

Does FinTech penetration drive financial development? Evidence from panel analysis of emerging and developing economies

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Abstract

Recent innovations in digital financial technologies (FinTech) have called into question the role of FinTech in financial development. This study examines FinTech's direct and conditional effects on financial development using data from emerging and developing economies. Three measures of financial development (broad money, Private credit, and bank deposits) and two conditional factors (financial performance and financial inclusion) were investigated vis-à-vis FinTech penetration. This paper demonstrates that FinTech penetration not only drives financial development but also strongly impacts the financial development of countries with weak financial sector performance and low financial inclusion. These findings have several policy implications: (1) countries with weak financial sector performance could leverage FinTech to improve financial development, and (2) appropriate policies on FinTech development can drive digital financial inclusion, financial deepening, and consequently economic growth.

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1. Introduction

Several studies have examined the determinants and drivers of financial development, particularly in emerging and developing economies (EMDEs). According to certain studies, financial development in emerging economies could be driven by foreign direct investment (FDI), remittances, and other relevant country-level micro- and macroeconomic variables (Alfaro et al., 2009; Desbordes & Wei, 2017; Irandoust, 2021; Majeed et al., 2021; Olayungbo & Quadri, 2019). However, as new technological innovations are introduced and applied in

the field of finance, other streams of the literature have begun to investigate financial integration, financial technologies (FinTech), and inclusive financing as possible drivers of financial and economic development (Demir et al., 2020; Kanga et al., 2021; Kling et al., 2020; Muganyi et al., 2022; Nsiah et al., 2021). These latter studies suggest that the drivers of financial development are dynamic (change over time) and multidimensional and may be influenced by FinTech diffusion, technological progress, and country-specific characteristics (Aduba & Asgari, 2021, pp. 1215–1233). The contention is that as emerging markets witnessed new technological innovations interacting with other macro- and microeconomic drivers of economic development, new drivers of financial development that altered the otherwise established equilibrium emerged.

Particularly, the role of FinTech in improving financial inclusion via digital access to financial products and services in

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economies or regions with fewer financial institutions and/or less-developed financial markets has received considerable attention from researchers in recent years.¹ For instance, significant progress in financial inclusion in specific African countries, namely, Zimbabwe, South Africa, and Nigeria, is almost exclusively driven by FinTech penetration (Sahay et al., 2020). Recent data show that 25% of unbanked and 16% of underbanked customers in ASEAN countries used digital payments, demonstrating a significant penetration of any FinTech segment in the region (Morgan, 2022). In addition, Basten and Ongena (2020) find that FinTech allows banks to extend mortgage loans and other financial services to clients in regions with zero bank branches, staff, or local expertise. In addition, a FinTech experiment that allows unbanked users to receive money directly into their mobile money accounts not only increases savings among users but also demonstrably provides them with the ability to withstand economic shocks (Breza et al., 2020). These studies suggest that FinTech is not only crucial for achieving financial inclusivity but also a *sine qua non* to inclusive growth, economic prosperity, and sustainable development (Arner et al., 2020).

Despite the rich body of literature on the drivers of financial development and the role of FinTech in achieving financial inclusivity, salient questions remain unanswered. For instance, what is the impact of recent digital FinTech on country-level financial development, and to what extent does the conditional effect of FinTech via financial performance and financial inclusion influence the pace and direction of financial development? As demonstrated in Section 2, none of the existing studies has specifically addressed these questions. Accordingly, this present study contributes to the literature by addressing these questions using a large sample of EMDEs with heterogeneous macroeconomic and country-specific conditions. The findings show that FinTech drives financial development in EMDEs. We find that FinTech drives financial development in countries with low financial inclusion and weak financial sector performance. These findings are significant and point to the diffusivity and role of FinTech innovations in improving financial access for the unbanked, underbanked, and other vulnerable groups. FinTech innovations include mobile money, mobile lending, peer-to-peer (P2P) lending, and similar service innovations. These findings contribute to the literature in two unique ways. First, we show a direct positive link between FinTech penetration and all measures of financial development and demonstrate how this effect could be conditional on country-level financial performance and/or financial inclusion. Second, we show that the effect of FinTech on financial development is stronger at lower levels of financial performance and/or financial inclusion. This finding consequently demonstrates that economies with weak financial performance

and/or low financial inclusion benefit from policies that improve FinTech penetration.

2. Related literature and hypothesis development

The traditional finance literature identifies determinants as well as drivers of financial and economic development, including FDI, country-level total factor productivity, official development assistance, and remittances. For instance, Alfaro et al. (2009) studied the link between FDI, productivity, and financial development. Their findings show that countries with well-developed financial markets gain significantly from FDI through factor productivity improvement. A decade later, Majeed et al. (2021) advanced a similar argument by examining the link between FDI and financial development under different country-level characteristics. They found that FDI, trade openness, government consumption, and inflation have significant impacts on financial development; specifically, the first three increased the financial development in Asia, Europe, and Latin America but not in Africa. Similarly, Irandoust (2021) studied the effect of host countries' financial development on FDI. The findings show unidirectional causality running from financial development to FDI in six of eight countries. Therefore, countries seeking to attract FDI should implement measures to ensure a well-developed financial system.

Remittances have also been identified as a crucial driver of financial development. Coulibaly (2015) investigated the link between remittances and financial development in Sub-Saharan Africa (SSA) using multiple financial development measures. The author argues that the effect of remittances on financial development depends on the country and the financial development measures used. In addition, the author finds reverse causality between remittances and financial development in some of the countries studied. In a related study, Olayungbo and Quadri (2019) examined the relationship between remittances, financial development, and economic growth in SSA. They found that remittances and financial development positively contributed to economic growth in the short and long term. Moreover, the authors argued that financial development is a substitute for the remittance growth relationship in SSA. Similarly, Sobiech (2019) examined whether financial development fosters the impact of remittances on economic growth and found that remittances foster growth only at low levels of financial development. Therefore, the more financially developed a country, the smaller the impact of remittances on growth.

Other streams of literature examined the link between financial integration, digital finance, financial innovations, financial inclusion, and financial development. For instance, Ozili (2018) discussed the benefits of digital finance and financial inclusion for users, providers, the government, and the economy. The author provided a possible connection between digital finance, financial inclusion, and financial stability in developing economies. In addition, the author argued that digital finance transmitted through FinTech positively impacts financial inclusion in EMDEs. Moreover, users are willing to pay extra costs to maximize the utility of digital finance. Markose et al. (2020) empirically examined the cost of

¹ FinTech broadly refers to the application of technology to finance, i.e., the use of digital platforms to deliver financial services to consumers and businesses. It covers all aspects of financial transactions, including borrowing, savings, and bank-client, lender-borrower, and buyer-seller relationships (Mehrotra, 2019).

financial inclusion in a certain implementation in India. They found that monetary/economic shortfalls exist for public banks that participate in financial inclusion policy schemes in India. However, the monetary shortfall was ameliorated mainly by electronic direct benefit transfer of government-to-person payments made possible through FinTech digital service innovation. Kling et al. (2020) examined whether financial inclusion, which includes digital payments, reduces income inequality. The authors argued that financial inclusion mitigates underinvestment in education and that access to bank accounts improves households' future income prospects.

2.1. FinTech: Driving digital financial inclusion, inclusive growth, and sustainable development

Numerous recent studies have pointed to the increasing role of FinTech in enhancing credit access for individuals and businesses, closing the gender gap, promoting inclusive growth via digital financial inclusion, achieving the Sustainable Development Goals (SDGs) via digital financing, and enabling a quick yet contactless deployment of government support measures to businesses and persons during disasters, such as the COVID-19 pandemic. Researchers have documented different findings, conclusions, and perspectives on how FinTech is changing the financial landscape, reshaping social demographic structures, and consequently contributing to the financial and economic development of emerging markets around the globe (Allen et al., 2021).² The first argument points to how FinTech, measured by digital financial access, affects country-level micro- and macroeconomic development indicators, such as income inequality, GDP, and poverty. For instance, Demir et al. (2020) examined whether FinTech affects income inequality directly and indirectly through financial inclusion for a panel of 140 countries. Their results show that FinTech reduces income inequality through financial inclusion. Additionally, their study shows that financial inclusion, enhanced by digital access, significantly reduces income inequality in all quantiles, especially in higher-income countries. Similarly, Kanga et al. (2021) examined how the diffusion of FinTech (operationalized as ATMs and mobile phone penetration) and financial inclusion affect per capita income. Their findings demonstrate that FinTech has long-run effects on financial inclusion and GDP per capita over and above their short-run impact. They concluded that increasing financial sector performance and enhancing FinTech diffusion are desirable policy directions. Finally, Muganyi et al. (2022) examined the effects of FinTech and regulatory technology (RegTech) on China's financial sector development. They found that FinTech supports China's financial sector development through access to loans, deposits, and savings. Additionally, RegTech significantly improves financial development outcomes. They argued that relevant policies should balance growth and risk in FinTech development. This stream of literature

demonstrates that FinTech is a key enabler of financial inclusion, with overarching economic and financial implications.

The second argument pertains to how FinTech is potentially democratizing and/or liberalizing the financial sector, providing unfettered credit access through digital lending platforms, and driving digital financial transformation that could lead to sustainable development. For instance, because of its low distribution cost relative to bank credit or informal borrowing, FinTech credit significantly compensates for local credit shortages, particularly in rural areas of China, India, Kenya, and other countries where loan volumes and distance to bank branches are significantly large (Hau et al., 2021). In addition, the authors found that FinTech facilitates credit access through P2P lending, e-commerce (online) lending, and digital wallets for unbanked individuals and businesses with low credit scores. Notably, FinTech not only breaks local or national barriers to financial services but also changes the current order in cross-border or international remittances. A recent study shows that FinTech enables more than a million digital remittance users globally to conduct cross-border remittances (digital remittances) of approximately USD 73.9 billion in 2019, equivalent to 11.1% of global remittances (Morgan, 2022). As noted by the author, the share of digital remittance enabled by FinTech is projected to grow by 14%, twice the rate of overall remittance growth. If the empirical literature on the remittance–economic growth nexus is anything to go by, the increasing share of digital remittances underscores the potential effect of FinTech on development and inclusive growth. Finally, FinTech is considered a potential driver of the United Nations' SDGs because it is the most suitable means through which financial resources can be redistributed to achieve sustainability. For instance, FinTech-enabled digital access to finance allows people to prepare for and manage risks, secure and manage credits, save and fund children's education, and access health insurance among others, all of which have direct consequences on many SDGs (Arner et al., 2020). The authors succinctly outline how FinTech could drive sustainability, namely, by enhancing the allocation of existing financial resources to support sustainable goals, designing new technologies, and adopting RegTech for enhanced financial and regulatory systems among others.

FinTech has also enabled seamless and sustained access to credit and financial aid distribution in times of disaster, which would otherwise prove difficult to process using the norms. For instance, earlier on and throughout the COVID-19 pandemic, FinTech-enabled platforms such as digital banking, mobile money account, and mobile wallet were integrated into government electronic payment systems. These platforms allow the government to provide wide-reaching aid and support without physical contact, thereby limiting the transmission of the novel virus (Sahay et al., 2020). In addition, FinTech-enabled platforms, such as P2P lending and equity crowdfunding, were much more stable and resilient to the COVID-19 crisis than bank lending in the US (Cumming et al., 2022).

In sum, the reviewed studies underscore the importance of FinTech as a channel for improving digital financial inclusion and providing unfettered credit access by financial system

² Allen et al. (2021) provided an extensive survey of Fintech research progress, policy discussion, and future directions.

