The Non-Linear Impact of Digitization on Remittances Inflow: Evidence From the BRICS

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ABSTRACT

Due to the impact of COVID-19, it is important now more than ever to analyze the relationship between the improvement in digitization and the flow of remittances in order to fill the void that has come as a result of stay at home and quarantine orders. Using a comprehensive measure of digitization that encompasses the commonly used proxies of financial technology (Fintech) and employing a System Generalized Method of Moments (GMM) panel estimation methodology on annual data over the period 2004-2018, this paper examines the impact of digitization, as a proxy of Fintech, on the inflow of remittances for a sample of 34 developed and developing countries. Our analysis provides a case study on Brazil, Russia, India, China and South Africa (BRICS), known as five emerging markets with a great number of workers out of abroad and below the average level of digital transfers. Using the Digital Ecosystem Development Index developed by Katz and Calorda (2018), the results of the paper uncover a statistically significant nonlinear relationship between the improvement in digitization measures and the inflow of remittances with an exact threshold level. More specifically, our results for the full sample indicate that improvement in digitization may initially increase the remittances inflow leading to an increase in the stock of remittances received. Nevertheless, once the digitization index reaches its threshold level further improvement in digitization tends decrease as penetration increases, giving rise to a decline in the rate of remittances inflow. This result implies that the marginal effect of the digital penetration is larger when at its lower level, before the threshold level. For countries such as the BRICS, with a level of digitization below the average of our sample, policy makers should apply more aggressive and comprehensive policies to recoup the maximum gains of a digital ecosystem. Hence, our policy implications are directed towards increasing the investments in developing human capacity including carrying different skill development training programs to prepare individuals for the information age, expanding the internet coverage and speed especially in educational establishments, encouraging the use and access of electronic banking by consumers, producers, and governments, and taking cyber security and fraud protection more seriously to encourage the flow of remittances, especially in light of its renewed utility due to the recent pandemic.

JEL Classification Numbers: C23; G21; O47
Keywords: Remittances; Digitization; FinTech; Financial Inclusion; BRICS

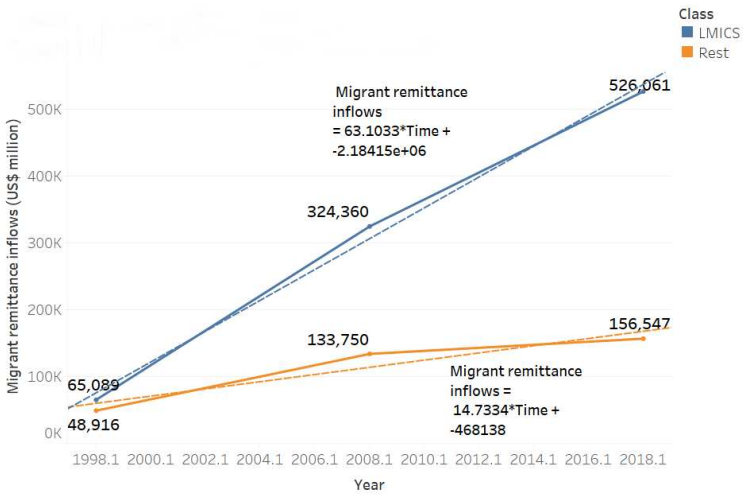
1. Introduction

In 2018, over 200 million migrant laborers sent over 689 billion USD to respective countries of origin, with approximately 529 billion USD to developing countries[1]. With the acceleration of globalization, international cooperation has been further strengthened. As a result, labor outflows are quicker than they used to be. Laborers, especially those who are from developing countries, may take advantage of the income gap between developed and developing countries to remit remittance back to their home countries. This concept is known as migrant remittance flow.

Remittance flow[2] is a transfer of money, often by a foreign worker to an individual in their home country. Money sent home by migrants competes with international aid as one of the largest financial inflows to developing countries. Workers' remittances are a significant part of international capital flows, especially with regard to labor-exporting countries. With the improvement of financial openness and economic liberalization, the government restrictions in remittance has been alleviated, and therefore an increasing number of other forms of foreign exchange transfer by overseas migrants have been increased, and the conventional forms of international remittances have been supplemented by an increasing number of remitters. The concept of international remittances is no longer limited to remittances at the family level. At present, governments and some international economic organizations have recompiled the data according to the Balance of Payments Manual 6th edition (BPM6) framework, and most of the data on international migrant remittances are well documented. The data for the standard component items is gradually updated and reclassified.

Remittance flows to Low- and Middle-Income Countries (LMICs) Other than China surpassed foreign direct investment (FDI) in 2015[3], becoming the largest source of foreign exchange earnings in the LMICs, reported from the World Bank (2017). And up to 2018, Remittance flow is $689 BN worldwide, $529 BN in developing countries, and $158 BN in BRICS.[4]

Figure 1
Remittances Inflows Increase In LMICs and the Rest of the World



Source: Authors based on data from World Bank staff calculation based on data from IMF Balance of Payments Statistics database and data releases from central banks, national statistical agencies, and World Bank country desks.

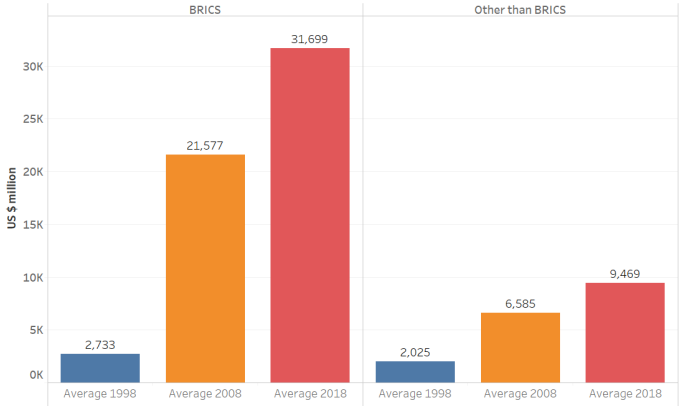
[1] For more data on remittance flows, "Remittances Matter: 8 Facts You Don't Know About The Money Migrants Send Back Home | UN DESA | United Nations Department Of Economic And Social Affairs". UN DESA | United Nations Department Of Economic And Social Affairs, 2020,https://www.un.org/development/ desa/en/news/population/remittances- matter.html

[2] For a discussion of the definition of remittances, see Dilip Ratha, 2003, "Workers' Remittances: An Important and Stable Source of External Development Finance", Global Development Finance 2003, World Bank. Data since 2005 are based on IMF BOP Statistics that use the definitions of IMF BPM6.

[3] See appendix A in World Bank (2017) for data and forecast methods.

[4] Visit https://www.knomad.org/ to get the latest data.

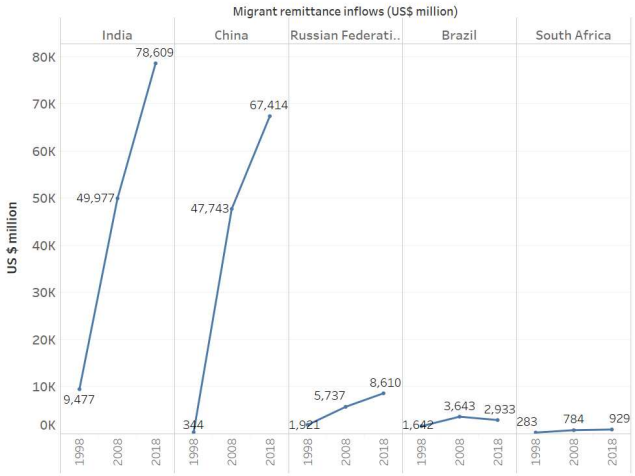
Figure 2
Remittances Inflows Increase Inside and Outside of BRICS



Source: Authors based on data from World Bank Migration and Remittances Data

The average inflow of remittances in the BRICS region has increased by about 12 folds over the period from 1998-2008. This is a significant increase compared with the other developing countries where the average remittances inflow has increased by about 5 folds only over the same period, as shown in Figure 2. This substantial increase in average remittances inflow in the BRICS region is mainly derived from the steep increase in remittances in both India and China over the same period, reaching around $79 BN and $67 BN in 2018, respectively, as shown in Figure 3.

Figure 3
Remittances Inflows Increase Among BRICS Countries



Source: Authors based on data from World Bank staff calculation based on data from IMF Balance of Payments Statistics database and data releases from central banks, national statistical agencies, and World Bank country desks.

