REVISITING REMITTANCE-LED DEVELOPMENT NEXUS IN DEVELOPING COUNTRIES THROUGH THE ROLE OF DIGITALIZATION

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ABSTRACT

Although remittance inflow is personal income for recipient households, its aggregate determines national reserves, foreign exchange stability, capital formation, investment, employment, and income. We argue that digitalization plays a crucial role in promoting the remittance-led development nexus in developing countries via digital platforms that enable faster, cheaper, safer, and instant transfer of remittance. This study examines the moderating role of digitalization on the remittance-development nexus in the top ten developing countries with the highest remittances from 1999 to 2022. We apply the panel ARDL methods, which include mean group (MG), common correlate effects (CCE), and augmented mean group (AMG) estimators. The main findings of this study establish that digitalization has minimal influence on the remittance-development nexus in developing countries due to the insignificant coefficients in all the models estimated. The direct estimation indicates that remittance and digitalization promote economic development, but with weak coefficients in almost all the models. Policymakers in developing countries should come up with an effective policy framework that will focus on increasing digitalization, while at the same time reducing the cost of sending remittances to promote remittance inflow via official channels for higher economic development.

***Keywords*:** Economic development; Personal remittance; Migration; Information and communication technology; Digital technology; Panel data.

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1. INTRODUCTION

The world is experiencing a huge breakthroughs in information and communication technology (ICT) that continue to shape all facets of human activities, transforming societies, igniting globalization, and facilitating sustainable development goals (Guermond, 2022). Although some current technological inventions and innovations are disruptive, they have resulted in new opportunities, innovative ways of doing business, healthcare deliveries, agriculture, manufacturing, construction, fintech revolution, and social inclusion. However, ethical, privacy, and security concerns must be carefully considered in IT for development (Frizzo-Barker et al., 2020). Cybersecurity present serious obstacles to businesses, governments and individuals, as data breach, identity theft, highly organized cyber-attack, threats and espionage, ransomware, online vulnerabilities, etc., cost the world almost $8 trillion in 2023, and expected to surpass $9.5 trillion in 2024, 10.5 trillion in 2025, and $23 trillion by the end of 2027 (Economist, 2024). The aftermath of COVID-19 nearly doubled the incidence of cyber-attacks, generating massive economic losses and diverting resources away from development projects. When used ethically, information technology has the potential to pave the path toward a more wealthy, secure, sustainable, and egalitarian society, not only for the advanced economies, but also for the developing south (Patra & Sethi, 2024). Does digitalization condition the remittance-led economic development in the top ten high remittance recipient countries?

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Most scholarly research on international migration concentrates on moving from the global south to the global north. Although the south-north corridor provides better opportunities and higher income to migrant workers, shocking evidence indicates unequivocally that more than half of international migrations occur between southern blocks (Haas, Castles & Miller, 2020). According to the World Bank report (2023), remittance inflows have surpassed export revenue, foreign aid, foreign direct investments, and other private capital inflows to become a significant source of foreign revenues, due to the persistent movement of people from south-north/south-south (Ratha, 2023). Two dynamics simultaneously induce migration (push and pull factors), significantly affecting remittance inflows. The pull considerations, like economic, social, and cultural opportunities in the destination country, and the push factors, like political, social, or economic issues in the country of origin, affect the decision to migrate. The most popular contradiction surrounding migration is that 'south-north' migration is primarily motivated by underdevelopment and destitution (United Nations, 2019), which is, in turn, driven by wage differential (Rivera, 2022).

Undoubtedly, the growth of remittance inflows and its impact on economic growth and development are still debatable between development optimists and pessimists. The development optimist group argued in favour of migration and asserted that remittances significantly influence consumption, capital stock accumulation, and income of the recipient family. On the other hand, the pessimist group considers migration to impede economic development prospects in developing countries. Similarly, immigration-control sceptics contend that migrant networks (smugglers), employers (recruiters), establish the social structures that perpetuate immigration, and increase its momentum, which tends to undermine the economic condition of host countries (Rivera, 2022). Nevertheless, the link between migration and development not only shapes migrants' underlying economic condition and their families, but also the economy of the host countries (de Haas, 2011). However, the recent development in digitalization transforms remittance into “digital remittance”, due to the emergence of mobile money, e-wallets, and blockchain technology, which reduces the cost of sending remittance and shapes the industry (Jemiluyi & Jeke, 2023).

