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Article

What are the effects of ICT diffusion on stock market in emerging countries?

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Abstract: Given the importance of Information Communication Technology (ICT) in stimulating stock market development, many researchers have investigated their influences on the developed markets and high-income economies. The aim of this study is to examine the impact of ICT diffusion on stock market development for a panel of 17 selected emerging countries over the period 1990–2020 and employed the system-generalized method of moments (S-GMM) to test its objective. Three stock market development indicators are also used, namely: stock market capitalization (SMC), stock market total value traded (SMTT), and stock market turnover (SMT). Three ICT indicators are also employed, namely: Fixed telephone subscriptions (FTS), Individuals using the Internet (IUI), and Mobile cellular subscriptions (MCS). Three financial development indicators (deposit money among bank assets (DMB), liquid liabilities (LLB), and private credit by deposit money bank (PCM)) were employed as control variables. In its findings, all selected ICT dynamics positively affect stock market development and its constituents. Secondly, no proof was confirmed in relation to the impact of fixed telephone and stock market development with its elements. Thirdly, evidence of a positive relationship is sparingly apparent in financial development and its components. Fourthly, compared with fixed telephone, internet users more positively and significantly affect stock market development indicators. Policy implications are discussed.

Keywords: stock market development; financial development; ICT diffusion; emerging countries; dynamic panel system GMM

1. Introduction

Currently, the stock market is considered to be one of the most important methods of financing economic activity. Indeed, the stock market is capable of mobilizing savings and directing capital towards the most efficient economic sectors (Igwilo and Sibindi, 2021; Jin and Xue, 2023; Xu et al., 2024; Yang and Ferrer, 2023; Zhao and Zhang, 2023). This role of optimal allocation of capital is closely linked to the degree of efficiency of the stock market. Indeed, the development of the financial system is increasingly seen as a prerequisite for economic development (El Alaoui et al., 2015). As a result, economic transactions take place primarily through the financial system. This is why financial deepening occupies a privileged place in growth and development strategies. The financial system—the financial markets and financial intermediaries—appears to improve market frictions, which essentially concern the costs of acquiring information and transactions (Cordes et al., 2022). When talking about an efficient financial system, several authors are increasingly emphasizing the decisive role of information and communication technologies (ICTs). Indeed, the development of ICTs improves the financial system by reducing the imperfections linked to transaction costs and informational asymmetry in the

market, while guaranteeing the promotion of financial functions (Aminuzzaman et al., 2003; Muto and Yamano, 2009). Thus ICT, through strong penetration of mobile phones and the Internet, reduces information asymmetries and can positively impact the efficiency of the financial system by reducing transaction costs (Andonova, 2006). As a result, the development of electronic means of payment was made possible thanks to the emergence of information and communication technologies (ICTs), which are helping to create new services, and by consumers' changing needs for other financial instruments in a global economy that is becoming increasingly digital.

When it comes to financial inclusion, mobile telephony plays an important role. It is becoming easier and cheaper for those who previously had no access to banking services to access deposits and loans. In addition, the improved flow of information thanks to mobile phones facilitates access to information for both depositors and financial institutions and enhances tracking. In fact, a high penetration rate of mobile telephony reduces physical constraints and spatial and temporal costs, thus lowering the costs of financial intermediation and contributing to the emergence of electronic banking services. This in turn improves access to finance for households that would otherwise be financially excluded. In this context, Ahmad et al. (2023) found that in African countries, mobile phone penetration improves financial inclusion and economic growth. Thus, their results show that financial inclusion has an impact on economic growth in African countries.

In conclusion, ICTs, and mobile telephony in particular, are contributing to economic growth in Africa, and part of this contribution is through greater financial inclusion. In order to maximize benefits from ICT development in Africa, countries should take advantage of this opportunity. Furthermore, the development of the ICT sector will require foreign direct investment (FDI) (Fakher, 2016; Latif et al., 2018; Osano and Koine, 2016). The literature supports the claim that FDI is able to facilitate the use of local raw materials, make technologies accessible, increase human capital, and create new job opportunities in countries (Latif et al., 2018). The impact of high taxes in the telecoms sector on government revenues needs to be weighed against the risks of lower growth due to higher telecoms costs. It is necessary to strengthen the links between ICTs and the financial sectors in order to promote financial inclusion. A number of challenges associated with mobile banking will need to be addressed in a manner that does not hinder the growth of mobile financial services, such as security concerns and compliance with anti-money laundering (AML)/countering the financing of terror (CFT) regulations.

