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Research paper

Does financial inclusion and ICT influence the economic growth: an evidence from select emerging economies using panel data estimates

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Abstract

Information Communication Technology (ICT) 's contribution to financial services and economic growth is extensively researched. With technological development, the financial systems are converging with ICT platforms, thereby leading to digital financial systems, creating opportunities that bridge the gap between affluent and disadvantaged sections in emerging economies. In this study, we employ the panel data estimation method to evaluate the impact of ICT in providing financial services that would lead to sustainable economic growth in 12 emerging economies from 2010 to 2024. The findings emphasize the critical role of digital financial services and ICT infrastructure in boosting financial inclusion and driving inclusive economic growth. The Random Effect model has inferred that there exists a moderate effect of fixed telephone lines and mobile cellular subscribers on GDP by simplifying digital applications, integrating regional languages. By ensuring secure systems in places, the regulators and service providers can contribute to the sustainable economic growth of both the country and the underserved communities.

Keywords: *Digital Financial Inclusion; Sustainable Economic Growth; Panel Data; ICT; Financial Inclusion.*

1. Introduction

Financial Inclusion (FI) and Information Communication Technology (ICT) play an increasingly recognized role in fostering economic growth. A process that ensures the availability of financial services to all sections of society irrespective of their cast, creed, religion, or social status is termed financial inclusion (RBI Annual Report, 2014). Financial inclusion is pivotal in reducing inequality, enhancing economic stability, and empowering marginalized populations (Demirgüç-Kunt et al., 2018). In the context of inclusive development, FI plays a crucial role as it helps in tackling poverty, inequality, thereby addressing the Millennium Development Goals (Chibba M, 2009). With access to the basic account at either a bank or a financial institution, people will start using different banking services like credit, insurance, etc, and this would lead to improvement in their overall quality of life (Global Partnership for Financial Inclusion, 2016). With access getting created for all, there will be an opportunity to lift themselves from extreme poverty (Wang et al. 2022; Beck et al., 2007; Owen and Pereira 2018; Mehrotra and Yetman 2015; Asante et al. 2023). Participation from a larger section of the society would ensure higher mobilization of financial reserves, thus ensuring creation of values for businesses, which impacts socioeconomic growth (Park and Mercado 2015; Kim 2016; Nanda and Kaur 2016). Given the established importance of FI, not just the countries but also the United Nations has prioritised financial inclusion in its Sustainable Development Goals (Ozili 2021). With the provision of financial services, the households and businesses will be able to save, invest, transfer, and transact with each other at a low cost, which is essential for socio-economic growth, and therefore the need for a well-functioning financial system. (Demirgüç-Kunt et al. 2017; Mehrotra and Yetman 2015).

Some studies have highlighted how FI could impact economic development (Levine, 2005; Goyal et al., 2004; Levine, Loayza, and Beck, 2000; Bruhn and Love, 2014; Mehrotra and Yetman, 2015). FI is often viewed as a catalyst for economic development, as the provision of finance enables economic drivers that result in participation in long-term productive activities. With finance being available and affordable, economic activities and therefore economic growth will be the output. FI is believed to benefit both high and low-income individuals to be integrated into the financial system (Raza et al, 2019).

Some studies have argued that technology contributes to the collective economic growth and the standard of living (Schumpeter, 1934; Solow, 1956; Romer, 1990). But certain studies questioned the importance of the technologies that influence well-being (Romer, 1993; Solow, 1988; Gordon, 2012). ICT is one such technology that has impacted multiple sectors significantly. As per the World Bank, "Telecommunication has without any doubt had a greater influence on people's lives than any other discovery in history" (World Bank, 2016).

ICT can be used in several ways in businesses to reduce cost, increase the reach of products and services, enhance efficiency, introduce new products and processes, and contribute directly to enhancing business performance. The business performance and market performance will improve by effectively utilising information communication technologies (Datta and Agarwal 2004; Waverman et al. 2005). Realizing the importance of applications of technology in finance, the Group of Twenty (G20), in the year 2010, advocated the Financial Inclusion Action Plan, which they dedicated to executing innovative financial inclusion under a shared vision (BIS and WB, 2016). ICT has made provision to financial services affordable and convenient for people across the world. With new ICT products being introduced into the market, there is an increase in access to financial services (Pradhan et al., 2021). Using ICT, financial services can be made both affordable and accessible to those who are in remote areas, too. Thus, ICT-enabled FI can contribute towards increased availability of organized financial services, which results in poverty alleviation, reduces income inequality, and results in economic development. (Husain et al, 2023).