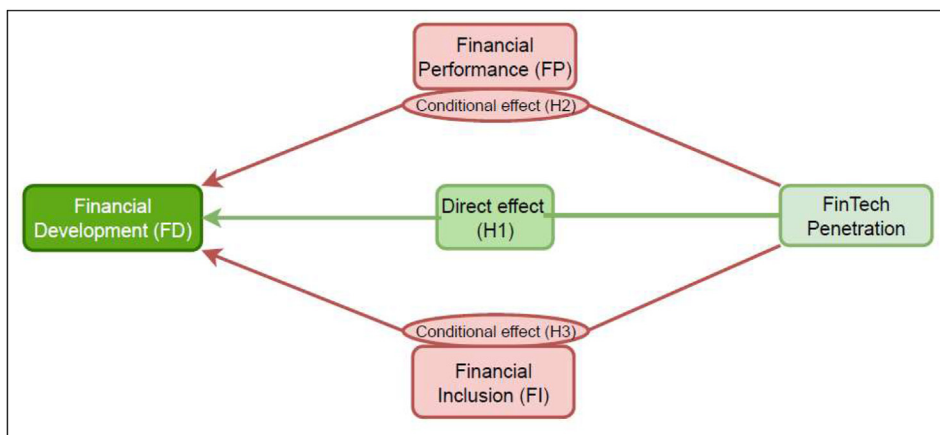


Fig. 1. Theoretical framework and hypotheses.

democratization, inclusive and sustainable growth, and potential economic and/or financial growth. However, whether FinTech drives financial development remains unclear, or, at least, no empirical evidence has been presented to this effect. Simply put, does FinTech drive financial development in emerging markets? The direct effect of FinTech on country-level financial development could provide important input for policy considerations. We argue that countries with high FinTech penetration are likely to have improved financial development. Thus, we propose the first hypothesis of this study as follows:

H1. *FinTech penetration has a positive effect on financial development.*

Furthermore, two stylized facts emerge from the above review. First, the determinants and drivers of financial development are multidimensional and include several macro- and microeconomic variables. Second, the drivers of financial development are dynamic (change over time) and depend on country-level characteristics. In addition, the review demonstrates that although the financial development drivers have been extensively studied, results are inconclusive, and the list is by no means exhaustive. The pace and direction of financial development may also depend on the country-level diffusion of emerging FinTech innovations and their interaction with other microeconomic variables, namely, *financial sector performance and financial inclusion*. Therefore, this study also seeks to examine how emerging financial innovations, technologies, and relevant policies concerning inclusive financing impact financial development, especially in EMDEs (Aduba & Asgari, 2021, pp. 1215–1233). In this regard, this study postulates that the impact of FinTech on a country's financial development may depend on its financial performance and/or financial inclusion. This proposition has been largely ignored in the literature.³ Accordingly, we frame the second and third hypotheses of this study as follows:

H2. *The effect of FinTech on financial development is conditional on country-level financial performance.*

H3. *The effect of FinTech on financial development is conditional on country-level financial inclusion.*

Fig. 1 illustrates the theoretical framework of the three hypotheses. Next, we present our empirical strategy.

3. Research methods

3.1. Conceptualizing financial development

Several financial development measures exist in the literature, from the traditional measures of broad money supply (BM) (% of GDP) to private credit (PC) (% of GDP) to bank deposit (BD) (% of GDP), and more recently, to the Global Financial Development Index computed by the International Monetary Fund (IMF). BM supply is the sum of currencies outside banks, foreign currency, time and demand deposits, and savings deposits in a country and has been extensively used as a measure of financial development in the finance literature (Olayungbo & Quadri, 2019). PC measures credit flows to the private sector; bank deposits show deposits to commercial banks, indicating available and loanable domestic financial capital (Karikari et al., 2016). These measures are quantitative measures of financial development. The Global Financial Development Index (GFDI) is a representative index that measures country-level financial access and the efficiency of financial institutions and markets (Sviryzdenka, 2016).

Unlike traditional financial development measures, the GFDI includes new measures of financial access defined by ATMs and financial branches per 100,000 adults and financial efficiency defined by common financial performance ratios, such as net interest margin (NIM), lending deposit spread, return on assets (ROA), and return on equity (ROE). Although innovative, the GFDI is not a suitable measure of financial development in this study because it captures some of the variables included in this study as potential determinants of financial development, as

³ We are aware of the extant literature showing that financial access depends on economic development, institutional quality, degree of credit information sharing, and physical infrastructure. These studies differ from the current study in focus and scope, including research questions, hypothesis, and data.

discussed below. Therefore, this study relies on three common measures of financial development: BM, PC, and BD. We theorize that FinTech penetration in a given country implies flexible and easy access to financial services and products that directly improve these quantitative financial development measures.

3.2. Financial performance measures

As suggested by the second and third hypotheses, this study contends that financial performance could mediate the effect of FinTech on financial development. If so, the threshold or financial performance level at which FinTech drives financial development could provide important implications that aid our understanding of the FinTech financial development nexus. Therefore, in the following, we describe the financial performance measures employed.

3.2.1. Profitability index measure

Three common profitability measures were selected for this study, namely, ROA, ROE, and NIM, which are also known as quick ratios. These ratios are traditional measures of financial sector performance that show profitability measured by return on total assets invested, total shareholder investment, and income generation capacity of the intermediation function of financial institutions, respectively. Each of these measures will be normalized between 0 and 1, and a common profitability index (PI) will be estimated using Equation (1):

$$PI = \sum_{i=1}^3 \Phi_i / 3 \tag{1}$$

where Φ_i is the normalized value of ROA, ROE, and NIM.

3.2.2. Efficiency index measure

This study identifies three measures of financial sector efficiency: z-score, cost efficiency, and service or lending efficiency.⁴ Again, each measure was normalized between 0 and 1, and a common efficiency index (EI) was estimated as follows:

$$EI = \sum_{i=1}^4 \Omega_i / 4 \tag{2}$$

where Ω_i is the normalized value of individual robust financial performance measures.

3.3. Measuring FinTech penetration and financial inclusion

Several FinTech and financial inclusion measures have been proposed in the literature. Most of these measures are taken from the World Bank's G20 Financial Inclusion Indicators (Global Partnership for Financial Inclusion, 2019). Although

FinTech and financial inclusion measures sometimes overlap, after careful consideration of the relevant literature, we clarify these two measures as shown in Table 1. We then created a simple country-level FinTech index (FinT) as follows: First, we normalized each of the four measures of FinTech penetration described in Table 1 using Equation (3). Second, we take the unweighted average (assuming each FinTech penetration measure is equally important) of all normalized measures using Equation (4)⁵

$$\tilde{X}_{ijk} = \frac{X_j - X_{jk_min}}{X_{jk_max} - X_{jk_min}} \tag{3}$$

$$FinT = \sum_{i=1}^n \tilde{X}_{ijk} / n \tag{4}$$

where \tilde{X}_{ijk} ($0 < \tilde{X}_i \leq 1$) is the normalized FinTech measure, and X_{jk_min} , X_{jk_max} are the minimum and maximum of each specific measure under consideration. *FinT* is the average of all normalized values used for the estimation.

We follow a similar step to compute the financial inclusion index (FinI) using the measures of financial inclusion outlined in Table 1.

3.4. Econometric model

To investigate the direct effect of FinTech penetration on financial development, we estimate a simple empirical model as follows:

$$FD_{it} = \beta_0 + \beta_\psi \cdot FinT_{it-1} + \beta_c \cdot controls_{it-1} + \varepsilon_{it} \tag{5}$$

where FD_{it} represents each of the three measures of financial development, and $FinT_{it}$ is lagged FinTech penetration index. β_0 and β_ψ are parameters to be estimated. Subscripts i and t refer to country and time, respectively. Lagging these independent variables in our model has two advantages: it corrects for spurious correlations between variables, and it theoretically assumes that the current level of financial development depends on the past levels or activities related to the country-level variables, such as FinTech penetration and other macroeconomic variables. In a cross-country analysis, controlling for economic activity differences that can be captured by GDP is imperative. Therefore, the model *controls* for country-specific economic growth (measured by *GDP*). The model also controls for population growth, implicitly assuming that population growth naturally triggers increased economic and financial activities that are likely to impact financial development. Moreover, the model was penalized by country-level inflation and the informal financial sector (measured by the shadow economy). High inflation and extensive underground economic and financial activities can harm financial development. These control variables are standard procedures for reducing omitted bias.

⁴ See Appendix A for the definition and estimation strategies of these measures.

⁵ Setting $x_{min} = 0$ as the minimum value is a common practice in the literature as well as $x_{max} = 95$ percentile in cases where normalization is difficult to achieve (Omar & Inaba, 2020; Saha & Qin, 2022).

Table 1
Data sources and variable definitions.

Variable classification		Variable description and measurement	Literature	Data source		
Dependent variables	Financial development	Broad money supply, M2, (%GDP)	Coulibaly (2015), Karikari et al. (2016), Olayungbo and Quadri (2019)	https://databank.worldbank.org/reports.aspx?source=global-financial-development		
		Bank credit to the private sector (%GDP)				
		Bank deposit (%GDP)				
Independent variables	Financial performance	Return on asset (ROA): net income to average total assets	European Central Bank (2010)	https://databank.worldbank.org/reports.aspx?source=global-financial-development		
		Return on equity (ROE): net income to total shareholder equity				
		Net interest margin (Nim): net income to average earning assets				
		z-score (zsc): country-level financial stability measured by the volatility of ROA measured against risk			Aduba and Harimaya (2023)	
		Cost efficiency			Aduba and Harimaya (2023)	Estimated from FSIs metadata: https://data.imf.org/?sk=51B096FA-2CD2-40C2-8D09-0699CC1764DA
		Lending efficiency				
		FinTech penetration (FinT)			The proportion using mobile phones (digital devices) to pay bills and receive or send money	Demir et al. (2020), Kanga et al. (2021)
	Population with a mobile money account (age 15+)					
	Population using the Internet to manage finance (save or borrow money) (age 15+)					
	Financial inclusion (FinI)	Financial technologies per 100,000 persons (ATM and POS)	Demir et al. (2020), Kanga et al. (2021)	https://databank.worldbank.org/reports.aspx?source=g20-basic-set-of-financial-inclusion-indicators		
Population with active accounts (age 15+)		Demir et al. (2020), Kanga et al. (2021), Omar and Inaba (2020), Saha and Qin (2022)			https://databank.worldbank.org/source/global-financial-inclusion	
Depositors in financial institutions (age 15+)						
Control variable	Financial inclusion (FinI)	The proportion of borrowers from the formal financial sector (age 15+)	Demir et al. (2020), Kanga et al. (2021), Omar and Inaba (2020), Saha and Qin (2022)	https://databank.worldbank.org/source/global-financial-inclusion		
		The proportion of the population saving in the formal financial sector (age 15+)				
		Commercial bank branches per 100,000 persons				
		GDP per capita			https://databank.worldbank.org/source/world-development-indicators	
		Population				
		Inflation				
Shadow economy	Kose et al., (2021) retrieved from https://www.worldbank.org/en/research/brief/informal-economy-database					

To address the second research question on the conditional effect of FinTech on financial development through financial performance/inclusion, we estimate three empirical models (6, 7, and 8), each containing a performance variable (PI_{it} or EI_{it}) and a financial inclusion variable ($FinI_{it}$). Equations (6) and (7) capture the conditional effect of FinTech on financial development based on country-level financial performance, whereas Equation (8) captures the conditional effect of FinTech on financial development based on country-level financial inclusion.

$$\partial_{it} = \beta_0 + \beta_\psi FinT_{it-1} + \beta_\phi PI_{it-1} + \beta_\delta FinT_{it-1} \times PI_{it-1} + \beta_c \cdot controls_{it-1} + \varepsilon_{it} \tag{6}$$

$$\partial_{it} = \beta_0 + \beta_\psi FinT_{it-1} + \beta_\phi EI_{it-1} + \beta_\delta FinT_{it-1} \times EI_{it-1} + \beta_c \cdot controls_{it-1} + \varepsilon_{it} \tag{7}$$

$$\partial_{it} = \beta_0 + \beta_\psi FinT_{it-1} + \beta_\phi FinI_{it-1} + \beta_\omega FinT_{it-1} \times FinI_{it-1} + \beta_c \cdot controls_{it-1} + \varepsilon_{it} \tag{8}$$

Based on Equations (6)–(8), the marginal effect of FinTech on financial development at various levels of financial performance/inclusion can be estimated by taking the first derivative of either equation with respect to the reference variables, namely, the performance or inclusion variable.

3.5. Data and variable definitions

The data used in this study were carefully cleaned from several sources (see Table 1). We developed unbalanced panel data comprising approximately 80 countries, spanning from 2010 to 2020, except for the indices of financial inclusion and FinTech penetration, which were only available for 2011, 2014, 2017, and 2021. As demonstrated in Table 1, the

Table 2
Summary statistics and correlation analysis of the main variables.