ICT has emerged as a pivotal factor in the development and modernization of stock markets globally, reshaping the landscape of financial markets. ICT has significantly enhanced market access and connectivity, allowing investors to participate in stock trading from diverse geographical locations. This increased connectivity has not only bolstered market liquidity but has also fostered efficiency and accessibility, attracting a wider range of participants (Yan and Haroon, 2023). Moreover, ICT has played a crucial role in enhancing market transparency by providing real-time access to crucial market information, including stock prices, trading volumes, and market data. This transparency is fundamental in maintaining investor trust and encouraging both local and international investment (Liu et al.,

2021).

Furthermore, ICT has automated various trading processes, such as order placement and execution, reducing operational errors and accelerating transaction speeds (Chordia et al., 2017). This automation has not only enhanced the efficiency of stock markets but has also improved their resilience to market uncertainties and fluctuations. Additionally, ICT has facilitated sophisticated market analysis and research tools, enabling investors to make well-informed decisions. These tools encompass technical analysis, fundamental analysis, and algorithmic trading strategies, all of which have contributed to the overall efficiency and effectiveness of stock markets (Dimpfl and Jank, 2015).

In conclusion, ICT has revolutionized stock markets, making them more transparent, efficient, and accessible to a broader range of investors. As technology continues to advance, the role of ICT in shaping the future of stock markets is expected to expand further, driving innovation and enhancing market efficiency (Khan et al., 2024).

The aim of the study is to investigate how the ICT affects the development of stock markets in emerging countries. This involves analyzing how the adoption and spread of ICT infrastructure, services, and technologies influence various aspects of stock market development, such as market liquidity, efficiency, transparency, and accessibility. The study seeks to understand the specific mechanisms through which ICT diffusion interacts with and shapes the dynamics of stock markets in emerging economies, ultimately aiming to provide insights that can inform policy decisions and strategies to promote more robust and inclusive stock market development in these countries.

Since this issue is very important, many studies have examined how macroeconomic variables affect stock markets. Because parallel markets are important to the emerging economy, we examined the impact of ICT diffusion on the Stock markets index, which was different from previous studies. Using the dynamic generalized method of moments (GMM), this study aims to examine how the stock market is affected by the ICT diffusion and other macro-level variables such as financial development indicators during the 1994–2020 period.

The study is organized as follows: Section 2 presents the literature review. Methodology and data are described in section 3. Results and discussion are presented in section 4. In section 5, policy implications are discussed.

2. Literature review

In the last decade, studies of industrialized economies and rising markets, as well as countries with high income, largely determined the relationship between ICT and stock market development. Therefore, this study focused largely on developed and developing economies, including those with high interest rates (Okwu, 2015). The COVID-19 pandemic demonstrated that people generally increase their equity holdings when faced with crises, supporting the contrarian view.

Based on aggregate financial sector data, another strand of literature investigated the link between ICT diffusion and financial development (FD). Asongu (2013) was a pioneer in studying the relationship between these variables in a panel

of 52 African countries during the 2003–2009 period. He found that the mobile phone penetration negatively affects traditional intermediate FD, while it positively affects informal FD. The same author obtained similar results in later empirical studies. In an empirical model including both information sharing offices and mobile phones, Asongu and Odhiambo (2019) analyzed the impact of mobile phones on FD in 53 African countries under different FD levels.

Petros (2012) maintained that stock markets support investments by individuals who save, which provides organizations with a means to finance their investment. Okwu (2015) studied the effects of ICT adoption on stock exchange markets in the African continent. He found that the Nigerian and Johannesburg Stock Exchanges, as well as Africa's financial markets in general, were significantly enhanced by the ICT adoption. In addition, Igwilo and Sibindi (2021) examined the causal relationship between ICT diffusion and stock market development in a panel of 11 African countries (Botswana, Ivory Coast, Egypt, Ghana, Bahrain, Oman, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa, and Tunisia) by using panel unit root tests and panel cointegration analysis. The results showed a bi-directional causal relationship between ICT diffusion and stock market development. More recently, financial market performance was examined by Sepehrdoust et al. (2022) by examining the impact of the ICT, the housing market, and other macroeconomic variables such as inflation and exchange rates in Iran for the 1994–2020 period. Their results reveal a positive impact of ICT and the inflation rate on stock exchange financial performance, but a negative impact of housing market development and exchange rate.