In this context, the study evaluates the relationships between financial inclusion (FI), ICT infrastructure, and economic growth in emerging economies. Unlike many existing studies, this research specifically focuses on emerging economies, exploring how their evolving financial sector and ICT development influence economic growth. Panel data is employed to assess the impact of financial inclusion and ICT on economic development.

The remainder of the article is spread over five sections. A review of the Literature is presented in the next section, which outlines the hypothesis development. Research Methodology is discussed in the following section, followed by data analysis and findings, which are presented in the fourth section. Conclusion, policy implications, and directions for future research are presented in Section 5.

2. Supporting theory and literature review

2.1. Economic and innovation diffusion theory

Economic & Innovation Diffusion Theories form the basis for interpreting the association between financial development, information communication technology, and economic development. As per the Economic theory, an effective financial system is essential for economic expansion. It also proposes that a robust financial ecosystem complements economic expansion. It also suggests that a robust financial system directs the savings to the most useful and efficient uses that contribute to the development of the economy. Capital resource, being the most pivotal element for economic growth, can be enhanced through the accumulation of capital by encouraging savings and investments that could be facilitated through inclusive finance. (Ahmad et al., 2022). Innovation Diffusion Theory IDT hereafter refers to the adoption and dissemination of technological innovations such as tech-enabled financial services. It also refers to the services that act as catalysts and speed up the delivery of financial services. By way of swiftness in information sharing, cost reduction towards the delivery of services, decreased operation costs, and aiding secure and quicker transactions, IDT contributes to innovating the financial services and products. With reduced transaction costs, there is an increased reach to all sections that were hitherto excluded.

As per the innovation diffusion theory, new-gen innovations like ICT-induced financial services can act as a catalyst to trigger innovation-led transformation by augmenting access to information, lowering transaction costs, and aiding in protected and swift transactions. IDT elaborates on how financial products and services are remodelled and innovated at lower costs with the interference of technology (Daud 2023). The following subsection presents the comprehensive literature review that leads to the literature gap and the hypothesis formulation that lays the foundation for the proposed research.

2.2. Financial inclusion and economic growth

An increasing number of economic and academic research studies underlines the vital role financial inclusion plays as an enabler for economic growth. Financial inclusion refers to the accessibility and affordability of financial services by all segments of society (Ozili, 2020). With financial services affordable and accessible to the underprivileged sections of society, would lead not only to their economic advancement but also economy's advancement. Several researchers have tried to explore the connection between financial inclusion and economic growth, and evidence appears to indicate that financial inclusion significantly impacts both growth and stability in the economy (Sethy & Goyari, 2022).

In addition, there is evidence connecting financial inclusion to decreasing non-performing loan levels and faster economic development in OECD nations (Zhang et al., 2022). This emphasizes how important financial inclusion is for promoting stability and progress in the economy. Furthermore, studies show how financial inclusion could contribute to reducing the gender disparity in accessing financial services. Roy & Patro (2022) identified factors affecting women's financial inclusion and highlighted the importance of promoting greater financial inclusion for women. Besides, this is acknowledged by the promotion of financial inclusion results in a commendable impact on reducing income inequality.

With increased focus on the relationship between social and financial inclusion, there is an increase in the need to address ways to bring in social inclusion from the lens of financial policies (Ozili, 2020). While the benefits of financial inclusion are evident, the literature also acknowledges the existence of challenges and potential losers in financially inclusive societies (Ozili, 2023). Though both developed and developing economies face similar kinds of challenges to ensure financial inclusion, the consequences are different. Financial Literacy and knowledge of technology result in greater awareness and welfare of the society (Lusardi & Mitchell, 2011) and are supported by Bire, Amram R., et al. (2019). It is observed that financial training, which refers to financial literacy, can enhance and improve financial inclusion practices. This critical perspective underscores the need to understand the implications of financial inclusion policies.

