WP/21/90

IMF Working Paper

Measuring Digital Financial Inclusion in Emerging Market and Developing Economies: A New Index

by Purva Khera, Stephanie Ng, Sumiko Ogawa and Ratna Sahay

INTERNATIONAL MONETARY FUND

 WP/21/90

IMF Working Paper

Monetary and Capital Markets Department

Measuring Digital Financial Inclusion in Emerging Market and Developing Economies: A New Index

Prepared by Purva Khera, Stephanie Ng, Sumiko Ogawa, and Ratna Sahay[1]

Authorized for distribution by Ulric Eriksson von Allmen

March 2021

Abstract

Adoption of technology in the financial services industry (i.e. fintech) has been accelerating in recent years. To systematically and comprehensively assess the extent and progress over time in financial inclusion enabled by technology, we develop a novel digital financial inclusion index. This index is based on payments data covering 52 developing countries for 2014 and 2017, taking into account both access and usage dimentions of digital financial services (DFSs). This index is then combined with the traditional measures of financial inclusion in the literature and aggregated into an overall index of financial inlusion. There are two key findings: first, the adoption of fintech has been a key driver of financial inclusion. Second, there is wide variation across countries and regions, with the greatest progress recorded in Africa and Asia and the Pacific regions. This index should offer a useful analytical tool for researchers and policy makers.

JEL Classification Numbers: C38, G10, G20, O30

Keywords: Fintech; digital financial services; financial inclusion

Author's E-Mail Address: pkhera@imf.org; sng@imf.org; sogawa@imf.org; rsahay@imf.org

[1] The authors wish to thank Tobias Adrian, Martin Čihák, Ulric Eriksson von Allmen, Amina Lahreche, Kimberly Beaton, and Majid Bazarbash for their guidance, support and immensely helpful feedback and comments. We'd also like to thank Itai Agur, Patricia Alonso-Gamo, Pelin Berkmen, Nicolas Blancher, Era Dabla-Norris, Bidisha Das, Jennifer Elliot, Federico Grinberg, Dirk Jan Grolleman, Frederic Lambert, Elena Lukoianova, Inutu Lukonga, Jennifer Moyo, Maria Soledad Martinez Peria, Nicolas Racine, Celine Rochon, Kazuko Shirono, Amadou Sy, Jose Torres, Tomohiro Tsuruga, Hector Carcel Vilanova for their helpful comments; and participants of various seminars and conferences in which we presented the key findings.

Table of Contents

I. INTRODUCTION

The rapid adoption of digital technology in finance offers a large potential to increase financial inclusion, namely, access to and usage of financial services by a wide section of the population. Digital financial services (DFSs), enabled by fintech (technological innovation in the financial sector), can help overcome the often-cited obstacles in accessing traditional financial services such as cost, geographical barriers, and information asymmetry. Recognizing this potential, the United Nations, Sustainable Development Goals include targets both on traditional and digital inclusion measures (Target 8.10). There are several anecdotal evidence, including country-based case studies (Jack and Suri, 2011; 2014; Tarazi and Breloff, 2010) and regional studies (Sy et. al., 2019; Berkmen et. al., 2019; Loukoianova et al, 2019, Lukonga, 2018, and Blancher et al., 2019), that show how fintech is increasing access to financial services, especially for those previously unbanked or underserved.

Existing literature primarily focuses on financial inclusion facilitated by financial institutions such as banks, i.e. traditional financial inclusion. This is measured by indicators related to access to and/or usage of traditional financial services, such as the number of bank account per capita and ATM per capita, or combining these indicators into a composite index (Beck, Demirguc-Kunt and Martinez Peria, 2007, Honohan, 2008). Some recent studies have quantified the degree of digital financial inclusion by looking at relevant indicators, such as mobile money accounts and financial transactions using mobile phone (Sy et al., 2019; Loukoianova et al., 2019; Camara and Tuesta, 2017). However, these measures capture a single aspect of digital financial inclusion at a time, and do not present a comprehensive picture of combining multiple aspects including access and usage.