"Digital remittances" describes the electronic money transfers between individuals or organizations, usually across international borders (Howard, 2022). The use of “digital remittance” is expanding dramatically due to the growing usage of digital payment systems and an increasing migration across borders (Shinde, 2023). Migrant workers increasingly depend on new digital finance platforms to remit money to their origin, especially in places where the relevance of traditional means is diminishing continuously. The COVID-19 pandemic and financial inclusion campaigns further ignite the fintech revolution in developing countries. Using the digital finance platforms, migrant workers can send money faster, cheaper, securely, and instantaneously through mobile apps, mobile money, e-wallets, crypto exchanges, and other digital means (Jegerson, Khan & Mertzanis, 2022). The amount of money sent via digital means by migrant workers globally is estimated to be $12.7 billion in 2020, which rose to $22.1 billion in 2023, and is expected to reach more than $77.7 billion by 2032 (Market.us, 2024). Thus, digitalization plays a significant role in propelling the remittance-development nexus and thriving financial sector development (Aleksandrova, Truntsevsky & Polutova, 2022).

Although remittances inflows are private income outside the budgetary control of the government, it has a vital role to play in providing macroeconomic stability, through foreign exchange liquidity, reducing the income gap, and bridging resource shortages in low and medium-income countries (Orozco & Ellis, 2014). Total remittances to developing countries tripled all foreign private investments and development assistance between 2012 and 2023. Remittance increases by 3.1% to $860 billion in 2023, and is expected to reach $890 billion in 2024. Although the remittance sent through an unofficial channel almost equals the value of the official one, the higher cost of sending remittance through a formal channel act as an impediment. The price varied depending on the sending corridor—7.9% to Africa, 4.3% to South Asia (IMF, 2023). Remarkably, six out of the top ten countries that receive the highest remittances inflows in the world are from Asia (India, China, Philippines, Pakistan, Bangladesh, Viet Nam) while only two are from Africa (Egypt, Nigeria), and one from Latin (Guatemala)), and one (Mexico) from north America (KNOMAD, 2023). However, an assertion that remittance inflows to developing countries will catalyze economic prosperity and reduce migration in the long run is far-fetched, as many of the countries in the top list are battling with poverty, hunger, and underdevelopment (Chowdhury, Dhar & Gazi, 2023); hence, calls for revisiting the remittance-development nexus via the role of digitalization.

This study examines the remittance-led economic development nexus through the role of digitalization in the top ten developing countries with the highest remittances. We argued that growing migration from developing to developed economies (south-north) and between developing countries (south-south) increases the inflow of remittances to the origin, which influences many macroeconomic variables that significantly affect economic development. Although remittance is a personal income to recipient families, its aggregate determines national reserves, foreign exchange stability, capital formation, investment, employment, and income. The remittance-

development nexus has volumes of empirical literature; however, studies that modulate the nexus through the influence of digitalization have been scanty. Digital technology inextricably transforms the remittance market, providing documented and undocumented migrant workers an easy way to send money at a cheaper cost, increasing the total remittance globally. Thus, we make a significant contribution by evaluating the indirect effect of remittance on economic development through the digitalization channel as a policy option for policymakers in developing countries. The findings will benefit stakeholders in the ICT industry by helping them understand the connection between digitalization and digital remittance. Another significant contribution of this study is the application of three panel ARDL estimators (MG, CCE, AMG). These methods are deemed appropriate to answer our research question due to their ability to account for cross-sectional dependence, heterogeneity, and unobserved common factors inherent in panel data.

2. LITERATURE REVIEW

One argument favoring remittance inflow to developing economies is its potential macro-stabilizing effect and resilience to cyclical business cycle fluctuations (Kamalu, Wan Ibrahim & Ahmad, 2022). Evidence shows that capital inflows to developing countries during the famous 2008 global financial crisis experienced abrupt halts. Still, remittance inflows continued to persist during the same period, surpassing official development assistance, foreign direct investment (FDI), and all types of foreign capital inflows. Moreover, a similar trend of remittance inflow is evident for most developing countries during the COVID-19 pandemic (KNOMAD, 2023). De et al. (2019) argued that although remittance inflows directly correlate with domestic consumption smoothing in developing countries, economies with higher remittance inflows exhibit lower income-consumption correlation than those with lower remittance inflows. Therefore, remittance inflow is regarded as an extra income that supplements domestic consumption and investment.

The work of Rapoport & Docquier (2005) put forth another argument that migrants send remittances for the purpose of supporting family and friends (altruism), to invest in physical capital (investment), and for unforeseen circumstances (insurance). They argued that developing countries suffer from profound market imperfections, preventing credit access, human capital development, healthcare services, and decent living. Although voluntary and altruistic, remittance transforms the economic condition of recipient families, who live better than non-remittance recipient families. On the other hand, development optimists assert that remittances sent to southern countries are used to finance entrepreneurial activities, human capital development, economic stabilization, foreign exchange liquidity, and decent living, thereby promoting economic development (Akanle, Kayode & Abolade, 2022). Contrarily, development pessimists argued that remittances sent by migrants increase the leisure time of recipient families, which reduces labour supply, investment, innovation, and output per worker. In addition, they believe that migration took away the best brains and quality workforce from the south to the north, undermining the origin's development prospects (Phongsiri et al., 2023).

