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Measuring Digital Financial Inclusion Across the Globe: A New Multidimensional Index

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Abstract: *In this paper, a new index of digital financial inclusion is developed using the access, usage, and availability dimensions of digital financial inclusion. The two-stage principal component analysis is applied to develop an index using the IMF financial access survey data for 68 countries from the year 2014-2021. The countries are further divided into four groups using World Bank income classifications. The new index proposed in this study covers 68 countries based on continuous data from the IMF FAS survey. The index is a contribution to the ongoing literature on digital finance and will be used as a device to measure digital financial inclusion. The results show that the high-income countries are technologically advanced and have a higher ranking in digital financial inclusion while the upper middle (UMIC) and lower-middle-income countries (LMIC) are making steady progress with respect to the digitization of the financial sector while low-income countries are less digitally inclusive due to lack of digital infrastructure. Moreover, they have the problem of a lack of digital finance data. International financial institutions i.e. The World Bank, IMF, and national financial institutions such as central banks should work towards a vibrant and digitally inclusive financial sector.*

Key Words: Digital Financial Inclusion Index, Two Stage PCA, IMF, World Bank, Financial Institutions

Introduction

Digital finance is a technically sophisticated blend of finance and technology. Financial technology has led to the establishment of new types of businesses, expanding economic activities hence improving the standard of living across the globe (Nazir et al., 2020). In literature, financial inclusion is defined as the "provision of efficient and cost-effective financial services such as payments, investment, saving & credit to the financially excluded and under-served population" (World Bank, 2021). The digital financial service providers can be categorized into four sub-domains: "full-service banks offering basic financial accounts for payment, transfer, and storage of value with the help of mobile phone or payment cards, Limited-service bank offering transactional account, a mobile network operator, and a non-bank non-mobile network e-money issuer" (Lauer, 2015).

Traditional financial services have faced many challenges, including market failures such as transaction cost, information asymmetry, moral hazard, adverse selection, behavioral biases, poorly defined property rights, and weak legal and regulatory institutions creating hurdles in the efficiency of financial service delivery. The introduction of digital technology in the financial sector has affected the lives of people in many ways during the last decade. According to Nazir et al., (2020), financial technology has given rise to new kinds of businesses, more investment opportunities, saving, and raising the living standards. Digital technology's emergence and development in finance can be exciting places to work. Financial technology is a new active player in the world of finance during the late decade. It has changed the landscape of the world of commercial activities. Digital financial inclusion is one form of digitization of commercial activities.

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Digital finance offers promising benefits to users. It has empowered and benefited the marginalized segments of society that were previously excluded from traditional brick-and-mortar banking (Ozili, 2018). It provides more freedom and control for the users of financial services. According to Ozili (2021) one of the best aspects of digitizing financial services is that along with providing financial solutions to the existing users of financial services, it also targets the unbanked population who lack access to traditional banking. Keeping in mind these benefits and potential of digital finance in transforming the financial landscape of the world, in the current study we attempt to measure digital financial inclusion across 68 countries divided into 04 groups based on income level...

The literature review has shown that various authors and institutions have come up with a measure of inclusive finance by using alternative proxies and several statistical techniques over the past decade. In this respect, Sarma (2012) made a groundbreaking contribution to measuring financial services across countries. She took the number of bank branches as a proxy for access to financial services; ATMs as a proxy for the usage dimension of FI and domestic loans to the private sector as a percentage of GDP covering 94 countries from 2004 to 2010. In addition, Camara & Tuesta (2015) came up with an inclusive finance index based on a two-stage PCA method in which access and usage dimensions were employed for 2011. Moreover, the notable contribution in developing a device for measurement of financial inclusion was given by Sahay et al., (2015) in a comprehensive study covering 176 countries based on access to financial inclusion. Similarly many authors have attempted to develop an index to measure financial inclusion using different dimensions of inclusion i.e. usage dimension, availability dimension, and access dimension (Mialou et al., 2017; Norris et al., 2016; Loukoianova et al., 2018). However, these studies only covered the traditional aspects of financial inclusion and did not capture a digital aspect. To our best knowledge,, there are few studies that have attempted to include some dimensions of digital finance. Khera et al. (2021) constructed an index of DF inclusion based on 52 emerging economies by combining traditional and digital finance characteristics. To step further in this direction, this study is an attempt to measure digital financial inclusion across the globe using IMF data available for the 68 countries comprising the period from 2014 to 2021. To make the comparison comprehensive this study has utilized the World Bank income classification methods. The new index of DFI developed in this study by considering three dimensions i.e. usage, access, and availability of digital infrastructure is a new addition to the ongoing literature. To create the digital financial inclusion index, we used a two-stage principal component analysis (PCA).

Literature Review

Financial inclusion remains an interesting field both for academicians and practitioners. Research conducted during the past two decades focused on different dimensions of financial inclusion i.e. effect of financial inclusion on the economic well-being of people, the determinants of financial inclusion, and its measurement. Efforts have been made by international financial institutions i.e. World Bank & IMF and national financial institutions such as central banks and non-governmental organizations to create a vibrant and inclusive financial system. Few authors and organizations have proposed various scales for the measurement of financial inclusion. A review of the research is provided in the following section.

Measurement of Financial Inclusion

Measurement of financial inclusion is the first step towards creating an understanding of financial inclusion. It is also used as a tool to create awareness about the importance of financial inclusion. Achieve higher financial inclusion is now considered a sustainable development goal of the world.

Financial inclusion measurement has been widely studied leading to the development of various indices that evaluate the degree of financial inclusion in different countries and regions. The World Bank published a global Findex database for the years 2011, 2014, 2017 & 2021; most researchers refer to it for their work on financial inclusion worldwide for example Khera et al., (2021) & Camara & Tuesta, (2014). Demirgüç-Kunt & Klapper (2012) created a database, known as the Global Findex database which is now extensively utilized for gauging worldwide financial inclusion and published in the years 2014, 2017, and 2021 Demirgüç-Kunt et al., (2020, 2022). Likewise, Sarma & Pais (2010) developed the Inclusive Finance Index (IFI) to determine country-level factors contributing to financial inclusion. Additionally, Camara &

Tuesta (2015) proposed a multidimensional index to measure financial inclusion considering several dimensions of inclusion.

The FI index is a tool used to measure FI at both the country and global levels. The review of the literature revealed contributions made by diverse authors and organizations in developing a comprehensive measure of standard financial inclusion by employing different proxies and statistical techniques in the last decade. Using non-parametric approaches, researchers add exogenous weights to many measures of financial inclusion. For example, Sarma's (2016) research was a step toward the international measurement of financial inclusion for 94 countries over 2004-2010, it used bank branches, ATMs, and bank accounts as proxy variables for quantity.