This paper aims to fill this gap in the existing literature by incorporating both measures of access to and usage of DFSs into the measurement of financial inclusion. The key contribution of this paper is the construction of a digital financial inclusion index, covering 52 emerging markets and developing economics (EMDEs) for 2014 and 2017. The index is composed of indicators related to access to and usage of financial services provided through fintech, taking advantage of the new and expanded data coverage of the World Bank Global Findex Database and IMF's Financial Access Survey (FAS) data series on mobile money and other means of online financial services. We then construct a comprehensive aggregate index of financial inclusion, combining digital financial inclusion index with an index of financial inclusion through traditional financial institutions such as banks (traditional financial inclusion index), similar to those in existing literature.

We construct a total of seven indices, which capture the degree of financial inclusion in each country through various dimensions. A three-stage principal component analysis (PCA), a commonly used objective weighting methodology in the literature is employed to determine the weight on each indicator. The first stage computes the access and usage sub-indices. Access is primarily captured by indicators related to availability of means to access payments services (e.g., number of bank branches and ATM, and accesibility to the internet and mobile phone). Usage focuses on demand-side elements, such as account ownership and making/receiving payments through these accounts. The second stage then combines these sub-indices into separate indices for traditional and digital financial inclusion, and a weighted

combination of these forms an aggregate measure of overall financial inclusion at the third stage. The aggregate views help assess the overall advance in financial inclusion, whereas the granular view along the usage and access and digital and traditional aspects helps understand the drivers of changes and are helpful to inform policymakers in developing appropriate measures. Our indices exclusively focus on the payment aspects of financial inclusion.[2] This reflects the fact that payments are often the first step and the gateway to gaining access to financial services, while other aspects of financial services, such as credit and insurance, tend to come later with financial development and deepening. Moreover, cross-country comparable data on other measures of financial inclusion (credit, savings, insurance) are still not available.

Our financial inclusion indices have several advantages over past measures. First, it provides a more comprehensive picture of financial inclusion by incorporating the digital channel. Second, instead of relying on a single indicator, such as mobile money account ownership, combining data from a variety of sources allows us to capture DFSs' contribution to financial inclusion from a multidimentional perspective. Third, it distinguishes between digital and traditional financial inclusion, which allow for more granular understanding of the relative contribution of digitization versus traditional services in impacting financial inclusion in recent years. These indices were originally developed in the context of the IMF Monetary and Capital Markets Departmental Paper "The Promise of Fintech: Financial Inclusion in the Post COVID-19 Era". This paper presents and explains the methodology that underpins them.

Our new measure indicates that fintech has had a significantly positive impact on financial inclusion in payments. Digital financial inclusion increased between 2014 and 2017 across all countries, even where traditional financial inclusion was stalling or declining. Most countries saw an increase in both the access and usage dimensions. However, there are noticeable regional differences, with countries in Africa and Asia and the Pacific in the lead.

While our new index should offer a useful analytical tool for researchers and policy makers, the analyses in this paper has limitations that the user should be aware of. These are primarily driven by data limitations—the lack of granular and long time-series data on indicators related to digital financial inclusion. First, the size of the sample of countries is relatively small (52 EMDEs) and excludes advanced economies, due to data availability. Second, the databases used for the construction of the index do not differentiate between the providers of DFSs. In other words, the digital financial inclusion index would capture services provided by fintech companies as well as banks (such as mobile banking) including in partnerships with DFSs. Similarly, the databases do not provide granular information on the range of financial services a user has access to (e.g., only banks, only DFS, or both). This limits the understanding of whether fintech is broadening financial inclusion, or providing alternative means of access to those already financially included.

[2] The index specifically focuses on the payments aspect of financial inclusion facilitated by digital means, and does not cover wider topics such as cross-border payments, and the impact of central bank digital currency.