Panel A. Summary statistics									
	Mean	SD	Min	Max	1st Perc.	p25	p50	p75	p95
Broad money, % of GDP (BM)	53.4435	28.1001	9.0205	163.6504	11.8741	33.3560	48.6186	69.7933	112.1903
Private credit, % of GDP (PC)	39.1154	27.0085	3.4421	142.7854	4.0337	17.9591	33.1636	53.1667	96.9274
Bank deposit % of GDP (BD)	44.3144	26.3773	5.0289	142.1062	7.7884	23.0333	39.8090	58.5667	96.7173
Profitability index (PI)	0.7212	0.2026	0.0000	1.0000	0.1833	0.6048	0.7538	0.8789	0.9866
Efficiency index (EI)	0.8151	0.0744	0.3189	0.9985	0.5679	0.7890	0.8259	0.8583	0.9106
FinTech index (FinT)	0.7562	0.2180	0.0691	1.0000	0.1790	0.6060	0.8077	0.9488	1.0000
Financial incl. index (FinI)	0.8326	0.1460	0.2806	1.0000	0.3474	0.7693	0.8690	0.9445	1.0000
Zscore (zsc)	16.6690	8.6015	0.0000	56.0497	2.4771	9.9283	15.9269	20.6957	32.6207
Cost efficiency (CE)	0.6519	0.0836	0.2801	0.8434	0.3617	0.6097	0.6565	0.7021	0.7838
Lending efficiency (LE)	1.5128	0.1301	0.9290	1.6290	1.0944	1.4610	1.5592	1.6088	1.6285
Net interest margin (NIM)	5.6669	2.3812	1.6888	13.2558	2.0337	3.7242	5.1605	7.2228	10.1179
Return on assets (ROA)	2.2221	1.4907	0.0000	21.9248	0.0000	1.3549	1.9320	2.9448	4.4616
Return on equity (ROE)	13.9340	7.2071	0.0000	42.2313	0.0000	9.1156	13.1465	17.9746	27.7543
GDP per capita (000)	6.0220	7.0191	0.2342	47.7396	0.3158	1.4993	4.0142	7.7148	17.2888
Population (million)	4.6018	154.4115	0.05120	1380.000	0.0883	2.0115	9.7781	33.42379	163.0000
Inflation	4.4495	4.1014	-4.2949	48.6999	-1.7558	1.7753	3.7655	6.1972	11.8042
Shadow economy	37.7826	10.6139	14.0403	66.3893	14.4250	31.0697	36.7363	43.9840	56.7552

Panel B. Correlation matrix of main variables											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) lnBM	1.0000										
(2) lnPC	0.8413*	1.0000									
(3) lnBD	0.9059*	0.7875*	1.0000								
(4) PI	-0.0127	-0.0018	0.0066	1.0000							
(5) EI	0.2368*	0.2477*	0.2493*	0.4298*	1.0000						
(6) FinT	0.3011*	0.3122*	0.2901*	-0.1659*	0.2804*	1.0000					
(7) FinI	0.2367*	0.2284*	0.2385*	-0.0116	0.2263*	0.5002*	1.0000				
(8) lngdp	0.5218*	0.5630*	0.5765*	0.0016	0.1881*	0.2760*	0.1752*	1.0000			
(9) lnpop	-0.1216*	-0.0564	-0.2280*	-0.0242	0.0761*	-0.0562	-0.0227	-0.3476*	1.0000		
(10) lninf	-0.2773*	-0.2420*	-0.2962*	-0.0060	-0.1454*	-0.2194*	-0.1917*	-0.3555*	0.3803*	1.0000	
(11) lnSE	-0.3688*	-0.3468*	-0.1841*	-0.0428	-0.1746*	-0.0927*	-0.2552*	-0.2300*	-0.0730	0.1135*	1.0000

***p < .01, **p < .05, *p < .1.

classification of FinTech used in this study follows those in the extant literature, especially for EMDEs, as captured by the World Bank Global Findex.⁶ Table 1 summarizes all the variables, definitions, and data sources.

4. Empirical results

4.1. Summary statistics

Panel A of Table 2 presents the summary statistics for the dependent and independent variables, including the control variables.⁷ The mean value of all three measures of financial development varies between 39% and 53% of GDP, with a standard deviation that suggests large variations in country-level financial development. This result may be due to heterogeneous financial and economic activities across countries and years. Panel B of Table 2 shows the pairwise correlation

among all variables under consideration, demonstrating the anticipated relationship in the econometric models. Again, the pairwise relationship between the financial development measures and other variables reveals an interesting pattern. First, except for the PI, all other main variables are positively and significantly correlated with all the financial development measures. The lack of a significant and positive relationship between the PI and the financial development measures could be because profitability measures are generally not good measures of financial or market risk. Rather, they provide short-term analyses of financial performance that lack a robust representation of core financial activities. The correlation results also show a positive relationship between GDP per capita and financial development. However, the variables of the shadow economy, inflation, and population are negatively correlated with all the financial development measures.

Fig. 2 examines the progress in FinTech penetration across income groups using key FinTech indicators. Overall, FinTech penetration in all income groups has demonstrated significant progress between 2014 and 2021. Most FinTech indicators became prominent after 2014, and by 2021, a significant portion of the responding population in EMDEs adopted several FinTech services. The COVID-19 pandemic also

⁶ Like previous studies that rely on country-level aggregates on FinTech, we also do not have access to the specifics or volume of transactions on these digital platforms. This condition limits our ability to perform sensitivity analysis, such as volatility or shocks.

⁷ See Appendix D for the list of countries and mean estimates of all variables.

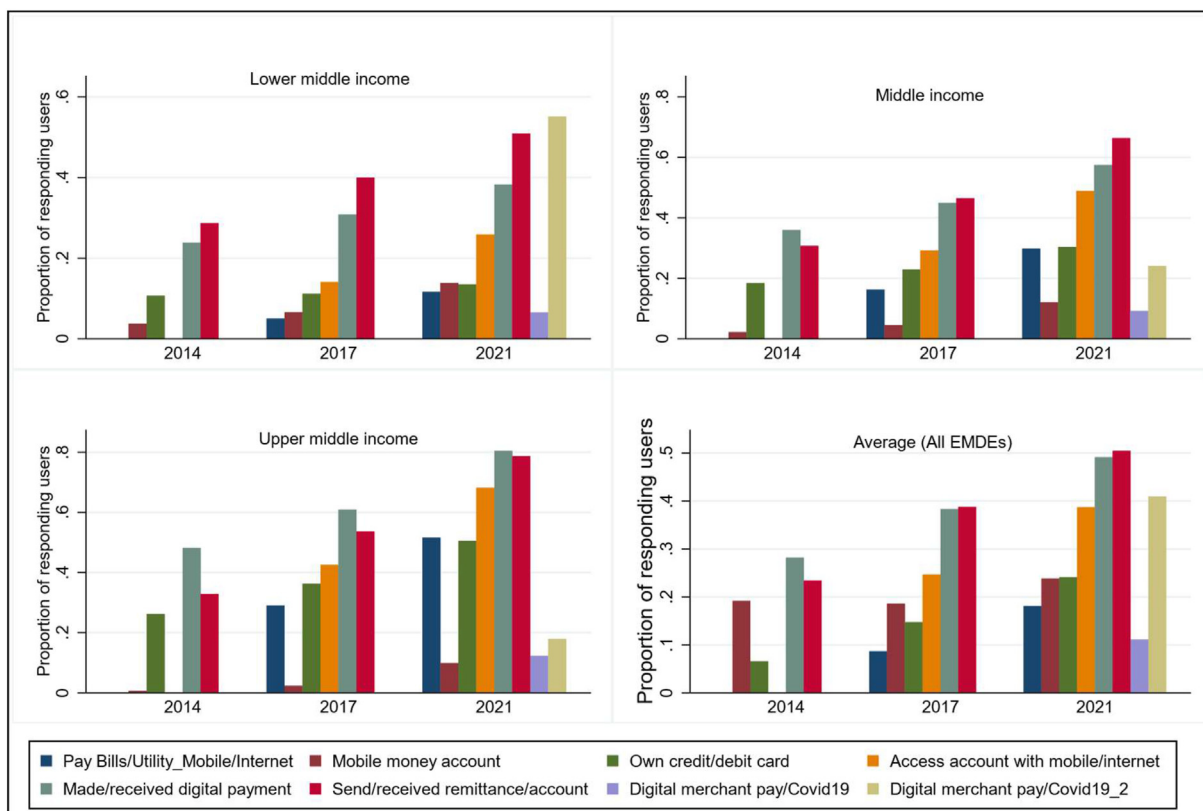


Fig. 2. Progress in FinTech penetration by income groups (source: authors' illustrations based on data).

played a significant role in FinTech adoption in 2021. In the figure, the proportion of first-time digital payment users after COVID-19 (“Digital merchant pay/Covid 19”) is at least 10% of the responding population in all income groups. Considering all digital merchant payment users, Fig. 2 shows a significant uptake in this FinTech service during and after COVID-19 (see the bar representing “Digital merchant pay/Covid19_2”). Twenty percent of digital merchant payment users in middle and upper-middle income, post-COVID-19, were first-time users. The uptake in lower-middle income was almost three-fold; approximately 58% of digital merchant payment users during and after COVID-19 were first-time users. These results suggest that the COVID-19 pandemic contributed to FinTech adoption/penetration in EMDEs.

4.2. Estimation results

Table 3 presents the estimation results corrected for autocorrelation, heteroscedasticity, and cross-sectional dependence using the feasible generalized least squares method.⁸ Panel A presents the baseline results, and Panels B and C show the full model with profitability and efficiency performance indices, respectively. We perform two estimations for all the financial development

⁸ Following the recent literature (Abadie et al., 2022; Moundigbaye et al., 2018; Reed & Ye, 2011), several estimation strategies and tests were performed. Based on the test results and the relationship between our panel length N and time T , the feasible generalized least squares with autocorrelation and heteroscedastic error structure was adopted see (Moundigbaye et al., 2018).

measures and in all regression analyses to account for country and time shocks. Each estimation controls for country-fixed effects and then both country- and time-fixed effects.

The baseline results show that FinTech penetration significantly improves financial development at the 1% level. This result remains statistically significant in both estimation strategies and all the financial development measures. Therefore, FinTech is a significant determinant of financial development in EMDEs. As expected, GDP per capita and population are also positive and significant predictors of financial development, whereas the shadow economy and inflation variables have an expected negative impact on all the financial development measures.

As shown in panels B and C of Table 3, the effect of FinTech on all financial development measures remains statistically significant under the full model estimation, which includes both indexes of financial performance (PI and EI) and financial inclusion. Thus, FinTech significantly improves financial development with and without these other determinants. Interestingly, the results also demonstrate that overall financial sector performance, especially the efficiency measure represented by EI, and financial inclusion are significant predictors of financial development in EMDEs.

4.3. Conditional effect of FinTech and financial inclusion on financial development

The second crucial question in this research deals with the effect of FinTech on financial development as mediated by

Table 3
Effect of FinTech financial development.

