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DIGITAL FINANCIAL INCLUSION AND IMPLICATIONS FOR DEVELOPING COUNTRIES ECONOMIC GROWTH

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ABSTRACT

This study aims to develop a model to measure financial inclusion by incorporating the evolution of digital finance and identifying its relationship with GDP growth in emerging nations. Data used are from 51 developing countries in 2014 and 2017. Principal component analysis (PCA) was used to create the Digital Financial Inclusion Index. The fixed effects model (FEM) is used to estimate the association between the inclusion of digital finances and economic growth. According to the study, metrics of digital financial inclusion in emerging nations are in the middle. Compared to other research, the financial inclusion indicator in this study strengthens it. The study discovered that the inclusion of digital finance enhances GDP growth in developing nations after testing the influence of digital financial inclusion on GDP growth in developing countries.

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Introduction

Financial inclusion is an essential strategy for sustainable development (Erlando et al., 2020; Shihadeh & Liu, 2019; Yin et al., 2019). Because economic opportunity is related to access to financial services and involvement in the development process for all social classes, the importance of financial inclusion is well known, but there is no formal consensus on its definition or behavior (Ismael & Ali, 2021; Wang & Guan, 2017). Researchers have created various approaches and indicators to assess the level of finance inclusion and its effect on economic growth (Cámara & Tuesta, 2014; Sarma & Pais, 2008; Wang & Guan, 2017). Empirical evidence on financial inclusion varies due to the methodology, indicators, and object of study considered.

The focus of financial inclusion is measured by a single indicator, such as ATMs, bank branches and accounts of financial institutions, as well as by combining various indicators to composite indexes (Honohan, 2008; Okoye et al., 2017; Sarma & Pais, 2008). Financial inclusion measurement still focuses on aspects of traditional financial services, which mainly rely on physical (Shen et al., 2021). However, previous measures of financial inclusion levels need to fully capture the contribution of technology's critical role in providing better public access to financial services.

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Adopting digital technology in the financial industry provides a different dynamic (Ismael & Ali, 2021). By using digital means, the financial industry can provide financial services without going through physical contact like traditional financial services. There has also been a recent increase in the use of digital technology in the financial industry. Data from WB Findex shows that digital service indicators experienced significant growth of 12%, compared to traditional services, which only grew 6% globally from 2014 to 2017. Digital financial services can reduce barriers to accessing traditional financial services such as costs, geography, and information asymmetry (Liu et al., 2021). Because this condition has important implications for financial inclusion, the measurement used must be dynamic in the sense of adjusting the development of access to banking when there is a change in digital technology (Khera et al., 2021; Tram et al., 2021). The measurement problem will have a different impact on the conclusions given (Cámara & Tuesta, 2014; Park & Mercado, 2018). Therefore, incorporating the digital aspect of technology into the measurement of financial inclusion can provide a more comprehensive understanding of the conditions and developments of the digital aspect in promoting financial inclusion.

Financial inclusion studies that include aspects of digital technology or what is known as digital financial inclusion still need to be completed. Recent research has measured the level of digital financial inclusion by looking at relevant indicators, such as mobile accounts, digital financial transactions, and several other indicators (Liu et al., 2021; Minh et al., 2020; Shen et al., 2021). However, the study captures one aspect of digital financial inclusion at a time and cannot compare its progress. Moreover, some studies must provide a comprehensive picture to combine various aspects, including access and use. Some of these studies also needed to provide further analysis regarding the validity of the resulting measurements.

This study aims to fill the gap in the previous literature by developing a measure of the degree of financial inclusion by including digital aspects. Sarma (2016) explains that measuring the degree of financial inclusion is one of the main components of providing a financial inclusion development strategy. The focus of the study in this research is on developing countries. This is because financial inclusion remains a major challenge in developing countries where the benefits of the digital era are not shared equally due to limited infrastructure, gaps between poor and rich households, and lack of financial literacy (Le et al., 2019; Park & Mercado, 2018; Tram et al., 2021). This study contributes to building a digital financial inclusion index in developing countries by including digital financial aspects for 2014 and 2017. The index comprises financial service access and uses indices based on the most recent World Bank data and the IMF's Financial Access Survey (FAS) on digital financial services in the financial industry.

There are several benefits to building a digital financial inclusion index in this study. One is to provide a comprehensive degree in financial inclusion by including digital channels. Second, by looking at financial inclusion from several aspects rather than relying on one indicator, this study allows this research to capture the contribution of digital financial services to financial inclusion from a multidimensional perspective. Thus, this measurement of digital financial inclusion is also needed to study the impact of various initiatives by stakeholders and to decide on future actions. One of them is the economic impact, especially on economic growth. Kim et al. (2018) explained that digital financial inclusion is one of the priority efforts in supporting inclusive growth to create prosperity.

Overall, this research has two main topics. The first is to assess the extent of financial inclusion in emerging nations by considering the advancement of digital technologies.

Measurement of digital financial inclusion used the PCA method. Meanwhile, the second subject of this research is to identify the relationship between digital financial inclusion and economic growth in developing countries.