Multiple factors are responsible for the variations in remittance flows over the recent years. Among a group of major factors, the development of financial inclusion has played a significant role. Financial inclusion, as United Nations Conference on Trade and Development (UNCTAD)[5] defines it, is an effective access and use by individuals and firms of affordable and sustainable financial services from formal providers. Demirguc-Kunt et.al (2012) posited that " Without inclusive financial systems, poor people must rely on their own limited savings to invest in their education or become entrepreneurs -and small enterprises must rely on their limited earnings to pursue promising growth opportunities. This can contribute to persistent income inequality and slower economic growth."

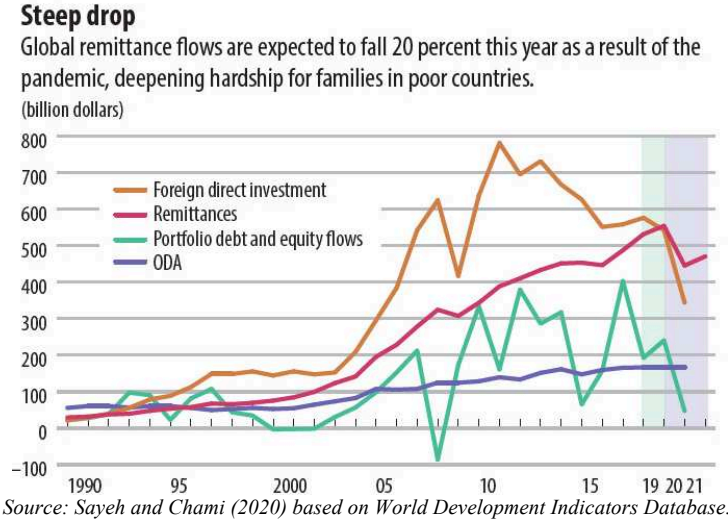
[5] United Nations Conference on Tarde and Development is a permanent intergovernmental body established by the United Nations General Assembly in 1964. Read more about UNCTAD on https://unctad.org/

To the countries whose financial markets are undeveloped, financial inclusion help them to diversify risk, lower income inequality, contribute to the global managing system and finally become a significant factor for economic growth. First of all, financial inclusion is a main access to activate the poorest to save (Dupas and Robinson, 2013) through utility improvement (Beck et al., 2007). Secondly, financial inclusion may increase the total welfare of society through consumption smoothing (Appelli and Pagano, 1989; Bacchetta and Gerlach, 1997; Ludvigson, 1999). Moreover, for the developing countries where trust systems are needy, financial inclusion is an opportunity for these countries to become a part of global financial system (Cihak et Al., 2016). Therefore, the strengths of financial inclusion finally power up the engine of economic growth, as well as reducing the risk and level of inequality (IMF, 2016; Emara and El Said, 2020; Emara and Rojas, 2020).

An important tool of financial inclusion is financial technology (FinTech), which in turn requires an enabling environment with a well-established digital ecosystem that encompasses the infrastructure of digital services, connectivity of devices, the digital transformation of households and production, the development of digital industries, and the availability of digital factors of production. FinTech provides people with an alternative lending access, changes payments and transfers (Juan J. Cortina Sergio L. Schmukler, 2015). FinTech happened to be a perfect way to sustain the social distancing rule as well, after Coronna virus began to wreak havoc in 2020. Offline banking systems were transformed online. It turns out that people are increasingly getting use to mobile banking and online banking supported by FinTech. Recently, FinTech has attracted huge amounts of investment. The funding from venture capitalists in technology sectors has risen from $414 million in 2014 to $608 million in 2018, according to the Financial Times (IFC, 2017). Another prominent example for FinTech is blockchains. According to a world bank research paper published in 2015, (Juan J. Cortina Sergio L. Schmukler, 2015), through a network called miner, blockchains automatically packaged and recorded the transfer from party A as a block, sending it to party B. The whole process is lacking intermediaries who typically charge high fees and cost a lot of time when transferring. Other kind of FinTechs, including mobile payment, saves a lot of time for individuals when transfer, which actually help commercial banks to enlarge their digital business, while weakening real business.

The boom of digitization and FinTech[6] is changing the remittance system profoundly. First of all, they no longer need to bare the heavy remittance fee while making the transactions, which significantly improve workers' willingness to bill the remittance; On the other hand, the receiver from home country would have a more convenient access to the remittance. With the unprecedented infectious disease forcing people to embrace digital transferring, the future of digital remittance and other forms of remittance stimulated by FinTech would sure to be prosperous.

Figure 4
Impact of COVID-19 on Remittances



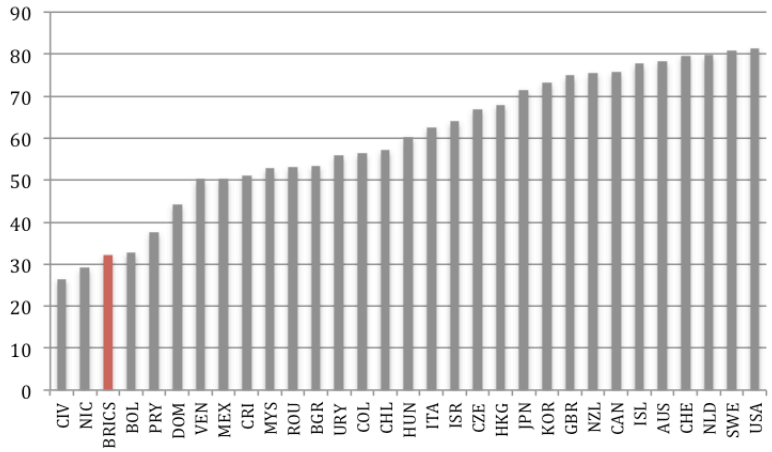
Source: Sayeh and Chami (2020) based on World Development Indicators Database.

[6] The new developments associated with the FinTech Revolution are best understood based on recent statistics from VentureScanner (www.venturescanner.com)

Due to the precautions that have to be taken as a result of the COVID-19 pandemic, digitization and financial technology have become more important to remittances than ever before. Projections by the World Bank (2020) have revealed that remittances could decline by 20% as a result of changes in migrant employee wages. This is significant because remittances typically have a profound impact on developing countries through alleviating poverty and improving living standards through education and employment. These outcomes are not as likely to happen without the development of digital solutions for remittances because people no longer have the option to access physical bank and financial institution branches. Thus, it is important to analyze the relationship between financial technology, or more broadly digitization, and remittances.

The digitization levels in BRICS region are still at its infancy. As per Figure (5), the average level of the Digital Ecosystem Development Index for the BRICS region is very low compared to other countries in our sample, only surpassing that of Côte d'Ivoire and Nicaragua. Hence, there are significant benefits that await the region from applying aggressive policies to fast track the digitization process especially to overcome the negative shocks on remittances inflow due to the recent pandemic. We believe that increasing the investment in mobile data, digital media, internet access, as well as encouraging the use and the access of electronic banking by consumers, enterprises, and governments along with investments in cyber security and fraud protection would significantly simulate workers to remit back the money.

Figure 5
The Digital Ecosystem Development Index - 2018



Source: Authors. Data from Katz and Callorda (2018)

Against the above background, the study contributes to the literature by using a comprehensive measure of digitization that goes beyond the commonly measures of FinTech in an attempt to answer the following questions: How digitization affects remittances inflow in developed and developing countries? Is the relationship linear or non-linear? Is the effect the different for the BRICS region? The rest of this paper will be divided as follows. Section 2 reviews the literature; Section 3 describes the data used; Section 4 highlights the methodology employed and the model specification; Section 5 presents our results; Section 6 concludes; and Section 7 includes the references. The appendix is at the end of the paper.

2. Literature Review

There is a reasonable amount of literature on the determinants and impact of financial technology as a tool of financial inclusion, its link to the flow of remittances, and economic growth.[7] However, the literature that examines the role of a comprehensive digital ecosystem as an enabling environment for remittances inflow and the possible presence of a non-linear relationship between these two variables is very thin. Hence, we briefly outline the most commonly cited literature on the financial and macroeconomic determinants of remittances.

[7] For a detailed survey on the literature on the relation between financial development and growth, see Levine (1997, 1999a).

Using data from 109 countries for the period 1975-2007, Aggarwal, Demirgüç-Kunt, and Martínez Pería (2011) find that remittances are significantly positively correlated with bank deposits and credit. Along the same lines, using a panel dataset of 38 developing countries over the period 2001-2002, Inoue and Hamori (2016) use the commercial branch network and reach the same conclusion. Employing a dynamic panel (on a sample of 187 countries over the period 2004-2015, Ben Naceur, Chami, and Trabelsi (2019) find that remittances have a positive effect on financial inclusion only when they are above a certain percentage of GDP, with the threshold for LMIC countries ranging between 12.28% and 22%. This implies that if the remittances are below this threshold, they are not saved by rather consumed or invested. If above the threshold, there is greater probability that money is saved in formal banking institutions, which promotes inclusion.