Panel A. (Baseline regression)						
	Broad money		Private capital		Bank deposit	
	(1)	(2)	(3)	(4)	(5)	(6)
FinT_1	0.2205*** (0.0362)	0.1582*** (0.0463)	0.3761*** (0.0459)	0.3336*** (0.0581)	0.3134*** (0.0488)	0.2388*** (0.0595)
Lgdp_1	0.2044*** (0.0080)	0.2063*** (0.0080)	0.3374*** (0.0096)	0.3368*** (0.0096)	0.2824*** (0.0102)	0.2857*** (0.0100)
Lnpop_1	0.0518*** (0.0051)	0.0507*** (0.0050)	0.1203*** (0.0059)	0.1201*** (0.0060)	0.0268*** (0.0064)	0.0276*** (0.0061)
lnInf_1	-1.5854*** (0.2186)	-1.4800*** (0.2432)	-1.6086*** (0.3204)	-1.5340*** (0.3251)	-1.4589*** (0.2959)	-1.3482*** (0.2906)
LnSE_1	-0.3883*** (0.0241)	-0.3864*** (0.0227)	-0.4748*** (0.0322)	-0.4779*** (0.0323)	-0.0634 (0.0397)	-0.0529 (0.0387)
_cons	9.8966*** (1.0618)	9.3874*** (1.1691)	7.6365*** (1.5073)	7.2821*** (1.5217)	7.6030*** (1.3835)	7.0072*** (1.3582)
Observations	513		513		513	
F-stat	69.7839		9.7030		5.2310	
Adj R ²	0.3461		0.3449		0.1950	
RMSE	0.4576		0.1201		0.0883	
Panel A. full model with profitability index (PI)						
	Broad money		Private capital		Bank deposit	
	(1)	(2)	(3)	(4)	(5)	(6)
FinT_1	0.0921** (0.0395)	0.0330* (0.0197)	0.3510*** (0.0712)	0.0227* (0.0122)	0.2347*** (0.0504)	0.1404** (0.0642)
FinI_1	0.1478** (0.0697)	0.0968*** (0.0292)	0.2162** (0.1097)	0.3011*** (0.0347)	0.2530*** (0.0795)	0.3015*** (0.0808)
PI_1	0.0429 (0.0387)	0.0349** (0.0144)	0.1021 (0.0660)	0.0412** (0.0190)	0.1969*** (0.0515)	0.1936*** (0.0505)
Lgdp_1	0.1576*** (0.0601)	0.0953*** (0.0239)	0.3471*** (0.0134)	0.3040** (0.0298)	0.2721*** (0.0106)	0.2798*** (0.0102)
Lnpop_1	0.0390 (0.0338)	0.4695*** (0.0605)	0.0870*** (0.0082)	0.8208*** (0.0828)	0.0308*** (0.0059)	0.0314*** (0.0059)
lnInf_1	-0.1676 (0.1859)	-0.1382 (0.0874)	-2.0633*** (0.4046)	-0.3719*** (0.1374)	-2.0154*** (0.2973)	-1.8119*** (0.2914)
LnSE_1	-0.4560** (0.1956)	-0.1211 (0.1477)	-0.4278*** (0.0373)	0.5737*** (0.1445)	-0.0116 (0.0351)	0.0067 (0.0367)
_cons	4.0738** (1.6758)	-4.5107*** (1.5778)	9.8564*** (1.9132)	-14.1847*** (1.6963)	9.7766*** (1.4169)	8.6676*** (1.3905)
Observations	513		513		513	
F-stat	6.0693		9.7030		6.2670	
Adj R ²	0.2667		0.3449		0.2231	
RMSE	0.0931		0.1201		0.0824	
Panel B. full model with efficiency index (EI)						
	Broad money		Private capital		Bank deposit	
	(1)	(2)	(3)	(4)	(5)	(6)
FinT_1	0.1030** (0.0404)	0.1002* (0.0578)	0.1681*** (0.0480)	0.1942*** (0.0543)	0.1324*** (0.0445)	0.0574*** (0.0214)
FinI_1	0.1325* (0.0714)	0.1432 (0.0915)	0.1924** (0.0822)	0.0977 (0.0878)	0.4280*** (0.0764)	0.1051*** (0.0313)
EI_1	0.3732* (0.2179)	1.4094*** (0.1977)	2.0216*** (0.1743)	2.0756*** (0.1752)	1.9868*** (0.1852)	0.1027 (0.0781)
Lgdp_1	0.1235** (0.0501)	0.1881*** (0.0098)	0.3133*** (0.0089)	0.3153*** (0.0088)	0.2652*** (0.0115)	0.1967*** (0.0256)
Lnpop_1	0.0609* (0.0362)	0.0480*** (0.0061)	0.1172*** (0.0051)	0.1174*** (0.0052)	0.0350*** (0.0063)	0.4524*** (0.0832)
lnInf_1	-0.0882 (0.2126)	-1.3570*** (0.3126)	-1.1521*** (0.3221)	-1.1248*** (0.3334)	-0.9398*** (0.3505)	-0.0889 (0.1296)
LnSE_1	-0.0858 (0.2640)	-0.2925*** (0.0286)	-0.4191*** (0.0292)	-0.4298*** (0.0295)	0.0189 (0.0338)	0.4682*** (0.1407)

(continued on next page)

Table 3 (continued)

Panel B. full model with efficiency index (EI)						
	Broad money		Private capital		Bank deposit	
	(1)	(2)	(3)	(4)	(5)	(6)
_cons	1.9963 (1.9275)	7.5038*** (1.4984)	3.8805** (1.5198)	3.7711** (1.5718)	3.1262* (1.6727)	-7.5887*** (1.7901)
Observations	513		513		513	
F-stat	6.0956		9.7030		5.2310	
Adj R ²	0.2085		0.3449		0.1950	
RMSE	0.0994		0.1201		0.0883	
CFE	Yes	Yes	Yes	Yes	Yes	Yes
TFE	No	Yes	No	Yes	No	Yes

Robust and country-clustered standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

country-level financial performance and financial inclusion. We investigated this relationship by estimating Equations (6)–(8). Panels A and B of Table 4 present the estimation results for the PI and EI, respectively. In Panel A, the interaction between FinTech (FT) and performance (PI) is negative and statistically significant for the two measures of financial development (BM and PC). Thus, FinTech drives financial development (BM and PC) in countries with low financial sector profitability. Similarly, the interactions between FinTech and financial inclusion are negative and statistically significant for all measures of financial development, implying that FinTech improves financial development in economies with low financial inclusion. Panel A shows that the three-way interaction between FinTech, profitability, and financial inclusion is statistically significant for all measures of financial development.

The results in Panel B show a negative and statistically significant interaction effect between FinTech and EI only when financial development is proxied to PC. However, the interaction effects of FinTech and financial inclusion, as well as all three-way interactions, are statistically significant for all measures of financial development. As was the case with the previous results discussed, these findings imply that FinTech penetration drives financial development (BM, PC, and BD) at lower levels of financial development. Thus, FinTech drives financial development in countries with low financial sector efficiency and low financial inclusion.

Table 5 shows the marginal effect of FinTech on all three financial development measures along various percentile levels of financial performance (panels A and B) and financial inclusion indices. The results show that marginal changes in FinTech with respect to other variables are positive and significant at the lower percentile for all financial development measures. This result confirms earlier conclusions that FinTech has a strong effect on financial development at lower levels of financial performance and financial inclusion. Moreover, the marginal contour plots in Fig. 3(a)–(c) show the changes in FinTech with respect to the other levels of predictor variables. These contour plots depict the marginal effects of FinTech on all financial development measures. The contour plots are consistent with the results in Table 5 and provide compelling

evidence of the conclusion reached earlier. More specifically, Fig. 3(a)–(c) show that as financial performance indices (PI and EI) approach 1, the effect of FinTech becomes less significant. Additionally, as financial inclusion approaches 1, the effect of FinTech becomes less significant.

4.4. Robustness check

Did the choice of the model and indexing affect the validity of the results? We conducted two robustness checks to evaluate the validity of the results. Three common ways are used to check robustness in empirical research: (1) employing a similar but different estimation strategy, (2) employing similar variables that measure the same characteristics (also called instrumental variables), and (3) alternative indexing of the variables. Due to the difficulty in obtaining alternative variables (instruments) for FinTech, financial performance, and/or financial inclusion, we implemented an alternative indexing approach, which is a common practice in empirical research (Ajide, 2020; Park & Mercado, 2018). The alternative indexing employed involves standardizing the original variable used to construct the index, rather than the earlier systematic indexing used in Equations (3) and (4). The indices were standardized using the following equation:

$$\rho = \frac{\chi - \bar{\chi}}{\sigma_{\chi}} \tag{9}$$

where ρ , χ , and σ_{χ} represent the alternative index, the original variables used for measuring the indices, as described in Table 1, and the standard deviation, respectively.

Then, we re-estimated our model by using the calculated alternative indices. Table 6 presents the estimated results for the new indices. A comparison of Table 6 with our main results presented in Table 3 reveals that the main findings remain valid.

Next, we re-estimated our results using the original financial performance measures rather than indexing. Table 7 summarizes the results. Overall, the results remain the same, with minimal variations relative to the profitability measures of financial performance. For instance, all profitability

Table 4
Effect of FinTech on financial development conditional on financial inclusion and profitability index.

Panel A. Profitability index (PI)									
	Broad money			Private capital			Bank deposit		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FinT_1	0.6006*** (0.2067)	0.3072*** (0.0702)	1.1649*** (0.3347)	-0.2792*** (0.0379)	0.5310*** (0.0970)	0.8611* (0.4740)	0.4941** (0.2467)	0.5617*** (0.0825)	1.4509*** (0.4356)
Profit_1	0.5106*** (0.1976)	0.0449*** (0.0140)	0.7445*** (0.2858)	-0.2447*** (0.0327)	0.0224 (0.0175)	0.7291* (0.4187)	0.5434** (0.2358)	0.0281* (0.0156)	0.7889** (0.3887)
FinI_1	0.0960 (0.0909)	0.3212*** (0.0578)	1.0673*** (0.3064)	0.2875*** (0.0329)	0.7169*** (0.0828)	1.7876*** (0.4548)	0.3323*** (0.0816)	0.5663*** (0.0711)	1.3837*** (0.4014)
FinT_1xPI_1	-0.5443** (0.2504)		-1.1128*** (0.4076)	0.3813*** (0.0387)		-0.4953 (0.5826)	-0.4666 (0.2910)		-1.1314** (0.5271)
FinT_1xFinI_1		-0.3448*** (0.0793)	-1.4602*** (0.4065)		-0.5933*** (0.1106)	-1.5775*** (0.5944)		-0.6219*** (0.0930)	-1.7940*** (0.5127)
FinI_1x PI_1			-0.9386** (0.3665)			-1.4027*** (0.5352)			-1.0381** (0.4818)
FinT_1xFinI_1xPI_1			1.4278*** (0.4932)			1.3204* (0.7175)			1.4856** (0.6240)
lnGDP_1	0.2152*** (0.0092)	0.0929*** (0.0222)	0.0874*** (0.0233)	0.2828*** (0.0234)	0.3012*** (0.0278)	0.2699*** (0.0180)	0.2809*** (0.0101)	0.1615*** (0.0241)	0.1628*** (0.0252)
LnPOP_1	0.0444*** (0.0060)	0.4414*** (0.0558)	0.4572*** (0.0579)	0.8692*** (0.0907)	0.6869*** (0.0944)	0.8176*** (0.0814)	0.0321*** (0.0060)	0.3567*** (0.0701)	0.4144*** (0.0766)
lnInf	-1.7896*** (0.2589)	-0.2037** (0.0848)	-0.1992** (0.0887)	-0.3804*** (0.1406)	-0.3410** (0.1512)	-0.3448** (0.1377)	-2.0159*** (0.2733)	-0.1931* (0.1079)	-0.1795 (0.1104)
LnSE_1	-0.3665*** (0.0330)	-0.1864 (0.1360)	-0.1474 (0.1386)	0.4906*** (0.0959)	0.4702*** (0.1490)	0.5668*** (0.1235)	0.0296 (0.0376)	-0.0779 (0.1436)	-0.0069 (0.1497)
_cons	10.3909*** (1.2772)	-3.6315** (1.4711)	-4.5692*** (1.4971)	-14.2976*** (1.7798)	-11.8631*** (2.1137)	-14.769*** (1.5852)	9.2223*** (1.3410)	-3.4608** (1.6730)	-5.4249*** (1.7725)
Panel B. Efficiency index (EI)									
	Broad money			Private capital			Bank deposit		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FinT_1	0.7362 (0.6540)	0.2987*** (0.0679)	12.2344*** (3.6925)	3.6000** (1.4255)	0.4321*** (0.1043)	8.8997** (4.2293)	1.2504 (1.3454)	0.4990*** (0.0774)	-0.8954 (1.0370)
FP(EI)_1	1.9961*** (0.6027)	0.1936*** (0.0695)	11.0469*** (3.4882)	5.5257*** (1.3998)	0.3852*** (0.1015)	6.4059* (3.7549)	3.7012*** (1.3514)	0.1139* (0.0620)	-1.1686 (0.9213)
FinI_1	0.1273 (0.0907)	0.3065*** (0.0580)	10.0592*** (3.5909)	0.0556 (0.2344)	0.7053*** (0.0908)	4.3603 (3.6068)	0.5878*** (0.2084)	0.4924*** (0.0684)	-0.4496 (0.9348)
FinT_1xEI_1	-0.7801 (0.7907)		-14.9316*** (4.6041)	-4.1620** (1.7430)		-10.4523** (5.2819)	-1.5786 (1.6512)		1.7654 (1.2970)
FinT_1xFinI_1		-0.3386*** (0.0784)	-14.8961*** (4.6185)		-0.5554*** (0.1227)	-10.0483** (4.9801)		-0.5536*** (0.0888)	0.6910 (1.2442)
FinI_1x EI_1			-12.1905*** (4.4711)			-4.8657 (4.5288)			1.2010 (1.1735)
FinT_1xFinI_1xEI_1			18.2545*** (5.7212)			11.9098* (6.1885)			-1.5892 (1.5475)
lnGDP_1	0.1900*** (0.0101)	0.1291*** (0.0234)	0.1873*** (0.0101)	0.3010*** (0.0258)	0.1670*** (0.0272)	0.3122*** (0.0098)	0.2544*** (0.0228)	0.1971*** (0.0241)	0.1987*** (0.0249)
LnPOP_1	0.0464*** (0.0061)	0.5256*** (0.0671)	0.0517*** (0.0063)	0.0973*** (0.0144)	0.8766*** (0.1002)	0.1142*** (0.0051)	0.0437*** (0.0142)	0.4578*** (0.0721)	0.4824*** (0.0767)
lnInf	-1.3926*** (0.3105)	-0.0494 (0.1088)	-1.7474*** (0.2038)	-1.7879* (1.0012)	-0.4622*** (0.1630)	-1.2133*** (0.3631)	-0.8068 (0.8370)	-0.1296 (0.1120)	-0.0912 (0.1184)
LnSE_1	-0.2901*** (0.0292)	0.4330*** (0.1345)	-0.2993*** (0.0367)	-0.3883*** (0.1000)	0.3212** (0.1546)	-0.4355*** (0.0331)	0.0540 (0.0834)	0.4206*** (0.1466)	0.4634*** (0.1503)
_cons	7.2105*** (1.4751)	-8.4718*** (1.5744)	1.4902 (3.0068)	4.3893 (4.6165)	-13.229*** (2.2318)	0.5894 (3.2714)	0.8207 (3.8912)	-7.6526*** (1.6670)	-7.4353*** (1.9890)
Observations	503	503	503	513	513	513	513	513	513
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust and country-clustered standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

Table 5
Marginal effect of FinTech on financial performance with reference to other measures at mean, median, and other percentile levels.