Literature Review

Digital Financial Inclusion

Digital financial inclusion (DFI) extends the previous financial inclusion. A more standardized concept and framework for digital financial inclusion come from the World Bank. DFI is a digital approach to expand the coverage and access to financial services by all circles of society by applying related digital technologies in the financial sector (World Bank, 2022). Yang & Zhang (2020) explained that DFI has several benefits. One of the benefits of financial inclusion is the rising availability and reach of financial services. DFI improves efficiency and reduces information asymmetry in financial services.

Previous measures to measure levels of financial inclusion need to fully capture the contribution of technology's increasingly important role in financial services. The use of digital technology in the financial industry is overgrowing in developing countries. Therefore, including financial inclusion through fintech can provide a more comprehensive understanding related to the conditions of financial inclusion. Studies that include aspects of digital services in measuring financial inclusion still need to be more comprehensive (Ismael & Ali, 2021; Khera et al., 2021; Shen et al., 2021; Yang & Zhang, 2020). However, some of these studies only looked at DFI from a single point in time, so they cannot be compared, more than not presenting a comprehensive picture to combine various aspects, including access and use. Despite the recent literature on digital financial inclusion, the existing literature mainly focuses on experiences in certain countries such as China (Ahmad et al., 2021; Liu et al., 2021); Egypt (Ismael & Ali, 2021); the Middle East and Central Asia (Blancher et al., 2019). There still needs to be more financial inclusion focused on developing countries. Several previous studies found that financial inclusion is still uneven in developing countries caused of several factors such as financial infrastructure, low financial literacy, macroeconomic conditions, and several other factors (Abubakar et al., 2020).

Empirical Study of Digital Financial Inclusion and Economic Growth

The link between DFI and economic growth has been recognized in previous research (Van et al., 2021). Sethi & Acharya (2018) explained that financial inclusion (FI) supports the economy through two events. First, FI increases access to financial services at an affordable cost among the public. This condition can be used to increase community production, increasing output, and economic growth. The second way is that, with a more significant FI, people can more easily access financial products such as savings and insurance. This condition will increase financial market funds that can be allocated efficiently in the form of investment (Safuan et al., 2021; Wardhono et al., 2016). This process also generates more output and employment, which leads to an increase in income distribution and economic growth (Mardanugraha et al., 2018; Wardhono et al., 2019).

Studies examining the relationship between economic growth and DFI are still relative. Although most financial inclusion studies find a positive relationship with economic growth, the question is whether this condition also applies to digital financial inclusion. Liu et al. (2021) analyzed the relationship between DFI and economic growth in China. The DFI data used are derived from the DFI index built by Peking University. The method used is Vector Autoregressive (VAR). The study by Liu et al. (2021) found that DFI encourages economic growth in China. It

occurs through a positive effect on increasing public consumption and developing MSMEs. DFI improves public and MSME access to financial services. With the convenience offered by the digital aspect of financial services, the public can quickly obtain the wrong funds used for consumption. Then, a larger DFI supports the performance of MSMEs by increasing the income used to support their business activities.

Furthermore, Ahmad et al. (2021), using data from 2011-2018 in 31 provinces in China using panel data regression, found that the DFI and human resources drive economic growth in China. Policymakers in China use fintech to provide digital financial services for all segments of society at low and affordable costs expected to support economic growth. Lai et al. (2020), using 2010-2016 data in China, found that households cannot afford insurance when there is a permanent shock to income, but they can mitigate about 70% of a temporary shock to income. Research by Lai et al. (2020) also finds that DFI reduces the ability of households to insure against transitory income shocks. Therefore, this study will also add to the literature discussing DFI and economic growth.

Data and Research Methods

Data

This research will focus on developing countries. The data used is the data of 51 countries that fall into the category of developing countries. The categorization of these countries is based on the IMF World Economic Outlook 2021. Moreover, the data used also consider the availability of existing digital financial inclusion indicator data because some countries have limited availability. Since 2011, Global Findex survey data is only available every three years, so this index was created for 2014 and 2017. Data volume for digital financial services in 2011 is relatively limited. Digital financial inclusion data utilize the availability of data sourced from WB Findex, FAS IMF, and the International Telecommunication Union (ITU).

Second, after identifying the financial inclusion level in developing countries, this study also attempts to conduct a cross-country test of digital financial inclusion on economic growth. Economic growth data is provided by the World Bank. Moreover, in the research model built, this study includes several control variables, including government spending, FDI, trade openness, and population. All data are sourced from the World Bank. Overall, the summary of the data in the study is shown in Table 1.

