022).

- Brown, Richard P., Fabrizio Carmignani, and Ghada Fayad. 2013. Migrants' remittances and financial development: Macro- and micro-level evidence of a perverse relationship. *The World Economy* 35: 636–60. [CrossRef]
- Cheng, Chih-Yang, Mei-Se Chien, and Chien-Chiang Lee. 2021. ICT diffusion, financial development, and economic growth: An international cross-country analysis. *Economic Modelling* 94: 662–71. [CrossRef]
- Coulibaly, Dramane. 2015. Remittances and financial development in Sub-Saharan Africa: A system approach. *Economic Modelling* 45: 249–58. [CrossRef]
- Das, Anupam, and Adian McFarlane. 2021. Non-linear relationship between remittance and financial development in Jamaica. *International Migration* 60: 242–60. [CrossRef]
- Daumont, Roland, Françoise Le Gall, and François Leroux. 2004. *Banking in Sub-Saharan Africa: What Went Wrong?* IMF Working Paper WP/04/55. Washington, DC: International Monetary Fund. Available online: <https://www.imf.org/external/pubs/ft/wp/2004/wp0455.pdf> (accessed on 5 December 2022).
- Demirguc-Kunt, Asli, Ernesto Lopez Cordova, Maria Soledad Martinez Peria, and Christopher Woodruff. 2009. *Remittances and Banking Sector Breadth and Depth: Evidence from Mexico*. Policy Research Working Paper Series 4983; Washington, DC: The World Bank.
- Donou-Adonsou, Ficawoyi, Gyan Pradhan, and Hem C. Basnet. 2020. Remittance inflows and financial development: Evidence from the top recipient countries in sub-Saharan Africa. *Applied Economics* 52: 5807–20. [CrossRef]
- Edo, Samson, Henry Okodua, and John Odeniyi. 2019. Internet adoption and financial development in sub-Saharan Africa: Evidence from Nigeria and Kenya. *African Development Review* 31: 144–60. [CrossRef]
- Ehigiamusoe, Kizito Uyi, Suresh Narayanan, and Wai-Ching Poon. 2022. Revisiting the role of inflation in financial development: Unveiling non-linear and moderating effects. *Asia-Pacific Journal of Business Administration* 14: 380–401. [CrossRef]
- Fakudze, Siphe-okuhle, Asrat Tsegaye, and Kin Sibanda. 2022. The relationship between financial development and economic growth in Eswatini (formerly Swaziland). *African Journal of Economic and Management Studies* 13: 15–28. [CrossRef]
- Ferreira, Cândida. 2022. Panel granger causality between financial development and economic growth. *International Advances in Economic Research* 27: 333–35. [CrossRef]
- Fromentin, Vincent, and Florian Leon. 2019. Remittances and credit in developed and developing countries: A dynamic panel analysis. *Research in International Business and Finance* 48: 310–20. [CrossRef]
- Guermou, Vincent. 2021. Whose money? Digital remittances, mobile money and fintech in Ghana. *Journal of Cultural Economy* 15: 436–51. [CrossRef]
- Ibrahim, Muazu, Olufemi Adewale, and Xuan Vinh Vo. 2022. The role of inflation in financial development-economic growth link in sub-Saharan Africa. *Cogent Economics & Finance* 10: 2093430. [CrossRef]
- Igwilo, Jerry Ikechukwu, and Anthenia Bongani Sibindi. 2022. ICT adoption and stock market development: Empirical evidence using a panel of African countries. *Risks* 10: 25. [CrossRef]
- International Monetary Fund (IMF). 2022a. Africa's Inflation among Region's Most Urgent Challenges. Available online: <https://www.imf.org/en/Blogs/Articles/2022/10/20/africas-inflation-among-regions-most-urgent-challenges> (accessed on 5 December 2022).
- International Monetary Fund (IMF). 2022b. Regional Economic Outlook: Sub-Saharan Africa: Tackling Rising Inflation in Sub-Saharan Africa. Available online: <https://www.imf.org/en/Publications/REO/SSA/Issues/2022/10/14/regional-economic-outlook-for-sub-saharan-africa-october-2022> (accessed on 10 November 2022).