The relationship between ICTs and financial inclusion was empirically examined in more recent studies. By analyzing a panel data sample of 162 banks in Africa using the Generalized Methods of Moments (GMM) and Quantile Regressions, Asongu et al. (2018) analyzed how ICT diffusion can reduce the adverse effects of market power. They found that ICT diffusion improved access to financial services by moderating market power. Several other studies, such as Gosavi (2018) and Bongomin et al. (2018), reported different results. Based on data from the World Bank's Enterprise Surveys Program for Eastern Sub-Saharan Africa in 2013, Gosavi (2018) found that mobile money promotes ease of getting lines of credit and loans for companies, and that firms use mobile money more productively. According to Bongomin et al. (2018), the interaction term between social networks and mobile money has a positive relationship with financial inclusion in Uganda. Using Granger causality test, Ngare et al. (2014) examined the relationship between stock market development and economic growth for 36 African countries for the 1980–2010 period. They found a bi-directional causality between market development and GDP. In a similar study, Nazir et al. (2010) tested the link between GDP and stock market development in Pakistan and found that the relationship was bi-directional.

Several studies were conducted on the factors influencing the development of India's stock market. According to Mahapatra and Bhaduri (2019), the stock market positively affects India's economic growth. In addition, this link revealed that economic growth improved stock market development. Similarly, Ohiomu and Godfrey (2011) studied the relationship between stock market and economic growth in Nigeria. They also found a positive correlation between these two variables.

Furthermore, Civcir and Akkoc (2021) analyzed the effect of capital market reforms on economic growth in Turkey and found that capital reforms were positive for the economy. Among other studies on Tanzania, according to Katuma (2012), the stock exchange market contributed only a small amount to economic growth. In contrast, Msangi (2015) analyzed the determinants of capital market development in Tanzania and found that there was no connection between stock market liquidity and capital market development. In addition, Ghana was an important focus within the African context. Quaidoo (2011) examined the relationship between Ghana's stock market capitalization and economic growth. He found that Ghana Stock Exchange was positively correlated with economic growth. Using Granger causality test, it was found that economic growth induces stock market capitalization without providing any feedback to support "demand following" hypothesis. In addition, Acquah-Sam (2016) studied macroeconomic factors affecting the development of the Ghanaian capital market. He found that stock market growth was positively correlated with economic growth.

The work of Mai et al. (1998) on the daily returns of indices on the Jamaican stock market between 1989 and 1996 showed that this market is not efficient. The authors highlighted the very strong serial correlations and hence the predictability of returns on this market. Derrabi (1999) reached the same conclusions after analyzing daily and weekly returns between 1996 and 1998 on the Moroccan market. Bakir (2002) tested the efficiency hypothesis on the Casablanca stock exchange using daily data for both the general index and most individual stocks. He used a range of tests, namely the ADF stationarity, autocorrelation, Portmanteau and Runs tests. His results led to the rejection of efficiency for the Casablanca stock exchange. Omran and Farrar (2006) studied the behavior of the main market indices of Egypt, Jordan, Morocco, Turkey, and Israel over the period 1996–2000. According to their results, all these markets are inefficient except for Israel. Al-Khazali et al. (2007) carried out the same study on eight stock market in the MENA region (Bahrain, Jordan, Kuwait, Morocco, Oman, Saudi Arabia, Tunisia, and Egypt) over the period October 1994–December 2003 and rejected the random walk hypothesis. According to these authors, the inefficiency of the MENA markets can be explained by a low frequency of transactions.

Hawaldar et al. (2017) tested the weak form of market efficiency of individual stocks listed on the Bahrain Stock Exchange for the period 2011–2015 using the Kolmogorov-Smirnov goodness-of-fit test and the autocorrelation test. The results of the tests reveal that the share prices of seven companies do not follow the random walk. The autocorrelation tests reveal that share prices display a weak and moderate correlation ranging from negative to positive values. During the 2010–2017 period, Elhami and Hefnaoui (2018) examined the behavior of eight indices, including the TASI index (Saudi Arabia), QSI index (Qatar), the EGX 30 index (Egypt), the DFMGI index (UAE), the MASI index (Morocco), the BAX index (Bahrain), the MSI index (Oman) and the Tunindex index (Tunisia). Several tests were used to verify the informational efficiency (including Anderson normality test, autocorrelation test, unit root test, variance ratio test). Their results indicate that the stocks market in the MENA region is inefficient.

According to the findings of this literature review, we should be cautious when

applying appropriate methodology to empirical data and make sure the results are clearly explained.