Few studies have employed a parametric approach in assigning weights to the different dimensions of FI endogenously. A case in point, for instance, Camara & Tuesta (2015) developed an inclusive finance index through the two-stage PCA method with regard to access and usage dimensions using data from 2011. Besides, Sahay et al., (2015) conducted a comprehensive study of 176 countries on access to financial inclusion in order to design a measure of the same. Similarly, other writers have produced an index of financial inclusion based on access and use components (Mialou et al., 2017; Norris et al., 2016; Loukoianova et al., 2018). These articles only deal with the traditional aspect of financial inclusion and do not account for digital.

With respect to evaluating DFI in emerging economies, Khera et al. (2022) established a distinctive indicator for emerging market and developing economies that is meant for digital finance. Contributing to the evaluation of the effects of digital financial inclusion, Khera et al., (2022) created a unique index for digital financial inclusion that covers emerging markets and developing economies. In addition, the DFI index of Peking University was used by Li et al. (2020) to ascertain the effects of digital finance on household consumption in China giving important information on the effects of DFI on consumption patterns.

Considering everything, researching traditional and digital indices of financial inclusion provides interesting details about how it is quantified and its effect on various social as well as economic aspects. These studies and indices assist in painting a broader picture of where financial inclusion stands at, and how the advent of digital financial inclusion has changed many sectors across different areas.

There isn't agreement on a single financial inclusion measure. Financial inclusion encompasses many aspects of the financial system hence, it cannot be measured by using a single aspect e.g. number of bank branches, number of bank accounts, or number of bank transactions. The countries may perform differently from other countries in different dimensions of financial inclusion. Similarly, different studies have used different measures to capture dimensions of financial inclusion. International agencies such as IMF and World Bank have developed financial inclusion indices. Similarly, at the country level, central banks, microfinance institutions, and non-government financial institutions also measure inclusiveness of the financial sector. The literature on the measurement of digital financial inclusion is limited and inconclusive. To add to the existing research, this study is an attempt to quantify DFI and develop a new index of DFI.

Digital Financial Inclusion (DFI) stylized facts.

The rapid improvement in FI with the advent of digital technology is transforming both the access and usage dimensions of FI. According to the Global Findex database (2021), it is noted that approximately seventy-one percent of people in developing countries have formal accounts in 2021 compared to 42 percent in 2011. The share of adults who are making transactions digitally in developing countries has increased from 24 percent in 2014 to 57 percent in 2021. In Africa, about 39 percent of adults use mobile accounts for savings. It was found that more than one-third of people in developing economies paid utility bills via mobile phones and around 76 percent of account owners, constituting 52 percent of the adult population, have used digital financial services. The statistics show that in high-income countries, about 97 % of people constituting 91 % of the adult population are capitalizing on digital financial products for daily life utilities. (IMF, 2021). Due to advancements in information technology, especially in the last decade the access, availability, and affordability of digital products has increased. Millions of customers

who were previously using cash-based financial services or excluded from the financial landscape are now using digital financial services (Lauer, 2015). The usage of mobile money significantly increased in developing countries. In 2020, the value of mobile money usage increased by 2% of GDP in developing economies (*Global Findex*, n.d.). The volume and number of mobile and Internet financial services have increased, especially in upper-middle, and high-income countries. The global financial sector was approximately US$26.5 trillion in 2022, with a cumulative growth rate of 6%. Mobile transactions are expected to proliferate, and around 88% of banking transactions are now hovering. The use of cash in markets has decreased by 42 % since 2019. (*Fintech: Financial Technology Industry Stats for 2022 | Tipalti*, 2022.)

Table 1

Global Account Ownership 2011-2021

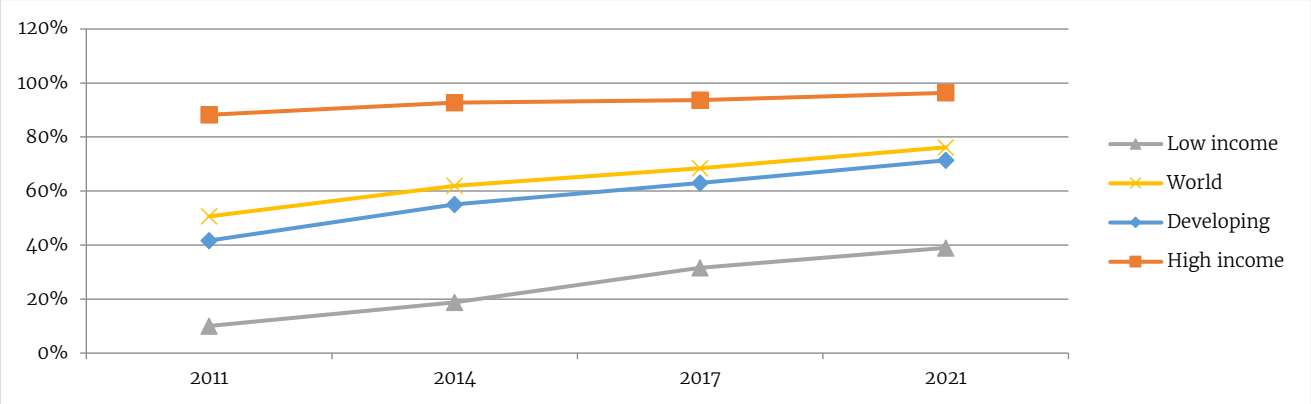
Year	Developing Countries	High-income Countries	Low-income Countries	World
2011	42%	88%	10%	51%
2014	55%	93%	19%	62%
2017	63%	94%	32%	68%
2021	71%	96%	39%	76%

Source: Global Findex Database 2021.

Table 1 shows Global Account Ownership from 2011 to 2021. The table shows that account holding at banks and financial institutions has increased from 51% in 2011 to 76% in 2021. Developing countries recorded enormous growth in account ownership from 42% in 2011 to 71 % in 2021. Approximately 4 times growth in account ownership was recorded in developing counties.

Figure 1

Global Account Ownership 2011-2021



Source: Global Findex Database 2021.

Figure 1 shows global account ownership from 2011 to 2021. The graph shows an increasing trend with respect to account holding by people and organizations. The Developing countries recorded enormous growth in account ownership from 42% in 2011 to 71 % in 2021. Approximately four times growth in account ownership was recorded in developing counties.