- Issabayev, Murat, Hayotbek Saydaliyev, Veysel Avsar, and Lee Chin. 2020. Remittances, institutions and financial inclusion: New evidence of non-linearity. *Global Economy Journal* 20: 2050002. [CrossRef]
- Issahaku, Haruna. 2019. Harnessing international remittances for financial development: The role of monetary policy. *Ghana Journal of Development Studies* 16: 113–37. [CrossRef]
- Joof, Foday, and Aliya Zhakanova Isiksal. 2020. The impact of urbanization and industrialization on bank development: Evidence from the Gambia. *International Journal of Economics, Business and Management Studies* 7: 16–26. [CrossRef]
- Kakhkharov, Jakhongir, and Nicholas Rohde. 2020. Remittances and financial development in transition economies. *Empirical Economics* 59: 731–63. [CrossRef]
- Karikari, Nana Kwasi, Sam Mensah, and Simon K. Harvey. 2011. Do remittances promote financial development in Africa? *SpringerPlus* 5: 1011. [CrossRef]
- Keho, Yaya. 2020. Impact of remittances on financial development: Revisiting the evidence for ECOWAS countries. *Theoretical Economics Letters* 10: 169–79. [CrossRef]
- Kim, Jounghyeon. 2021. Financial development and remittances: The role of institutional quality in developing countries. *Economic Analysis & Policy* 72: 386–407. [CrossRef]
- Majeed, Abdul, Ping Jiang, Mahmood Ahmad, Muhammad Asif Khan, and Judit Olah. 2021. The impact of foreign direct investment on financial development: New evidence from panel cointegration and causality analysis. *Journal of Competitiveness* 13: 95–112. [CrossRef]
- Makun, Keshmeer Kanewar, and T. K. Jayaraman. 2020. Role of ICT as a contingency factor in financial sector development, remittances and economic growth nexus: An empirical study of Indonesia. *Bulletin of Monetary Economics and Banking* 23. [CrossRef]
- Misati, Roseline N., Anne Kamau, and Hared Nassir. 2019. Do migrant remittances matter for financial development in Kenya? *Financial Innovation, Heidelberg* 5: 1–25. [CrossRef]
- Muktadir-Al-Mukit, Dewan, and Nazrul Islam. 2016. Relationship between remittance and credit disbursement of the banking sector: A study from Bangladesh. *Journal of Business and Management Research* 1: 39–52. [CrossRef]

- Nguyen, Canh Phuc, Thanh Dinh Su, and Nadia Doytch. 2020. The drivers of financial development: Global evidence from internet and mobile usage. *Information Economics and Policy* 53: 100892. [CrossRef]
- Nicoli, Marco, and Usman Ahmed. 2019. *How Digital Remittances Can Help Drive Sustainable Development*. Washington, DC: World Bank, April 6, Available online: [worldbank.org](https://www.worldbank.org) (accessed on 5 December 2022).
- Nyahete, Alois. 2017. The role of international mobile remittances in promoting financial inclusion and development. *European Journal of Sustainable Development* 6: 256–66. [CrossRef]
- Oyelami, Lukman O., and Adeyemi A. Ogundipe. 2020. An empirical investigation of remittances and financial inclusion nexus in Sub-Saharan Africa. *Cogent Business & Management* 7: 1712126. [CrossRef]
- Pal, Shreya. 2022. Does remittance and human capital formation affect financial development? A comparative analysis between India and China. *Asia-Pacific Financial Markets*. [CrossRef]
- Polat, Burcak. 2018. The impact of workers remittances on financial market development: A case study for developing countries. *Journal of Business Research Turk* 10: 27–36. [CrossRef]
- Qamruzzaman, Md, and Rajnish Kier. 2021. The role of remittances on financial development through capital formation and FDI channels: A symmetric and asymmetric investigation for Selected South Asian countries. *Universal Journal of Accounting and Finance* 9: 1433–53. [CrossRef]
- Qiang, Sun, Adnan Khurshid, Adrian C. Calin, and Khalid Khan. 2019. Do remittances contribute to the development of financial institutions: A new evidence from the developing world. *Romanian Journal of Economic Forecasting* 22: 78–97. Available online: https://ipe.ro/rjef/rjef2_19/rjef2_2019p78-97.pdf (accessed on 10 November 2022).