Table 1: Data

Variable	Definition	Unit	Source
Digital Financial Inclusion (DFI)	The financial inclusion index was built using eight financial inclusion indicators: the number of ATMs, bank branches, accounts, loans, digital transactions, mobile subscriptions, percentage of people who have internet access.	Index	IFS, ITU, and World Bank
GDP	Gross Domestic Product Per capita (2010 USD constant).	nominal	World Bank
Government Expenditure (GE)	Percentage of government spending to GDP.	Percent (%)	World Bank
FDI	Percentage of total FDI to GDP.	Percent (%)	World Bank
Population	Population using an annual population growth rate	Percent (%)	World Bank
Trade	Total imports and exports of goods and services are measured as a percentage of GDP.	Percent (%)	World Bank

Development of Digital Measurement of Financial Inclusion

Digital Financial Inclusion Indicators

This study develops a model to measure Digital Financial Inclusion (DFI) by detailing the evolution of digital technologies in the financial industry. The financial inclusion index in this study was adopted from the study of Wang & Guan (2017) and then developed by including digital financial inclusion indicators in its construction. Like Wang & Guan (2017), this study includes two dimensions of financial inclusion: the access dimension on the supply side and the usage dimension from the demand side of financial services.

The first dimension is the access dimension. Inclusive financial services must be easily accessible to the public (Sarma, 2012). The indicators used are based on financial inclusion indicators from the World Bank related to access, namely ATMs, bank branches, internet access, and mobile subscriptions. Cámara & Tuesta (2014) said the number of ATMs and bank branches considers the physical point of commercial service banks offer. The spread of ATMs and bank branches allows the public to use formal financial services. The number of ATMs and bank branches is also used as a representative of access to financial services in the study of Beck et al. (2007), Sarma (2012, 2016), and Van et al. (2021) describe the per capita size of branches and ATMs used to capture the demographic penetration of the banking sector. Meanwhile, the World Bank (2022) explains that subscriptions and internet access are essential digital infrastructures for digital access to financial services. These two indicators are important components that provide new channels for accessing digital financial services (Banna & Alam, 2021; Khera et al., 2021a; Shen et al., 2021).

In the dimensions of use, several indicators used in this study are also based on indicators of use for financial inclusion from the World Bank, namely the number of accounts, deposits, loans, and digital transactions. Sarma (2016) explains that using an account is a primary aspect of using financial services provided by banks. Several previous studies also used account indicators, such as Sarma (2012, 2015) and Wang & Guan (2017). The amount of deposits and loans used follows the usage indicators from the World Bank, which is a product of financial services. Digital transactions are services of digital finance. Beck et al. (2007) explained that bank deposits and loans are the primary services offered by banks. Beck et al. (2007) interpret more deposits and loans as a signal of more significant service usage. Beck & Demirgüç-Kunt (2008), Gupte et al. (2012), and Sarma (2016) also use deposit and loan indicators as indicators of financial inclusion in terms of usage. Moreover, the World Bank (2022) explains that digital transactions are an essential indicator in viewing digital financial inclusion in terms of usage. It is used to find out whether the use of financial services is fully utilized both through physical and digital access.

Table 2: Summary of Digital Inclusion Financial Indicators

Dimension	Variable	Definition	Unit
Access (banking penetration)	ATM	Number of ATMs/100,000 Adults	Numerical
	BANK	Number of Bank Branches/100,000 Adults	Numerical
	Mobile	Mobile subscription/100 people	Numerical
	Internet	Percentage of people who have internet access	Percent (%)
Usage	Account	Percentage of people who have a financial institution account	Percent (%)
	Deposit	Outstanding Deposits (% of GDP)	Percent (%)
	Loan	Outstanding Loans (% of GDP	Percent (%)
	Dtrans	Digital Transaction with Made or received digital payments (% age 15+)	Percent (%)

Digital Financial Inclusion Index Development Approach

The method used in building the financial inclusion index in this study is Principal Component Analysis (PCA). This methodology was also used in previous studies, such as the study by Park & Mercado (2018), Ahamed & Mallick (2019), Sahay et al. (2020), and Tram et al. (2021), and several other researchers. PCA is used to adequately capture the overall variability between these correlated components of financial inclusion as a single measure (Ahamed & Mallick, 2019). In summary, PCA research has two estimation stages in the index creation process. In the first stage, the research estimates the scores of the two dimensions (sub-index) of access and use and the weight of each indicator. It is used to determine the contribution of indicators in shaping access and use in financial inclusion. The study estimates the overall DFI index and dimensional weights in the second stage. Before applying PCA, the metrics for each aspect were standardized due to the different units of measurement between variables, so the measurement scale was immaterial. In PCA, data processing is done using Stata 16 Software.

The first level of PCA is intended for dimensional access of Y_{it}^{a} and use Y_{it}^{u} in the following:

$$Y_{it}^{a} = \gamma_1 ATM_{it} + \gamma_2 BANK_{it} + \gamma_3 Mobile_{it} + \gamma_4 Internet_{it} \quad (1)$$

$$Y_{it}^{u} = \delta_1 Account_{it} + \delta_2 Deposit_{it} + \delta_3 Loan_{it} + \delta_4 Dtrans_{it} \quad (2)$$

After obtaining a score for each dimension, the study continued to the second stage of PCA. Like the first stage, it used scores on the resulting access and used dimensions (IFI sub-index) to obtain a digital financial inclusion index.

$$DFI_{it} = w_1 Y_{it}^{a} + w_2 Y_{it}^{u} \quad (3)$$

Where DFI is a composite index of digital financial inclusion (DFI), w_1, w_2 is the relative weight for each dimension of DFI. Finally, the study obtained the weight of each dimension, w_k, in the index DFI with the following equation:

$$w_k = \frac{\sum_{j=1}^{3} \lambda_j \varphi_{jk}}{\sum_{j=1}^{3} \lambda_j}, k = 1,2,3 \quad (4)$$

Where λ is the eigenvalue of each principal component. φ is the factor loading of each sub-index. Moreover, the weights for the dimensions of access and use are also obtained using the same schema in Equation 4.