There is increased academic discussion that has analyzed the association between financial inclusion and economic growth. Sarma & Pais (2010) studied the association between financial inclusion and development and identified specific influences of the level of financial inclusion, further supporting the positive impact of financial inclusion on economic development. Anand & Chhikara (2006), highlight the importance of financial inclusion in driving financial development and increasing economic growth. A study by Sethi & Acharya (2018) evidenced that there is a link between financial inclusion and economic growth. The study has proved that with financial intermediation, there is a significant relationship between financial inclusion on economic growth. However, Azimi (2020) presented a contrasting view, which showed a negative association between financial inclusion and economic growth. They highlight an adverse effect of financial inclusion on growth and a statistically significant causal relationship between them. This contradicts the findings of (Nizam et al., 2020), who demonstrated a positive impact of financial inclusion on economic growth in a linear or monotonic relationship. Affandi (2021) adds to this by highlighting the role of financial innovation in promoting financial inclusion and, subsequently, economic growth in low and lower-middle-income economies. This result is supported by Van and Linh (2019) and Yones (2018).

Besides, the literature also discusses the role of financial inclusion in specific regions. Gourène and Mendy (2019) examined the causal association connecting financial inclusion and economic growth in the West African Economic and Monetary Union (WAEMU), providing insights into the regional dynamics of this relationship. In addition to the direct impact on economic growth, financial inclusion is also linked to other economic aspects. For example, said et al. (2019) highlight the role of financial inclusion in facilitating consumption smoothing, lowering income inequality, enabling risk diversification, and positively affecting economic growth. This multifaceted impact is further supported by (Ozili et al., 2022), who established that the level of innovation in the delivery of financial services, financial sector stability, level of poverty, level of financial literacy, regulatory frameworks, and state of economy impact the scale of financial inclusion. Moreover, the literature also probes the impact of financial inclusion on certain sectors and countries. For instance, Joseph et al. (2021) focus on the link between monetary policy effectiveness and financial inclusion in Nigeria, while Arshad et al. (2021) explored the association between financial inclusion and monetary policy efficacy in developed and underdeveloped countries. In conclusion, the literature provides convincing testimony of the importance of financial inclusion in driving economic growth, reducing inequalities, and promoting financial stability. It highlights the need for broad policies that tackle gender disparities, technological access, and social inclusion to understand the need for financial inclusion. Based on the literature review, the following hypotheses are developed.

H_1: There is an impact of the number of commercial bank branches on the GDP

H_2: There is an impact of the number of depositors per 1,000 adults of an economy on the GDP

H_3: There is an impact of the number of borrowers per 1,000 adults of an economy on the GDP

2.3. ICT and economic development

The impact of ICT on economic development has garnered interest among both academic and policy research circles. Researchers have examined the relationship between ICT infrastructure and economic growth, with many finding a positive and significant impact. Toader et al. (2018) outlined that augmenting ICT infrastructure strengthens the momentum of financial development, leading to positive economic growth. However, Lee & Brahmasrene (2014) pointed out a narrow influence of ICT advancement on economic growth in emerging economies. This incongruity in conclusions emphasizes the need for further research into the specific contexts where ICT may or may not significantly contribute to economic development. Moreover, the existing studies have even emphasized the importance of ICT in driving economic growth and productivity.

Farhadi et al. (2012) highlighted the scarcity of evidence to prove the impact of ICT on economic growth and productivity, indicating a gap in the existing research. Niebel (2014) analysed the influence of ICT on economic growth in countries at different development stages, providing insights into the varying effects of ICT. Iqbal et al. (2022) discussed the link between ICT and economic development and emphasized the need for comprehensive studies to understand the multifaceted impact of ICT on sustainable economic growth. Siregar et al. (2022) highlighted ICT as a critical factor in a country's economic and social development, emphasizing its positive consequences on economic growth, productivity, and employment. It is noted that ICT could facilitate financial services delivery, thereby enhancing customer access in developed economies where there is widespread digital banking (Al-Busaidi & Al-Muharrami, 2020). Given the differences in access to ICT, the financial inclusion efforts could be affected, particularly for the unbanked or underbanked sections of the developed economies (Ying et al., 2024). Based on the above discussions, the following hypotheses are developed to test the association between ICT infrastructure and economic development.