3. Data and methodology

3.1. Data

During the period 1990–2020, this study examined 17 emerging economies. This period was chosen based on the availability of stock markets development data. The list of selected countries is presented in the appendix (see list A, B, C, and D). According to Saygın and Iskenderoglu (2022), the stock markets development is measured by three indicators: the ratio of stock market capitalization to GDP (SMC), the ratio of stock market total value traded to GDP (SMTT), and the ratio of stock market turnover (SMT). In addition, according to Chien et al. (2020), three ICT indicators are used. These include Fixed telephone subscriptions (FTS), Individuals using the Internet (IUI), and Mobile cellular subscriptions (MCS). The definition of stock market development indicators and ICT indicators are presented in Appendix (**Table A1**). According to Acheampong (2019), three indices to measure financial development (FD) are used including: the ratio of deposit money among bank assets to GDP (DMB), the ratio of liquid liabilities to GDP (LLB), and the ratio of private credit by deposit money bank to GDP (PCM). The data for stock market indicators is provided from the Financial Structure and Economic Development Database. Global Financial Development Database (GFDD) and World Development Indicators (WDI) provide data on FD and ICT indicators, respectively. The logarithm of all variables is used in established models.

The descriptive statistics are presented in **Table 1** for 17 countries. The average value of stock market varies between 1.804, 1.624 and 1.771 for the SMC, SMTT, and SMT, respectively. In addition to exploring the mean and standard deviation of the variables in the model, correlations between stock market, ICT, and financial development can also be studied.

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
SMC	476	1.804	0.324	0.901	3.051
SMTT	476	1.624	0.523	0.187	2.964
SMT	476	1.771	0.358	0.529	2.698
FTS	476	1.960	1.751	-2.033	4.321
IUI	476	1.461	2.356	-8.048	5.667
MCS	476	2.351	2.814	-6.215	5.671
DMB	476	3.984	1.320	-0.104	6.014
LLB	476	3.891	1.210	-0.055	6.110
PCM	476	3.554	1.153	-0.138	5.084

Correlations between variables in the panel data are shown in **Table 2**. According to this table, stock market and ICT indicators are not strongly correlated. Conversely, there appears to be a relatively strong correlation between the stock

market indicators. Therefore, estimating a single equation based on all stock market indicators may produce inconsistent and misleading results due to multicollinearity. Consequently, we estimated separate models for each indicator of stock market to provide consistent estimates.

Table 2. Coefficients of Pearson correlation.

Independent variables									
	Dependent variables			**Financial development indicators**			**ICT indicators**		
Variables	**SMC**	**SMTT**	**SMT**	**DMB**	**LLB**	**PCM**	**FTS**	**IUI**	**MCS**
SMC	1.000	-	-	-	-	-	-	-	-
SMTT	0.601	1.000	-	-	-	-	-	-	-
SMT	0.654	0.721	1.000	-	-	-	-	-	-
DMB	0.287	0.187	0.397	1.000	-	-	-	-	-
LLB	0.365	0.254	0.214	0.213	1.000	-	-	-	-
PCM	0.421	0.365	0.341	0.287	0.204	1.000	-	-	-
FTS	0.101	0.031	0.117	0.110	0.198	0.114	1.000	-	-
IUI	0.201	0.147	0.114	0.351	0.307	0.243	0.334	1.000	-
MCS	0.142	0.154	0.116	0.264	0.228	0.099	0.368	0.561	1.000

3.2. Methodology

Since the financial sector behavior is dynamic in nature, the effect of ICT diffusion and financial development on stock markets at disaggregate level in African countries can also be estimated using the GMM estimator proposed by Arellano and Bond (1991). In dynamic form, Equation (1) is expressed as follows:

$$SMD_{it} = \alpha_i + \beta_1 SMD_{i,t-1} + \beta_2 IUI_{i,t} + \beta_3 FTS_{i,t} + \beta_4 MCS_{i,t} + \beta_5 FD_{i,t} + \omega_{i.t} \quad (1)$$

In Equation (1), we examine the impact of ICT on SMD, where the dependent variable SMD refers to the stock markets development indicators of country *i* in year *t* and is proxied by three different indicators, namely: SMC, SMTT, and SMT. Further, α_i represents the country-specific effect, whereas ω_i represents the error term.

In the above model, the dependent variable (SMD) depends not only on the current values of its explanatory variables but often on their past values as well as its own past value. Wang et al. (2023) argue that the stock market-ICT diffusion relationship may be affected by a simultaneity bias. These generally produce the inefficiency of the usual estimation techniques on panel data (OLS, fixed effect and random effect). Indeed, the use of these traditional methods results in biased and non-convergent estimates due to endogeneity problems and the presence of correlation between the endogenous variable and the residuals from the regression. To overcome this problem, we use Blundell and Bond's (1998) generalized method of moments-system (GMM-system), which generates consistent estimators for dynamic panel models. The advantage of this approach is that it provides solutions to the problems of simultaneity bias, reverse causality, and possible omitted variables. Moreover, it controls for specific temporal effects. In addition, we add that the method (GMM-system) estimates an equation simultaneously in levels and in

differences and instruments the levels by the contemporaneous differences and the differences by the levels. The use of this estimation method is also based on the assumptions of the absence of second-order autocorrelation in the errors of the first-difference equation and of the validation of the instruments. In this respect, two tests, including the rejection of the null hypothesis, confirm the specification of the model: a test of the autocorrelation of Arellano and Bond residuals of order AR(1), AR(2) and a Sargan test of the Over-identification of restrictions on moments.