In the studies based on household surveys, findings generally indicate that remittances are significantly positively associated with whether a household has a bank or savings account. Using household survey data from El Salvador over the period 1996 - 2002, Anzoategui, Demirgüç-Kunt, and Martínez Pería (2014) find that remittances are positively and significantly correlated with households' use of deposit account. Similarly, using data from 7,572 Mexican households from the years 2002 and 2005, Ambrosius and Cuecuecha (2016) find that remittances are significantly positively correlated with the household's ownership of savings accounts and recent borrowing. These authors also note that the remittances drive borrowing from informal channels, which highlights the deficiencies of the formal financial sector in addressing the needs of these households. Chishti (2007) studied the dramatic growth in remittances in the Indian economy over the period 1990-2005. He finds that liberalizing policy measures from the government and banking institutions had expected effects which manifested in two major ways: firstly, remittances moved increasingly into formal channels from informal networks, and secondly, more non-resident Indians are becoming investors rather than pure savers.[8]

Transactional cost is an important determinant of remittances flow. A global survey of remittance flows from central banks, including those of the BRICS nations, found that most respondents from central banks in both receiving and sending countries cited the high cost of remittances as the biggest factor preventing migrants from using formal channels. The lack of bank branches in the region of the remitter and the inability of the remitter/receiver to open a bank account were listed as the second major obstacle. In addition, the lack of and/or distrust of electronic transfer information and distrust of formal financial institutions impedes the use of formal channels and can have a significant impact on the recipient country's remittance inflow.

Several studies investigate the relationship between transaction costs and remittance flows. Using panel data on remittance flows to Pakistan from 23 host countries, Ahmed, Martinez-Zarzoso (2016) find that the effect of transaction costs on remittance flows is negative and significant. Thus, a high transaction cost reduces the rate of remittance flows through formal channels. Improved access to financial services is noted as opportunities to reduce costs and enhance financial inclusion, redirecting informal flows to formal channels. Similarly, Freund and Spatafora (2008) highlight that countries with high transaction costs (i.e. Mali, Armenia, Moldova) experience larger informal remittance flows. They explain the dramatic increase in recorded remittances to Latin America since 1995 as reflecting a shift from informal to formal remittances. They attribute this shift to FinTech developments and competition reducing transaction costs in the formal financial sector.

FinTech is one aspect of financial inclusion[9], which refers to emerging technologies that increase access to financial services. Examples include mobile banking, which allows individuals with formal bank accounts to engage in quick digital transactions over their mobile phones. Another is mobile money, which allows for activities such as deposits, withdrawals, and transfers all without a bank account. A prominent example of mobile money is M-Pesa, which originated in Kenya in 2007 and has been very successful in Sub-Saharan Africa, spurring the creation of more mobile money services in the region. Another area of promise is that of blockchain-based technologies, which remove the third-party intermediaries who charge high transaction fees. Thus, FinTech can reduce delays and costs involved in cross-border remittances. Using data from 21 Western European countries to 7 countries in the European Neighboring Region, Schiopu and Siegfried (2006) find that remittances increase when remittance costs are lower. In a World Bank research paper, Cortina Lorente and Schmukler (2018) note that as the use of FinTech providers has increased, remittance costs have declined and the speed of transactions has increased. Continuing with the same pattern, Singh (2010) studies the impact of transfer costs and efficiency on worker's remittances in India. He finds that antiquated financial infrastructure

[8] You can check the paper freely from the link: http://www.migrationpolicy.org/article/rise- remittances- india- closer- look

[9] For detailed discussion on the literature on financial inclusion, check Emara and El Said (2020) and Emara and Moheildin (2020).

and high transfer costs that come as a result of these old systems impact the level of remittances to a country. Lower transfer costs as well as increased time efficiency that come as a result of digitization both increased remittances over the medium-term.

Along the same lines, there is recent research investigating the macroeconomic impact of digitization, especially after the COVID-19 pandemic. The study of Katz, Jung, and Callorda (2020) shows empirical evidence that high level of digitization is important for alleviating the bad consequences of the pandemic. In an International Telecommunication Union (ITU) report, Katz (2020) finds that advanced levels of digital infrastructure create a resilient economy in the face of pandemics. Focusing on the impact of digitization on remittances and using data from the Global Findex and Global FinTech Index, Lyons et al (2020) study the impact of digital FinTech development across 16 emerging economies. They find that countries with more developed digital payment systems (i.e. China, South Africa) are more likely to send and receive remittances using a mobile device or financial institution. They also find that that use of digital financial services increases the likelihood of remittances via both mobile phones and financial institutions, but with the magnitude of the effect greater for mobile phones than formal institutions. They also find a positive and significant relationship between FinTech development and remittances sent or received via mobile phone, especially for Asia. These relationships are likely due to a reduced cost of remittance as a result of FinTech developments.

To the best of our knowledge, only few studies examined the nonlinear macroeconomic impacts of FinTech or digitization[10]on either the economy, or specifically on remittances. Vu (2011) studies the impact of the usage of personal computers, mobile phones and Internet penetration for a sample of 85 countries over the period 1996-2005. The study provides evidence of a positive of Information and communications technology (ICT) on economic growth, however this impact lessens with more penetration. Along the same lines, Hawash and Lang (2010) used a sample of 33 developing countries over the period 2002-2006 and confirmed that high levels of Information Technology (IT) adoption leads to negative effects on total factor productivity, confirming the presence of a non-linear relationship. Similarly, in studying the German economy over a period of 45 years Lang (2009) finds that the positive impact of R&D on the stock of knowledge is unsustainable and is decreasing over time. For a sample of Sub-Saharan African countries over the period 1990-2014, Albiman and Sulong (2017) provide evidence that fixed telephone mainlines, mobile phone and internet subscriptions, all per 100 inhabitants, have non-linear effects on economic growth, with a definite estimated threshold level for each ICT variable. On another note, The IMF study of Kpodar and Adranaivo (2011) on a group of African countries over the period 1988-2007 uses three measures of ICT: mobile phones, Internet penetration, and fixed telephone lines to find evidence of a positive linear impact on economic growth with no evidence of non-linear effects.

Aside from the impact of digitization on simulating remittances, a large portion of existing literature on remittances focuses on said individual motives. Stark (2009) identifies altruistic migrants as those who remit more the poorer their recipient family. Tullao and Cabauy (2016) point out that under this altruistic motivation, remittances increase when the home country and/or recipient family are hit with negative income shocks. Insurance motives are those that are intended to protect the recipient family from risks insure against unexpected income variation. As a result, it is not surprising that if inflation increases in a migrant's home country, their remittances increase as well in order to ensure their family can maintain their living standard. Using a matched sample of Nigerian immigrants in Chicago and their families back in Nigeria, Osili (2007) finds both altruistic and insurance motives for remittance, suggesting that migrants tend to remit more when recipient household's purchasing power decreases due to inflation. Moreover, he notes that migrants may send remittances earlier to serve as savings in the case of an economic downturn. Using a cross-section dataset from 2003 surveys in the Philippines, Alba and Sugui (2003), find that economic shocks (such as increased inflation) in the country of the recipient family will lead to increased remittance inflow. Using data from the Philippine economy over the period 2000-2019, Rivera and Tullao (2020) find that increased inflation statistically significantly increases remittance sending, as migrants want to help recipient households smooth and maintain their consumption. This supports the altruism and investment motives. Similarly, using data from the Egyptian economy over the period 1967-91, El-Sakka and McNabb (1999) find that home country inflation has a positive and significant impact on remittance inflow. This information is in line with findings from Oded Stark (2009), Tullao and Cabuay (2016), Relian Edgar Soriente (2018), and Christopher Cabuay (2018).

[10] Along the same lines, Emara and Kasa (2020) find a statistically significant non-linear effect of financial access index (measured principal component analysis of two variables measured per 100,000 adults: number of bank branches per and number of ATMs) on the accumulation of domestic savings for a group of emerging markets.

Being a part of a global financial system provides ample opportunity for these countries. A study by Gupta, Pattillo, and Wagh (2007) on the impact of remittances on poverty and financial development in Sub-Saharan Africa found that trade openness has positive relationship with remittances. By joining a global financial system, these countries increase their opportunity to trade with other nations conditioned on the exchange rate, among other macroeconomic determinants. In that context, existing literature deems the relationship between exchange rates and remittances to be a significant positive relationship. Lucas and Stark (1985) examine the motivations of migrant workers from Botswana to remit and find that currency depreciation increases remittances. In line with his prior research, Stark and Taylor (1991) find similar results. Faini (1994) studies five Mediterranean countries over the period 1977-1989 to determine how responsive remittances are to certain macroeconomic factors and confirmed that real exchange rate is a significant and positive determinant of remittances, as depreciation in the home country leads to higher remittances. Additional empirical support on the positive relationship between exchange rate and remittances inflow is found in El-Sakka and McNabb (1999), Dakila and Claveria (2007), Pant and Budha (2016), and Kuncoro (2020).