H_4: There is an impact of the number of fixed telephone subscriptions of an economy on GDP

H_5: There is an impact of the number of mobile cellular subscriptions of an economy on GDP

H_6: There is an impact of the number of internet users of an economy on GDP

2.4. Financial inclusion, ICT, digital literacy, and economic growth

The implementation of ICT has a positive impact on financial inclusion and economic development in developing countries. Andrianaivo and Kpodar (2020) conducted a study on 44 African countries and found that the implementation of ICT significantly impacts financial inclusion, leading to a positive impact on economic growth. Similarly, the study by Chatterjee (2020) also supports this claim and states that there is enough evidence to accept that financial inclusion and ICT play a positive role in economic growth. Further, Joia & Santos (2017) emphasized that ICT is a vital enabler of financial inclusion, particularly in developing communities, leading to the development of inclusive financial services, particularly those related to mobile communication technology. Additionally, Fauzia et al. (2022) highlighted the collaborative impact of financial inclusion and ICT in proposing development and climate change policies, emphasizing the importance of considering both factors in policy making. However, it is essential to note that the impact of ICT and financial inclusion on economic development may vary based on specific contexts. For instance, Damrah et al. (2022) discussed the moderating role of ICT in the association between financial inclusion and environmental degradation in oil-exporting countries, indicating the need to consider contextual factors when assessing the impact of ICT and financial inclusion on economic development.

Annisa et al., 2024, through their study on Generation Z in Indonesia, analyzed that high awareness about digital literacy and social capital has positively impacted FI, as with digital literacy, there is an ease of use of the digital banking services. It is also observed that digital literacy augments digital financial inclusion as it enables individuals to use digital financial services without much difficulty (Gumilar et al., 2024). It is also noted that improved digital skills can enhance the capability of the workforce to engage with the digital economy, which could contribute to overall economic productivity (Villanueva & Herrera, 2021). Bilan et al., 2019, in their study, noted that expanding internet access would promote economic development by improving the utilisation of ICT.

The implementation of Information and Communication Technology (ICT) has been widely recognized as a significant factor in promoting financial inclusion and its subsequent impact on economic development. Studies have highlighted the positive role of financial inclusion and ICT in driving economic growth (Chatterjee, 2020; Ozili et al., 2022; Nizam et al., 2020). The review emphasizes the need for continued studies that explore the influence of financial inclusion on economic growth, indicating the growing interest in this area of study (Chimbo, 2020). Furthermore, the study extends the literature to cover financial inclusion as a determinant of economic growth, emphasizing the significance of financial inclusion in economic development (Erdil et al., 2010). The positive impact of ICT on economic growth has been a consistent finding in the literature, with studies pointing to its significant role in driving economic development (Jóia & Santos, 2018). Additionally, the works have been instrumental in establishing the developmental dimensions associated with ICT implementation and assessing the financial inclusion of communities, further underlining the importance of ICT in promoting financial inclusion (Akinwunmi & Isik, 2020; Fauzia et al., 2022). Moreover, the review of literature on the assessment of mobile telephony on financial inclusion highlights the importance of telecommunication in accessing information on finance and consummating financial and commercial transactions,

emphasizing the role of ICT in facilitating financial inclusion. The study highlights the impact of financial inclusion and ICT in suggesting development and climate change policies, further accentuating the linked nature of these factors in driving sustainable development.

2.5. Research objective

Though there are studies that have focused on the role of FI on the Economic development of a country, there are not many studies that have focused on finding the role of FI and ICT on Economic development by employing the panel data analysis. Given the changing role of emerging economies, the countries selected for the study are unique and highly relevant in the current times. Based on the research gap, the primary objective of the study is to analyse how FI and ICT contribute to the economic development of emerging economies.