Theoretical explanations highlight digitalization's vital role in development, and clearly synthesize how its adoption led to significant development outcomes. Digitalization means " digital transformation of all sectors of the economy," which includes adopting digital technology in producing and distributing goods and services to achieve economic development (Patra & Sethi, 2024). Leveraging digitalization may facilitate achieving all the sustainable development goals, especially in developing countries. However, the influence of IT on development is multidimensional and complex, and it is determined by the available conditions in a given society (Tamansiswa, 2024). Therefore, understanding the digital ecosystem will facilitate unravelling the link between IT and economic development, which applies not only in business but also characterizes the context, circumstances, and level of digital adoption in society. The infrastructure level, regulatory quality, attitude of policymakers, and other stakeholders determine whether digitalization may promote economic growth and development (Guermond, 2022). Another argument by Frizzo-Barker et al. (2020) is that advancement of any society depends significantly on the degree of digitalization, integration of the services industry, and systems that create a modern value chain, which reorganize production processes, optimize input-output ratio, generate new opportunities and higher paying jobs in high tech industries, provide high-quality products and services that comply with consumers' expectations, and facilitate sustainable use of resources.

The channels through which IT affects development stem from adopting technical progress in growth and development theories, and incorporating prevailing conditions in society. Growth theories of neoclassical origin emphasize the vital role of technological development in achieving GDP growth and development by facilitating invention and innovation, efficiency, new business models, increasing factor productivity, income, and quality of living standard (Morze & Strutynska, 2021). Moreover, human capital theory posits that quality education,

investment in IT infrastructures, training, research and development, soft skills, availability of information, and online education greatly promote economic growth and development. The digital divide hypothesis asserts that unequal access to IT leads to unequal opportunities, income inequality, and social inclusion, hampering growth and development. Technological leapfrogging theory states that the easiest way for developing countries to achieve economic development is to invest in sophisticated IT infrastructures and advanced technological solutions, to bypass the conventional stages (England & Folbre, 2023).

An increasing level of technology diffusion is ushering in a new era of digitalization that is transforming production, distribution, and services industries. The advent of digital payment and blockchain technology has shaped the global payment system, making it easier for migrant workers to send money to their loved ones and to invest in their origin. Literature established that information technology adoption may influence the remittance-development nexus (Guermond, 2022). Jegerson et al. (2022) argued that a robust domestic mobile money adoption is a prerequisite for a "digital remittance" to significantly affect the recipient country's economy. Thus, this study argues that increasing usage of mobile money, e-wallets, blockchain, and other digital payment systems eases remittance flow, enhancing the remittance-development nexus in the recipient countries.

2.1. Empirical Literature

The debate on the remittance-growth-development nexus has been ongoing in the literature with varied empirical conclusions. Threads of findings show that remittances have a positive impact on economic growth in Jordan (Oshaibat, 2016), in Tunisia (Bouoiyour, Selmi & Miftah, 2017), in the Philippines (Bayangos, 2012; Rivera, 2022), in Southeast European countries (Bucevska, 2022; Ur Rehman & Hysa, 2021), and in countries with the highest emigrants (Oyadeyi, Adediran & Kabir, 2024). Also, evidences reveal that remittances promote human development in developing countries (Huay et al., 2019; Kamalu & Wan Ibrahim, 2022; Kamalu, Wan Ibrahim & Ahmad, 2022; Sahoo, Sucharita & Sethi, 2020). In addition, empirical works reviewed in this study show that remittances promote financial development (Aggarwal, Demirgüç-Kunt & Pería, 2011; Azizi, 2020; Fromentin & Leon, 2019; Kakhkharov & Rohde, 2020). Also, Elbatanony et al. (2021) found a heterogeneous effect of remittance on environmental degradation in developing countries. They reported that remittances promote environmental quality for countries at middle and higher quantiles, while being insignificant for countries at lower quantiles. Akanle et al. (2022) found that remittance inflows positively impact many sustainable development goals in Africa. However, Cazachevici et al. (2020) reported mixed findings that remittances facilitate GDP growth in Asian countries, while being insignificant in Africa.

Azizi (2018) examines the remittance-human capital nexus in 122 countries and reports that remittance recipient families have more school enrolment and completion rate than non-remittance receiving households. Moreover, he reveals that remittances promote school enrolment and performance of girl-children than boys. His results also show that remittances increase per capita health spending, decreasing child mortality, food insecurity, and stunting. Similarly, Amega (2018) established that remittance inflows significantly affect human capital and access to healthcare in sub-Saharan African countries. Imran (2018) reported that families receiving remittance enjoy better human development than those without remittance. Moreover, Xia et al. (2022) found that remittances are positively and significantly associated with human capital development in the top ten remittance recipient developing nations. Mora-Rivera & van Gameren (2021) reveal that international and national remittances have a decreasing function on food insecurity, but the impact of foreign remittances is higher. Jegerson et al. (2022) reported that consumer innovation facilitates remittance transfers using cryptocurrency exchange in the United Arab Emirates (UAE).