Panel A. Profitability and financial inclusion index						
	Broad money		Private capital		Bank deposit	
	(PI)	(FI)	(PI)	(FI)	(PI)	(FI)
1p	0.4901*** (0.1576)	0.1860*** (0.0439)	-0.1993*** (0.0364)	0.3236*** (0.0600)	0.4345** (0.1962)	0.3447*** (0.0516)
25p	0.2670*** (0.0692)	0.0407** (0.0190)	-0.0448** (0.0176)	0.0742*** (0.0224)	0.2028** (0.0902)	0.0828*** (0.0209)
Median	0.1881*** (0.0532)	0.0064 (0.0178)	0.0099 (0.0124)	0.0153 (0.0202)	0.1209* (0.0674)	0.0209 (0.0190)
Mean	0.2054*** (0.0551)	0.0189 (0.0179)	-0.0021 (0.0134)	0.0368* (0.0203)	0.1388** (0.0708)	0.0435** (0.0192)
75p	0.1219** (0.0570)	-0.0197 (0.0192)	0.0557*** (0.0101)	-0.0293 (0.0223)	0.0521 (0.0663)	-0.0260 (0.0204)
95p	0.0649 (0.0716)	-0.0388* (0.0212)	0.0952*** (0.0109)	-0.0621** (0.0255)	-0.0070 (0.0799)	-0.0604*** (0.0229)
Observ.	434	434	444	444	444	444

Panel A. Efficiency and financial inclusion index						
	Broad money		Private capital		Bank deposit	
	(PI)	(FI)	(PI)	(FI)	(PI)	(FI)
1p	0.2932 (0.2106)	0.1811*** (0.0422)	1.2364*** (0.4494)	0.2391*** (0.0631)	0.3539 (0.4207)	0.3066*** (0.0480)
25p	0.1207* (0.0646)	0.0382** (0.0183)	0.3162** (0.1391)	0.0048 (0.0225)	0.0049 (0.1294)	0.0731*** (0.0200)
Median	0.0919 (0.0585)	0.0045 (0.0177)	0.1624 (0.1334)	-0.0506** (0.0215)	-0.0535 (0.1263)	0.0179 (0.0189)
Mean	0.1004* (0.0589)	0.0168 (0.0175)	0.2076 (0.1319)	-0.0304 (0.0211)	-0.0363 (0.1242)	0.0380** (0.0188)
75p	0.0667 (0.0646)	-0.0211 (0.0194)	0.0279 (0.1525)	-0.0925*** (0.0252)	-0.1045 (0.1462)	-0.0239 (0.0208)
95p	0.0259 (0.0902)	-0.0399* (0.0216)	-0.1898 (0.2134)	-0.1233*** (0.0294)	-0.1871 (0.2055)	-0.0546** (0.0233)
Observ.	503	503	513	513	513	513

Notes: Robust standard errors are in parentheses. ***p < .01, **p < .05, *p < .1.

performance measures, namely, ROA, ROE, and NIM, have significantly negative effects on financial development. However, consistent with our earlier results, all efficiency measures of financial performance (cost efficiency, lending efficiency, and z-score) have significantly positive effects on financial development.

5. Implications and concluding remarks

5.1. Implications of the findings

Financial development has been described as the engine of economic growth. For policymakers in EMDEs, financial sector development aimed at reducing poverty and fostering financial integration and inclusiveness is a matter of policy thrust. Although many studies have examined the drivers of financial development, with emerging innovation in FinTech and the push for financial inclusivity in many EMDEs, further research questions are noteworthy. For instance, what is the impact of recent digital FinTech on country-level financial development and to what extent does the interaction effect of FinTech and country-level financial performance and/or financial inclusion influence the pace and direction of financial development? As demonstrated earlier, previous studies have

examined related but different questions involving FinTech, financial inclusion, and country-level financial stability (Ozili, 2018; Wolbers, 2017); FinTech, financial inclusion, and income per capita (Kanga et al., 2021); financial inclusion and income inequality (Demir et al., 2020); FinTech credit and entrepreneurial growth (Hau et al., 2021); and FinTech, financial inclusion, and sustainable development (Arner et al., 2020). However, none of these studies addressed the questions raised above or established a direct link between FinTech and several financial development measures, and/or how FinTech could drive financial development through country-level financial system efficiency, profitability, and/or financial inclusion.

This study contributes to the literature by investigating the impact of recent changes in the financial ecosystems of more than 80 EMDEs on financial development. The findings show that FinTech positively drives financial development. These findings are consistent for all three financial development measures. However, the findings also demonstrate that FinTech improves financial development in countries with low financial inclusion. This finding demonstrates that FinTech is not only a collection of service innovations that leverage the existing financial infrastructure, as previously construed in the literature, but also functions as an ecosystem that provides the

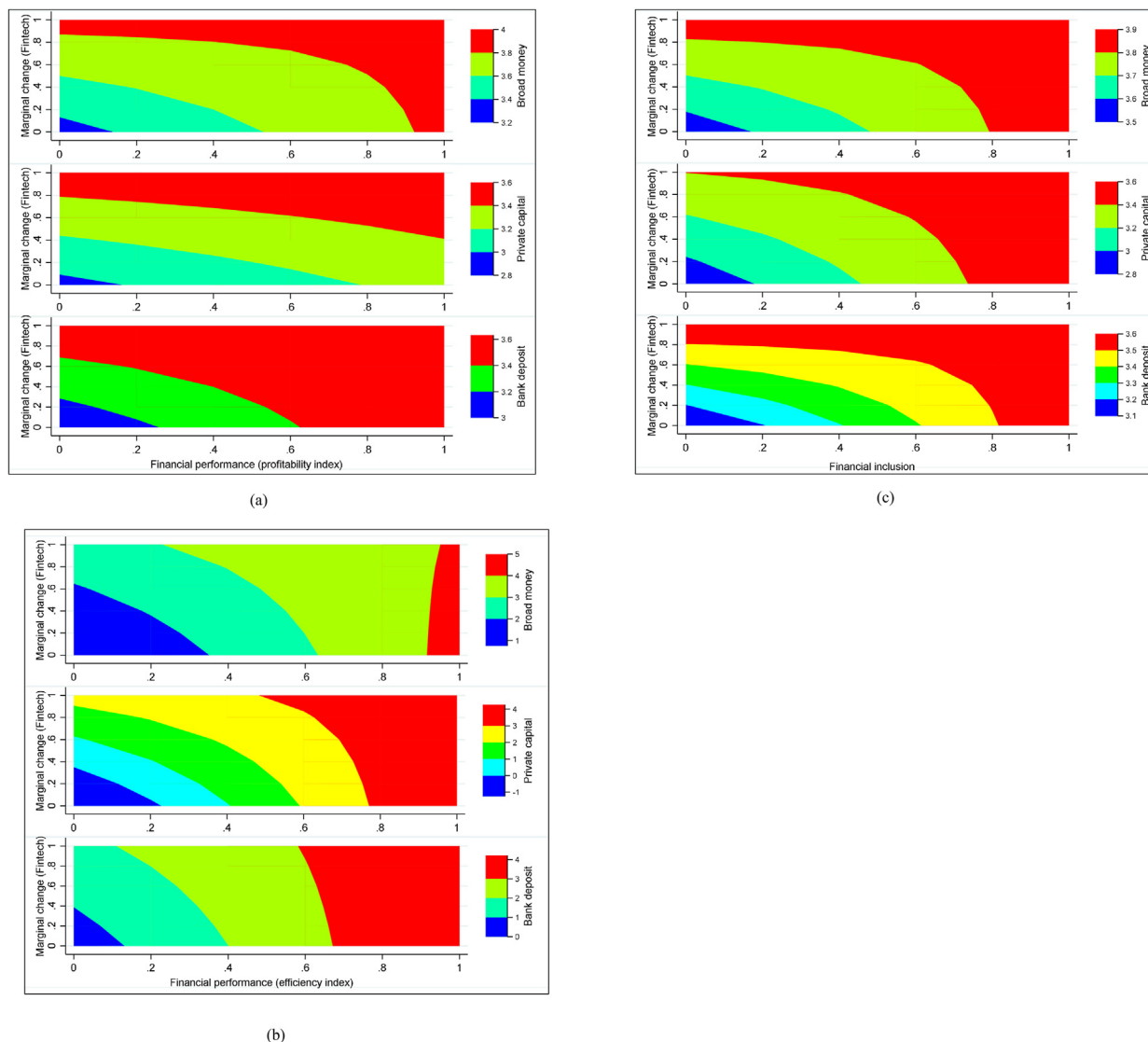


Fig. 3. (a) Marginal effect of FinTech on financial development conditioned on profitability index (PI). (b) Marginal effect of FinTech on financial development conditioned on efficiency index (EI). (c) Marginal effect of FinTech on financial development conditioned on financial inclusion (FI).

infrastructure necessary for its functioning (Galvin et al., 2018). Additionally, the results suggest that the effect of FinTech on financial development weakens at higher levels of financial inclusion. This finding demonstrates that FinTech development is an important strategy for achieving financial deepening or inclusiveness, especially in economies with a large number of financially excluded populations (Sahay et al., 2020). These findings agree with those of similar studies on how FinTech significantly improves financial inclusion, potentially leading to economic development (Demir et al., 2020; Kanga et al., 2021).

Several interesting findings emerged in terms of how country-level financial performance mediates the effect of FinTech on financial development. First, the findings demonstrate that FinTech drives financial development at lower levels of financial performance when performance is proxied by PI. Thus, FinTech could improve financial development in countries with lower financial sector profitability. Second, the

findings also show that FinTech has a strong impact on financial development at lower levels of financial performance when proxied by EI. Thus, FinTech drives financial development in countries with lower financial sector efficiency.

Additionally, the robustness checks demonstrate that FinTech improves financial development, especially in countries with stable financial systems, cost efficiency, and lending efficiency. This finding is significant and points to the diffusivity and penetration of FinTech service innovations, such as mobile lending, P2P lending, merchant lending, digital online lending, and similar service innovations, in reaching large unbanked and underbanked populations in EMDEs. Recent studies have documented similar impacts of FinTech. For instance, Basten and Ongena (2020) found that FinTech (digital banking) allows banks to extend credit, such as mortgage loans, to clients in regions with no branch networks. Similarly, Hau et al. (2021) found that FinTech credit take-up increases with distance from a local bank branch in China. Finally, a more recent

Table 6
Robustness check 1: Effect of FinTech on financial development (alternative indexing of FinT and FinI).