Continuing on with the pattern of examining factors affecting the flow of remittances, Loschmann and Siegel (2015) find that migrants who are debt-financed, send less remittances than migrants who are not. Another interesting takeaway from their research is a negative relationship between interest rates and remittances. In a similar manner, Rahman (2013) studies the source of funds for migrants from Bangladesh and also found that increased interest rates decreased remittance flows. Research on how lending rates impact remittances by Hassan and Homes shows that in the long run, increases to real lending rates decrease remittances. Similar empirical finding is reached in the study of El-Sakka and McNabb (1999). Furthermore, the study of Faini (1994) does not find a significant effect of interest rates on remittance flows. Similarly, in studying the determinants of remittances in Caribbean countries, Alleyne et al (2008) find the interest rate differential to be an insignificant determinant of remittances in their preferred model. Along the same lines, the relationship is also found to be insignificant by Swamy (1981) and Straubhaar (1986) and Schiopu and Siegfried (2006). This suggests that the findings on this relationship are inconclusive.

Against the above background, our study estimates the remittances model by including the frequently cited variables in the literature and focusing on a comprehensive measure of digitization that encompasses the FinTech indicators commonly used in the literature (such as fixed broadband subscriptions, mobile money subscriptions, Internet access, etc.) as well as a broader set of indicators covering important complementary aspects of an economy such electronic banking, digital supply chain, human capacity, E-government, cyber security, piracy control etc. which are crucial for a secured flow of funds between the host and the receiving country.

3. Data

The panel data set covers 34 countries from East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, and Sub-Saharan Africa over the period 2004-2018[11]. The list of countries included in the sample is reported in Tables A1 of the Appendix.

The dataset is constructed from the World Development Indicators (WDI) of the World Bank's database[12]. The dependent variable in the model is personal remittance received (as a percent of GDP) and the set of independent variables consists of the real GDP growth rate, GDP deflator, openness, real effective exchange rate, and real interest rate. Additionally, our regressors' set includes the Digital Ecosystem Development Index developed by Katz and Callorda (2018), which cover 8 pillars and 64 indicators[13]. The eight pillars cover digital connectivity, household digitization, digitization of production, digital industries, factor of digital production, digital competitive intensity, and regulatory framework and public policies. Tables A2 and A3 of the Appendix reports the descriptive statistics of the macroeconomic and digitization variables, respectively. And Table 1 below provides a detailed list of the macro and digitization variables used, their definitions, units of measurement, abbreviations, and data sources.

[11] We started with the widest possible data on our dependent variable, remittances received (% of GDP).
[12] The data that support the findings of this study are openly available in the World Bank Database at https://datacatalog.worldbank.org/dataset/world-development-indicators.

[13] More details on the index are available in Katz and Callorda (2018), Annex B, pp 19-22.

Table 1 Definition of Variables

Variable Name	Definition	Unit of Measurement	Abbreviation	Data Source
Remittance	Personal remittances, received (% of GDP).	*Percent of GDP*	*remit*	WDI
Growth of real per capita GDP	Growth rate of real GDP per capita (constant 2000 US$).	*Percent*	*gr*	WDI
Deflator	GDP deflator (base year varies by country).	*Index*	*def*	WDI
Real Interest Rate	The lending interest rate adjusted for inflation as measured by the GDP deflator.	*Percent*	*ri*	WDI
Openness (% of GDP)	The sum of net exports of goods and services, net primary income, and net secondary income.	*Percent of GDP*	*op*	WDI
Exchange Rate	Real effective exchange rate index (2010 = 100)	*Index*	*reer*	WDI
Digital Ecosystem Development Index	It is measured based on the Principal component analysis of the following eight pillars.	*Index*	*digindex*	Katz Callorda (2018)
Infrastructure of Digital Services Index	It comprises 4 sub-pillars including investments, quality of services, coverage and service infrastructure. It is measured based on 15 indicators such as telecommunication investment, fixed broadband connections and coverage, number of secure servers, and satellites.	*Index*	*infra*	Katz and Callorda (2018)
Digital Connectivity Index	It contains 3 sub-pillars covering affordability, penetration and ownership. It is measured based on 11 indicators such as mobile broadband subscription and penetration, smartphone users, and pay TV penetration.	*Index*	*conn*	Katz and Callorda (2018)
Household Digitization Index	It contains 4 sub-pillars covering internet use, E-government, E-commerce, and over the top media services (OTTs). It is measured based on 7 indicators such as percentage of population using the internet and using dominant social network, mobile data average revenue per use (ARPU), E-government index, internet commerce, national health policy, and video on demand penetration.	*Index*	*dighou*	Katz and Callorda (2018)
Digitization of Production Index	It contains 4 sub-pillars of digital infrastructure, digital supply chain, digital distribution, and digital processing. It is measured based on 6 indicators including the percentage of enterprises with internet access, electronic banking, and using internet to sell and buy products. It also includes the percentage of workers using the internet and computers.	*Index*	*digprod*	Katz and Callorda (2018)
Digital Industries Index	It contains 4 sub-pillars of export, weight of digital industries, internet of things (IoT), and content production. It is measured based on 7 indicators such as high technology exports, computer software spending, and Wikipedia pages edited per month.	*Index*	*comp*	Katz and Callorda (2018)
Factors of Digital Production Index	It contains 5 sub-pillars of human capital, schools, innovation, investment in innovation, and economic development. It is measured based on 8 indicators such as education years expectancy, educational establishments with internet access, and R&D spending.	*Index*	*eco*	Katz and Callorda (2018)
Digital Competitive Intensity Index	It contains sub-pillar of competition level and is measured based on 4 indicators such as the Herfindahl-Hirschman Index (HHI) fixed broad band, mobile broad band, pay TV, and mobile telephony.	*Index*	*fp*	Katz and Callorda (2018)
Regulatory Framework and Public Policies Index	It contains 2 sub-pillars including cyber-security & piracy, and government role. It is measured based on 4 indicators covering percentage of non-licensed installed software and its commercial value, the percentage of regulatory agency attributions, and functions based on International Communication Union (ITU) regulatory tracker.	*Index*	*instr*	Katz and Callorda (2018)

4. Model Specification and Estimation Methodology

We start the estimation methodology by examining the impact of changes in the macroeconomic variables on the inflow of remittances. Second, we analyze the impact of the improvement in digitization on the inflow of remittances. Third, we test the potential non-linear relationship between digitization and remittances. And finally, we focus the analysis on the BRICS countries to study how they might differ from the rest of our sample.

The remittances model is estimated using System GMM panel estimation methodology proposed by Arellano and Bover (1995), Blundell and Bond (1998), and Blundell, Bond, and Windmeijer (2001)[14] to examine the impact of changes in the macroeconomic variables and digitization levels on the inflow of remittances. Our main model is as follows,

$$Rem_{i,t} = \alpha + \rho Rem_{i,t-1} + \beta X_{i,t} + \delta Dig_{i,t} + \varepsilon_{i,t} \quad (1)$$
$$i = 1, 2,\ldots N,\ t = 2004,\ldots T$$

Where Rem_{it} refers to remittances received (as a percent of GDP[15]) by country i at time t, $Remi_{it-1}$ is the AR(1) endogenous variable, $X_{i,t}$ is the set of regressors, $Dig_{i,t}$ represents the main digitization index and its eight pillars, each one in a turn, and ε_{it} is the error term of the regression. The set of regressors include growth rate of real GDP per capita, GDP deflator, real interest rate, openness (% of GDP), and exchange rate. It is important to note that Equation (1) will be estimated for the main digitization index and its eight pillars, each one in a turn, to analyze which area contributes the most to remittances inflow.