The Correlation of Digital Financial Inclusion and GDP Growth

This study, in particular, used a panel model to investigate the influence of DFI on GDP growth. First, the study makes a panel data regression model with a logarithmic transformation of GDP so that the relationship between DFI and economic growth can be estimated using these data. The model built in this study was adopted from the study of Sethi & Acharya (2018) and Khera et al. (2021), who also examine financial inclusion and economic growth. The panel model for this study is:

$$\ln GDP_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 GE_{it} + \beta_3 FDI_{it} + \beta_4 POP_{it} + \beta_5 TRADE_{it} + \varepsilon_{it} \quad (5)$$

In this model, the dependent variable is GDP which describes economic growth, and the independent variable is DFI. This model considers GE, FDI, POP, and TRADE control variables. Control variables are included in the panel model estimation, one of which to minimize is the omitted variable bias (OVB). Incorporating government expenditure controls (GE) based on studies by Sethi & Acharya (2018) and Van et al. (2021), then foreign direct investment based on Kim et al. (2018), Chatterjee (2020) and Van et al. (2021), population and trade control based on Kim et al. (2018), Sethi & Acharya (2018) and Van et al. (2021). Moreover, to get a good model, whether PLS, Random Effect Model, or Fixed Effect Model, one of them will be tested with the Hausman and LM tests.

Result and Discussion

Digital Financial Inclusion Index

In the first stage of PCA, it is used to determine the contribution of each indicator in obtaining the value of the access and usage dimensions. The contribution is known from the resulting weight. Before implementing the first stage of PCA, it is necessary to carry out the Kaiser-Meyer-Olkin test. This test ensures that the adequacy of the sample and the selected indicators are correlated.

Table 3: Kaiser–Meyer–Olkin Test in First Stage PCA

Access dimension		**Usage dimension**	
Variable	**KMO**	**Variable**	**KMO**
ATM	0.6953	Account	0.6038
BANK	0.7950	Mobile Transaction	0.8538
Mobile	0.7820	Deposit	0.6990
Internet	07497	Loan	0.6103
Overall	**0.7429**	**Total**	**0.6558**

The results of the KMO test in Table 3 show that the KMO test value is greater than or equal to 0.5, in the sense that the research sample size is sufficient and the indicators used in this study are correlated. KMO for the access dimension is 0.74, and KMO for the usage dimension is 0.65. With these results, the analysis can be continued for PCA estimation. Furthermore, Table 4 presents the outcome of the first PCA stage.

Table 4: Principal Component Analysis Estimation in First Stage

Access dimension					
Variable	**PC1**	**PC2**	**PC3**	**PC4**	**Norm Weight**
ATM	0.5665	-0.0453	-0.1772	-0.8046	0.253883
BANK	0.3732	0.8905	0.1968	0.1705	0.440964
Mobile	0.5002	-0.4127	0.7289	0.2193	0.321518
Internet	0.5382	-0.1862	-0.6327	0.5248	0.261139
Eigenvalues	**2.44017**	**0.79922**	**0.448463**	**0.312146**	
Usage dimension					
Variable	**PC1**	**PC2**	**PC3**	**PC4**	**Norm Weight**
Account	0.5914	-0.1778	-0.2541	-0.7444	0.257119
Dtrans	0.4943	0.0278	0.8640	0.0912	0.426954
Deposit	0.3138	-0.9176	0.2201	0.1052	0.02504
Loan	0.5545	-0.3544	0.3754	-0.6531	0.285013
Eigenvalues	**2.43134**	**0.870141**	**0.54103**	**0.157485**	

From the results of the PCA estimation regarding the weighting scheme on the access dimension, this study found that the highest weight was the indicator of the number of Bank Branches. Tram et al. (2021) explained that bank branches would be the beginning of access to financial services. More direct data is directed to the nearest bank branch office for the first account creation or the introduction of public financial services. These results are supported by a study from Bruhn & Love (2014) that opening new commercial banks encourages increased access to credit for low-income individuals in Mexico. Then, digital financial services infrastructure indicators such as the internet and mobile cellular are essential in increasing access to financial services, with weights of 26% and 32%, respectively. This component serves to provide adequate infrastructure for accessing digital financial services. PCA results on the usage dimension also show that digital transaction indicators have the highest weight in the use of financial services. The convenience and costs offered by digital transactions are significant implications for using financing services provided by banks (Indrawati et al., 2020; Rekha et al., 2022).

Then for the second stage of PCA, to construct financial inclusion from the dimensions of access and use, like the first stage of PCA, before implementing the second stage of PCA, the KMO test must be done. The results of the second stage of KMO are in Table 5.