Panel A. (Baseline regression)			
	Broad money	Private capital	Bank deposit
	(1)	(2)	(3)
FinT_1	0.0003*** (0.0001)	0.0007*** (0.0001)	0.0016*** (0.0003)
Lgdp_1	0.1347*** (0.0224)	0.3495*** (0.0100)	0.3165*** (0.0116)
Lnpop_1	0.7612*** (0.0497)	0.1259*** (0.0058)	0.0440*** (0.0058)
lnInf_1	-0.0866 (0.0970)	-1.6488*** (0.3376)	-1.5916*** (0.2794)
LnSE_1	0.3072** (0.1278)	-0.5101*** (0.0328)	-0.0457 (0.0387)
_cons	-11.7690*** (1.3737)	7.9133*** (1.5761)	7.6365*** (1.5073)
Observations	513	513	513
F-stat	5.1552	6.3506	3.6566
Adj R ²	0.1528	0.2250	0.1715
RMSE	0.0906	0.1389	0.1017

Panel A. full model with profitability index (PI)			
	Broad money		Private capital
	(1)	(2)	(3)
FinT_1	0.0012*** (0.0003)	0.0006** (0.0002)	0.0023*** (0.0004)
FinI_1	0.0384*** (0.0126)	0.0615*** (0.0195)	0.0232* (0.0119)
PI_1	0.0706 (0.0445)	0.1291** (0.0553)	0.1453*** (0.0549)
Lgdp_1	0.2456*** (0.0097)	0.3854*** (0.0133)	0.3272*** (0.0125)
Lnpop_1	0.0460*** (0.0056)	0.0839*** (0.0083)	0.0396*** (0.0066)
lnInf_1	-1.8387*** (0.2744)	-2.1906*** (0.4015)	-2.3606*** (0.2226)
LnSE_1	-0.4051*** (0.0334)	-0.4183*** (0.0360)	-0.0439 (0.0360)
_cons	10.9703*** (1.3035)	10.5029*** (1.8857)	11.3653*** (1.1513)
Observations	513	513	513
F-stat	6.0693	4.3025	9.7030
Adj R ²	0.2667	0.2369	0.3449
RMSE	0.0931	0.0950	0.1201

Panel B. full model with efficiency index (EI)			
	Broad money		Private capital
	(1)	(2)	(3)
FinT_1	0.0003*** (0.0001)	0.0486*** (0.0117)	0.0021*** (0.0004)
FinI_1	0.0108*** (0.0034)	0.0346*** (0.0127)	0.0080 (0.0126)
EI_1	0.1783** (0.0702)	2.0701*** (0.1717)	2.2081*** (0.1995)
Lgdp_1	0.1117*** (0.0233)	0.3238*** (0.0095)	0.2979*** (0.0131)
Lnpop_1	0.6674*** (0.0531)	0.1177*** (0.0049)	0.0366*** (0.0065)
lnInf_1	-0.0607 (0.0995)	-1.1945*** (0.3286)	-0.9435** (0.3673)
LnSE_1	0.3500*** (0.1279)	-0.4398*** (0.0293)	0.0097 (0.0352)

(continued on next page)

Table 6 (continued)

Panel B. full model with efficiency index (EI)			
	Broad money		Private capital
	(1)	(2)	(3)
_cons	-10.2756*** (1.4051)	4.2697*** (1.5485)	3.0838* (1.7485)
Observations	513	513	513
F-stat	6.0956	8.4885	3.6925
Adj R ²	0.2085	0.3163	0.1949
RMSE	0.0994	0.1305	0.1003
CFE	Yes	Yes	Yes
TFE	No	Yes	No

Robust and country-clustered standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

study showed that FinTech supports financial sector development in China by enhancing loans, deposits, and savings (Muganyi et al., 2022).

5.2. Concluding remarks

This study investigates the effect of FinTech on financial development and the mediating role of supporting factors, such as country-level financial inclusion and financial performance. This important research agenda has largely been ignored in previous studies. Moreover, recent changes in the financial landscape of emerging markets necessitate the analysis of these relationships. This study questions the effects of these recent changes driven primarily by FinTech and how they interact with other financial, micro, and macroeconomic variables to drive financial development.

The findings show that FinTech drives financial development in EMDEs. Specifically, we found that FinTech drives financial development in countries with low financial inclusion and weak financial sector performance. These findings are significant and point to the role of FinTech service innovations, namely, mobile lending, P2P lending, digital merchant lending, and similar digital service innovations, in improving the financial access of unbanked, underbanked, financially excluded, and vulnerable groups. These findings contribute to the literature in at least two unique ways: First, we showed a direct positive link between FinTech penetration and all financial development measures. Second, we demonstrated that this effect also depends on country-level financial performance and/or financial inclusion.

Specifically, this study found the following.

- a) FinTech drives financial development, especially in countries with low levels of financial inclusion. Moreover, in addition to leveraging the existing infrastructure, FinTech could serve as a complete ecosystem that drives financial integration and subsequently improves financial development.
- b) FinTech improves financial development in countries with weak financial sector performance. However, the effect of FinTech on financial development is less strong in countries with stronger financial sector performance, such as

Table 7

Robustness check 2: Effect of FinTech on financial development (conditioned on unindexed financial performance).

Panel A. Profitability measure											
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(7)	(1)	(2)	(3)
	Broad money	Private capital	Bank deposit	Zsc_1	Broad money	Private capital	Bank deposit	VA_eff_1	Broad money	Private capital	Bank deposit
ROA				ROE				NIM			
FinT_1	0.1459*** (0.0476)	0.2631*** (0.0664)	0.0635*** (0.0232)	FinT	0.1672*** (0.0452)	0.2768*** (0.0605)	0.1937*** (0.0531)	FinT	0.1919*** (0.0544)	0.2176*** (0.0755)	0.1137** (0.0499)
FinL_1	0.1626* (0.0864)	0.1824* (0.1101)	0.1169*** (0.0350)	FinI	0.1438* (0.0772)	0.1809* (0.1079)	0.2569*** (0.0779)	FinI	0.2888*** (0.0880)	0.2441* (0.1255)	0.2439*** (0.0812)
ROA_1	-0.0539*** (0.0062)	-0.0734*** (0.0103)	0.0033 (0.0035)	ROE_1	-0.0083*** (0.0009)	-0.0129*** (0.0015)	-0.0032** (0.0015)	NIM_1	-0.1098*** (0.0048)	-0.1152*** (0.0065)	-0.1087*** (0.0046)
lnGDP_1	0.1856*** (0.0101)	0.3415*** (0.0128)	0.1773*** (0.0272)	lnGDP_1	0.1994*** (0.0099)	0.3532*** (0.0122)	0.2693*** (0.0116)	lnGDP_1	0.1031*** (0.0105)	0.2331*** (0.0139)	0.1668*** (0.0102)
LnPOP_1	0.0394*** (0.0053)	0.0690*** (0.0079)	0.3619*** (0.0849)	LnPOP_1	0.0430*** (0.0057)	0.0687*** (0.0074)	0.0247*** (0.0064)	LnPOP_1	0.0013 (0.0055)	0.0092 (0.0073)	-0.0074 (0.0055)
lnInf	-1.4608*** (0.2862)	-1.8062*** (0.3806)	-0.1628 (0.1254)	lnInf	-1.6342*** (0.2652)	-2.3445*** (0.3536)	-2.1676*** (0.2875)	lnInf	-1.5332*** (0.2851)	-1.3645*** (0.3399)	-0.7109*** (0.2752)
LnSE_1	-0.3687*** (0.0276)	-0.3805*** (0.0343)	0.1632 (0.1643)	LnSE_1	-0.3711*** (0.0286)	-0.3746*** (0.0309)	0.0341 (0.0362)	LnSE_1	-0.2017*** (0.0271)	-0.3163*** (0.0335)	0.1307*** (0.0272)
_cons	9.6844*** (1.3730)	9.1725*** (0.2631***)	-4.3004** (1.9357)	_cons	10.3278*** (1.2668)	11.5902*** (1.6574)	10.6717*** (1.3790)	_cons	11.5278*** (0.1919***)	9.6334*** (1.5703)	5.5443*** (1.2852)
Panel B. Robust regression (corrected for AHCD)											
	(1)	(2)	(3)		(1)	(2)	(3)		(1)	(2)	(3)
	Broad money	Private capital	Bank deposit		Broad money	Private capital	Bank deposit		Broad money	Private capital	Bank deposit
Zscore				Cost efficiency				Lending efficiency			
FinT_1	0.1717*** (0.0472)	0.3328*** (0.0678)	0.1896*** (0.0507)	FinT	0.0448** (0.0183)	0.2773*** (0.0472)	0.0815*** (0.0212)	FinT	0.0828 (0.0515)	0.1833*** (0.0411)	0.0462** (0.0196)
FinL_1	0.0586 (0.0893)	0.1890* (0.1112)	0.3167*** (0.0809)	FinI	0.0714*** (0.0268)	0.1996** (0.0812)	0.0780*** (0.0297)	FinI	0.2470*** (0.0874)	0.3564*** (0.0770)	0.1009*** (0.0275)
zscore_1	0.3026*** (0.0817)	0.2461** (0.1237)	0.2707*** (0.0886)	Ceff_1	0.5271*** (0.1024)	1.2266*** (0.1512)	0.7151*** (0.1116)	Leff	1.1815*** (0.3195)	1.7781*** (0.2728)	0.6931*** (0.0976)
lnGDP_1	0.2127*** (0.0090)	0.3500*** (0.0130)	0.2732*** (0.0114)	lnGDP_1	0.0914*** (0.0266)	0.3070*** (0.0105)	0.1425*** (0.0269)	lnGDP_1	0.1947*** (0.0087)	0.3258*** (0.0089)	0.1708*** (0.0252)
LnPOP_1	0.0471*** (0.0058)	0.0863*** (0.0081)	0.0322*** (0.0061)	LnPOP_1	0.6433*** (0.0700)	0.1261*** (0.0050)	0.5533*** (0.0816)	LnPOP_1	0.0438*** (0.0058)	0.1081*** (0.0066)	0.3110*** (0.0834)
lnInf	-2.0540*** (0.1923)	-1.9734*** (0.3991)	-1.7656*** (0.3307)	lnInf	-0.0508 (0.1060)	-1.3787*** (0.3192)	-0.0481 (0.1137)	lnInf	-1.5188*** (0.2999)	-1.4416*** (0.2774)	-0.1444 (0.1190)
LnSE_1	-0.3731*** (0.0320)	-0.4099*** (0.0368)	0.0020 (0.0357)	LnSE_1	0.3580*** (0.1387)	-0.4624*** (0.0357)	0.2883** (0.1185)	LnSE_1	-0.3776*** (0.0256)	-0.4500*** (0.0362)	0.5457*** (0.1364)
_cons	11.7935*** (0.9605)	9.2506*** (1.8975)	8.4228*** (1.5809)	_cons	-10.0479*** (1.6164)	5.7690*** (1.5443)	-8.9348*** (1.6665)	_cons	8.5249*** (1.4612)	5.1995*** (1.3688)	-5.3628*** (1.7811)
Observations	538	538	538		538	538	538		538	538	538
R-squared	3.9710	8.2963	3.8256	0.5150	4.6150	11.3435	4.5686		4.8085	7.1397	3.7823
F-stat	0.1745	0.2053	0.1500	166.7392	0.2162	0.3921	0.1772		0.2334	0.2786	0.2029
RMSE	0.0942	0.1317	0.0840	0.1106	0.1012	0.1257	0.0894		0.0978	0.1278	0.0984

Robust and country-clustered standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

those with higher cost/lending efficiency and financial sector stability.

Based on these findings, we conclude that beyond the individual financial, micro, and macroeconomic drivers of financial development in emerging markets, policymakers should pay attention to the marginal impact of these drivers of financial development, which could provide crucial inputs for future policy formulation.

This study has certain limitations. A major limitation of this study is that IMF surveys on FinTech measures were only available for 4 years (2011, 2014, 2017, and 2021). Although the period could be considered sufficient to reflect advances in FinTech and when used with a large country sample, as was the case in this study, could provide robust results, the data count is considerably limited for economic modeling. Therefore, future research should consider alternative FinTech measures for longer periods.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Methodology for country-level financial efficiency measure

With regard to financial efficiency, we identify three measures: zscore, cost efficiency, and lending efficiency. We estimate the zscore as follows:

$$zscore = \frac{ROA + EQT}{\sigma(ROA)} \tag{A.1}$$

where ROA and EQT denote the years moving averages of returns on total assets and the equity-to-asset ratio, respectively. σ represents the standard deviation of returns on total assets during the same period. Since the z-score represents a financial institution's distance from insolvency, a higher z-score indicates greater banking stability.