Table 2

Made or Received Digital Payments % of adults 2014-2017-2021

Year	World	High-Income Countries	Upper-Middle Countries	Lower-Middle Income	Low-Income Countries
2014	44%	88%	48%	24%	12%
2017	52%	90%	61%	31%	22%
2021	64%	95%	80%	38%	35%

Source: Global Findex Database 2021

Table 2 shows the percentage of the population who made or received digital payments during the years 2014, 2017 & 2021. The digital payments have increased from 44 percent in 2011 to 64 percent in 2021. On the other hand, only 12 percent of the population was using digital finance in 2014 while 35 percent population was using digital financial tools in 2021.

Figure 2

Usage of Digital Finance (Region Wise)

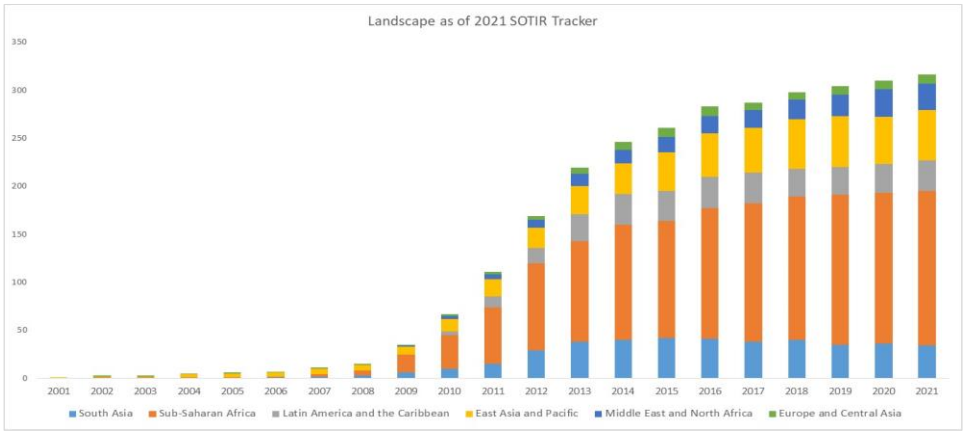


Figure 2 shows progress in mobile money usage across the regions. The orange bar represents Sub-Saharan Africa, and the graph shows that there is a significant increase in the usage of digital finance in this region. Similarly, other important regions of the world such as South Asia, East Asia & Pacific have also recorded an increase in the use of mobile money.

Figure 3

Unbanked Population Across the Globe

Source: Global Findex database 2021

Figure 3 presents a map of the unbanked population in the world. According to the data, approximately 1.4 billion people around the world are excluded from financial services. An opportunity arises for the providers of digital finance to fill the gap. The majority belong to Southeast Asia, Sub-Saharan Africa, and Australia.

Methodology

Sample of Study

The study covers both the developed and developing world. The sample is composed of 68 countries across the globe. The analysis is based on 08 years of data comprising from 2014-21. The countries were selected

based on availability of data in the database of financial access survey of IMF. To make the comparison comprehensive this study has utilized the World Bank income classification methods of countries to divide the sample into four groups i.e. "High-income countries having per capita income greater than $13205, Upper-middle income countries, having per capita income ranges between $4256 - $13205, Lower-middle income countries having per capita income in the range of $1086 - $ 4255 and Low-income countries having per capita income less than $1085".

Definition & measurement of variables for DFII

Table 3

Definition and measurement of variables

Name of variable	Definition of Variable	Data Source
Access to Digital Finance	1. "Number of ATMS 2. Number of ATMs per 100000 adults 3. Number of Automated Tellers Machines per 1000 KM"	IMF FAS Survey
Usage of Digital Finance	1. "Number of mobile & internet banking transactions". 2. "Value of mobile and net banking transactions as a percentage of GDP"	IMF FAS Survey
Availability of digital finance	1. Mobile subscriptions per 100 adults 2. Broadband Subscriptions 3. Individuals using the Internet percent of the population	GSMA

Construction of DFII.

Prior to the application of PCA, the indicators explaining different dimensions of digital financial inclusion were normalized to get the value between 0 and 1 to make the original measurement scale irrelevant and to avoid large values. The following method was used to normalize the data.

$$X_{\text{normalized}} = \frac{\text{Actual value} - \text{Min Value}}{\text{Max Value} - \text{Min Value}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{i}$$

Application of Principle Components Analysis

Construction of Digital Financial Inclusion Index

The digital financial inclusion index is constructed using two-stage Principal Component Analysis. We adopted two-stage PCA approaches followed by Khera et al., (2021) to measure DFII. Principle Component Analysis is the most commonly used method of dimension reduction for index construction in social science research. In PCA, principal components are calculated which are linear functions of the variables. The PCA is a dimension reduction method encompassing maximum variation in data and reducing multiple components to a single component for measurement with minimum loss of information.

We measured the "digital financial inclusion in terms of three dimensions i.e. dimension of access of digital finance, usage dimension of digital financial inclusion, and availability dimension of digital financial inclusion" (Khera et al., 2021; Lyons et al., 2020; Rekha et al., 2021; Venet, 2019). "The principle component analysis (PCA) is a dimension reduction technique which helps to combine maximum information in one component using different correlated components without significant loss of information" (Jiang et al., 2021; Rekha et al., 2021). In the first stage, three sub-indices i.e. access of digital finance, usage of digital finance, and availability dimension of DFI are estimated using the indicators of each dimension.

Calculation of Sub-Indices

First Stage PCA

To calculate the sub-indices of access, usage, and availability of digital financial inclusion, the value of the underlying explanatory variable is multiplied by absolute loadings of principal components. The absolute loadings are taken from the first principle components. The following equations were used in the first stage of PCA to calculate sub-indices.

$$Y_{access} = \beta_0 + \beta_1 ATMs + \beta_2 ATMSper1000km + \beta_3 ATMper1000adults + e_t \ldots\text{ii}$$

$Y_{usage} = \beta_0 + \beta_1 Noofmobilebanking\ transactons + \beta_2 Valueofmobilebanking\ transactons + e_t$ ……………………………………………iii

$Y_{availabillity} = \beta_0 + \beta_1 Monbilesubscription + \beta_2 Broadand\ subscribers + \beta_2 Internetusage + e_t$ ……………………………………………iv

Second Stage PCA

A similar procedure was applied in the second phase of PCA to calculate the overall DFII.