3. Methodology

3.1. Sample and data extraction

The present study initially intended to include annual data from top 20 emerging economies over the period 2010 to 2024. However, due to the unavailability of crucial financial inclusion indicators—specifically, Depositors with commercial banks (per 1,000 adults) and Borrowers from commercial banks (per 1,000 adults)—eight countries were excluded from the final analysis. For instance, India, Chile, Iran (Islamic Republic), Mexico, the Russian Federation, and South Africa lacked data for both indicators throughout the study period, while the Philippines had missing data specifically for borrowers as well as Indonesia had missing data specifically for Depositors with commercial banks (per 1,000 adults). The absence of these key variables rendered it methodologically inappropriate to retain these countries, as the inclusion of incomplete data would undermine the validity, reliability, and comparability of the results across the panel dataset. A consistent and balanced panel structure is critical for drawing meaningful and statistically sound inferences, particularly in longitudinal studies that rely on uniform variable availability across countries and time. Therefore, only twelve countries—Argentina, Brazil, China, Colombia, Egypt (Arab Republic), Hungary, Malaysia, Poland, Saudi Arabia, Thailand, Turkey, and the United Arab Emirates—were retained in the final sample. These countries were selected based on the complete availability of all required variables over the 14 years, thereby ensuring the robustness of the empirical analysis and the integrity of the study's findings. Data on the above-mentioned variables are extracted from the Bloomberg Terminal. Table 1 provides the detailed descriptions of the chosen variables for the study.

Table 1: Description of the Variables

Variables	Abbr.	Unit of Measurement	Type	Source
Commercial bank branches (per 100,000 adults)	CBB	Number of commercial bank branches	Exogeneous	Bloomberg
Depositors with commercial banks (per 1,000 adults)	DWC	Number of Depositors	Exogeneous	Bloomberg
Borrowers from commercial banks (per 1,000 adults)	BCB	Number of Borrowers	Exogeneous	Bloomberg
Fixed telephone subscriptions (per 100 people)	FTS	Number of fixed telephone subscriptions	Exogeneous	Bloomberg
Mobile cellular subscriptions (per 100 people)	MCS	Number of mobile cellular subscriptions	Exogeneous	Bloomberg
Individuals using the Internet (% of population)	IUT	% of population using the internet	Exogeneous	Bloomberg
Gross Domestic Product	GDP	In figures	Endogenous	Bloomberg

3.2. Econometrics model adopted for the study

For exploring the relationship between different variables, the explanatory research approach is useful (Bryman & Bell, 2015). According to Saunders (2011) & Mohammed et al. (2019), this approach may be useful for defining unclear problems. Longitudinal data is collected for the study. Panel data estimate that comprises of pooled Ordinary Least Squares method, Fixed Effect, and Random Effect has been adopted.
The study has framed the research model, which is given below.

$$GDP_{it} = \beta_0 + \beta_1 (CBB_{it}) + \beta_2 (DWC_{it}) + \beta_3 (BCB_{it}) + \beta_4 (FTS_{it}) + \beta_5 (MCS_{it}) + \beta_6 (IUT_{it}) + u_{it} \quad (1)$$

Where,
β_0 – Intercept
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ –Beta coefficient of each variable
u – stochastic error term
it – notation for panel data

4. Analysis and discussions

4.1. Descriptive statistics

The descriptive statistics summary in Table 2 gives useful information about the distribution and characteristics of seven variables: BCB, CBB, DWC, GDP, IUT, FTS, and MCS.

Table 2: Summary of Descriptive Statistics

	BCB	CBB	DWC	GDP	IUT	FTS	MCS
Mean	5.81	2.52	6.52	27.15	4.13	2.79	4.82
Std. Dev	0.60	0.46	1.11	1.08	0.33	0.40	0.23
Minimum	3.22	1.51	2.33	25.55	3.07	1.80	4.15
Maximum	6.77	3.52	7.55	30.51	4.60	3.46	5.39
Skewness	-0.96	-0.04	-2.52	1.49	-1.00	-0.56	0.24
Kurtosis	4.45	2.81	8.57	5.05	3.72	2.89	2.89
Jarque -Bera Test (P value)	0.000	0.866	0.000	0.000	0.000	0.015	0.441
Observations	156	156	156	156	156	156	156

The mean values reflect each variable's central tendency and indicate the average level across the 156 observations. It is observed that DWC has the greatest mean at 6.52, indicating a relatively high average value, whilst IUT has the lowest mean at 4.13. The standard deviation is a measure of variability or dispersion around the mean. Variables such as DWC and GDP have higher standard deviations, indicating greater fluctuation, whereas MCS has the lowest standard deviation, 0.23, showing less variability during the study period. Skewness and kurtosis indicate the shape of the distribution. The negative skewness in BCB, CBB, DWC, IUT, and FTS indicates a leftward tail, whereas the positive skewness in GDP and MCS shows a rightward tail. Kurtosis values indicate the peakedness of a normal curve, and noted that DWC, GDP, BCB, and IUT kurtosis values are greater than three, which indicates a peak greater than the normal curve, and other variables are showing less than three, which points to less than the normal curve. Except for CBB and MCS, the probability value of the Jarque-Bera test for the chosen variables is less than 5 percent, which indicates data on these variables are not normally distributed.