The model is expanded to allow us to differentiate between the BRICS countries and the rest of our sample in the effect of digitization on remittances inflow. To do so we add a dummy variable "BRICS", which is 1 when a country is among the five BRICS countries and 0 otherwise, along with its interaction term with the digitization index, as follows.

$$Rem_{i,t} = \alpha + \rho Rem_{i,t-1} + \beta X_{i,t} + \delta Dig_{i,t} + \theta BRICS_{i,t} + \vartheta(BRICS_{i,t} * Dig_{i,t}) + \varepsilon_{i,t} \quad (2)$$
$$i = 1, 2,\ldots N,\ t = 2004,\ldots T$$

The total effect of a digitization in the BRICS region is estimated by adding up the coefficient δ to the coefficient ϑ and their statistical significance is determined by from the variances and covariance of the variables $BRICS_{i,t}$ and $Dig_{i,t}$. Further, to examine the potential non-linear effect of digitization on remittances inflow, the squared term of the digitization index is added to the model as follows,

$$Rem_{i,t} = \alpha + \rho Rem_{i,t-1} + \beta X_{i,t-1} + \delta Dig_{i,t} - \gamma Dig_{i,t}^2 + \theta BRICS_{i,t} + \vartheta\left(Dig_{i,t} * BRICS_{i,t}\right) - \varphi(Dig_{i,t}^2 * BRICS_{i,t}) + \varepsilon_{i,t} \quad (3)$$
$$i = 1, 2,\ldots N,\ t = 2004,\ldots T$$

For the full sample analysis, we set the BRICS dummy to zero, and by computing the first derivative of Equation (3) with respect to the $Dig_{i,t}$ variable, we get $\frac{\partial Rem_{i,t}}{\partial Dig_{i,t}} = \delta - 2 * \gamma Dig_{i,t}$. We do expect that a positive δ coefficient and a negative γ coefficient which implies that a one unit increase in the digitization index increases remittances by a magnitude of δ, however this effect is increasing at a decreasing rate of "$2 * \gamma$". Additionally, the cut-off point (or threshold level) of the digitization index, or $Dig_{i,t}^*$ will be equal to $\left|\frac{\delta}{2\gamma}\right|$ where any level of $Dig_{i,t}$ below $Dig_{i,t}^*$ will result in a positive increase in remittances inflow and any level above it results in a rate decrease. Additionally, the total effect of the digitization index on remittances is estimated by adding the coefficient δ to the coefficient γ and the statistical significance of the effect is estimated using the standard errors of these two coefficients.

Similarly, For the BRICS sample, the dummy BRICS takes 1 in Equation (3) and the impact of digitization would be computed as $\frac{\partial Rem_{i,t}}{\partial Dig_{i,t}} = (\delta + \vartheta) - 2 * (\gamma + \varphi) Dig_{i,t}$, Thus, for the BRICS region we expect that the impact of digitization on remittances is positive with a magnitude $(\delta + \vartheta)$ that decreases with a rate of $2 *$

[14] For more details on the estimation methodology, please check Emara and Kasa (2020).
[15] To control for country size.

$(\gamma + \varphi)$ and with a cutoff point of $\left|\frac{(\delta+\vartheta)}{2*(\gamma+\varphi)}\right|$. And the total effect of digitization is computed by adding the coefficient δ, ϑ, γ, and φ and jointly tested using the F-test.

5. Estimation Results

In this section we use the Arellano-Bond System GMM estimation methodology to estimate the main model of remittances inflow under six specifications and to analyze the impact of digitization for both the full sample and the BRICS region. The set of instruments used in the model passed the relevance and the over-identification tests ensuring that simultaneous causality and possible correlation between country's fixed effects and the set of explanatory variables are under control. All estimation tables report the Arellano-bond autocorrelation test and the Hansen over-identification test to confirm the absence of serial correlation in second order and that the set of instruments used is over-identified.

As a starting point, we estimate the baseline model for the full sample. Table A5 of the Appendix shows the estimation results of the remittances model, where Column (1) confirms that the autoregressive term is positive and statistically significant as expected and consistent with the results of Gupta, Pattillo, and Wagh (2007). In Column (2), when GDP growth rate is added to the model, the coefficient of the lagged remittances remains positive and statistically significant. The results of this column show that the coefficient of GDP growth is also significant where a 1% increase leads to about 8.79% (of GDP) increase in remittances received. This goes in line with the results Niimi and Ozden (2008) who found that a 3% increase in economic growth resulted in a 7% increase in remittances inflows as well as Wandati (2013), Schrooten (2005), and Siddique et. al (2012), ensuring that economic growth is an important determinant of remittances received.

Column 3 adds the GDP deflator to the model as a proxy for macroeconomic stability (Walsh and Wu, 2010), where the results show that 10% increase in the deflator leads to about 0.016% (of GDP) increase in remittances received. It is important to note that both the coefficients on lagged remittances and GDP growth continued to be statistically significant after the inclusion of the price measure. This result support the findings of cycle (Osili 2007), Stark (2009), Tullao and Cabuay (2016), Alba and Sugui (2009), Relian Edgar Soriente (2018), Christopher Cabuay (2018) Rivera and Tullao (2020) and El-Sakka and McNabb (1999) that the increase in prices in the receiving country leads to more remittances inflow.

When we add the measure of openness to the model in Column 4, our results show that a 10% increase in the openness measure leads to an increase in remittances received by around 0.07% of GDP, an expected result, at the five percent significance level. This result confirms the findings of the IMF study by Gupta, Pattillo, and Wagh (2007) that trade openness is a statistically significant determinant of remittances, reflecting the fact that labor mobility and commodity trade are complementary. Next, Columns (5) shows that adding the real effective exchange rate has a statistically significant impact on remittances, where a 10% currency depreciation leads to about 0.25% increase remittances inflow and aligning with the results from the literature (Lucas and Stark, 1985; Stark and Taylor, 1991; Faini 1994; El-Sakka and McNabb 1999; Dakila and Claveria 2007; Pant and Budha 2016; Kuncoro 2020) that domestic currency depreciation, statistically significantly reduces the transaction cost for the remitter, and thus increases the inflow the remittances in the receiving country.

The last column of our main model, Columns (6), shows that adding the real interest rate does not provide a statistically significant impact on remittances received, even though we expect a negative relationship between how an expansionary monetary policy leads to reduction in the cost of debt repayments for the remitter, and thus increases the inflow of remittances in the receiving country (Loschmann and Seigel, 2014; Rahman 2013; Hassan and Holmes, 2018). Our result, however, is in line with the empirical evidence provided by Straubhaar (1986) who found that changes in real interest rate did not impact remittances inflow because political stability was more of a significant determinant of remittances in Turkey. Additionally, our result aligns with the empirical findings of Swamy (1981), Straubhaar (1986), Faini (1994), Alleyne et al (2008), and Schiopu and Siegfried (2006) that interest rate has an insignificant impact on remittances inflow suggesting that investment motive is not leading the flow of remittances. Furthermore, continuing with Column (6) the coefficient on openness turned to an insignificant impact after showing a significant result in Column (4). This result is in line with the literature on the non-robust relationship between the increase in the current account deficit and the different types of capital flows (Koepke, 2015; Emara & El Said, 2020).

To analyze the impact of digitization on remittances inflow in the full sample, Table A6 reports the results of adding the Digital Ecosystem Development Index and its eight pillars to our baseline model, each one in a

turn. Column (1) shows that a 10% increase in the Digital Ecosystem Development Index, or *digindex,* leads to about 0.05% increase in remittances inflow, an expected statistically significant result. Columns (2) to (9) show the addition of the eight pillars of *digindex* to our main model, each one in a turn. All digitization pillars have a positive and statistically significant impact on remittances received, with the exception of the *comp* pillar. As per the results, the highest impact comes from the *eco* pillar, followed by *instar*, *digprod, fp*, *infra*, *conn*, then *dighou* where a 10% increase in each of these pillar results in 0.093%, 0.0508%, 0.0462%, 0.0461%, 0.0373%, 0.0363%, and 0.0315% increase in remittances received, respectively. These results are in line with the empirical evidence provided in Hawash and Lang (2010), Vu (2011), Kpodar and Adranaivo (2011) Albiman and Sulong (2017), Katz, Jung, and Callorda (2020), Katz (2020), and Lyons et al. (2020) who confirm the presence of statistically significant positive effects of digitization on the economy.

Next, to examine the potential non-linear effect of the improvement in digitization on remittances inflow in the full sample, Table A7 shows the estimation results after expanding our main model by adding the squared term of the digitization index and its eight pillars, each one in a turn. Column 1 shows that *digindex* has a statistically significant positive effect on remittances inflow, where a 10% increase in this index results in an increase in remittances by about 0.14%, however this rate is increasing at a decreasing rate of two times 0.00113, or 0.0023%, with a threshold level of about 61.66 points[16], which is on the 75th percentile of the index. Furthermore, the table shows the computation of the total effect of *digindex* by adding its coefficient to the coefficient of its square term as explained in Equation (3), we find that the total effect of a 10% increase in *digindex* leads to a statistical significant increase in remittances of about 0.139%. This result is consistent with the evidence provided in Lang (2009), Hawash and Lang (2010) Vu (2011), and Albiman and Sulong (2017) who find evidence of non-linear effects of different ICT measures on productivity and economic growth.