4. Empirical results and discussions

We start our empirical analysis by performing system GMM estimator for the 17 emerging countries for the period of 1990–2020. Three different dependent variables (SMC, SMTT, and SMT) were used separately in models to measure stock market development in this study. System GMM panel estimation results of the SMC, SMTT, and SMT dependent variables for the emerging countries are shown in **Table 3**. Consistent with the most existing literature, each specification includes a lagged value of stock market, current period ICT, and financial development variables to evaluate the nexus between stock market development and ICT.

Table 3. Dynamic GMM estimations.

	SMC_t	**SMT_t**	**$SMTT_t$**
SMC_{t-1}	0.005*** (0.000)	-	-
SMT_{t-1}	-	0.007*** (0.002)	-
$SMTT_{t-1}$	-	-	0.009*** (0.000)
FTS	−0.013 (0.211)	−0.001 (0.181)	−0.005 (0.119)
IUI	0.019** (0.024)	0.015** (0.037)	0.020*** (0.001)
MCS	0.014** (0.043)	0.013** (0.000)	0.016** (0.026)
DMB	0.022*** (0.003)	0.034* (0.077)	0.025** (0.035)
LLB	0.023** (0.017)	0.019*** (0.008)	0.033* (0.084)
PCM	0.020** (0.046)	0.031* (0.067)	0.016** (0.048)
Diagnostic checking			
Hansen Test for over-identifying restriction: *p*-value	(0.123)	(0.203)	(0.137)
Arellano-Bond Test for first order Autocorrelation: *p*-value	(0.325)	(0.378)	(0.288)
Arellano-Bond Test for second order Autocorrelation: *p*-value	(0.501)	(0.254)	(0.651)
No of Instruments	12	12	12
No of Countries	17	17	17
No of Observations	527	527	527

Notes: *p*-values are in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% thresholds, respectively.

As seen in **Table 3**, the estimated coefficient on the lagged stock market variable is positive, highly persistent, and statistically significant at the 1% threshold for each model. This indicates that stock market in one year is heavily influenced by stock market in the previous year. Thus, the results show that these coefficients admit more or less high values, which explains why the growth of the stock market development indicators (SMC, SMTT, and SMT) depends on their past. The results

displayed in **Table 3** show that, in the long term, the ICT variables (Fixed, mobile and Internet) have a positive and significant coefficient at the 5% threshold. Indeed, if the Internet users and Mobile cellular subscriptions increase by 1%, then the stock market capitalization follows the same trend on average with 0.019% and 0.014%, respectively. In addition, if these variables increase by 1%, then the stock market turnover follows the same trend on average with 0.015% and 0.013% respectively. Therefore, if these variables increase by 1%, then the stock market total value traded follows the same trend on average with 0.020% and 0.016%, respectively. In contrast, the coefficient for fixed telephony (Telephone) is negative and not statistically significant at the 5% threshold. The findings regarding the impact of ICT dynamics on stock market development indicators reveal several key insights. Firstly, ICT indicators, such as Individuals using the Internet (IUI), and Mobile cellular subscriptions (MCS), have a positive and significant impact on stock market capitalization. This suggests that higher levels of ICT diffusion are associated with larger stock market capitalization, reflecting increased market value and size. Secondly, ICT indicators also show a positive impact on stock market total value traded (SMTT). Countries with higher levels of ICT diffusion tend to have greater trading activity in their stock markets, indicating higher liquidity and market participation. Thirdly, the impact of ICT dynamics on stock market turnover (SMT) is also positive, indicating that ICT diffusion is associated with higher levels of trading turnover in stock markets. This suggests that ICT facilitates more active trading in stock markets, potentially leading to greater price discovery and market efficiency. The non-significance of the fixed-line telephone variable can be explained by the disconnection of fixed-line telephony in favor of mobile telephony. This is referred to as the substitution effect of the fixed-line telephony by the mobile telephony. These results indicate that ICT does not affect stock market in emerging countries when ICT is measured using the fixed telephone subscriptions variable.