4.2. Unit root test

It is mandatory to check the data of each variable for stationarity before applying any econometric model. If the data on the variable contains any trend, seasonal, or cyclical variations, it may lead to non-stationarity, and the same could not be used for further analysis. Therefore, the panel unit root test is applied to check whether the variables have a unit root problem or not with the help of two tests, namely ADF-Fisher Chi-Square and Levin. Lin and Chu t*. The following hypothesis has been formulated for the unit root test.

H_0 – Data has a unit root problem

H_1 – Data has no unit root problem

Table 3: Summary of Panel Unit Root Test

Variables	ADF-Fisher Chi-Square		Levin. Lin and Chu t*		Results
	I (0)	I(I)	I (0)	I(I)	
BCB	72.69[a]	76.34[a]	-10.02[a]	-27.63[a]	I(0)
CBB	20.11	35.92[b]	-1.41	-3.56[a]	I(1)
DWC	10.31	45.90[a]	-1.33	-2.02[b]	I(1)
GDP	19.14	52.16[a]	-1.00	-4.83[a]	I(1)
IUT	19.13	52.41[a]	-3.43[a]	-6.03[a]	I(1)
FTS	-1.05	32.42[a]	15.30	-3.02[a]	I(1)
MCS	34.36[c]	42.99[b]	-2.30[b]	-4.94[a]	I(0)

Note: (a) significant at 1 percent level, (b) significant at 5 percent level, (c) significant at 10 percent level.

Results of panel unit root tests are indicated in table 3. The result confirms that BCB and MCS are integrated at level i.e I (0), since the p value of both ADF-Fisher Chi-Square and Levin.Lin and Chu t are less than the significance level. Other variables such as CBB, DWC, GDP, IUT and FTS are integrated at first difference i,e I(1). Hence, H_1 is accepted which indicates there is no problem of unit root in the variable data.

4.3. Correlation analysis

Table 4: Summary of Correlation Matrix

Variables	GDP	BCB	CBB	DWC	IUT	FTS	MCS
GDP	1						
BCB	-0.02	1					
CBB	0.17[b]	0.10	1				
DWC	-0.06	0.01	0.13	1			
IUT	0.05	0.03	0.17[b]	0.17[b]	1		
FTS	0.14[c]	-0.03	-0.02	-0.07	-0.01	1	
MCS	0.31[a]	0.02	0.17[b]	0.07	0.01	-0.02	1

Note: (a) significant at 1 percent level, (b) significant at 5 percent level, (c) significant at 10 percent level.

Table 4 summarizes the output of the correlation matrix for the chosen variables. It is noted that a positive and significant relationship between GDP and MCS ($r=0.31$, $p<0.01$) indicates that an increase in GDP per capita is associated with better affordability and accessibility of mobile phones. As people's salaries improve, they become more able to afford mobile devices and the associated subscription plans. Also, a positive relationship is found between GDP and CBB ($r=0.17$, $p<0.05$), which points out that as a country's GDP increases, so does demand for financial services. This demand may fuel the expansion of commercial banking networks to fulfill the demands of a rising economy. In consequence, the availability of banking services can boost economic activity, investment, and entrepreneurship. Low correlation is identified between GDP and FTS ($r=0.14$, $p<0.10$), which indicates that, as GDP per capita increases, individuals and businesses may have greater access to and affordability for fixed telephone services. On the other hand, Depositors with commercial banks (DWC), Borrowers from commercial banks (BCB), and Individuals using the Internet (IUT) do not have any significant relation with the economic development of selected emerging countries. Also, the results removed the multicollinearity issues between the explanatory variables since the correlation values are far from being perfectly correlated.