Moreover, Table A7, confirms that this positive non-linear impact of digitization is mainly derived from the positive significant non-linear impact of the *eco* pillar, followed by *dighou*, *digprod*, *infra*, *fp*, *comp*, and then *instr*, where a 1% increase in each of these pillars results in an increase in remittances inflow by about 0.0347%, 0.0194%, 0.0188%, 0.0147%, 0.012%, 0.0108%, and 0.0104%, respectively. The threshold levels of each pillar are reported in Column (4). It is important to note that the *conn* pillar does not show a statistical significant non-linear effect on remittances.

Next, in order to analyze how the levels of digitization in the BRICS can affect remittances received in this region as compared with our full sample. Table A8 presents the results of expanding our linear model by adding an interaction term for the BRICS dummy variable as explained in Equation (3). More specifically, the dummy variable for the BRICS region is interacted with *digindex, infra, conn, dighou, digprod, comp, eco, fp, and instr*, each one in a turn. Column (1) reports the coefficients of the *digindex*, its eight pillars, and their interaction terms with the BRICS dummy. The total effects of digitization are computed by adding the coefficient of *digindex* or its pillars, each one in a turn, to the interaction term with the BRICS dummy, as explained in Equation (3) of the previous section.

Column (2) shows the computation of the total effect of the *digindex* and its eight pillars on the flow of remittances into the BRICS region. The results suggest that a 10% increase in *digindex* results in 0.062% increase in the inflow of remittances into the BRICS region. This effect is about 23% higher than that of the full sample[17].

Next, looking at the results of the eight pillars, the results show a statistically significant positive impact on remittances with the exception of *comp* and *instr* pillars. Similar to our result for the full sample, the highest and the second highest effects are coming from the *eco* and the *fp* pillars, where a 10% increase in these pillars leads to an increase of 0.135% and 0.079% in remittances received in the region, which are about 1.5 and 1.7 folds the impacts for the full sample, respectively.[18]

Additionally, the results confirm a positive and statistically significant impact of the remaining four pillars on remittances inflow, with the highest impact derived from *digprod*, followed by *infra*, *dighou,* and then *conn* where a 10% increase in each of these pillars leads to 0.068%, 0.060%, 0.044%, and 0.042% increase in remittances received in the BRICS region, respectively. Again, the coefficients of *digprod*, *infra*, *dighou*, and *conn* for the BRICS sample are about 1.47, 1.61, 1.40 and 1.16 times the coefficients of the full sample, respectively[19].

[16] The index ranges from 3.03 points to 81.53 points, check Table 3 of the Appendix for descriptive statistics.
[17] Refer to Table A6 for the full sample results. The coefficient of *digindex* is 0.00504.
[18] Refer to Table A6 for the full sample results. The coefficient of *eco* and *fp* are 0.0093 and 0.00461, respectively.
[19] Refer to Table A6 for the full sample results. The coefficient of *digprod*, *infra*, *dighou*, and *conn* are 0.00462, 0.00373, 0.00315, 0.00363, respectively.

Finally, to check the potential non-linearity impact of digitization on remittances in the BRICS region, Column (1) of Table A9 shows the estimation results of adding the quadratic term of digitization index along with its interaction term with the BRICS dummy variable. With the exception of *infra* and *conn* pillars, the results of Column (2) show that the *digindex* and its eight pillars have non-linear effects on remittances flow into the region. More specifically, Column 1 shows that *digindex* has a statistically significant positive effect on remittances, where a 10% increase in this index results in an increase in remittances inflow by about 0.259%, however this effect is increasing at a decreasing rate of two times 0.0037, or 0.0023%, with a threshold level of about 34.88 points, which is under the 50th percentile of the index. [20] Additionally, Colum (3) shows the computation of the total effect of *digindex* by adding its coefficient to the coefficient of its square term as shown in Equation (3), we find that the total effect of a 10% increase in *digindex* leads to a statistical significant increase in remittances of about 0.256%, about 1.8 folds the impacts for the full sample[21].

The results of Column (3) indicate that this positive non-linear impact of digitization in the BRICS region is mainly derived from the positive significant non-linear impact of eco, followed by *digprod*, *instr*, *dighou*, *fp*, and then *comp*, where a 1% increase in each of these pillars leads to an increase in remittances inflow by about 0.662%, 0.352%, 0.285%, 0.231%, 0.198%, and 0.153%, which are about 1.91, 1.87, 2.74, 1.19, 1.65, and 1.42 times the coefficients of the full sample, respectively[22]. The threshold levels of each pillar are reported in Column (4). The results of Columns (5) and (6) confirm the absence of serial correlation in second order and the exogeneity of our set of instruments using the Arellano & Bond test and the Hansen test, respectively.

6. Conclusion

Using a comprehensive measure of digitization that encompasses the commonly used measures of FinTech and employing a System GMM estimation methodology on a sample of 34 developed and developing countries over the period 2004-2018, our results confirm that improvement in a country's digital ecosystem simulates individuals to remit their money back to the home country and provides a convenient way for individuals, businesses, and governments to get the money digitally in the receiving country.

The study reveals a non-linear (quadratic) impact of the improvement in the digital ecosystem on the inflow of remittances, where a 10% increase in the comprehensive digitization index results in an increase in remittances inflow by about 0.14%, however this effect is increasing at a decreasing rate of 0.0023%, with at total effect of 0.139%, and a threshold level of about 61.66 points, which is on the 75th percentile of the index in our sample. Additionally, our results show that this positive non-linear impact of digitization on the inflow of remittances is mainly derived from the non-linear effects of the *eco* pillar, followed by *dighou*, *digprod*, *infra*, *fp*, *comp*, and then *instr* pillars, with a definite threshold level for each pillar.

Given that the mean of the digitization index for the BRICS region of 32.18 points is lower than the threshold level of the comprehensive digitization index for the full sample, our results confirms that improvement in digitization has a higher impact in BRICS region than the full sample, which is mainly derived from the non-linear impacts of *eco*, followed by *digprod*, *instr*, *dighou*, *fp*, and then *comp*.

For the full sample and the BRICS region, we find that the index of factors of digital production (or the *eco* index) has the highest impact on remittances inflow as compared to the other digitization pillars. For instance, for the full sample, the magnitude of the total effect of the eco index is about 2.42 times the average of the other 6 significant pillars (*conn* was insignificant). And for the BRICS region, the total effect of the eco index is about 2.71 times the average of the other 5 significant pillars (*conn* and *infra* were insignificant). Additionally, for the BRICS sample, our results show that the impact of Regulatory Framework and Public Policies Index (or *Instr* index) on remittances inflow is about 2.74 times the full sample. This result imply that tracking the percentage of non-licensed installed software, its commercial value, and the percentage of percentage of regulatory agency attributions and functions based on ITU regulatory tracker is crucial for encouraging remittances inflow into the BRICS region.

Finally, the duality of the pattern of the non-linear relationship between the improvement in digitization and remittances inflow implies that countries with relatively low levels of digitization, such as the BRICS region, would benefit the most from a developed digital ecosystem. Hence, our policy implications are directed

[20] The index ranges from 3.03 points to 81.53 points, check Table 3 of the Appendix for descriptive statistics.
[21] Refer to Table A7 for the full sample results. The coefficient of *digindex* is 0.0139.
[22] Refer to Table A7 for the full sample results. The coefficient of *eco*, *digprod*, *instr*, *dighou*, *fp*, and then *comp* are 0.0347, 0.0188, 0.0104, 0.0194, 0.012, and 0.0108 respectively.

towards increasing the investments in human capital with widening the accessibility of internet use in educational establishments, increasing the investment in mobile data, digital media, internet access, as well as encouraging the use and the access of electronic banking by consumers, enterprises, and governments. Finally, with the rising levels of mobile and internet use, especially due to the impact of COVID-19, policy makers must invest in cyber security and fraud protection to minimize cyber threats, protect and encourage workers abroad to remit back the money.