Overall, the findings suggest that ICT dynamics play a significant role in shaping various aspects of stock market development, including market capitalization, trading activity, and turnover. These results highlight the importance of ICT diffusion in driving stock market development and underline the need for policies that promote ICT adoption and investment.

According to these findings, Information Communication Technology drives stock market development using controlled devices. These provide traders with trading information to help them make investment decisions about their future financial stability. These results are in line with those of Traoré and Ouédraogo (2020) in their studies of ECOWAS countries. Overall, our results show the essential nature of ICTs in the development of a country's stock market. Indeed, ICTs provide numerous positive externalities for the entire production system and represent real opportunities in terms of openness and access to the international market, enabling emerging countries to better integrate into the global economy and the information society.

In terms of control variables, the estimated coefficient on financial development variables (DMB, LLB, and PCM) is positive in each of the three models and all variables are statistically significant. The results of this study are important since that they support the idea that there is a close relationship between the level of financial

development in emerging countries and the level of stock market development when financial development is measured by banking variables. These findings are similar to those reported by Vithessonthi and Kumarasinghe (2016) for positive effect between financial development and stock market in a panel sample of 15 developed and developing countries in Asia, and Igwilo and Sibindi (2021) for African countries.

The validity of the GMM system estimator is assessed by two specification tests: Arellano and Bond (1991), and Arellano and Bover (1995). Blundell and Bond (1998) suggest the Sargan overidentification test and the second-order autocorrelation test. Sargan's test on the identification of restrictions checks the overall validity of the instruments. Rejecting the null hypothesis amounts to rejecting the validity of the model. The second test examines the null hypothesis that the error term is not correlated over time. Once again, the rejection of the null hypothesis reflects the failure of the model. Indeed, we find that, according to the Sargan tests, the lagged variables in level and differences, which are used as instruments, are valid in the different regressions. Subsequently, the Sargan test probabilities are higher (varying between 0.123 and 0.203), which implies greater confidence in the acceptance of the null hypothesis of the validity of the instruments for the mere reason that the Sargan statistic provides an upper bound for each of the test statistics corresponding to the null hypothesis in the estimated model. This reflects the good specification of the models, particularly regarding the choice of instruments. For example, the probabilities of the Arellano and Bond autocorrelation test [AR(2)] do not allow us to reject the null hypothesis of no second-order autocorrelation in all the regressions.

After this, to assess the sensitivity of our findings, we used the robustness test. The countries in the sample were grouped according to income level and the regressions were made for each group of countries: 5 high-income economies countries ($13,205 or more) (see list B of the Appendix), 9 upper-middle-income economies countries ($4256 to $13,205) (see list C of the Appendix), and 3 lower-middle income economies countries ($1086 to $4255) (see list D of the Appendix) according to the classification proposed by Word Bank (WB). The basic hypotheses do not change when the stock market model (SMC, SMTT, and SMT) in **Table 4** is estimated on the sample of countries in these different groups.

Table 4. Dynamic GMM estimations for different income economies.

	SMC$_t$	**SMT$_t$**	**SMTT$_t$**
High-Income economies ($13,205 or more)			
SMC$_{t-1}$	0.010*** (0.004)	-	-
SMT$_{t-1}$	-	0.006*** (0.005)	-
SMTT$_{t-1}$	-	-	0.003*** (0.008)
FTS	0.011** (0.042)	0.007* (0.081)	0.002** (0.014)
IUI	0.021*** (0.001)	0.035** (0.022)	0.041*** (0.000)
MCS	0.018** (0.036)	0.015** (0.011)	0.025*** (0.006)
DMB	0.016** (0.027)	0.034* (0.059)	0.019** (0.029)
LLB	0.020*** (0.002)	0.010** (0.043)	0.014*** (0.003)
PCM	0.017** (0.022)	0.023*** (0.003)	0.030** (0.037)

Table 4. (*Continued*).