4.4. Pooled ordinary least squares method

The pooled OLS estimator considers all observations within the cross-section as identical, disregarding any variation and distinctiveness among enterprises by merging the cross-sections into a single pool (Abdullah et al., 2020). Hence, this study applies fixed effects (FE) and random effects (RE) panel models, and the results are outlined below.

Table 5: Appropriate Model Selection Test

Test	Null Hypothesis	Model	χ^2Stat.	P-value	Results
Breusch-Pagan	No Panel Effect	1	53.48[a]	0.000[a]	Panel effect
Hausman	Random Effect Model is appropriate	1	5.11	0.529	Random effect

Note: (a) significant at 1 percent level.

Table 5 depicts the outcome of the appropriate model selection test. Breusch- Pegan test has been used to check whether the pooled OLS model is appropriate or Fixed Effect Model (FEM)/Random Effect Model (REM) is appropriate. The following hypothesis is formulated.
H_0 – Pooled OLS is appropriate
H_1 – FEM/REM is appropriate
Since the probability value of the Breush-Pegan test is less than one percent (χ^2=53.48, p< 0.00), it is evidence that pooled OLS is not appropriate for the prediction. Further, Hausman test has been conducted to check whether Fixed Effect Model (FEM)/Random Effect Model (REM) is appropriate. The following hypothesis is formulated.
H_0 – REM is appropriate
H_1 – FEM is appropriate
The result of the Hausman test shows that the p-value is greater than five percent (χ^2=5.11, p>0.05), and it is proven that Random Effect Model is appropriate for the prediction. Hence, the study chooses an acceptable model that accounts for panel effects and favours the use of a random effects model over a fixed effect model.

4.5. Random effect model

Table 6: Results of Random Effect Model of Regression Analysis

Endogenous Variable: GDP				
	β	S. E	t-Stat	Prob.
BCB	-0.01	0.030	-0.462	0.644
CBB	0.175	0.146	1.194	0.234
DWC	-2.35E-05	2.10E-05	-1.117	0.265
IUT	0.038	0.167	0.227	0.820
FTS	0.146	0.078	1.862	0.064[c]
MCS	0.542	0.149	3.640	0.000[a]
C	0.050	0.024	2.023	0.0449[c]
R^2	0.148			
Adj. R^2	0.110			
F-Stat.	3.972			
Prob. F-Stat.	0.000			
D.W. Stat.	1.766			
No of obs.	156			

Note: (a) significant at 1 percent level, (b) significant at 5 percent level, (c) significant at 10 percent level.

Table 6 shows the findings of a random effects model in a regression analysis with the endogenous variable GDP. The table includes coefficients (β) for each exogenous variable, standard errors (S.E.), t-statistics, and p-values. BCB has a non-significant negative connection with GDP (β = -0.01, p>0.05), indicating that changes in BCB do not correlate with changes in GDP. CBB, DWC, and IUT do not have a statistically significant influence on GDP. FTS shows a moderately significant positive connection with GDP (β = 0.146, p< 0.10), indicating that changes in FTS may positively affect GDP at the 10 percent significance level. MCS has a significant positive correlation with GDP (β = 0.542, p<0.01), indicating that increasing MCS leads to higher GDP. The intercept (C) is statistically significant (β=0.050, p<0.05), demonstrating that even when all independent variables are zero, GDP has a positive baseline effect.
The model fit is evaluated using the R-Squared (R^2), which indicates overall panel random effect model explained 14.8 percent, and 85.2 percent was explained by some other factors, which are not considered in this model. The F-statistic (F=3.972, p<0.00) is statistically significant at a one percent significance level, which indicates that the entire model is meaningful. The Durbin-Watson test score is 1.766, indicating that there is no presence of autocorrelation. Overall, this model inferred that the beneficial effects of extensive fixed telephone and mobile cellular subscribers on GDP are complex. These telecommunications services lay the groundwork for improved connectivity, allowing organisations to communicate easily, make faster choices, and increase overall operational efficiency. Improved communication infrastructure also promotes innovation and entrepreneurship, which helps firms thrive and stimulates economic activity.
Furthermore, mobile cellular subscriptions help to promote financial inclusion by giving access to mobile banking and payment services, allowing a larger proportion of the population to engage in the formal economy. Furthermore, the availability of communication services promotes market expansion, both domestically and globally, allowing enterprises to reach larger audiences and conduct more efficient commerce. Overall, the widespread availability of fixed and mobile communication services is critical to boosting economic growth, increasing efficiency, and favourably influencing GDP. Hence, H_4 and H_6 are accepted.
The results of the study confirm a positive relationship between mobile cellular subscriptions and fixed telephone subscriptions on GDP, suggesting that foundational ICT infrastructure continues to provide support to formal business operations and government services, which in turn leads to better economic growth. According to the innovation diffusion theory, for its adoption, innovation results in broad behavioural and structural changes. similarly, Mobile technology has evolved with a greater and better shape to overcome the traditional barriers related to fixed-line infrastructure in emerging economies and provide affordable communication solutions to a larger population.
On the other side, variables such as Commercial Bank Branches (CBB), Depositors with Commercial Banks (DWC), Borrowers from Commercial Banks (BCB), and Individuals Using the Internet (IUT) were statistically insignificant in influencing economic. This insignificance may reflect a shift in how financial and digital services contribute to economic activity. The expansion of branchless banking, fintech