7. References

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Appendix

Table A1: List of Countries

Country ID	Country	Code	Region	Income Classification
1	Australia	AUS	East Asia & Pacific	High income
2	Bolivia	BOL	Latin America & Caribbean	Lower middle income
3	Brazil	BRA	Latin America & Caribbean	Upper middle income
4	Bulgaria	BGR	Europe & Central Asia	Upper middle income
5	Canada	CAN	North America	High income
6	Chile	CHL	Latin America & Caribbean	High income
7	China	CHN	East Asia & Pacific	Upper middle income
8	Colombia	COL	Latin America & Caribbean	Upper middle income
9	Costa Rica	CRI	Latin America & Caribbean	Upper middle income
10	Czech Republic	CZE	Europe & Central Asia	High income
11	Côte d'Ivoire	CIV	Sub-Saharan Africa	Lower middle income
12	Dominican Republic	DOM	Latin America & Caribbean	Upper middle income
13	Hong Kong SAR, China	HKG	East Asia & Pacific	High income
14	Hungary	HUN	Europe & Central Asia	High income
15	Iceland	ISL	Europe & Central Asia	High income
16	India	IND	South Asia	Lower middle income
17	Israel	ISR	Middle East & North Africa	High income
18	Italy	ITA	Europe & Central Asia	High income
19	Japan	JPN	East Asia & Pacific	High income
20	Korea, Rep.	KOR	East Asia & Pacific	High income
21	Malaysia	MYS	East Asia & Pacific	Upper middle income
22	Mexico	MEX	Latin America & Caribbean	Upper middle income
23	Netherlands	NLD	Europe & Central Asia	High income
24	New Zealand	NZL	East Asia & Pacific	High income
25	Nicaragua	NIC	Latin America & Caribbean	Lower middle income
26	Paraguay	PRY	Latin America & Caribbean	Upper middle income
27	Russian Federation	RUS	Europe & Central Asia	Upper middle income
28	South Africa	ZAF	Sub-Saharan Africa	Upper middle income
29	Sweden	SWE	Europe & Central Asia	High income
30	Switzerland	CHE	Europe & Central Asia	High income
31	United Kingdom	GBR	Europe & Central Asia	High income
32	United States	USA	North America	High income
33	Uruguay	URY	Latin America & Caribbean	High income
34	Venezuela, RB	VEN	Latin America & Caribbean	Upper middle income

Notes: The region classification is based on the World Bank and the income classification is based on the IMF.

Table 2: Descriptive Statistic of Economic Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
remit	2592	4.69	6.68	0.00	44.13
gr	2636	0.02	0.05	-0.98	0.80
def	2836	170.65	324.55	10.63	5983.91
op	2302	91.97	55.99	18.23	434.42
reer	1423	100.30	21.44	54.59	740.61
ri	1876	6.80	11.44	-97.62	252.12

Table 3: Descriptive Statistic of Digitization Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
digindex	1110	44.33	18.42	3.03	81.53
infra	1110	35.69	18.80	0.94	93.61
conn	1110	53.29	25.06	0.00	95.72
dighou	1110	38.12	21.73	1.07	91.44
digprod	1110	54.46	31.16	1.45	100.00
comp	1110	64.64	19.45	5.73	96.76
eco	1110	17.77	10.07	0.68	55.78
fp	1110	34.55	21.58	1.03	83.62
instr	1110	54.01	18.88	1.01	88.49

Table 4: Descriptive Statistic of Digitization Variables in the BRICS Region

Variable	Obs.	Mean	Std. Dev.	Min	Max
digindex	75	32.18	12.34	8.37	55.41
infra	75	22.96	12.57	2.58	47.50
conn	75	43.32	21.56	7.34	85.72
dighou	75	31.49	16.95	6.17	68.44
digprod	75	31.98	20.33	2.48	67.36
comp	75	51.96	16.01	18.62	76.59
eco	75	12.64	4.96	5.90	23.89
fp	75	23.83	11.72	7.85	43.15
instr	75	38.78	18.34	4.86	69.24

Table A5: Remittances and Macroeconomic Variables – Full Sample

Dependent variable: Remittances, Received (% of GDP)
Estimation Method: Arellano-Bover/Blundell-Bond Dynamic Panel System GMM.

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
L.remit	0.537***	0.837***	0.763***	0.755***	0.593***	0.654***
	(0.120)	(0.0289)	(0.0346)	(0.0680)	(0.155)	(0.103)
gr		8.786***	11.37***	5.543***	3.521**	2.792*
		(2.067)	(2.391)	(1.545)	(1.683)	(1.482)
def			0.00156***	0.00141*	-0.000620**	-0.000571**
			(0.000602)	(0.000827)	(0.000309)	(0.000260)
op				0.00701**	-0.00858	-0.00229
				(0.00321)	(0.00569)	(0.00421)
reer					0.0245**	0.0187**
					(0.0106)	(0.00798)
ri						-0.00926
						(0.0105)
Observations	2,408	2,391	2,391	1,969	1,058	698
Countries	181	179	179	171	87	65
Arellano-Bond Test						
Order 1 p-value	0.016	0.000	0.000	0.000	0.024	0.021
Order 2 p-value	0.363	0.299	0.241	0.150	0.626	0.274
Hansen p-value	0.013	0.000	0.000	0.003	0.284	0.348

*Notes: ***, **, * and *' denotes statistical significance at the 1%, 5%, 10%, and 15% levels respectively. Numbers in round parentheses (.) are the robust standard errors*

Table A6: Remittances and Digitization – A Linear Model – Full Sample

Dependent variable: Remittances, Received (% of GDP)

Estimation Method: Arellano-Bover/Blundell-Bond Dynamic Panel System GMM.

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.remit	0.995***	0.987***	0.994***	0.979***	1.008***	1.005***	0.994***	0.998***	0.988***
	(0.0419)	(0.0474)	(0.0479)	(0.0507)	(0.0341)	(0.0262)	(0.0385)	(0.0403)	(0.0312)
gr	-0.810	-0.854	-0.804	-0.842	-0.689	-0.843	-1.106	-1.268	-0.729
	(0.919)	(0.913)	(0.904)	(0.902)	(0.968)	(0.937)	(0.966)	(0.990)	(0.961)
def	6.39e-05	7.62e-05*'	5.76e-05	7.90e-05*'	0.000103	1.31e-05	8.39e-05	9.01e-05	5.54e-05
	(4.84e-05)	(5.12e-05)	(5.22e-05)	(5.59e-05)	(7.54e-05)	(3.02e-05)	(6.02e-05)	(6.70e-05)	(5.12e-05)
op	0.00164	0.00223	0.00184	0.00250*'	0.00169*'	0.00140	0.00207*'	0.00239*'	0.00148
	(0.00132)	(0.00162)	(0.00154)	(0.00163)	(0.00116)	(0.00134)	(0.00140)	(0.00148)	(0.00112)
reer	0.00305	0.00284	0.00357	0.00307	0.00224	0.00187	0.00245	0.00279	0.00262
	(0.00682)	(0.00671)	(0.00676)	(0.00687)	(0.00705)	(0.00542)	(0.00699)	(0.00723)	(0.00678)
ri	-0.00407***	-0.00367***	-0.00402***	-0.00377***	-0.00487**	-0.00420*	-0.00394**	-0.00435**	-0.00431***
	(0.00140)	(0.00131)	(0.00146)	(0.00136)	(0.00208)	(0.00242)	(0.00178)	(0.00182)	(0.00150)
digindex	0.00504**								
	(0.00204)								
infra		0.00373*							
		(0.00211)							
conn			0.00363**						
			(0.00174)						
dighou				0.00315*					
				(0.00161)					
digprod					0.00462***				
					(0.00175)				
comp						0.00418			
						(0.00396)			
eco							0.00930**		
							(0.00407)		
fp								0.00461**	
								(0.00188)	
instr									0.00508***
									(0.00195)
Observations	420	420	420	420	420	420	420	420	420
Countries	34	34	34	34	34	34	34	34	34
Arellano-Bond Test									
Order 1 p-value	0.035	0.034	0.035	0.034	0.036	0.037	0.035	0.036	0.035
Order 2 p-value	0.525	0.516	0.580	0.508	0.511	0.541	0.471	0.474	0.529
Hansen p-value	0.393	0.437	0.259	0.381	0.293	0.447	0.521	0.513	0.404

*Notes: ***, **, * and *' denotes statistical significance at the 1%, 5%, 10%, and 15% levels respectively. Numbers in round parentheses (.) are the robust standard errors .*

Table A7: Remittances and Digitization – Non-Linear Model – Full Sample

Dependent variable: Remittances, Received (% of GDP)

Estimation Method: Arellano-Bover/Blundell-Bond Dynamic Panel System GMM.