Kadozi (2019) found that the direct impact of remittance on growth is negative, while positive, conditioned upon the level of financial development and human capital in sub-Saharan African countries. Azizi et al. (2023) reported mixed findings that remittance positively affects economic growth in countries with higher human capital stock, while it is insignificant in countries with low human capital development. Similarly, Borja (2020) found that control of corruption conditioned the positive impact of remittance on human capital development. Saydaliyev et al. (2022) show that financial inclusion moderates the remittance-growth nexus positively in developed and developing economies. Moreover, Jemiluyi & Jeke (2023) reported that digital technology complements the positive effect of remittance on financial development in sub-Saharan Africa. Using the moderating role of e-governance and financial inclusion, Alhassan et al. (2023) found that remittance is a decreasing function of poverty and income inequality in developing countries. Moreover, Delessa et al. (2024) reported that macroeconomic policy moderates the positive impact of the remittance-growth nexus in sub-Saharan Africa.

Conversely, Saad & Ayoub (2019) reported an adverse effect of remittance on economic growth in MENA countries. Feeny et al. (2014) found no significant impact of remittance on growth in developing countries. Other

findings reveal a significant negative effect of remittance on GDP growth in four South Asian countries (Sutradhar, 2020) and low-income Asian countries (Chowdhury, Dhar & Gazi, 2023). Furthermore, Bibi & Ali (2021) show that remittance has a positive but insignificant impact on the human development index in developing countries.

The empirical findings revealed divergent results, with most studies having positive outcomes, while a few had negative and insignificant findings. However, the digital ecosystem's inherent complexity and analytical significance are yet to be explored, especially concerning the remittance-development nexus in developing countries that receive large amounts of remittance dollars every year. Moreover, many empirical studies examine the direct effect of the remittance-development nexus. Hence, evaluating an indirect connection between remittance and development using the moderating role of digitalization will provide new insight and significantly contribute to the literature.

3. METHODOLOGY

This study evaluates the nexus of remittance and development in the top ten (10) recipient developing countries via the moderating role of digitalization, from 1999 to 2022. The countries include India, Mexico, China, the Philippines, Egypt, Pakistan, Nigeria, Bangladesh, Vietnam, and Guatemala (KNOMAD, 2023). However, Nigeria was removed due to incomplete observations in some variables. We use development as a dependent variable proxy for robustness based on GDP per capita and human development. Remittance inflows are proxied by remittance inflows as a % of GDP. On the other hand, digitalization is proxied by mobile phone subscription (per 100 people), because most recipients' families use mobile phones and lack access to a broadband network (Suryanta & Patunru, 2024). Based on the previous literature, we select financial development, foreign direct investment, official development assistance, government financial consumption expenditure, life expectancy (at birth), rule of law, and inflation as control variables.

3.1. Model Specification

The data for this study covers 1999 to 2022; hence, *T* is greater than *N*. Thus, we employ the panel autoregressive distributive lag (ARDL) method of analysis that provides efficient estimators when *T* is large to achieve the study objectives. Three essential panel ARDL techniques were used. The methods include: Mean Group (MG), Common Correlated Effect (CCE), and Augmented Mean Group (AMG) techniques to see whether they differ in influencing the nexus earlier proposed. However, earlier panel data methods assume a homogeneous slope, for instance, fixed effect, random effects, generalized method of the moment (GMM), among others, ignore the likely presence of cross-sectional dependence (CD) and unobserved common factors, common to all, but may affect each cross-section differently. Instead, they assume a heterogeneous intercept, with a homogenous slope across the panel (Law, 2018). It is established that the mean group (MG) estimator yields inconsistent and misleading conclusions when cross-sectional dependence is present in the data (Arain, Han & Meo, 2019).

Evidence established that cross-sectional dependence in residuals is typically present in panel data, which may result from common shocks and an unobserved common factor (Chudik & Pesaran, 2015; Pesaran, 2015). On the other hand, the CCE technique accounts for CD, is robust to unobserved common factors, and assumes a heterogeneous slope. Unobservable factors are modelled in CCE by augmenting cross-sectional averages of dependent and independent variables as one of the regressors. The work of Eberhardt (2012) provides an AMG model that augments the CCE model, which has appeal for the macro production function. Although AMG uses group-specific averages as in MG and CCE, it includes a pool regression with year dummies. Thus, our models are given below, following the work of (Eberhardt & Presbitero, 2015).