$DFII = Access + Usage + Availabillity + e_t$ ………………….v

Results & Discussion

Descriptive Statistics

Descriptive statistics are presented in Table 4. The average value of the number of ATMs in selected 68 countries during the years 2014 to 2021 is 19086 with a minimum value of 114 for Guinea and a maximum value of 222761 for Russia. The ATM per 1000 KM was used to measure the geographic coverage of ATMs in a country. The average value of the number of ATMs per 1000km was 69.07 the maximum per 1000 km coverage of ATMs was recorded as 1255.14 in Korea and the least geographic coverage of ATMs was recorded in Guinea. The average value of mobile and internet banking transactions as a percentage of gross domestic product was 302.87 and the maximum value was recorded for 3786.437 in The Netherlands. The minimum value for the access dimension of digital finance is -.446 and the maximum value is 4.665, similarly the minimum value of the usage dimension is -.89, and the maximum value is 8.271 and the minimum value of the availability dimension is -2.265 and the maximum value is 1.413. The digital financial inclusion index was normalized to have a value between 0 and 1 to make comparison easy and simple. The average value of the digital financial inclusion index is 0.61 this shows that the selected countries are continuously making progress with respect to the digitization of the financial systems. The average index of DFI is higher because most of the countries are either higher or upper-middle-income countries and very few low-income countries were included in the sample due to the non-availability of the data on low-income countries. The unavailability of data for lower-income countries in the IMF financial access survey is why we have few lower-income countries.

Table 4

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ATM	544	19086.043	42917.022	114	222761
ATMper1000km	544	69.076	146.818	.464	1255.14
ATMper100000adults	544	57.985	45.877	1.869	280.808
"Value of Mobile & Internet transactions as a percent of GDP"	544	302.877	413.634	0	3786.437
Number Transact per 100Adults	544	41449.109	60337.642	.105	553564.5
Broadband Sub per 100 Adults	544	17.694	13.856	.008	47.498
Mobile subscribers per 100 adults	544	113.088	27.273	0	181.77
Individuals using the Internet % of the Population	544	63.625	25.484	5.83	99
Access dimension of DFI	544	0	1	-.446	4.665
Usage dimension of DFI	544	0	1	-.89	8.271
Availability dimension of DFI	544	0	1	-2.265	1.413
DFII	544	.616	.272	0	1

Source: Calculated by authors in STATA 14.

Construction of the DFI Index

The DFI index is constructed using the well-known methodology of two-stage principal component analysis as used by Khera et al. (2021) to measure DFI.

Calculation of Sub-Indices

First Stage PCA

First, the method of principle component analysis is applied to develop sub-indices of access, usage, and availability of DFI. The values of the underlying explanatory variable are multiplied with absolute loadings of principal components. The absolute loadings are taken from the first principle components. Using the PCA method at the first stage we estimated the latent variable Access (Yac) as a function of principal components. Table 5 shows that the eigenvalues for the access dimension of digital finance are 1.88, 0.78, and 0.33, similarly, the eigenvalues for the usage of digital finance are 1.068 and 0.932. The eigenvalues for availability dimensions of digital finance are 2.17,0.674 and 0.148. Using Kaiser's (1960) criteria the factors with eigenvalues greater than 1 are included and considered as prominent indicators. Therefore, the first component of each dimension with eigenvalues 1.88, 1.068, and 2.17 are greater than 1, hence included in the analysis.

Table 5

Principle Component Analysis for sub-indices

"Component	Eigenvalue	Difference	Proportion	Cumulative"
Access of Digital Finance-Estimates Y^{ac}				
"Component 01	1.889	1.109	0.63	0.63
Component 02	0.78	0.449	0.26	0.89
Component 03"	0.331	.	0.11	1
Usage of Digital Finance-Estimates Y^{us}				
Component 01	1.068	0.135	0.534	0.534
Component 02	0.932	.	0.466	1
Availability of Digital Finance-Estimates Y^{av}				
Component 01	2.178	1.504	0.726	0.726
Component 02	0.674	0.526	0.225	0.951
Component 03	0.148	.	0.049	1

Source: Calculated by authors in STATA 14.

Table 6

First Stage PCA Loadings- Access to Digital Finance

Component	Component 1	Component 2	Component 3	Unexplained
Number of ATMs	0.465	0.861	0.208	0
ATMper1000km	0.603	-0.479	0.638	0
ATMper1000 Adults	0.649	-0.171	-0.742	0

Table 7

First Stage PCA Loadings- Access to Digital Finance Usage of Digital Finance

Component	Component 1	Component 2	Unexplained
Number of Internet Transactions	0.707	0.707	0
Value of mobile & internet Transactions % of GDP	0.707	-0.707	0

Table 8

First Stage PCA Loadings- Availability of Digital Finance

Component	Component 1	Component 2	Component 3	Unexplained
Broadband subscribers per 100 adults	0.605	-0.456	0.653	0
Mobile subscribers per 100 adults	0.475	0.865	0.163	0
Individuals using the Internet % of the population	0.639	-0.212	-0.740	0

Source: Calculated by authors in STATA 14.

Kaiser-Meyer-Olkin) KMO for Indicators

Kaiser-Meyer-Olkin) The KMO test was conducted to check whether the factorization is possible or not. The values of the KMO test are presented in Table 9. Table 9 shows that the KMO values for each indicator of access dimension are greater than 0.5, similarly, the values of KMO are also greater than 0.5 for indicators measuring the usage and availability dimension of digital financial inclusion. The overall value of the KMO test is also greater than 0.5 hence we can conclude that the factorization is possible in given data.

Table 9

Kaiser-Meyer-Olkin) KMO for indicators

Dimension	Variables	KMO
Access Dimension	ATMS	0.5583
	Number of ATMS per 1000 adults	0.5527
	No ATMS per 1000 KM	0.5037
	Overall	0.5413
Availability Dimension	Broadband subscribers	0.557
	Mobile Subscribers	0.698
	Individual Using Internet	0.542
	Overall	0.572
Usage Dimension	Number of Internet banking transactions	0.5
	value of net banking transactions as % of GDP	0.5
	Overall	0.572

Source: Calculated by authors in STATA 14

Kaiser-Meyer-Olkin) KMO for Sub-Indices

Kaiser-Meyer-Olkin) KMO test was also applied to the calculated indices of DFI. The results are presented in Table 10. The results confirm that the KMO value of each of the dimensions of DFI and overall is greater than 0.5 therefore the analysis of the factors is consistent with the data.