Cost efficiency was estimated using the stochastic frontier analysis (SFA) approach. Empirical studies suggest that SFA is better suited for efficiency estimation because it allows measurement errors in the data structure and provides firm-specific efficiency estimates (Yamori et al., 2017). Therefore, with the usual linear homogeneity restriction in input prices, we apply the standard *trans-log* function to estimate *cost efficiency* as.

$$\begin{aligned} \ln\left(\frac{C_{it}}{P_{lit}}\right) &= \theta_0 + \sum_j \theta_j \ln Y_{jit} + \sum_{k \neq 1} \beta_k \ln\left(\frac{P_{kit}}{P_{lit}}\right) + \tau_1 T \\ &+ \frac{1}{2} \sum_j \sum_m \theta_{jm} \ln Y_{jit} \ln Y_{mit} + \frac{1}{2} \sum_{k \neq 1} \sum_{n \neq 1} \beta_{kn} \ln\left(\frac{P_{kit}}{P_{lit}}\right) \ln\left(\frac{P_{nit}}{P_{lit}}\right) \\ &+ \frac{1}{2} \tau_2 T^2 + \sum_j \sum_{j \neq k} \varphi_{jk} \ln Y_{ijk} \ln\left(\frac{P_{kit}}{P_{lit}}\right) + v_{it} + u_{it} \end{aligned} \tag{A.2}$$

Where $\theta_{jm} = \theta_{mj}$ for all j and m , and $\beta_{kn} = \beta_{nk}$ for all k and n . C_{it} denotes the total observed cost. p_i ($i = 1, 2, 3$) are the three input prices: labor, deposit, and capital. Y_j ($j = 1, 2$) are two outputs: total loans and total security investment. T denotes time trend. θ, β, τ , and φ are parameters to be estimated. v_{it} is a standard statistical error term independently and identically distributed as $N(0, \sigma_v^2)$, and u_{it} is a non-negative error term representing technical inefficiency. Regarding the a priori distributional assumptions for the inefficiency term, we employ half-normal and exponential distributions.

The lending efficiency score is estimated using the learning curve model. The learning curve captures cost reduction in the unit of production or service as the overall production/service doubles. Moreover, it has been shown that the information-intensive process of asset transformation in financial institutions generates knowledge (learning) that reduces the cost of input (Aduba & Izawa, 2021). We use the financial institutions' indirectly measured service (FISIM), defined as the spread between loan interest rate and deposit interest rate relative to the market spread rate, as the most suitable output to capture lending efficiency. We then apply the learning curve model in (A.3) to extract lending efficiency scores.

$$\ln \eta_{it} = \omega + \beta_\varnothing \ln \widehat{\omega}_{t-1i} + \sum_s \beta_s \ln w_{siti} + \beta_c \text{controls} + \varepsilon_{it} \tag{A.3}$$

Where $\eta_{it} = \left(\frac{C_{it}}{\varnothing_{it}}\right)$ is the cost required to produce an additional unit of output. $\widehat{\omega}_{t-1i}$ is the lagged cumulative output produced through time t , proxied for output learning (efficiency). Efficiency is measured by a significant negative coefficient of experience term (β_\varnothing). w_{siti} are input prices.

The cubic form of (A.3) can be derived as shown in (A.4).⁹

$$\begin{aligned} \ln \eta_{it} &= \omega + \beta_{\varnothing 1} \ln(\widehat{\omega}_{t-1i}) + \beta_{\varnothing 2} \ln(\widehat{\omega}_{t-1i})^2 + \beta_{\varnothing 3} \\ &\ln(\widehat{\omega}_{t-1i})^3 + \sum_s (\beta_s) \ln w_{siti} + \beta_c \text{controls} + \varepsilon_{it} \end{aligned} \tag{A.4}$$

The first derivative of (A.4) with respect to $\ln(\widehat{\omega}_{t-1i})$ yields (A.5) and provides a means to extract the annual country-level lending efficiency score.

$$\delta_{t,i} = \frac{\partial(\ln \Gamma_{t,i})}{\partial \widehat{\omega}_{t-1,i}} = \widehat{\beta}_{\varnothing 1} + 2 \cdot \widehat{\beta}_{\varnothing 2} \cdot \ln(\widehat{\omega}_{t-1i}) + 3 \cdot \widehat{\beta}_{\varnothing 3} \cdot (\ln \widehat{\omega}_{t-1i})^2 \tag{A.5}$$

⁹ The cubic learning function is especially important for estimating the dynamic annual learning rates (Aduba & Asgari, 2020; Badiru, 1992; Karaoz & Albeni, 2005).

Appendix B. Cost efficiency estimation: different distributional assumption and specifications

	(1)	(2)	(3)	(4)	(5)	(6)
	lcn	lcn	lcn	lcn	lcn	lcn
lya	.9327*** (.0226)	.939*** (.0224)	.9548*** (.0225)	.962*** (.0222)	.0681** (.0344)	.0611* (.0341)
lp1n	.0035 (.1058)	.014 (.1097)	.0248 (.1072)	.0224 (.1112)	.0163 (.0285)	.0314 (.0286)
lp2n	.7231*** (.1124)	.7353*** (.1139)	.7021*** (.1138)	.7297*** (.1154)	.5723*** (.0306)	.5546*** (.0307)
lya2	.0161 (.01)	.0203** (.0098)	.0157 (.01)	.0206** (.0098)	-.0586*** (.0136)	-.0633*** (.0137)
lp11n	-.0196 (.0324)	-.0257 (.0335)	-.0262 (.0328)	-.0322 (.0348)	.0375* (.0196)	.0335* (.0196)
lp12n	.3002*** (.0837)	.3034*** (.0859)	.3618*** (.0832)	.3577*** (.0872)	.0245 (.0411)	.0502 (.041)
lp22n	.1834*** (.0447)	.184*** (.0444)	.1617*** (.0452)	.1664*** (.0447)	.0166 (.0133)	-.014 (.0134)
lyp11n	-.0029 (.0258)	-.0005 (.0264)	-.0066 (.026)	-.0063 (.0265)	-.0329*** (.007)	-.0269*** (.0069)
lyp12n	.0353 (.0285)	.0376 (.029)	.0339 (.0289)	.0398 (.0292)	.0438*** (.0078)	.0381*** (.0078)
tm	.1081*** (.0313)	.1142*** (.0309)			.1561*** (.01)	
tm2	-.0056 (.0047)	-.0068 (.0047)			-.0047*** (.0012)	
_cons	21.5489*** (.1625)	21.5849*** (.1058)	21.463*** (.1764)	21.5101*** (.1456)	24.9564*** (.2592)	25.2014*** (.3002)
lnsig2v: _cons	-.8013*** (.1325)	-.8795*** (.0845)	-.8669*** (.1224)	-.9271*** (.0829)		
lnsig2u: _cons	-1.3933** (.6289)	-2.1172*** (.2839)	-1.1578*** (.4337)	-2.0082*** (.2485)		
lnsigma2: _cons					1.182*** (.1764)	1.2638*** (.1751)
lgtgamma: _cons					4.567*** (.1887)	4.6732*** (.187)
mu: _cons					5.0913*** (.3525)	5.3572*** (.3892)
eta: _cons					-.0059*** (.0012)	-.0042*** (.0012)
Observations	804	804	804	804	804	804

Standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

Appendix C. value-added efficiency estimation using learning curve model.

	(2)	(4)
	IYF	IYF
lp1	-0.2229*** (0.0327)	-0.2164*** (0.0319)
lp2	0.4562*** (0.0263)	0.4524*** (0.0256)
lp3	0.2515*** (0.0256)	0.2504*** (0.0278)
lnpl	0.0090 (0.0184)	0.0055 (0.0175)
IGDP	0.3992*** (0.0476)	0.4116*** (0.0421)
las	0.2235*** (0.0482)	0.2744*** (0.0528)
lcqF	0.1004*** (0.0143)	0.1732 (0.7927)
lcqF_2		0.0031 (0.0370)
lcqF_3		-0.0002 (0.0006)

(continued on next page)

(continued)

	(2)	(4)
	IYF	IYF
_cons	9.2160*** (1.0815)	6.4978 (6.1079)
Observations	715	715
F-stat	36.9606	64.5565
Adj R ²	0.1322	0.1687
RMSE	0.3214	0.3142

Standard errors are in parentheses.