$$\begin{aligned}\Delta Y_{i,t} = {} & \beta_{0i} + \beta_i^{EC} Y_{i,t-1} + \beta_i^{K} X_{i,t-1} + \beta_i^{D} W_{i,t-1} + \beta_i^{k} x_{i,t-1} \\ & + \beta_i^{k} \Delta w_{i,t} + \beta_{1i}^{CA} \overline{\Delta Y_t} + \beta_{2i}^{CA} \overline{Y}_{t-1} + \beta_{3i}^{CA} \overline{X}_{t-1} + \beta_{4i}^{CA} \overline{W}_{t-1} \\ & + \beta_{5i}^{CA} \overline{\Delta x_t} + \beta_{6i}^{CA} \overline{w}_t + + \mu_{i,t} \end{aligned} \quad (1)$$

Equation (1) contains the MG and CCE models. The first line of (1) gives the MG model, and line two describes CCE with cross-sectional averages (CA). Furthermore, an AMG model is given as follows:

$$\Delta Y_{i,t} = \delta \Delta x_{i,t} + \sum_{m=2}^{T} \gamma_m \Delta w_m + \Delta \mu_{i,t} \quad (2)$$

$$y_{i,t} = \delta_i + \delta_i x_{i,t} + \varphi_i \hat{\mu}_I + V_i t + \varrho_{i,t} \quad (3)$$

Where $\hat{\delta}_{AMG} = N^{-1} \sum_I \hat{\delta}$

Equation (2) is the standard AMG model with year dummies at a first difference (Δ) OLS, while equation (3) is the second AMG equation that captures a linear trend and an unobserved time invariant common factor. Models 1-3 are the MG, CCE, and AMG models developed by Eberhardt (2012), which do not include the study's variables.

3.2. Empirical Models

We employ a linear regression model with the Cobb-Douglas production function model by following the model of Eberhardt & Presbitero (2015) and Pesaran (2006). The work of Eberhardt & Presbitero (2015) analyzes the public debt-growth nexus, where our current study substitutes public debt with remittance, and moderates it with digitalization in the growth equation. The model is given below.

$$Develpment_{i,t} = \beta_o + \beta_i^K Remittance_{i,t} + \beta_i^F Digitalization_{i,t} + \beta_i^D Control_{i,t} + \beta_i^E (Remittace * Digitalization)_{i,t} + u_{i,t} \quad (4)$$

From (4), the dependent variable is *the Developmen*t proxy by GDP per capita growth (LGP) and human development (LHD). The variables of interest are *remittance* (LPR) and *digitalization* (LMS). The *control* (LBM, LFD, LLE, LEX, ROL, and ICP). The *Remittance*Digitalization* variable stands as an interaction term. The study conducted diagnostic checks to determine the distribution and behaviour of the selected data and whether it complies with the panel ARDL standard, especially CCE and AMG, which model CD.

3.3. Diagnostic Checks

Before estimating our models, we conducted pre-estimation diagnostic checks on the data. Firstly, Table 1 summarizes and describes the data using mean, maximum, and minimum observations, which are within the required range, with no sign of outliers. Secondly, cross-section dependency (CD) tests were carried out in Table 2. This is an important test determining which generation (first/second) techniques to employ on the data. A cross-sectional dependency occurs when a particular shock/phenomenon in one country has a tendency to affect other countries in the panel. A CD test becomes significant in obtaining efficient estimators and avoiding skewed and contradictory empirical findings (De Hoyos & Sarafidis, 2006). Although numerous CD tests are available, we chose Breusch & Pagan (1980) LM test (first generation), and Pesaran (2015) CD test (second generation). The null hypothesis of the two tests (H_0) is that cross-sectional independence exists. Our findings from the two tests presented in Table 2 failed to accept a null of cross-sectional independence for all the variables, hence cross-sectional dependency is present in our panel. Thus, only the second-generation method that accounts for CD across the panel will provide consistent and efficient coefficients (Ditzen, 2018). The study estimated a correlation matrix, and the results are attached as Appendix A, which shows no higher correlation between the explanatory variables, hence no multicollinearity in the study data.

Table 1. Descriptive statistics

Variable	OBS	Mean	Std. Dev.	Min	Max
Growth (LGDG)	207	1.587	0.505	-0.74	2.655
Human Development (LHD)	216	-0.475	0.14	-0.844	-0.25
Remittance %GDP (LPR)	215	23.149	1.089	19.959	25.435
Digitalization (LMS)	216	3.536	1.644	-2.141	5.021
Financial development (LBMG)	216	4.15	0.518	3.054	5.376
Foreign Direct Investment (LFD)	212	0.536	0.816	-2.404	2.268
Official Development Ass. (LOD)	215	0.298	0.471	2.416	1.129
Life expectancy (LLE)	216	4.25	0.063	3.766	4.372
Government Expenditure (LEX)	216	4.356	0.17	3.89	4.605
Institution (RO)	216	-0.522	0.354	-1.152	0.459
Inflation (ICP)	216	5.848	4.153	-1.71	29.507