Table 10

Kaiser-Meyer-Olkin) KMO for Sub-Indices

Variables	KMO
Access	0.734
Usage	0.5808
Availability	0.5676
Overall	0.5982

Source: Calculated by authors in STATA 14

Result of Second Stage PCA

The same procedure of the first phase was adopted in the second stage. The eigenvalues of the PCA analysis are presented in Table 11 as 1.80, 0.77, and 0.42. Table 11 also shows that more than 60% of variation is the data is explained by the first principal component, hence this study took the first PC. The square root of PC1's eigenvalue is divided by the loading values of each indicator on principle component 1 to determine the weights for the digital financial inclusion index. Table 12 displays the weights that have been adjusted. The PCA gives the availability component of digital financial inclusion a weight of 36.9 percent, the usage dimension of 35 percent, and the access dimension of 27 percent. The weights assigned to each aspect of digital finance in the final digital financial inclusion index calculation are represented by equation vi.

$$DFII = 0.277Access + 0.353Usage + 0.369Availabillity + e_t \dots\dots\dots\dots\dots\dots\dots \text{vi}$$

Table 11

Principle Component Analysis second stage for DFII

"Component	Eigenvalue	Difference	Proportion	Cumulative "
Component 01	1.808	1.037	0.603	0.603
Component 02	0.771	0.349	0.257	0.860
"Component 01	0.422	.	0.141	1.000

Source: Calculated by authors in STATA 14.

Table 12

Second Stage PCA Loadings- Digital Financial Inclusion Index

Indicators	Comp1	Comp2	Comp3	Normalized Weights
Access of DFI	0.477	0.867	0.142	0.277
Usage of DFI	0.607	-0.442	0.661	0.353
Availability of DFI	0.636	-0.229	-0.737	0.369

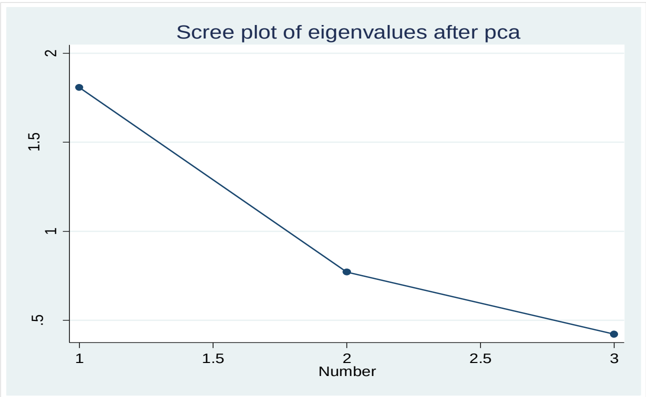
Source: Calculated by authors in STATA 14.

Scree Plot

Utilizing Cattell's (1966) suggested scree plot as a guide, we assessed the number of components to be kept. Figure 5.1 illustrates that the higher portions of the scree plot may be kept, while the lower portions may be removed.

Figure 4

Scree Plot of Eigenvalues after PCA



Digital Financial Inclusion Index of Sample Countries (2014-2021)

Using these three indices we have developed an overall DFII in the second stage. To facilitate comprehension, we have employed a normalization approach to normalize the index for every country. The scale ranges from 0 to 1, where 1 denotes a country's complete digital financial inclusion and 0 represents its complete exclusion. Higher levels of digital financial inclusion are indicated by higher index values, and vice versa. The following formula is used to do the normalization.

$$DFII_{\text{normalized}} = \frac{\text{Actual value} - \text{Min Value}}{\text{Max Value} - \text{Min Value}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .. \text{vii}$$

The difference in measurement methods and selection of variables for the financial inclusion index has produced different index values for countries. Previous studies have used data from the word Bank Financial Inclusion Index i.e. Camara & Tuesta, 2017 & Khera et al. 2021.

DFII of High-Income Countries

The DFII for high-income countries from 2014 to 2021 is shown in table 13. It is discovered that most of the high-income countries have higher digital financial inclusion with an index value greater than 0.8. The

higher-income countries are more technologically advanced and innovative. The access, usage, and availability dimensions of DFI are higher in HIC compared to LIC. The DFII values for Denmark, Luxemburg, Norway, and Korea are greater than 0.95 during the last decade.

Table 13

DFII of High-Income Countries (2014-2021)

S. No	Country	2014	2015	2016	2017	2018	2019	2020	2021
1	Austria	0.81	0.84	0.84	0.88	0.88	0.88	0.88	0.93
2	Belgium	0.85	0.85	0.87	0.88	0.89	0.91	0.92	0.93
3	Chile	0.59	0.76	0.83	0.82	0.85	0.86	0.89	0.90
4	Croatia	0.67	0.69	0.72	0.66	0.75	0.79	0.78	0.81
5	Cyprus	0.68	0.71	0.75	0.80	0.84	0.86	0.91	0.91
6	Czech Republic	0.73	0.75	0.76	0.78	0.80	0.81	0.81	0.82
7	Denmark	0.97	0.97	0.98	0.98	0.98	0.99	0.97	1.00
8	Estonia	0.84	0.89	0.87	0.88	0.90	0.91	0.89	0.91
9	France	0.84	0.77	0.79	0.80	0.82	0.83	0.85	0.86
10	Hungary	0.75	0.72	0.79	0.76	0.75	0.80	0.85	0.89
11	Korea	0.88	0.90	0.93	0.96	0.97	0.97	0.97	0.98
12	Latvia	0.75	0.79	0.79	0.80	0.83	0.86	0.89	0.92
13	Lithuania	0.71	0.70	0.74	0.77	0.79	0.81	0.83	0.87
14	Luxembourg	0.95	0.97	0.99	0.98	0.98	0.98	1.00	1.00
15	The Netherlands	0.92	0.92	0.91	0.94	0.92	0.94	0.92	0.93
16	Norway	0.97	0.98	0.98	0.97	0.97	0.99	0.98	1.00
17	Panama	0.42	0.49	0.52	0.58	0.60	0.62	0.63	0.64
18	Poland	0.65	0.67	0.72	0.75	0.77	0.80	0.83	0.85
19	Portugal	0.63	0.67	0.69	0.73	0.74	0.75	0.78	0.82
20	Slovak Republic	0.80	0.77	0.80	0.81	0.80	0.83	0.90	0.89
21	Slovenia	0.71	0.72	0.75	0.78	0.79	0.83	0.87	0.89
22	Spain	0.76	0.78	0.80	0.85	0.86	0.91	0.94	0.95
23	Sweden	0.93	0.91	0.90	0.94	0.90	0.95	0.95	0.89
24	Switzerland	0.88	0.88	0.89	0.90	0.92	0.94	0.95	0.96