***p < .01, **p < .05, *p < .1.

Appendix D. List of countries and summary of major variables in the study

Economy	Code	Broad money	Private credit	Bank deposit	PI	EI	FinT	FinI	zscore	Cost eff.	Lending eff.	NIM (%)	ROA (%)	ROE (%)	GDPk	Pop. (million)	Inflation	Shadow Eco
Afghanistan	AFG	35.131	3.976	18.295	0.532	0.797	0.449	0.750	18.077	0.645	0.823	4.975	0.715	6.747	567.368	33.773	4.954	48.890
Albania	ALB	82.954	35.493	66.472	0.717	0.911	0.472	0.769	21.650	0.520	0.940	3.808	0.843	6.035	4573.483	2.881	2.082	33.403
Algeria	DZA	75.322	19.057	46.325	0.788	0.845	0.451	0.726	20.947	0.730	0.985	3.251	1.854	13.228	4678.066	38.998	4.949	31.911
Angola	AGO	35.249	21.381	32.526	0.648	0.810	0.514	0.684	9.167	0.610	0.978	5.371	2.347	19.961	4703.651	25.861	9.991	43.726
Antigua	ATG	90.404	48.115	85.808	0.671	0.566	0.435	0.489	10.989	0.528	0.637	4.351	1.440	11.493	15,486.106	0.096	1.029	39.482
Bangladesh	BGD	58.807	44.393	48.997	0.555	0.803	0.574	0.709	15.749	0.620	0.993	3.225	1.767	11.380	1357.489	157.100	6.637	34.911
Bolivia	BOL	85.760	52.058	58.981	0.792	0.816	0.601	0.361	10.533	0.638	0.963	5.474	1.582	14.111	2963.570	10.866	3.997	63.107
Bosnia	BIH	69.485	54.073	57.647	0.652	0.851	0.601	0.389	17.629	0.683	0.960	4.059	0.783	5.293	5481.100	3.387	-0.234	32.062
Botswana	BWA	45.278	34.283	43.896	0.694	0.826	0.560	0.771	8.678	0.653	0.946	5.542	2.586	20.950	7062.719	2.176	3.879	30.286
Brunei	BRN	76.807	35.114	71.303	0.567	0.816	0.413	0.680	13.148	0.741	0.913	4.575	1.680	12.933	35,831.369	0.417	0.098	32.120
Burundi	BDI	25.963	18.198	20.382	0.640	0.789	0.606	0.801	14.626	0.655	0.856	7.551	2.623	15.661	260.993	9.717	9.218	39.373
Cent. Afr. Rep.	CAF	23.379	11.182	10.943	0.677	0.751	0.350	0.655	13.520	0.654	0.868	5.432	1.918	13.709	461.627	4.547	4.235	42.241
Cambodia	KHM	75.590	73.293	67.022	0.774	0.830	0.442	0.341	26.802	0.657	0.924	6.192	2.558	11.951	1203.841	15.517	3.064	46.052
Cameroon	CMR	19.289	13.108	15.542	0.716	0.754	0.526	0.591	10.064	0.516	0.924	4.541	1.953	15.148	1479.420	23.357	1.910	31.573
Chad	TCD	14.386	7.500	7.503	0.548	0.769	0.476	0.628	10.348	0.662	0.862	7.098	2.264	15.191	825.012	14.138	1.744	43.772
Chile	CHL	80.645	78.361	51.340	0.744	0.821	0.409	0.690	8.471	0.665	0.937	3.781	1.382	13.154	13,881.482	18.043	2.966	18.547
Colombia	COL	46.728	44.170	23.484	0.769	0.808	0.635	0.718	5.944	0.634	0.944	5.770	2.249	12.740	6587.160	47.810	3.625	34.991
Comoros	COM	21.357	11.331	15.795	0.694	0.643	0.630	0.764	8.707	0.660	0.605	5.298	1.962	14.058	1418.284	0.715	1.804	38.095
Congo	COD	11.513	5.221	8.933	0.685	0.750	0.493	0.539	9.866	0.661	0.747	8.604	1.195	4.785	437.013	71.500	5.403	46.508
Costa	CRI	49.498	52.960	26.640	0.806	0.819	0.500	0.718	19.682	0.621	0.988	5.359	1.271	7.867	10,463.487	4.843	2.931	25.469
Djibouti	DJI	69.927	20.904	58.664	0.615	0.779	0.537	0.471	14.136	0.699	0.813	3.707	1.442	15.702	2743.777	0.929	1.720	36.266
Dominican	DOM	33.540	23.800	21.227	0.868	0.788	0.432	0.583	33.871	0.568	0.990	9.450	2.293	17.972	6401.448	10.164	3.661	30.687
Equatorial	GNQ	12.644	10.412	10.473	0.743	0.772	0.554	0.495	19.389	0.672	0.893	6.780	1.550	11.582	14,199.715	1.170	3.155	32.747
Eswatini	SWZ	26.674	20.663	25.194	0.825	0.798	0.464	0.655	24.336	0.651	0.884	6.454	3.906	19.507	3989.972	1.103	5.729	39.449
Ethiopia	ETH	35.696	18.944	28.890	0.892	0.797	0.497	0.551	10.398	0.571	0.958	4.941	2.662	20.416	798.603	109.200	13.443	34.293
Fiji	FJI	71.006	61.269	62.803	0.913	0.813	0.476	0.484	28.340	0.705	0.927	3.405	2.072	14.048	5019.061	0.871	3.226	32.031
Gabon	GAB	22.656	12.180	18.351	0.577	0.756	0.543	0.686	15.967	0.624	0.917	5.727	2.524	14.016	8456.981	1.936	2.126	51.218
Gambia	GMB	36.990	8.558	30.239	0.792	0.734	0.544	0.504	13.737	0.485	0.927	8.717	3.809	23.000	747.328	2.061	6.146	47.386
Georgia	GEO	40.363	47.186	33.667	0.681	0.795	0.485	0.698	8.297	0.731	0.889	7.693	2.593	14.458	4100.616	3.733	3.828	63.737
Ghana	GHA	26.900	15.394	24.735	0.765	0.785	0.343	0.558	13.415	0.519	0.978	10.546	4.577	22.412	1818.291	27.882	11.784	38.836
Grenada	GRD	86.380	53.905	81.971	0.704	0.640	0.555	0.258	12.854	0.656	0.634	8.171	3.376	18.472	9905.583	0.111	0.451	50.294
Guatemala	GTM	50.470	31.999	42.650	0.830	0.832	0.670	0.725	30.307	0.624	0.980	6.175	1.862	16.797	3811.021	15.564	3.959	51.289
Guinea	GIN	23.688	9.783	17.133	0.801	0.758	0.604	0.816	25.984	0.564	0.844	9.863	3.404	21.600	890.082	11.950	9.596	38.338
Honduras	HND	52.432	51.142	46.822	0.798	0.777	0.576	0.606	30.312	0.572	0.971	8.180	2.117	12.653	2020.576	8.718	5.184	48.340
India	IND	77.764	52.583	68.987	0.610	0.796	0.559	0.686	16.935	0.633	0.902	3.008	0.772	7.276	1660.746	1317.000	6.255	20.467
Indonesia	IDN	39.245	31.248	34.955	0.801	0.771	0.512	0.688	4.805	0.588	0.909	5.805	2.543	15.252	3433.398	258.100	4.493	18.654
Iraq	IRQ	40.836	9.204	22.358	0.730	0.831	0.487	0.471	17.601	0.701	0.941	2.381	1.522	5.798	5224.182	37.496	0.460	31.450
Jordan	JOR	109.445	73.003	94.904	0.886	0.863	0.524	0.649	55.438	0.664	0.979	3.614	1.629	8.028	4219.784	9.643	1.533	17.926
Kitts & Nevis	KNA	122.073	50.821	115.072	0.757	0.568	0.397	0.341	23.695	0.662	0.449	3.702	1.616	9.089	19,834.464	0.052	-0.805	22.124
Kazakhstan	KAZ	35.568	30.359	29.755	0.478	0.709	0.455	0.614	2.905	0.679	0.993	5.103	3.599	13.215	10,125.613	17.538	7.286	38.425
Kenya	KEN	38.951	30.740	35.371	0.835	0.811	0.589	0.649	23.055	0.616	0.982	8.224	4.542	20.387	1328.129	46.702	7.281	30.830
Kosovo	XKX	43.756	36.669	42.182	0.739	0.793	0.529	0.786	26.273	0.694	0.919	5.161	2.847	12.680	3693.614	1.795	1.974	27.326
Kyrgyz	KGZ	34.604	19.490	18.515	0.586	0.782	0.555	0.767	16.329	0.616	0.884	9.416	2.611	14.284	1189.941	5.974	5.508	37.674
St. Lucia	LCA	69.664	62.583	66.485	0.869	0.675	0.735	0.272	2.913	0.634	0.733	3.291	1.512	22.121	10,539.993	0.181	-0.540	33.564
Lesotho	LSO	36.309	18.209	32.601	0.796	0.748	0.554	0.795	18.841	0.624	0.807	8.176	3.939	26.427	1110.176	2.063	4.906	29.647
Madagascar	MDG	23.469	11.580	16.133	0.805	0.782	0.356	0.556	15.491	0.637	0.917	7.017	3.481	26.854	505.701	24.310	6.982	43.099
Malawi	MWI	23.730	8.011	14.185	0.828	0.799	0.457	0.682	16.276	0.582	0.888	11.165	5.170	21.276	495.962	17.920	14.256	37.750

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Economy	Code	Broad money	Private credit	Bank deposit	PI	EI	FinT	FinI	zscore	Cost eff.	Lending eff.	NIM (%)	ROA (%)	ROE (%)	GDPk	Pop. (million)	Inflation	Shadow Eco
Malaysia	MYS	131.550	118.828	122.286	0.477	0.828	0.579	0.841	19.106	0.681	0.947	2.497	1.682	13.163	10,120.862	30.288	1.835	30.543
Maldives	MDV	47.935	30.505	43.405	0.821	0.814	0.432	0.673	18.105	0.733	0.873	7.338	4.865	14.473	8808.723	0.474	2.200	29.629
Mauritius	MUS	111.181	93.993	101.640	0.666	0.886	0.564	0.797	16.802	0.817	0.913	2.832	1.581	9.416	9496.502	1.261	2.927	21.543
Moldova	MDA	45.714	25.515	33.752	0.658	0.835	0.576	0.626	9.007	0.753	0.896	5.385	1.768	9.383	3280.590	2.789	5.787	41.294
Montenegro	MNE	53.795	53.254	53.459	0.529	0.796	0.527	0.662	8.464	0.660	0.951	4.312	0.371	2.576	7386.520	0.621	1.465	30.752
Mozambique	MOZ	47.457	26.820	42.736	0.699	0.768	0.618	0.652	6.024	0.549	0.949	7.555	2.749	15.084	546.887	27.890	7.085	38.622
Namibia	NAM	59.844	52.763	58.255	0.799	0.863	0.465	0.609	24.877	0.770	0.899	4.793	3.467	19.565	5235.828	2.322	4.913	29.568
Nepal	NPL	98.772	76.168	85.654	0.847	0.846	0.546	0.637	32.808	0.731	0.922	4.088	2.519	15.927	4112.456	28.147	5.420	35.635
Nicaragua	NIC	36.795	30.853	33.378	0.814	0.786	0.493	0.573	20.066	0.660	0.947	7.615	2.945	17.914	1828.659	6.224	5.389	44.108
Nigeria	NGA	24.374	11.852	17.514	0.629	0.849	0.544	0.652	16.364	0.696	0.992	7.548	2.111	15.039	2412.033	181.500	11.588	55.553
Macedonia	MKD	55.277	48.572	49.628	0.713	0.836	0.565	0.810	10.318	0.703	0.940	4.215	1.268	9.206	5240.375	2.068	1.406	34.996
Pakistan	PAK	52.070	16.744	33.630	0.784	0.790	0.622	0.789	10.959	0.577	0.988	3.754	1.755	13.271	1326.218	205.900	6.332	34.815
Panama	PAN	42.129	77.267	67.231	0.872	0.921	0.571	-0.670	36.644	0.659	0.986	3.297	1.410	12.240	11,886.762	3.973	2.030	57.795
Papua	PNG	33.066	17.109	30.227	0.944	0.798	0.518	0.489	13.409	0.656	0.931	6.716	6.379	33.103	2489.230	8.118	5.131	34.450
Peru	PER	44.558	36.877	36.407	0.810	0.816	0.588	0.660	17.302	0.658	0.963	6.241	2.668	18.766	6378.833	30.725	2.764	55.978
Philippines	PHL	69.991	39.876	61.192	0.828	0.843	0.559	0.683	21.162	0.686	0.982	3.662	1.534	11.552	2861.001	102.000	2.963	39.047
Russian	RUS	56.349	49.703	46.117	0.685	0.766	0.584	0.640	6.912	0.580	0.874	4.215	1.491	9.207	11,540.209	143.800	6.803	43.221
Rwanda	RWA	18.843	17.337	16.579	0.799	0.783	0.457	0.713	20.198	0.623	0.906	9.017	2.407	10.175	694.992	11.122	4.339	36.145
Samoa	WSM	52.300	48.914	47.430	0.780	0.745	0.508	0.636	16.393	0.709	0.806	5.784	2.025	12.425	4219.754	0.196	2.059	43.598
Seychelles	SYC	70.890	28.605	68.178	0.789	0.801	0.432	0.560	14.631	0.752	0.783	5.112	3.401	24.491	13,575.448	0.093	2.993	40.503
Solomon	SLB	38.296	18.019	31.554	0.763	0.727	0.420	0.588	14.534	0.688	0.769	6.032	2.331	14.074	2176.399	0.605	3.032	31.953
South	ZAF	67.316	61.494	55.554	0.836	0.885	0.524	0.672	15.230	0.803	0.987	3.151	1.387	13.807	6962.680	55.323	4.988	27.772
Sri lanka	LKA	52.108	36.820	43.508	0.759	0.823	0.486	0.785	36.192	0.558	0.996	4.210	1.961	15.897	3738.019	21.120	5.160	40.414
Tajikistan	TJK	19.738	15.016	10.485	0.553	0.704	0.521	0.620	11.412	0.575	0.837	6.401	1.353	4.798	943.726	7.882	7.164	40.602
Tanzania	TZA	22.125	12.812	17.817	0.761	0.836	0.464	0.736	18.363	0.704	0.933	8.006	2.193	11.518	956.155	51.706	6.839	54.757
Thailand	THA	122.481	110.428	112.110	0.853	0.820	0.572	0.756	7.612	0.702	0.927	2.956	1.458	9.987	5989.984	68.626	1.366	49.022
Tonga	TON	52.355	35.260	46.269	0.732	0.743	0.411	0.543	18.395	0.734	0.757	5.393	1.741	10.550	4515.584	0.103	2.149	46.199
Trinidad	TTO	62.646	34.597	57.542	0.556	0.841	0.594	0.616	20.290	0.792	0.928	5.156	1.392	6.945	17,749.784	1.367	4.366	32.747
Turkiye	TUR	54.347	58.417	49.700	0.713	0.840	0.570	0.593	10.871	0.730	0.956	4.265	1.837	12.953	10,644.556	78.469	10.060	31.157
Uganda	UGA	18.950	12.091	15.513	0.727	0.792	0.500	0.641	14.631	0.604	0.951	9.769	3.614	16.712	779.632	38.623	5.958	40.039
Ukraine	UKR	48.161	43.616	35.069	0.348	0.695	0.519	0.530	5.362	0.517	0.942	6.632	1.438	8.330	3184.176	45.097	11.668	47.101
United	ARE	82.640	72.734	78.809	0.837	0.935	0.505	0.784	25.218	0.661	0.919	2.923	1.604	11.363	39,377.371	9.314	1.143	28.100
Uruguay	URY	47.232	24.573	42.352	0.637	0.688	0.326	0.691	6.835	0.402	0.976	5.897	2.153	15.318	13,971.702	3.415	8.022	47.673
St. Vin. & Gren.	VCT	72.057	46.277	67.039	0.637	0.571	0.595	0.216	13.011	0.585	0.565	6.305	2.202	12.931	7218.141	0.110	0.480	40.728
Vanuatu	VUT	81.841	70.353	74.323	0.615	0.750	0.407	0.529	12.606	0.685	0.840	5.439	1.849	11.985	2934.473	0.260	1.706	40.901
Vietnam	VNM	106.072	114.616	15.809	0.703	0.787	0.573	0.589	14.573	0.609	0.981	3.254	1.173	11.176	1898.862	92.203	6.081	14.410

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