The remainder of the paper is organized as follows: Section II presents literature review; Section III lays out the methodology; Section IV discusses underlying data and stylized facts; Section V presents the index and findings; and Section VI concludes.

II. LITERATURE REVIEW

Existing measures of financial inclusion in the literature focus on financial services primarily provided by banks (Appendix I). Initial studies relied on single measures of financial inclusion by using different banking-service indicators such as: the number of branches and/or ATMs per adult population, and bank accounts per capita (e.g., Beck, Demirgüç-Kunt, and Martinez Peria, 2007; Honohan, 2008). But Sarma (2008) points out that the use of an individual indicator to assess the extent and impact of financial inclusion can be misleading. More recent studies have constructed more comprehensives measures of financial inclusion that combine different dimensions of financial inclusion, taking into account various aspects of access and usage by household and firms (Amidžić, Massara, and Mialou, 2014; Dabla-Norris et al, 2015; Camara and Tuesta, 2017). These composite measures are constructed typically using two parametric approaches—principal component analysis (PCA) and common factor analysis.[3] The papers generally find improved access over the last ten years. However, women, the poor, the young, and rural population are found to be disproportionally excluded (Demirguc-Kunt, Klapper and Singer, 2013; Aslan et al., 2017).

These measures, however, do not fully capture the contribution from the increasingly important role of technology in financial services. There is an increasing adoption of technology in financial services (i.e., fintech)—with mobile money operators and other fintech companies newly entering the financial sector—at varying pace across geographical regions and countries.[4] At the same time, financial institutions are starting to adopt technology in delivering financial services. While the latter may be partially reflected in the traditional measures of financial inclusion, improved access and usage of financial services enabled by fintech companies are yet to be fully captured and quantified. Therefore, incorporating financial inclusion through fintech could present a more comprehensive, and potentially a very different, understanding of the progress across time and country. Some recent studies quantify the degree of digital financial inclusion by looking at relevant indicators, such as mobile money accounts and financial transactions using mobile phone (Sy et al., 2019; Loukoianova et al., 2019; Camara and Tuesta, 2017). However, these measures capture a single aspect of digital financial inclusion at a time, and do not present a comprehensive picture of combining multiple aspects including access and usage.

[3] See Appendix II on the PCA used in this paper.

[4] See Box 1 for the definition of terms used in this paper.

Box 1. Definition of Terms[1]

Fintech: The technology-enabled innovation in financial services that could result in new business models, applications, processes or products with an associated material effect on the provision of financial services. Financial inclusion: Financial inclusion is commonly defined as the "access to and use of formal financial services." It captures a range of financial services (notably transactions, savings, credit, and insurance) for individuals and firms (Sahay et al., 2015b).

Digital financial inclusion or fintech-enabled financial inclusion: We use the two terms interchangeably in the paper. Digital access to and usage of formal financial services, such as through mobile phone (both smart and non-smart phones) and computers (to access the internet). This concept includes services provided by fintech companies and financial institutions.

Digital payment: Payment which is executed digitally. Includes payments using mobile phones, computer and/or internet. This does not include card payments.

Mobile banking: Use of an application on a mobile device to access and execute banking services.

Mobile money: Pay-as-you-go digital medium of exchange and store of value using mobile money accounts, facilitated by a network of mobile money agents. It refers to electronically stored monetary value that is (1) available to a user to conduct transactions through a mobile device, (2) issued upon receipt of funds, (3) accepted as a means of payment by persons other than the issuer, and (4) redeemable for cash. In most countries, traditional bank accounts that are accessible via electronic means are excluded from the definition of "mobile money." Mobile money services are a subset of electronic money services, which may be delivered via mobile phones, prepaid cards, or other means (GSMA). A bank account is not always necessary to use mobile money services—the only pre-requisite is a basic mobile phone. Providers of mobile money services include mobile network operators and fintech companies.