Table 5: Kaiser–Meyer–Olkin Test in Second Stage PCA

Variable	KMO
Access	0.5000
Usage	0.5000
Total	0.5000

The results of the KMO test in Table 5 show that the KMO test value is equal to 0.5 in the sense that it is sufficient and the indicators used are correlated. KMO for the dimensions of access and usage dimensions is 0.52. With these results, PCA analysis can be continued. Table 6 presents the results of the second stage of PCA.

Table 6: Principal Component Analysis Estimation in Second Stage

Dimension	PC1	PC2	Norm Weight
Access dimension	0.7071	0.7071	0.7071
Usage dimension	0.7071	-0.7071	0.2907
Eigenvalues	1.73549	0.264508	

This study finds that access to financial services gives more significant weight than the usage dimension regarding the weighting scheme. These results indicate that improvement in access is an essential aspect of providing opportunities for the public to enjoy the financial services provided.

Then, from PCA estimation stages 1 and 2, the digital financial inclusion index is shown in Table 7 (Appendix). Following previous studies, this study's ranking or category of digital financial inclusion is divided into three categories: high, medium, and low. High, medium, and low refer to countries in the 75th percentile or higher, the 25th to 75th percentile, and below. Overall, the PCA estimation results show that the average level of DFI in developing countries is in the middle category. In more detail from Table 7, it can be seen that in 2014 there were 13 countries with digital financial inclusion in the high category, 25 countries in the middle category, and 13 countries in the low category. The country that has a high financial inclusion index is Mongolia, followed by Thailand and Malaysia. Mongolia is taking advantage of new technologies, such as mobile banking, which can provide opportunities to increase penetration in rural areas (World Bank, 2012).

Meanwhile, the country with the lowest DFI index in the results of this study for 2017 is Madagascar, followed by Congo, Dem. Republic and Pakistan with indexes of 0.008 and 0.073, respectively. The three countries' obstacles to financial inclusion are limited access, such as the need for digital infrastructure, and physical services, such as access and ATMs.

According to this study, the financial inclusion index increased by 25% between 2014 and 2017. The component of access to financial institutions dominated the increase. The number of ATMs has been the most significant increase over the last decade, especially in developing countries. Moreover, an essential factor in DFI in the form of digital infrastructure, such as mobile cellular, is increasing sharply in developing countries, and mobile phones have played an essential role in accessing the internet, especially in countries with lower per capita incomes (Khera et al., 2021; Liu et al., 2021; Sahay et al., 2020). The rapid development of ownership of cellular telephones and the internet has increased access and use of financial services, especially for transaction purposes. Data from the World Bank show that the use of digital transactions increased by 12% from 2014 to 2017. The convenience and benefits offered by digital financial services in conducting financial activities encourage an increase in this component in developing countries (Shen et al., 2021; Wardhono et al., 2020; Yang & Zhang, 2020). This condition is also evidenced by the results of the second phase of the PCA, which shows that digital transactions are the primary indicator in encouraging the acceleration of the use of financial services in developing countries.

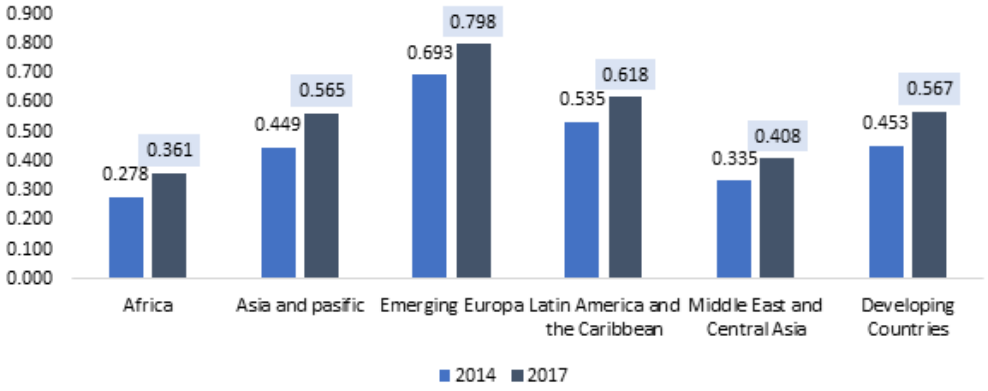

Figure 1: Financial Inclusion Index in Developing Countries

Digital financial inclusion in regional divisions also increased between 2014 and 2017. The highest increase in DFI was in the African region, which increased by 29% in the 2014 to 2017 period. The rapid increase in ownership of mobile phones and internet access has encouraged the use of financial services in Africa. Between 2014 and 2017, sub-Saharan African adults with mobile money accounts nearly doubled (12% to 21%). However, although Africa experiences the highest development of financial inclusion, financial inclusion in Africa has relatively lower financial inclusion than other regions such as Asia, Europe, and the Americas. Girón et al. (2021) show that financial infrastructure, income inequality, and financial literacy hinder financial inclusion in Africa. In a different direction, the European region has the highest level of financial inclusion compared to other regions. Over the past decade, Europe's account ownership increased from 45% of the adult population in 2011 to 65% in 2017. The transformation of digital financial services has driven financial inclusion in the European region in recent years (Khera et al., 2021). The ease and affordability of the costs offered in the financial industry from the application of technology provide opportunities for greater access for all circles of society in using financial services.