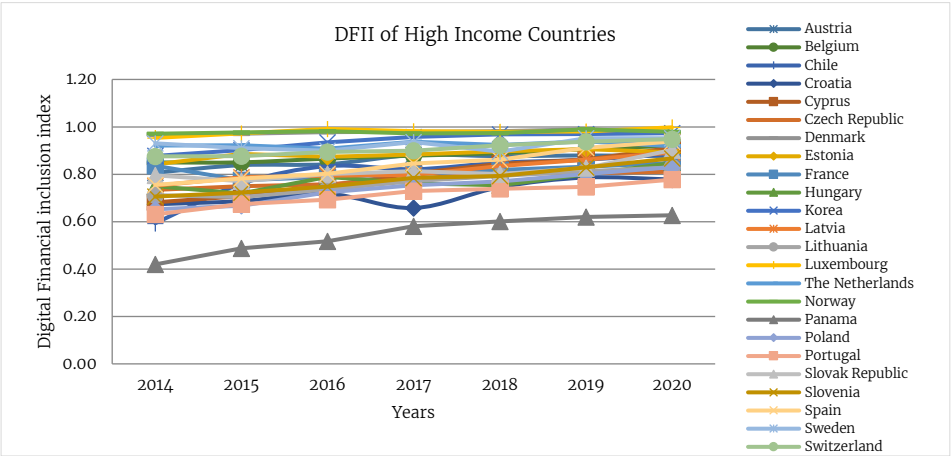
Source: Calculated by authors in STATA 14.

DFII of High-Income Countries

Figure 5.2 presents the pattern of DFII in high-income countries during the period 2014 to 2021. The DFII values for Denmark, Luxemburg, Norway, and Korea are greater than 0.95 during the last decade. Panama is the least inclusive country with respect to digital finance in our sample of high-income countries, but the trend line shows an increasing trend from 0.40 value in 2014 to 0.62 in 2021.

Figure 5

DFII of High-Income Countries (2014-2021)



DFII of Upper Middle-Income Countries

The DFII for upper middle-income countries from 2014 to 2021 is shown in Table 14. Digital financial inclusion is high in the majority of upper-middle-income countries. Most upper-middle-income countries have DFII scores that are higher than 0.5. The Russian Federation, Lebanon, and Kazakhstan have demonstrated a greater digital financial inclusion score in comparison to other countries in upper-middle-income countries.

Table 14

DFII of Upper Middle Income Countries (2014-2021)

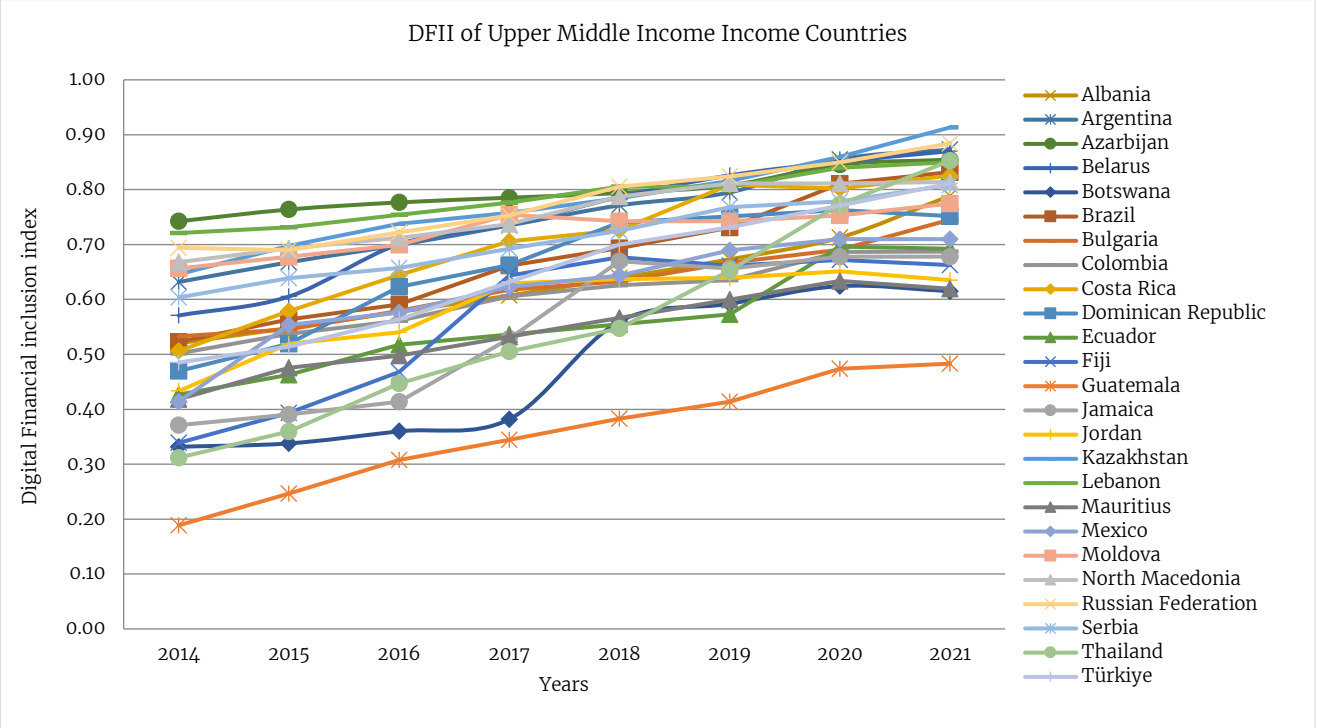
S. No	Country	2014	2015	2016	2017	2018	2019	2020	2021
1	Albania	0.52	0.55	0.58	0.61	0.64	0.67	0.71	0.79
2	Argentina	0.63	0.67	0.70	0.73	0.77	0.79	0.86	0.87
3	Azarbijan	0.74	0.76	0.78	0.79	0.79	0.81	0.85	0.85
4	Belarus	0.57	0.61	0.70	0.74	0.79	0.83	0.85	0.87
5	Botswana	0.33	0.34	0.36	0.38	0.56	0.59	0.62	0.62
6	Brazil	0.52	0.56	0.59	0.66	0.69	0.73	0.81	0.83
7	Bulgaria	0.53	0.55	0.58	0.62	0.63	0.67	0.69	0.75
8	Colombia	0.50	0.54	0.56	0.61	0.63	0.64	0.69	0.69
9	Costa Rica	0.51	0.58	0.64	0.71	0.73	0.81	0.80	0.83
10	Dominican Republic	0.47	0.52	0.62	0.66	0.74	0.75	0.76	0.75
11	Ecuador	0.43	0.46	0.52	0.54	0.55	0.57	0.70	0.69
12	Fiji	0.34	0.39	0.47	0.64	0.68	0.66	0.67	0.66
13	Guatemala	0.19	0.25	0.31	0.34	0.38	0.41	0.47	0.48
14	Jamaica	0.37	0.39	0.41	0.53	0.67	0.66	0.68	0.68
15	Jordan	0.43	0.52	0.54	0.63	0.64	0.64	0.65	0.64
16	Kazakhstan	0.65	0.70	0.74	0.76	0.78	0.82	0.86	0.91
17	Lebanon	0.72	0.73	0.75	0.78	0.81	0.81	0.84	0.85
18	Mauritius	0.42	0.48	0.50	0.53	0.57	0.60	0.63	0.62
19	Mexico	0.41	0.55	0.58	0.62	0.64	0.69	0.71	0.71
20	Moldova	0.66	0.68	0.70	0.75	0.74	0.74	0.75	0.77
21	North Macedonia	0.67	0.69	0.71	0.74	0.79	0.81	0.81	0.81
22	Russian Federation	0.69	0.69	0.72	0.75	0.81	0.82	0.85	0.88
23	Serbia	0.60	0.64	0.66	0.69	0.72	0.77	0.78	0.81
24	Thailand	0.31	0.36	0.45	0.51	0.55	0.65	0.77	0.85
25	Türkiye	0.49	0.51	0.56	0.63	0.70	0.73	0.77	0.81