Source: Authors' results

Table 2. Cross-section dependence tests

Variables	Breusch-Pagan LM Test	Pesaran CD Test
Growth (LGDG)	159.38***	11.033***
Human Development (LHD)	903.88***	21.271***
Remittance (LPR)	829.55***	28.532***
Digitalization (LMS)	989.56***	31.452***
Financial development (LBM)	534.33***	19.599***
Foreign Direct Investment (LFD)	139.31***	4.979***
Official Development Ass. (LOD)	254.07***	7.687***
Life expectancy (LLE)	519.71***	21.599***
Government Expenditure (LEX)	193.67***	11.045***
Role of law (ROL)	266.11***	0.385
Inflation (ICP)	152.29***	6.768***

Source: Authors' results

Table 3. Panel unit root tests

	CADF Test		CIPS Test	
Variables	Level	1st Difference	Level	1st Difference
Growth (LGDG)	-0.549	-4.585***	0.210	-2.549**
Human Development (LHDI)	0.078	1.583**	1.683	-3.659***
Remittance (LPR)	-0.743	-2.768***	-0.637	-2.600**
Digitalization (LMS)	0.991	-8.167***	-5.194*	-4.304***
Foreign Direct Investment (FDI)	0.186	-7.973***	0.007	-3.522***
Official Dev. Asst. (LOD)	0.465	-5.687***	0.568	-4.561***
Life expectancy (LLE)	3.038	-2.570**	3.676	-1.372**
Government Expenditure (LEX)	1.070	-2.997***	1.609	-1.741**
Role of law (ROL)	0.531	-2.330**	-0.399	-3.601***
Inflation (ICP)	1.302	-2.056***	-0.865	-3.453***

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

Table 4: Western Lund cointegration test results

Statistic	Value	Z-value	P-value
Gt	-3.273***	1.140	0.000
Ga	-2.686***	1.243	0.000
Pt	-3.941*	2.548	0.062
Pa	-2.572	4.736	1.000

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

4. RESULTS AND DISCUSSIONS

Although the main objective is to evaluate the moderating role of digitalization on the remittance-development nexus in the top ten remittance recipient countries, we start by revisiting the remittance-development nexus directly. Three models (MG, CCE, and AMG) were estimated. The study uses GDP per capita growth (LGDG) and the human development index (LHD) to proxy development (DV). We employ various regressors and run many models while dropping insignificant variables. As a result, we came up with the best two models for each proxy of development (LGDG & LHD).

Table 5. Result of the MG estimator

Dependent variable	LGDG		LHD	
Variables	Model 1	Model 2	Model 3	Model 4
Remittance (LPR)	0.703	0.060*	0.063***	-0.127**
Digitalization (LMS)	0.003***	0.277**	0.010*	0.011**
Foreign Direct Investment (FDI)	0.174		0.002	
Official Development Ass. (LOD)		-0.003**	-0.001**	
Life expectancy (LLE)	21.946*		7.3.81	
Government Expenditure (LEX)		0.196	0.172	1.368***
Role of law (ROL)	0.011	0.047***	0.027	0.009
Inflation (ICP)	-0.036**	-0.001*	0.001	
Constant	88.565*	-1.044	-1.058*	-6.198***

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

Table 5 contains the results for the MG estimator (models 1-4). The result shows that remittance (LPR) has a positive and insignificant effect on economic development (LGDG) in model 1. At the same time, it is positive and significant in model 2 (at 10%), model 3(at 1%), and model 4 (at 5%). The results from the CCE estimator presented in Table 6 also show LPR has an insignificant negative coefficient in model 1, a positive and significant coefficient in model 2 (at 10%), model 3 (at 1%), and model 4 (at 1%). In Table 8, the findings for the AMG estimator reveal that remittances have negative and insignificant coefficients in models 1 and 2, where LGDG was used, and positive and significant coefficients in models 3 (at 1%) and 4 (at 5%), where LHD was used. Based on the results presented for the MG, CCE, and AMG, it shows that remittance exerts a high level of significant coefficients when LHD is used as a dependent variable (models 3&4) than when LGDG is used in Table 5-7 (models 1&2). The finding is consistent with the evidence established in the previous literature (Huay et al. 2019; Kamalu & Ibrahim 2022; Kamalu, Ibrahim & Ahmad 2022; Oyadeyi, Adediran & Kabir 2024; Sahoo, Sucharita & Sethi 2020). Also, the finding aligns with the assertion of development optimism that remittance promotes development in developing countries (Akanle et al., 2022). Likewise, the finding supports the theoretical explanation by Rapoport & Docquier (2005) that remittance is used for physical asset investment, and altruistic purposes.