	SMC_t	SMT_t	$SMTT_t$
Diagnostic checking			
Hansen Test for over-identifying restriction: *p*-value	(0.244)	(0.354)	(0.514)
Arellano-Bond Test for first order Autocorrelation: *p*-value	(0.234)	(0.504)	(0.412)
Arellano-Bond Test for second order Autocorrelation: *p*-value	(0.319)	(0.422)	(0.515)
No of Instruments	3	3	3
No of Countries	5	5	5
No of Observations	155	155	155
Upper-middle-income economies ($4256 to $13,205)			
SMC_{t-1}	0.012*** (0.007)	-	-
SMT_{t-1}	-	0.008*** (0.003)	-
$SMTT_{t-1}$	-	-	0.006*** (0.002)
FTS	−0.014 (0.144)	-0.010 (0.224)	−0.011(0.247)
IUI	0.019*** (0.031)	0.016* (0.057)	0.021*** (0.009)
MCS	0.030* (0.022)	0.023** (0.042)	0.024*** (0.006)
DMB	0.017** (0.033)	0.031* (0.071)	0.027* (0.075)
LLB	0.038*** (0.004)	0.033* (0.085)	0.011* (0.067)
PCM	0.015** (0.045)	0.040*** (0.005)	0.045** (0.028)
Diagnostic checking			
Hansen Test for over-identifying restriction: *p*-value	(0.541)	(0.317)	(0.254)
Arellano-Bond Test for first order Autocorrelation: *p*-value	(0.314)	(0.417)	(0.531)
Arellano-Bond Test for second order Autocorrelation: *p*-value	(0.446)	(0.514)	(0.421)
No of Instruments	7	7	7
No of Countries	9	9	9
No of Observations	279	279	279
Lower-middle income economies ($1086 to $4255)			
SMC_{t-1}	0.015*** (0.005)	-	-
SMT_{t-1}	-	0.011*** (0.002)	-
$SMTT_{t-1}$	-	-	0.008*** (0.009)
FTS	−0.030 (0.241)	−0.022 (0.350)	−0.020 (0.322)
IUI	0.010* (0.066)	0.018** (0.017)	0.024*** (0.001)
MCS	0.035* (0.036)	0.028** (0.032)	0.018** (0.029)
DMB	0.024** (0.041)	0.036* (0.069)	0.021** (0.025)
LLB	0.031** (0.026)	0.027* (0.071)	0.015* (0.088)
PCM	0.044*** (0.005)	0.047*** (0.001)	0.033** (0.040)
Diagnostic checking			
Hansen Test for over-identifying restriction: *p*-value	(0.551)	(0.345)	(0.356)
Arellano-Bond Test for first order Autocorrelation: *p*-value	(0.334)	(0.541)	(0.641)
Arellano-Bond Test for second order Autocorrelation: *p*-value	(0.247)	(0.255)	(0.320)
No of Instruments	2	2	2
No of Countries	3	3	3
No of Observations	93	93	93

Notes: *p*-values are in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% thresholds, respectively.

The results confirm the positive relationship between each stock market index

and the four ICT indicators. Indeed, the positive impact of the ICT on the stock market seems to be verified for the three groups of countries with a positive and statistically significant sign at the 5% threshold. Nevertheless, this marginal impact of ICT indicators on the stock market varies considerably between groups of countries. On the other hand, for the fixed telephone subscriptions variable, its negative impact on the stock market persists for lower-middle and upper-middle income.

Comparing the impact of ICT diffusion on stock market development across different income groups allows to assess how economic status influences this relationship. High-income countries may have more advanced ICT infrastructure and financial systems, which could lead to different outcomes compared to emerging economies or low-income countries.

For example, high-income countries may already have well-developed stock markets and may use ICT more for efficiency rather than for significant market development. On the other hand, emerging economies or low-income countries may experience greater impacts from ICT diffusion on stock market development, as they may be in earlier stages of market development and could benefit more from ICT advancements.

By comparing these different groups, we can highlight unique challenges and opportunities faced by each income group regarding ICT and stock market development. This comparative analysis can inform policymakers and stakeholders on the best strategies to leverage ICT for stock market development based on the economic context of the country.

5. Conclusion and policy implications

This study investigates the effects of ICT diffusion on stock market development (SMD) for 17 emerging countries over the period 1990–2020 by employing the system GMM estimators while controlling for the impact of three financial development variables. To advance knowledge about the impact of ICT diffusion on stock market development, three ICT variables and three stock market development were used to investigate this relationship. Additionally, income heterogeneities among the countries considered in the study were considered in sensitivity analyses. The study mainly found two main findings, which can be summarized as follows. Firstly, the results of this study confirmed the existence of a relationship between the stock market development indicators and the ICT indicators (except fixed telephone subscriptions). This implies that an increase in the spread of ICTs, with consumers making use of the internet and Mobile cellular subscriptions, leads to an increase in stock market indicators. Secondly, our results indicate that the mobile telephone subscriptions have a negative and not significant effect. Analyzing the results of the emerging countries show that all the ICT variables have a significant effect, and the variables are significant except fixed telephone subscriptions. It is clear from this that the strengthening of ICT can significantly contribute to the stock market development. In terms of control variables, the coefficients of financial development (including DMB, LLB, and PCM) exhibit a significantly positive impact on stock market development (including SMC, SMTT,

and SMT).