- Raithatha, Rishi, Saad Farooq, and Akankisha Sharma. 2021. Using Mobile Technology to Improve Remittances to the Pacific. Global System for Mobile Communication Association (GSMA). Available online: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2021/07/CIU_PacificRemittances_R_WebSingles1.pdf (accessed on 10 November 2022).
- Roodman, David. 2009. How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal* 9: 86–136. [CrossRef]
- Sacerdoti, Emilio. 2005. *Access to Bank Credit in Sub-Saharan Africa: Key Issues and Reform Strategies*. IMF Working Paper WP/05/166. Washington, DC: International Monetary Fund. Available online: <https://www.imf.org/external/pubs/ft/wp/2005/wp05166.pdf> (accessed on 5 December 2022).
- Sanga, Bahati, and Meshach Aziakpono. 2022. The impact of technological innovations on financial deepening: Implications for SME financing in Africa. *African Development Review* 34: 3528–3544. [CrossRef]
- Saydaliyev, Hayot Berk, Lee Chin, and Yessengali Oskenbayev. 2020. The nexus of remittances, institutional quality and financial inclusion. *Economic Research Ekonomiska Istraživanja* 33: 3528–3544. [CrossRef]
- Seraphin, Yao Prao. 2019. Effect of urbanization on banking sector development in WAEMU countries: Evidence from panel quantile regression. *Journal of Economics and Public Finance* 5: 105. [CrossRef]
- United Nations Conference on Trade and Development (UNCTAD). 2022. Investment Flow to Africa Reached a Record \$83 Billion in 2021. Available online: <https://unctad.org/news/investment-flows-africa-reached-record-83-billion-2021#:~:text=Despite%20the%20strong%20growth%2C%20investment,financial%20transaction%20in%20South%20Africa> (accessed on 30 November 2022).
- United Nations Department of Economic and Social Affairs (UN-DESA). 2018. Population Facts: The Speed of Urbanization Around the World. Available online: https://population.un.org/wup/publications/Files/WUP2018-PopFacts_2018-1.pdf (accessed on 30 November 2022).
- United Nations Department of Economic and Social Affairs (UN-DESA). 2019. World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). World Urbanization Prospects The 2018 Revision. Available online: [un.org](https://www.un.org) (accessed on 30 November 2022).
- Williams, Kevin. 2016. Remittances and financial development: Evidence from Sub-Saharan Africa. *African Development Review* 28: 357–67. [CrossRef]
- World Bank. 2014. Foreign Direct Investment Flows into Sub-Saharan Africa. Available online: <https://documents1.worldbank.org/created/en/505071468203651135/pdf/860600BRI0WB0H00Box382147B00PUBLIC0.pdf> (accessed on 20 November 2022).
- World Bank. 2020. Urban Development. Available online: <https://www.worldbank.org/en/topic/urbandevelopment/overview> (accessed on 23 November 2022).
- World Bank. 2022a. African Governments Urgently Need to Restore Macro-Economic Stability and Protect the Poor in a Context of Slow Growth, High Inflation. Available online: <https://www.worldbank.org/en/news/press-release/2022/10/04/african-governments-urgently-need-to-restore-macro-economic-stability-and-protect-the-poor-in-a-context-of-slow-growth> (accessed on 5 December 2022).
- World Bank. 2022b. World Development Indicators (WDI). Available online: <https://databank.worldbank.org/source/world-development-indicators> (accessed on 17 October 2022).
- Yinusa, Olumiyiwa G., Ibrahim A. Odusanya, and Olusola E. Olowofela. 2018. Foreign direct investment and financial development in Economic Community of West African States. *EuroEconomica* 37. Available online: <https://journals.univ-danubius.ro/index.php/euroeconomica/article/view/4386> (accessed on 18 December 2022).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.