Then for the robustness check for the strength of the financial inclusion index, this study conducted a validity test based on the idea of Beck & Demirgüç-Kunt (2008) and Ahamed & Mallick (2019). This study tested the correlation between financial inclusion in this study and the FI index from Park & Mercado (2018). The results can be seen in Tables 7 and 8. The results show that the DFI index of this study and the FI index of Park & Mercado (2018) (IFI) are strongly correlated. These results indicate that the digital financial inclusion index in this study has sufficient evidence to confirm that the FI index of this study is valid and relatively strong compared to the measurement of financial inclusion conducted in previous studies.

Table 7: Correlation of Digital Financial Inclusion Index and IFI Park and Mercado (2018)

	DFI	IFI ParkMercado
DFI	1.0000	
IFI ParkMercado	0.6976*	1.0000

Note: Significant *p<0.05

Table 8: Estimation Results of Research DFI and IFI from Park and Mercado (2018)

Variable	Result
DFI	29.4127***
	4.315412
CONT	0.8865453***
	(2.943275)
Observation	51
R-Square	0.4867

Note: Significant ***p<0.01; **p<0.05; *p<0.10

Relationship between Digital Financial Inclusion and Economic Growth

This section relates to the relationship between DFI and economic growth estimation results. Before doing the estimation, the model selection test was used to find out the best model that was carried out in the study. Two tests are used, namely the Lagrange Multiplier and Hausman tests.

Table 9: Model Selection Test

Lagrange Multiplier Test		Hausman Test	
Chibar2	33.69	Chi2	37.62
Prob > Chibar2	0.0000	Prob > Chi2	0.0000

The results of the Lagrange Multiplier test show that the random effect model was chosen compared to the least squares (PLS) panel model. Then, for the Hausman test, it is known that the pro>chi2 value is 0.0000 or below 0.05, which indicates that the model chosen is the fixed effect model.

In this case, the estimation results of the fixed effect model are in Table 10, column 1. The test results using the fixed effect model show that DFI has a significant positive effect on GDP at 1%, 5%, and 10%. The resulting coefficient is 0.63. This result means that when there is an increase in DFI by 1%, it will increase GDP by 0.63%. The positive impact of DFIs on GDP growth in the fixed effect model were also confirmed by the random effects model and the PLS model, both of which found that DFI had a significant positive effect on GDP with coefficients of 0.81 and 2.81, respectively. This condition means that this positive result follows other models. This is following research conducted by Aminou et al. (2020), Khera

et al. (2021), Shen et al. (2021), and Rekha et al. (2022) state that an increase in DFI affects increasing economic growth. Economic growth conditions are driven by consumption (Khera et al., 2021; Wardhono et al., 2016).

Table 10: Estimation Results of Digital Financial Inclusion on Economic Growth

Variable	Fixed Effect Model	Random Effect Model	PLS Model
DFI	0.6364461***	0.8162988***	2.8112623***
	(0.0910985)	(0.1081634)	(0.2546697)
GE	0.0030217	0.0114543**	0.0113476*
	(0.008095)	(0.0088193)	(0.010866)
FDI	-0.0100245***	-0.0408183***	0.0190295**
	(0.026506)	(0.0032386)	(0.0120199)
POP	-0.0183081	-0.0408183*	-0.0497707
	(0.0227218)	(0.027095)	(0.0606249)
TRADE	0.0011248	0.0015152	-0.0040226
	(0.0997842)	(0.000917)	(0.0017624)
CONS	7.600157	67.4110781	6.750337
	(0.1331351)	(0.172561)	(0.2568245)
Observation	**102**	**102**	**102**
R-Square	**0.5786**	**0.5771**	**0.6778**

Note: Significant: ***p<0.01; **p<0.05; *p<0.10

Sethi & Acharya (2018) also show that financial inclusion affects economic growth in two ways. The first is increasing access to credit which encourages the creation of a production process that ultimately leads to an increase in output and economic growth. The second is great access to deposit or insurance products. This condition encourages increased funds in the money market to efficiently use resources by allocating or investing in productive sources (Wardhono et al., 2019). This results in more output, which leads to increased economic growth.

Moreover, Yang & Zhang (2020) explained that digital financial inclusion has several benefits, namely increasing the accessibility of financial services, increasing the scope of financial services, diversifying financial service products suitable for the community, and efficient use of financial services. The benefits received from financial inclusion are increased access to affordable credit and increased access to other financial services products such as deposits and insurance (Safuan et al., 2021; Sethi & Acharya, 2018). Excellent access to credit, especially for previously unbanked people, will allow them to take advantage of the ease of financing for productive use. Organized production activities feel these benefits, which ultimately create more output (Sethi & Acharya, 2018). In other words, access to affordable credit can encourage an increase in output production and will impact increasing income. Then the existence of public savings encourages long-term investment, which can produce more output and employment. This condition will create an improvement in income distribution. It is also supported by the study of Kendall et al. (2010), which found that greater access supports economic efficiency, leading to increased economic growth.