The results of this study have several policy implications. It is commonplace to point out the absence of adequate ICT policies focused on the development of equity markets in emerging countries. ICT initiatives were mainly focused on FinTech; however, policymakers need to focus on ICT policies that can support stock market development, considering the impact of the development of stock markets on the economy.

One of the key policy issues that this study seeks to address is that, given the rapid integration of emerging stock markets, particularly with the agreement of the European Free Trade Association (EFTA) by most emerging countries, a major shift in ICT policy is needed not only to stimulate stock market integration for emerging countries, but also to foster their development. The lack of a coherent or uniform ICT policy can be a major obstacle to adequate stock market integration for emerging countries in this era of EFTA. Thus, a major opportunity to further develop the stock market in emerging countries would be lost if ICT initiatives were not well exploited. Therefore, if governments in emerging countries consider sound ICT policies that encourage investment in improving the infrastructure of Internet services and mobile cellular subscriptions, this will stimulate the development of stock markets. For example, governments in emerging countries can remove restrictions on the repatriation of dividends or profits on ICT-related investments by foreign investors. They can also grant tax exemptions for a specific period or give tax credits to companies that invest in ICT infrastructure.

Based on the observed relationships between ICT and stock market development indicators, policymakers can consider the following recommendations:

(i) Promote ICT Adoption: Policymakers should continue to promote the adoption of ICT technologies, especially internet usage and mobile phone subscriptions, as these have shown positive impacts on stock market development. This could involve investing in ICT infrastructure, providing incentives for ICT adoption, and improving digital literacy among the population. (ii) Enhance Market Transparency: ICT can enhance market transparency by providing real-time access to market information. Policymakers should encourage the use of ICT tools for market surveillance and regulatory oversight to detect and prevent market abuses. (iii) Encourage Financial Inclusion: ICT can help promote financial inclusion by providing access to stock markets for individuals who were previously excluded. Policymakers should support initiatives that leverage ICT to expand access to stock markets, especially for underserved populations. (iv) Facilitate Algorithmic Trading: Policymakers should create a regulatory environment that supports the responsible use of algorithmic trading, which can enhance market liquidity and efficiency. This could involve establishing guidelines for algorithmic trading practices and monitoring for market manipulation. (v) Invest in ICT Research and Development: Policymakers should invest in research and development to drive innovation in ICT technologies. This could lead to new tools and solutions that further enhance stock market development and overall economic growth.

In addition to its contributions, this study has certain limitations that could be addressed by future research. Specifically, while this study utilized panel estimations, future studies could focus on individual countries, taking into account

potential structural breaks. Furthermore, future research could employ a quintile approach to offer more nuanced policy implications at a deeper level.

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Appendix

A. Countries used in the study:

Argentina, Brazil, Chile, China, Hungary, India, Indonesia, Korea. Malaysia, Mexico, Philippines, Poland, Romania, South Africa, Thailand, Turkey, Venezuela.

B. High-income economies ($13,205 or more):

Chile; Hungary; Korea; Poland; Romania.

C. Upper-middle-income economies ($4256 to $13,205):

Argentina; Brazil; China; Malaysia; Mexico; South Africa; Thailand; Turkey; Venezuela.

D. Lower-middle income economies ($1086 to $4255):

India; Indonesia; Philippines.

Table A1. Definition of variables.

Variables	Definition
Stock market development indicators	
Stock market capitalization (SMC)	This indicator measures the total market value of all listed companies' outstanding shares in a stock market. It is used to gauge the overall size and value of a stock market.
Stock market total value traded (SMTT)	This indicator represents the total value of all securities traded in a stock market over a specific period, typically a day, month, or year. It reflects the level of trading activity in the market.
Stock market turnover (SMT)	The turnover ratio measures the value of shares traded as a percentage of total market capitalization. It indicates the level of trading activity relative to the size of the market and is used as a liquidity indicator.
ICT indicators	
Fixed telephone subscriptions (FTS)	This indicator represents the number of fixed telephone lines in use per 100 inhabitants in a country. It is used to measure the level of access to fixed-line telephone services, which is a basic indicator of ICT infrastructure.
Individuals using the Internet (IUI)	This indicator measures the percentage of individuals in a population who use the Internet regularly. It is used to assess the level of Internet penetration and access to online services and information.
Mobile cellular subscriptions (MCS)	This indicator represents the number of mobile cellular subscriptions per 100 inhabitants in a country. It is used to measure the level of access to mobile phone services, which have become increasingly important for communication and accessing online content.