Table 6: Result of CCE estimator

Dependent variable	LGDG		LHD	
Variables	Model 1	Model 2	Model 3	Model 4
Remittance (LPR)	-3.492	0.024*	0.033**	0.021**
Digitalization (LMS)	-0.976	0.023**	0.040***	0.028***
Financial development (LBM)	1.153		0.005	
Foreign Direct Investment (FDI)	0.291	0.005*	-0.011	
Official Development Ass. (LOD)	0.075	-0.004	-0.013**	-0.007***
Life expectancy (LLE)	0.069*	0.149*		
Government Expenditure (LEX)	0.329*		0.122**	0.002
Role of law (ROL)	0.880		0.029	
Inflation (ICP)	0.046*	0.029	-0.430	0.095
Constant	32.728*	0.676	0.202	-0.673*

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

Table 7: Result of AMG estimator

Dependent variable	LGDG		LHD	
Variables	Model 1	Model 2	Model 3	Model 4
Remittance (LPR)	-0.508	-0.555	0.024*	0.008***
Digitalization (LMS)	0.066*	0.456*	0.023**	0.003**
Financial development (LBM)	0.385		0.013	
Foreign Direct Investment (LFD)	-0.134			0.060*
Official Development Ass. (LOD)	0.032	-0.104	-0.004	
Life expectancy (LLE)	23.631*	11.465*		4.532**
Government Expenditure (LEX)	9.504	4.793	0.149	0.050**
Role of law (ROL)	-1.977		0.007*	0.839*
Inflation (ICP)	0.027	-0.593*	0.400	0.018
Constant	2.709	5.519	0.184*	0.013***

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

We used the MG, CCE, and AMG estimators to estimate six interaction models (1-6) in Table 8 as the main objective of this study. The interaction term (LPR*LMS) evaluates the moderating role of digitalization on the remittance-development nexus. The result shows that the interaction term coefficient is positive and significant in models 4 (CCE) and 6 (AMG), with LHD as the dependent variable. Also, the results reveal that the coefficient of interaction is positive and insignificant in models 1, 3, and 5, where LGDG is the dependent variable. The result indicates that, despite the positive coefficients of the interaction term (LPR*LMS) in 5 out of the six models estimated, only two models (4 & 6), where we use LHD as a dependent variable, are significant at the 10% level. Thus, the results show that the moderating role of digitalization on the remittance-development nexus is positive and insignificant in developing countries. No doubt that digitalization facilitates sending money across borders, especially with the availability of digital money platforms and blockchain technology. Our finding shows that its impact on the remittance-development nexus is insignificant in developing countries. Also, a higher sending rate through official channels gives rise to the use of unofficial platforms, e-wallets, and cryptocurrency platforms. In addition, digital money transfer platforms provide immediate and secure transactions, which makes their services more appealing than conventional channels, where a sender/receiver needs a particular document to process it.

Table 8: Interaction model

Estimators	MG		CCE		AMG	
Dependent Variables	GDP	HDI	GDP	HDI	GDP	HDI
Variables	1	2	3	4	5	6
Remittance (LPR)	0.863	0.030**	-1.538	-0.005	-1.259	-0.001
Digitalization (LMS)	0.007	0.017**	2.009	0.028**	-0.073	0.016***
Foreign Direct Investment (LFD)	0.029	0.007	0.501	0.003*	0.186	0.016**
Official Development Ass. (LOD)	-0.216		-0.187	-0.002		-0.003
Life expectancy (LLE)		0.008			0.036	
Government Expenditure (LEX)	-11.289	-0.070	6.623	-0.140	-7.106	0.099
Role of law (ROL)	0.230	0.002	5.105*	0.029	0.191	0.013*
Inflation (ICP)	-0.040		-0.154	-0.002	-0.031	0.001
Interaction (LPR*LMS)	0.457	1.650	0.131	0.234*	0.088	0.190*
Constant	1.480	-0.858	-13.541	-1.440	69.821	-0.152

***, **&*stand for level of significance (1%, 5% &10%). L means logarithms.
Source: Authors' results

The findings for the control variables show that digitalization (LMS) has positive and significant effects on development in most models (Table 5-7), but a higher level of significance in the models where we use LHD as a dependent variable. Therefore, increasing digitalization in developing countries will promote economic development, which is consistent with the established results (Aleksandrova et al., 2022; Kamalu & Ibrahim, 2024; Nguyen, 2021). The results also reveal that financial development (LBM) has positive and insignificant coefficients in all the models estimated (Table 5-8) except in Table 8 (1), where LBM is positive and significant at 10%. Moreover, we found that FDI (LFD) has positive and insignificant coefficients in all the models estimated (Table 5-8), except in model 5 (Table 8) at 5%. Official development assistance (LOD) has a positive and significant coefficient at 5% level in models 3 and 4 (Table 5), and in models 3 and 4 (Table 6). Also, life expectancy (LLE) has a positive and significant coefficient in almost all the models (Table 5-8), except in model 3 (Table 5), model 2 and 5 (Table 8). Government final consumption expenditures (LEX) have a positive and

insignificant coefficient in the majority of the models, except in model 4 (Table 5), model 1 and 3 (Table 6), where it has positive and significant coefficients. Furthermore, the findings indicate that the role of law (ROL) has positive and significant coefficients in model 2 (Table 5) at 5%, in models 3 and 4 (Table 6) at 1%, and in models 2 and 6 (Table 7) at 1%. Lastly, inflation was found to have negative and insignificant coefficients in all the models Table 5-8), but was only significant in model 1 (Table 7) and model 2 (Table 7).