Source: Calculated by authors in STATA 14.

Figure 5.3 presents the pattern of the digital financial inclusion index of upper-middle-income countries during the period 2014 to 2021. The most upper-middle income has shown a rise in digital financial inclusion from 2014 to 2021, Russian Federation, Lebanon Kazakhstan, Argentina, and Brazil have shown significant progress in digital financial inclusion. Some countries in upper middle-income categories such as Guatemala, Jamaica, & Mauritius are still struggling to improve digital financial inclusion.

Figure 6

DFII of Upper Middle-Income Countries (2014-2021)



DFII of Lower Middle-Income Countries (2014-2021)

Table 15 shows DFII for lower middle-income countries (LMIC). The table shows that most of the lower-middle-income countries are making progress with respect to DFI. The DFII of most LMIC countries is increasing during the period 2014 to 2021. Malaysia has made significant progress in the digital financial inclusion index with an index value of 0.62 in 2014 and 0.98 in 2021. Similar progress has been recorded in Cobe Verde, Ghana, Mongolia Tunisia, and Vietnam. Some of the lower-middle-income countries such as Pakistan and Bangladesh have low digital financial inclusion.

Table 15

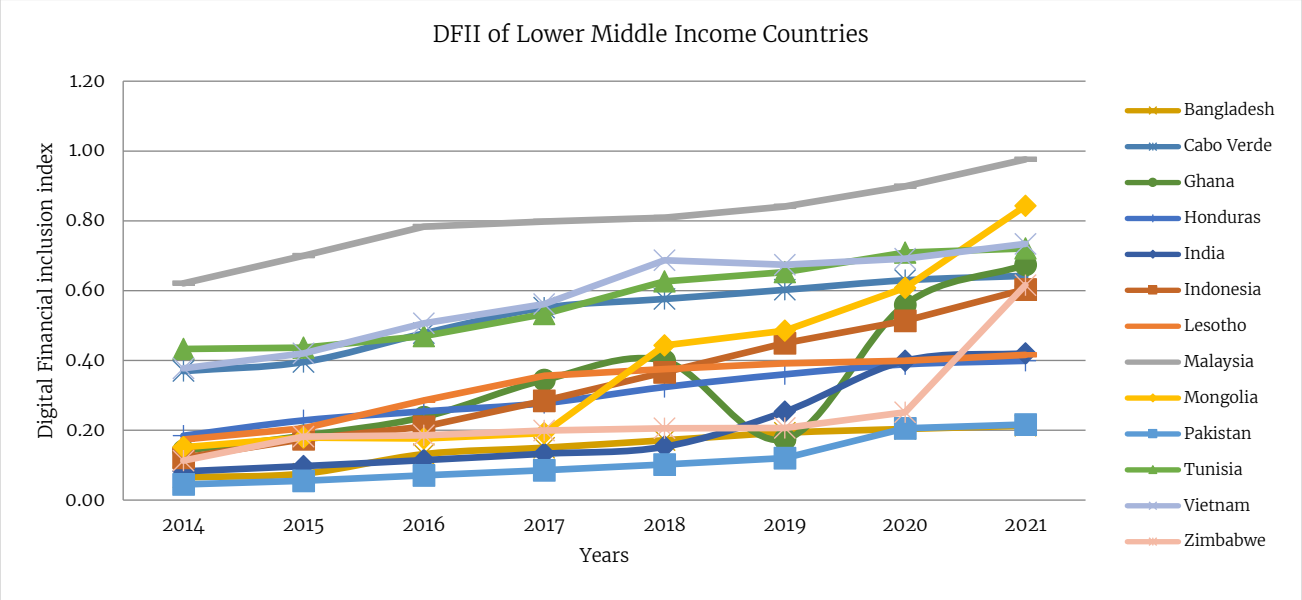
DFII of Lower Middle-Income Countries (2014-2021)

S. No	Country	2014	2015	2016	2017	2018	2019	2020	2021
1	Bangladesh	0.07	0.08	0.13	0.15	0.17	0.19	0.20	0.21
2	Cabo Verde	0.37	0.40	0.48	0.55	0.58	0.60	0.63	0.64
3	Ghana	0.14	0.18	0.24	0.34	0.40	0.17	0.56	0.67
4	Honduras	0.18	0.23	0.25	0.28	0.32	0.36	0.39	0.40
5	India	0.08	0.10	0.11	0.13	0.15	0.25	0.40	0.42
6	Indonesia	0.12	0.17	0.21	0.28	0.37	0.45	0.51	0.60
7	Lesotho	0.17	0.21	0.29	0.36	0.38	0.39	0.40	0.42
8	Malaysia	0.62	0.70	0.78	0.80	0.81	0.84	0.90	0.98
9	Mongolia	0.15	0.18	0.18	0.19	0.44	0.49	0.61	0.84
10	Pakistan	0.04	0.06	0.07	0.09	0.10	0.12	0.21	0.22
11	Tunisia	0.43	0.44	0.47	0.53	0.63	0.65	0.71	0.72
12	Vietnam	0.38	0.42	0.51	0.56	0.69	0.67	0.69	0.73
13	Zimbabwe	0.11	0.18	0.19	0.20	0.21	0.21	0.25	0.62

Source: Calculated by authors in STATA 14.