Regressors	(1) Coefficient & Interaction	(2) Total Effect of Digitization	(3) Threshold Point	(4) Number of Countries/ Observations	(5) AB Test Order 1 & 2 p-values	(6) Hansen p-value
digindex	0.0140*	0.0139*	61.66*	34/420	0.041	0.378
	(0.00768)	(0.0076)			0.495	
Digindex²	-0.000113*					
	(6.73e-05)					
infra	0.0149	0.0147*	49.97*	34/420	0.039	0.491
	(0.00926)	(0.0101)			0.453	
Infra²	-0.000149*					
	(8.53e-05)					
conn	0.00953	0.0095	80.89	34/420	0.041	0.389
	(0.00766)	(0.0076)			0.573	
conn²	-5.89e-05					
	(5.94e-05)					
dighou	0.0196*	0.0194*	37.34*	34/420	0.021	0.483
	(0.0120)	(0.0118)			0.983	
dighou²	-0.000263*					
	(0.000146)					
digprod	0.0189***	0.0188***	70.33***	34/420	0.040	0.472
	(0.00711)	(0.0071)			0.492	
digprod²	-0.000135**					
	(5.27e-05)					
comp	0.0109*	0.0108*	80.60*	34/420	0.039	0.428
	(0.00564)	(0.0056)			0.488	
comp²	-6.74e-05*					
	(3.96e-05)					
eco	0.0354***	0.0347***	26.43***	34/420	0.039	0.435
	(0.0136)	(0.0133)			0.432	
eco²	-0.00067***					
	(0.000256)					
fp	0.0126**	0.012**	55.68**	34/420	0.037	0.319
	(0.00545)	(0.0054)			0.464	
fp²	-0.000113**					
	(5.08e-05)					
instr	0.0105*'	0.0104*'	60.55*'	34/420	0.041	0.213
	(0.00658)	(0.0115)			0.482	
instr²	-8.69e-05					
	(6.44e-05)					

*Notes: ***, **, * and *' denotes statistical significance at the 1%, 5%, 10%, and 15% levels respectively.*
Numbers in round parentheses (.) are the robust standard errors. Column (1) refers to the coefficients δ and γ in Equation (3).
The total effects in Column (2) are computed by adding the coefficients δ and γ. In Column (3) the threshold levels are equal to $\left|\frac{\delta}{2*\gamma}\right|$.
This computation is done for the comprehensive digitization index and its eight pillars, each one in a turn.

Table A8: Remittances and Digitization – Linear Model – BRICS

Dependent variable: Remittances, Received (% of GDP)
Estimation Method: Arellano-Bover/Blundell-Bond Dynamic Panel System GMM.

Regressors	(1) Coefficient & Interaction	(2) Total Effect of Digitization	(3) Number of Countries/ Observations	(4) AB Test Order 1 & 2 p-values	(5) Hansen p-value
digindex	0.00488**	0.0062**	34/420	0.034	0.348
	(0.00201)	(0.0029)		0.533	
*Digindex*BRICS*	0.00127				
	(0.00197)				
infra	0.00350*	0.0060**	34/420	0.034	0.394
	(0.00205)	(0.0030)		0.525	
*infra*BRICS*	0.00250				
	(0.00154)				
conn	0.00357**	0.0042**	34/420	0.034	0.235
	(0.00177)	(0.0019)		0.583	
*conn*BRICS*	0.000604				
	(0.000875)				
dighou	0.00297*	0.0044*	34/420	0.034	0.341
	(0.00161)	(0.0023)		0.515	
*dighou*BRICS*	0.00139				
	(0.00161)				
digprod	0.00451***	0.0068**	34/420	0.036	0.287
	(0.00175)	(0.0030)		0.517	
*digprod*BRICS*	0.00225				
	(0.00263)				
comp	0.00417	0.0048	34/420	0.037	0.429
	(0.00399)	(0.0046)		0.547	
*comp*BRICS*	0.000588				
	(0.00114)				
eco	0.00874**	0.0135***	34/420	0.034	0.498
	(0.00414)	(0.0051)		0.485	
*eco*BRICS*	0.00474				
	(0.00367)				
fp	0.00418**	0.0079***	34/420	0.035	0.458
	(0.00187)	(0.0027)		0.484	
*fp*BRICS*	0.00374**				
	(0.00165)				
instr	0.00434	0.0063	50/674	0.026	0.232
	(0.00427)	(0.0076)		0.434	
*instr*BRICS*	0.00197				
	(0.00371)				

*Notes: ***, **, * and *' denotes statistical significance at the 1%, 5%, 10%, and 15% levels respectively.*
Numbers in round parentheses (.) are the robust standard errors. Column (1) refers to the coefficients δ and ϑ Equation (2).
In Column (2) the total effects are computed by adding the coefficients δ and ϑ.
This computation is done for the comprehensive digitization index and its eight pillars, each one in a turn.

Table A9: Remittances and Digitization– Non-Linear Model – BRICS

Dependent variable: Remittances, Received (% of GDP)

Estimation Method: Arellano-Bover/Blundell-Bond Dynamic Panel System GMM.

Regressors	(1) Coefficient & Interaction	(2) Linear & Non-Linear Total Effects	(3) Total Effect of Digitization	(4) Threshold Point	(5) Number of Countries/ Observations	(6) AB Test Order 1 & 2 p-values	(7) Hansen p-value
digindex	0.0145*'				34/420	0.041	0.367
	(0.00918)					0.489	
*Digindex*BRICS*	0.0114*	0.0259*					
	(0.00601)	(0.0134)					
$digindex^2$	-0.000112						
	(8.03e-05)						
$digindex^2$*BRICS	-0.000260*	-0.00037*	0.0256*	34.88*			
	(0.000139)	(0.0002)	(0.0029)				
infra	-0.00236				34/420	0.032	0.366
	(0.0470)					0.525	
*infra*BRICS*	0.0154**	0.0130					
	(0.00674)	(0.0440)					
$infra^2$	6.44e-05						
	(0.000529)						
$infra^2$*BRICS	-0.000285	-0.00022	0.0128	29.51			
	(0.000218)	(0.00072)	(0.0433)				
conn	0.00971				34/420	0.041	0.382
	(0.00829)					0.576	
*conn*BRICS*	0.00447	0.0142					
	(0.00417)	(0.0111)					
$conn^2$	-5.68e-05						
	(6.23e-05)						
$conn^2$*BRICS	-6.90e-05	-0.00012	0.0141	56.36			
	(6.11e-05)	(0.00012)	(0.011)				
dighou	0.0133*'				34/420	0.040	0.226
	(0.00861)					0.474	
*dighou*BRICS*	0.0101*	0.0234*					
	(0.00592)	(0.0132)					
$dighou^2$	-0.000121*'						
	(7.67e-05)						
$dighou^2$*BRICS	-0.000216*	-0.00034*	0.0231*	34.73*			
	(0.000128)		(0.0130)				
digprod	0.0197**				34/420	0.040	0.439
	(0.00772)					0.489	
*digprod*BRICS*	0.0160*	0.0357**					
	(0.00949)	(0.0154)					
$digprod^2$	-0.000139**						
	(5.69e-05)						
$digprod^2$*BRICS	-0.000332*'	-0.00047*	0.0352**	37.86**			
	(0.000210)	(0.00025)	(0.0151)				
comp	0.0110*				34/420	0.038	0.416
	(0.00580)					0.487	
*comp*BRICS*	0.00440	0.01544**					

	(0.00346)	(0.0072)					
comp²	-6.81e-05*'						
	(4.30e-05)						
*comp²*BRICS*	-7.29e-05	-0.00014*	0.01530**	54.75**			
	(6.18e-05)	(0.0001)	(0.0071)				
eco	0.0402***				34/420	0.039	0.448
	(0.0148)					0.423	
*eco*BRICS*	0.02848'	0.0685**					
	(0.0185)	(0.0277)					
eco²	-0.00074***						
	(0.000274)						
*eco²*BRICS*	-0.00161*	-0.00236**	0.0662**	14.53**			
	(0.000843)	(0.0010)	(0.0277)				
fp	0.0125**				34/420	0.008	0.308
	(0.00584)					0.466	
*fp*BRICS*	0.00751	0.0200*					
	(0.00753)	(0.0112)					
fp²	-0.000111**						
	(5.44e-05)						
*fp²*BRICS*	-0.000183	-0.0003*'	0.0198*	34.11*			
	(0.000177)	(0.0002)	(0.011)				
instr	0.0109				50/674	0.028	0.165
	(0.00855)					0.446	
*instr*BRICS*	0.0179	0.0289*					
	(0.0133)	(0.0154)					
instr²	-6.43e-05						
	(9.77e-05)						
*instr²*BRICS*	-0.000302*'	-0.0004*	0.0285*	39.40*			
	(0.000202)	(0.0002)	(0.0152)				

*Notes: ***, **, * and *' denotes statistical significance at the 1%, 5%, 10%, and 15% levels respectively.*
Numbers in round parentheses (.) are the robust standard errors. Column (1) refers to the coefficients $\delta, \vartheta, \gamma, \text{and } \varphi$ in Equation (3). Column (2) linear effects are the sum of $\delta \text{ and } \vartheta$, non-linear effect is the sum of $\gamma \text{ and } \varphi$. The total effects in Column (3) are computed by adding the coefficient $\delta, \vartheta, \gamma, \text{and } \varphi$. The threshold level is equal to $\left|\frac{(\delta+\vartheta)}{2*(\gamma+\varphi)}\right|$. This computation is done for the comprehensive digitization index and its eight pillars, each one in a turn.