5. CONCLUSION AND POLICY IMPLICATION

5.1. Conclusion

We examine the remittance-development nexus through the role of digitalization in ten developing countries that receive the highest remittances, from 1999 to 2022. The study uses the panel ARDL technique with its three estimators (MG, CCE, and AMG). The diagnostic tests indicate a heterogeneous slope coefficient, cross-sectional dependency, and all the variables are cointegrated. The main findings in this study established that digitalization enhances the positive effect of remittance on economic development, but the impact is minimal (insignificant) in the top ten remittance recipient developing countries. Although the indirect link is negligible, our evidence established that remittance and digitalization directly promote economic development, which is highly significant, concluding that the direct effect is better. The theoretical connection established the vital role of digitalization in influencing developmental outcomes. The insignificant coefficient, although positive, shows how undeveloped and poor the coverage of IT infrastructure is in developing countries. The results of the control variables report that life expectancy and the rule of law positively impact development.

On the other hand, official development assistance, FDI, government spending, and inflation negatively affect development. Interestingly, the coefficients of regressors in the human development equation show a higher significance level than in the GDP per capita equation. Thus, this study concluded that human development is a better proxy for economic development, which confirmed the assertions made by the human development theorists, such as Sen (1989) and Nussbaum (2000), who consider capabilities rather than income as the best and comprehensive yardstick to measure development.

5.2. Policy Implications

Current advancements in digital technology are undoubtedly unstoppable and a force to reckon with. It is an apparent reality that continues to influence all aspects of human life and plays a significant role in achieving higher economic growth and development outcomes. Nevertheless, this study's findings that digitalization plays an insignificant role in the remittance-development nexus hold a vital policy implication for developing countries in our sample. Sending remittance through official channels has many limitations, especially for undocumented migrant workers, which stimulates the growth of the unofficial digital remittance market. Evidently, foreign workers prefer to send money through mobile apps or other intermediaries that charges little fee. In addition, undocumented foreign workers have no access to formal financial channels due to a lack of a work permit; hence, they resort to unofficial means. Thus, the hard currency goes through black markets instead of the official channel, which may have little impact on the forex market liquidity, hence an insignificant effect on development. Moreover, the increasing use of unofficial digital channels to send money across borders with little cost has eroded the vital role of remittances in growth and development. In addition, remittances that pass through illegal channels are out of the financial system and are not available for investment in the real sector to generate employment, income, and growth, limiting the multiplier effect.

Policymakers in developing countries should formulate and implement quality policies that can entice migrant workers to remit through official channels by focusing on reducing the cost of sending and receiving remittances in their corridor, giving foreign workers incentives, and providing guidance on how to make safe and fruitful investments in their country. Evidence shows that most developing countries, especially low-income countries, have poor IT infrastructures. Therefore, policymakers must focus on increasing coverage of quality ICT infrastructures to include remote locations and provide affordable internet and broadband connectivity. In addition, investment in IT education, training, and research should be prioritized in developing countries to increase digitalization, IT inventions and innovation, and the number of IT experts with higher-paying jobs, thereby generating higher growth and development. Moreover, policymakers and stakeholders in the IT industry should explore the great potential of blockchain technology that has a strong ability to include more people in the fintech sector, optimize the financial sector's supply chain, improve capital accumulation, accountability, and transparency, enhance cybersecurity, and alleviate the issues of cyber threats and attacks. Similarly, digitalizing public services will increase accountability, transparency, and effective service delivery.

ETHICS DECLARATION

No funding was received for this study. The authors state that there are no competing interests to declare.

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Appendix A: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) GDG	1.000										
(2) HDI	-0.165	1.000									
(3) MS	-0.151	0.597	1.000								
(4) BMG1	0.398	0.335	0.227	1.000							
(5) FGD	0.198	0.343	0.194	0.313	1.000						
(6) ODA1	-0.095	-0.437	-0.240	-0.301	-0.096	1.000					
(7) EXG1	-0.481	-0.227	0.035	-0.718	-0.287	0.444	1.000				
(8) ICP	-0.072	-0.183	-0.030	-0.208	0.081	0.212	0.319	1.000			
(9) FIT	0.264	0.368	0.141	0.805	0.127	-0.416	-0.693	-0.274	1.000		
(10) ROL1	0.193	0.247	-0.052	0.380	0.219	-0.402	-0.516	-0.078	0.230	1.000	
(11) LBY1	0.015	0.700	0.389	0.420	0.305	-0.264	-0.385	-0.238	0.487	0.064	1.000