Figure 7

DFII of Lower Middle-Income Countries (2014-2021)



DFII of Low-Income Countries (2014-2021)

The index of low-income countries' DFI is shown in Table 16. The International Financial Statistics Database contains the complete data for just six low-income countries in the given period. The findings indicate that the majority of low-income countries lack digital financial services and have inadequate digital infrastructure. Mozambique has a DFII rating of 0, while Cameron had the highest DFII value in 2020, which is 0.34. Regarding digital financial inclusion, Cameron is making headway as evidenced by the fact that its index value rose from 0.11 in 2014 to 0.30 in 2021. In low-income nations, digital financial inclusion is essential because it enables people to access financial services via digital channels like digital wallets and mobile money.

Table 16

DFII of Low-Income Countries (2014-2021)

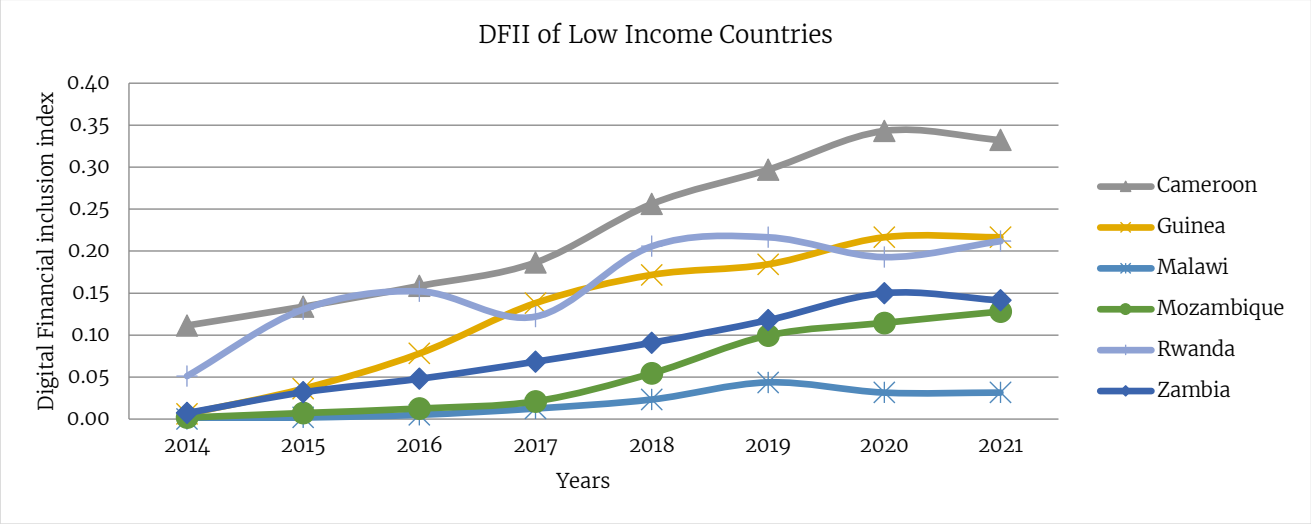
S. No	Country	2014	2015	2016	2017	2018	2019	2020	2021
1	Cameroon	0.11	0.13	0.16	0.19	0.26	0.30	0.34	0.33
2	Guinea	0.01	0.04	0.08	0.14	0.17	0.18	0.22	0.22
3	Malawi	0.00	0.00	0.01	0.01	0.02	0.04	0.03	0.03
4	Mozambique	0.00	0.01	0.01	0.02	0.05	0.10	0.11	0.13
5	Rwanda	0.05	0.13	0.15	0.12	0.21	0.22	0.19	0.21
6	Zambia	0.01	0.03	0.05	0.07	0.09	0.12	0.15	0.14

Source: Calculated by authors in STATA 14

Figure 5.5 shows the pattern of the DFII of low-income countries from 2014 to 2021. The results show that most of the low-income countries have poor digital infrastructure, and digital financial services are not available in low-income countries but they are slowly and gradually making progress in DFI. The DFII value is 0 for Mozambique and the highest value of DFII is 0.34 for Cameron in 2020. Cameron is making progress with respect to digital financial inclusion as its index value has increased from 0.11 in 2014 to 0.30 in 2021. Low-income countries are facing challenges in data privacy and data security. Governments and financial stakeholders in these countries can work towards a more inclusive financial system that benefits all members of society (Geng & He, 2021).

Figure 8

DFII of Low-Income Countries (2014-2021)



Conclusion

The objective of this study was to develop a new multidimensional measure of digital financial inclusion. The study used the IMF financial access survey data for the 68 countries for 8 years from 2014 to 2021. The principle component analysis (PCA) was applied. The sampled countries were further divided into 04 groups based on the Word Bank income classification. The results revealed that the world is making progress in digital finance. Financial services across the globe are digitized to reduce transaction costs, improve transparency, and enhance financial independence.

The comparison has been made in the high-income, upper-middle, lower-middle, and lower-income countries. A huge digital divide is reported in high and low-income countries across the globe, but it is appealing that the world is collectively making progress with respect to digital financial inclusion. The findings of this study show that the high-income countries are highly inclusive with respect to financial inclusion as the financial sector of the high-income countries is developed, the banks and financial institutions in these countries provide more efficient financial services through digital means. As far as upper-middle and lower-middle-income countries are concerned, the digital inclusion of financial services has been increasing since 2014. On the other hand, low-income countries are progressing at a very slow rate. Studies have shown that high digital financial inclusion helps improve the income and standard of living of people. The World Bank, IMF, and financial institutions in low-income countries should work together to improve digital financial inclusion in low-income countries. It is recommended that the World Bank and IMF, being proponents of financial inclusion should work to increase income-generating activities in low-income countries.

Implications of the Study

1. There is an unequal distribution of DFI across the world. There is a gap between low-income countries and high-income countries with respect to the inclusiveness of digital finance.
2. The government in lower middle- and low-income countries should switch payments such as salaries, transfer payments to a cashless system. The role of government in facilitating payments is inevitable for promoting digital financial inclusion in low-income economies.
3. Lower middle- and low-income countries have poor digital infrastructure. Limited ATMs, and limited access to smart phones and the internet hence the policy makers in these countries must focus on developing infrastructure for digital finance. The IMF & World Bank should work on transferring financial technology to low-income countries.
4. Access to the mobile phones and internet should also be provided to the people in lower middle-income countries and low-income countries.

Limitations & Future Research Directions

1. The findings of the study are limited to the time period under study and the sample of study. The data for the 68 countries for 8 years was available on the financial access survey. In future more research can be conducted using large data sets covering more countries and years.
2. This index can be used as a tool to measure DFI in future. The digital financial inclusion index proposed in this study can be used as a tool to measure digital financial inclusion at individual country level and regional level.
3. Similarly, the DFII proposed in this study can be used to investigate the effect of digital financial inclusion on various macroeconomic variables.

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