Robustness Test Relationship of DFI and Economic Growth

Robustness tests of the estimation results of the relationship between DFI and economic growth, in this case, the coefficient sensitivity and consistency tests of the results, were carried out by eliminating or breaking the control variables. As explained earlier, four

control variables are included in the model built in Chapter 3 to test digital financial inclusion and economic growth. In this case, the estimate will be tested when the control variable is not included, using one control variable, two control variables, and three control variables, and all control variables are included. In this case, the consistency of the results is achieved when the direction and coefficient values do not change much. The results of the robustness test by playing the control variables in the estimation results of the relationship between DFI and economic growth can be seen in Table 11.

Table 11: Robustness Test Estimation Results of Digital Financial Inclusion on Economic Growth

Variable	Model FE without control variable	FE Model with 1 control variable	FE Model with 2 control variables	FE Model with 3 control variables	FE Model with full control variable
DFI	0.586796***	0.585008***	0.613089***	0.603572***	0.6364461***
	(0.0961499)	(0.0969861)	(0.0877744)	(0.0891542)	(0.0910985)
GE		0.0040297	0.0035456	0. 004136	0.0030217
		(0.0086264)	(0.0080685)	(0.0081477)	(0.008095)
FDI			-0.08935***	-0.00889***	-0.010024***
			(0.0025451)	(0.0025582)	(0.026506)
POP				-0.0168052	-0.0183081
				(0.0229515)	(0.0227218)
TRADE					0.0011248
					(0.0997842)
CONS	7.677189	7.733542	7.652186	7.675598	7.600157
	(0. 0464037)	(0. 1293844)	(0. 1188886)	(0.123672)	(0.1331351)
Observation	102	102	102	102	102
R-Square	0.6549	0.6304	0.6039	0.6070	0.05786

Note: Significant: ***p<0.01; **p<0.05; *p<0.10

The robustness test calculation of the association between digital financial inclusion and GDP growth is shown in Table 12. In general, the coefficient values for all models used are known, but the coefficient values for digital financial inclusion are not much different. The range of coefficient values for digital financial inclusion is 0.58 for the model without control variables and 0.63 for all control variables. Overall, from all models, the results show that financial inclusion significantly affects economic growth. These results indicate that the model built is consistent with the results offered. Financial inclusion, in particular, has a considerable positive impact on economic growth.

Conclusion

This study develops the development of a digital financial inclusion index by including the development of digital technology in the financial industry. Developing a digital financial inclusion index takes advantage of the latest World Bank and IMF FAS data development. Moreover, after getting the results of the digital financial inclusion index built into this study, this paper provides empirical evidence of the impact of the inclusion of digital finance on developing-country economic growth.

According to the test results in this study, the overall digital financial inclusion index in developing countries is in the middle category, with the most significant increase in the African region. A comparison with other studies shows that the index of this study strengthens

the previous study. Moreover, the results also show that the accessibility dimension is a significant component in determining digital financial inclusion with a determining indicator, namely the number of bank branches. Then, in the dimension of use, the results show that digital transactions are the component with the highest weight in determining the use of financial services. For the results of testing the effect of digital financial inclusion on economic growth in developing countries, the inclusion of digital finance has a strong positive effect on increased GDP. It strengthens the evidence and follows financial inclusion objectives in developing countries. Namely, one of the goals of developing financial inclusion is encouraging economic growth.

Based on the results of this study, several policies are embodied from this study's results; first, related authorities such as the government and central banks need to increase digital financial inclusion as a strategy to increase economic growth. Increasing digital financial inclusion in terms of access can be encouraged by improving the quantity and quality of public and digital financial service infrastructure. Meanwhile, in terms of usage, this can be done through diversification and innovation in providing digital services that suit the community's needs. The second is the need to consider issues that impede the development of financial inclusion. The World Bank explained that the main regulatory issues raised regarding digital financial inclusion were consumer protection, payment system regulation, and financial competition. The relevant authorities, therefore, need to build trust in digital finance through well-developed electronic payment systems, solid and transparent regulations, and consumer protection. Third, the collaboration between various national and international stakeholders is essential in developing digital financial inclusion.

One of the limitations of this study is the limited measurement of financial inclusion using the PCA method. We can also consider other methods of building a digital financial inclusion index in the future. Second, case study research only focuses on developing countries. In the future, we can consider a comparison with developed countries. Third, the period used in building digital financial inclusion is only two time periods. This period is partly due to limited data availability. Using a more extended time will provide many perspectives from the results obtained.

Declaration

In this section, I declare that this research: (1) does not conflict with anyone's interests (2) Availability of data and materials, (3) there are the author's contributions, (4) there is a source of funding and (5) and acknowledgments.

Conflict of Interest

The authors declare that there is no significant competing financial, professional, or personal interests that might have affected the performance.