solutions, and mobile-based financial services may have reduced the relevance of traditional banking indicators like CBB, DWC, and BCB. Similarly, while internet access (IUT) is widespread, its impact on economic productivity depends on the depth of digital integration and usage, which may vary significantly across regions. These findings suggest that the quality and nature of ICT and financial inclusion matter more than mere access or availability.

5. Conclusion, policy implications and scope for future research

5.1. Conclusion

FI has contributed to the overall development of the economy, and coupled with ICT infrastructure, the impact they have on the economic development of a country is immense. The present study correspondingly emphasized understanding the impact of select variables on GDP, which is the endogenous variable. The variables were subjected to a pooled OLS test to assess which model needed to be adopted, and it was found that the random effect model was more appropriate for the study. The panel data of 12 emerging economies was subject to Random effect regression analysis to assess the impact of the exogenous variables on the endogenous variable, that is, GDP.
The Random Effect model has inferred that there is a significant effect of fixed telephone lines and mobile cellular subscribers on GDP. Both increased telecommunication services and improved connectivity result in both households and industries benefiting immensely. The entities will be in a position to make decisions faster, increase overall operational efficiency, improve innovation, and increase entrepreneurial opportunities, which in total act as a catalyst and contribute to the GDP of the country.

5.2. Policy implications

The study analyzed the interconnections between the dimensions of financial inclusion, ICT infrastructure, and economic development of select emerging economies. Commercial bank branches measure the availability of financial services, deposits with commercial bank branches per 1,000 customers, and Loan accounts with commercial bank branches per 1,000 customers denote the access to financial services by the customers. The fixed telephone subscriptions and mobile cellular subscriptions per 100 customers and internet usage as a % of the population denote the widespread use of ICT by the country's population. The countries must increase the accessibility of financial services across the underserved section of society. The banking and government bodies together must ensure that the underserved communities can access the banking and financial services that are being offered. All government benefits and transfers must happen through the digital mode, such that people start using the services.
To ensure the safety of all digital transactions, appropriate measure needs to be in place such that customers will not be affected by any fraudulent activities. It is important to all the concerned stakeholders that the digital applications be kept simple and very easy to operate, such that people don't shy about using them. Integrating the same in all regional languages needs to be adopted by technology providers, including voice-based applications.

5.3. Scope for future research

The study, though, started with the top 20 emerging economies; later, the study was restricted to only 12 economies due to the availability of required data. A similar study can be conducted in the future by comparing different economies based on World Bank classifications, such as Category A: High income. Category B: Upper middle income. Category C: Low and lower-middle-income economies. Future studies can also consider different dimensions of FI that represent the access and usage of financial services, along with the number of ATMs and the number of online banking transactions. Incorporating a longer time or high-frequency data, like quarterly, can enhance the robustness of panel estimations and can identify short-term versus long-term dynamics. Given the influence of ICT, the scope for future researchers would be to study how the technology adoption model and UTUAT would influence the adoption of digital financial services and, therefore, enhance financial inclusion.

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