Availability of Data and Materials

The data are freely available on World Development Indicator, published by World Bank on given URL ID: https://databank.worldbank.org/source/global-financial-inclusion.

Authors' Contribution

Sugiharso Safuan and Misbahol Yaqin conceptualized the study; Misbahol Yaqin created the methodology; Sugiharso Safuan and Misbahol Yaqin wrote, reviewed, and edited the manuscript; Sugiharso Safuan and Misbahol Yaqin wrote the original draft.

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Appendix

Table 12: Digital Financial Inclusion Index Results

2014				2017			
Negara	**DFI**	**Ranking**	**Category**	**Country**	**DFI**	**Ranking**	**Category**
Armenia	0.511	18	Medium	Armenia	0.702	13	High
Bangladesh	0.218	40	Low	Bangladesh	0.359	36	Medium
Benin	0.192	42	Low	Benin	0.307	41	Low
Bolivia	0.445	26	Medium	Bolivia	0.572	21	Medium
Botswana	0.552	16	Medium	Botswana	0.546	24	Medium
Brazil	0.838	4	High	Brazil	0.837	8	High
Cambodia	0.273	35	Medium	Cambodia	0.333	38	Medium
Cameroon	0.105	48	Low	Cameroon	0.226	46	Low
Chile	0.846	3	High	Chile	0.942	4	High
China	0.612	12	High	China	0.764	10	High
Colombia	0.564	15	Medium	Colombia	0.651	17	Medium
Congo, Dem. Rep.	0.041	50	Low	Congo, Dem. Rep.	0.073	50	Low
Congo, Rep.	0.152	45	Low	Congo, Rep.	0.201	47	Low
Dominican Republic	0.434	27	Medium	Dominican Republic	0.561	23	Medium
Egypt, Arab Rep.	0.244	37	Medium	Egypt, Arab Rep.	0.389	33	Medium
El Salvador	0.471	21	Medium	El Salvador	0.495	29	Medium
Georgia	0.645	10	High	Georgia	0.865	7	High
Ghana	0.305	34	Medium	Ghana	0.474	30	Medium
Guatemala	0.517	17	Medium	Guatemala	0.584	20	Medium
Honduras	0.375	29	Medium	Honduras	0.468	31	Medium
India	0.373	30	Medium	India	0.533	25	Medium
Indonesia	0.452	25	Medium	Indonesia	0.646	18	Medium
Jordan	0.431	28	Medium	Jordan	0.495	28	Medium

2014				2017			
Negara	**DFI**	**Ranking**	**Category**	**Country**	**DFI**	**Ranking**	**Category**
Kenya	0.455	24	Medium	Kenya	0.529	26	Medium
Madagascar	0.002	51	Low	Madagascar	0.008	51	Low
Malaysia	0.935	1	High	Malaysia	0.967	3	High
Mauritania	0.309	33	Medium	Mauritania	0.370	35	Medium
Mexico	0.463	22	Medium	Mexico	0.524	27	Medium
Moldova	0.600	13	High	Moldova	0.673	15	Medium
Mongolia	0.850	2	High	Mongolia	1.000	1	High
Myanmar	0.077	49	Low	Myanmar	0.197	48	Low
Namibia	0.564	14	Medium	Namibia	0.760	11	High
Nicaragua	0.255	36	Medium	Nicaragua	0.378	34	Medium
Nigeria	0.330	32	Medium	Nigeria	0.326	40	Low
Pakistan	0.117	47	Low	Pakistan	0.184	49	Low
Panama	0.750	9	High	Panama	0.740	12	High
Peru	0.458	23	Medium	Peru	0.663	16	Medium
Philippines	0.350	31	Medium	Philippines	0.410	32	Medium
Romania	0.641	11	High	Romania	0.685	14	Medium
Rwanda	0.221	39	Low	Rwanda	0.281	42	Low
Senegal	0.199	41	Low	Senegal	0.332	39	Low
South Africa	0.795	7	High	South Africa	0.830	9	High
Thailand	0.796	6	High	Thailand	0.975	2	High
Togo	0.118	46	Low	Togo	0.250	44	Low
Tunisia	0.483	20	Medium	Tunisia	0.585	19	Medium
Turkey	0.766	8	High	Turkey	0.899	5	High
Uganda	0.165	44	Low	Uganda	0.244	45	Low
Ukraine	0.811	5	High	Ukraine	0.868	6	High
Vietnam	0.506	19	Medium	Vietnam	0.564	22	Medium
Zambia	0.177	43	Low	Zambia	0.260	43	Low

2014				2017			
Negara	**DFI**	**Ranking**	**Category**	**Country**	**DFI**	**Ranking**	**Category**
Zimbabwe	0.231	38	Low	Zimbabwe	0.352	37	Medium
Developing Countries	**0.432**		**Medium**	**Developing Countries**	**0.527**		**Medium**

Note: The category of digital financial inclusion level (high, medium, and low) for each country follows the study of Sarma (2012) and Khera et al. (2021) assigned to the 75th percentile or higher (high category), 25th to 75th percentile (medium category) and below 25th (low category) of the index.