[1]See also Espinosa-Vega et. al (2020) on definition of mobile money and its difference from mobile and internet banking.

While the rapidly growing literature on fintech and financial inclusion is useful, it has largely focused on experiences in specific countries or regional developments in fintech activities. Jack and Suri (2011, 2014) survey the rapid adoption of mobile phones and mobile money in Kenya, and find that mobile money has a significant impact on households' ability to share risks. Tarazi and Breloff (2010) reviews the regulatory approaches taken in light of the increasing role of mobile network operators in providing financial services, including to safeguarding and isolating funds. Others follow regional development in fintech activities, for example, Sy et al. (2019), on Sub-Saharan Africa; Berkmen et al. (2019) on Latin America and the Caribbean; Loukoianova et al. (2019) on Pacific Islands; and Lukonga (2018) and Blancher et al. (2019) on Middle-East and Central Asia. Following up on Bali Fintech Agenda (IMF, 2018), IMF (2019) takes stock of the fintech developments by geographical regions. Based on a global survey of authorities, it discusses key policy issues such as balancing competing policy priorities, addressing infrastructure constraints, developing legal and regulatory framework, and data and cybersecurity issues.

III. METHODOLOGY

This paper enhances the measurement of financial inclusion in the existing literature, by incorporating the digital aspects of inclusion to compute a more comprehensive index. We construct a composite measure of financial inclusion ("comprehensive financial inclusion index") consisting of both financial inclusion through financial institutions such as banks

("traditional financial inclusion index") and through fintech ("digital financial inclusion index"). Digital financial inclusion index reflects financial services provided through digital means, including mobile money operators, fintech companies, others newly entering the financial sector, as well as internet and mobile banking offered by traditional banks.

We focus on developing economies, and the access to and the use of payment services. The indices cover 52 EMDEs for which comprehensive data on financial inclusion related variables is available. Data on various dimensions of financial inclusion are compiled using global data sources including IMF's Financial Access Survey (IMF FAS),[5] the World Bank Global Findex (WB Findex), International Telecommunication Union (ITU), and the GSMA Mobile Money Dataset (Table 1). The indices are constructed for 2014 and 2017, as the Global Findex survey data is only available every three years since 2011, and that its coverage of data related to DFSs is relatively limited for 2011. The focus on payments reflects its role as an entry point to financial inclusion, and the greater role mobile money payment services play in low-income and lower middle-income countries. While mobile money payment service providers have also started to extend credit and insurance services to their users in many of these countries, it is still at an early stage and their sizes remain miniscule. For example, total outstanding alternative finance is less than 0.1 percent of GDP in 2017 for most countries in our sample, except China (the Cambridge Centre for Alternative Finance).[6] This compares with the value of mobile money transactions, ranging from around 20 percent of GDP in Bangladesh and Senegal to over 140 percent of GDP in Zimbabwe in 2018.

A three-stage PCA is used to construct this new measure (Appendix II).[7] This is done to capture different aspects of financial inclusion in each stage: in the first stage, the supply-side ("access") and demand-side ("usage") aspects of financial inclusion; in the second stage, the financial inclusion through financial institutions ("traditional") and enabled by technology ("digital"); and 3) on the third and final stage, a comprehensive index encompassing all these sub-components. The weights assigned to the underlying indicators using PCA are biased towards those that are highly correlated to each other. Estimating the sub-indices in separate stages, rather than estimating the comprehensive index in one stage, helps address this bias. As the three indices (traditional, digital and comprehensive) are constructed and normalized separately based on data for both 2014 and 2017, their respective levels can be compared over time but are not directly comparable across indices. However, they give a sense of where a country stands relative to the sample (e.g., most advanced in digital inclusion but around average on traditional).

Table 1 and Appendix II provide a detailed overview of the underlying indicators and the weights assigned to each for constructing these indices. Indicators for digital financial inclusion index broadly mirror the components of traditional financial inclusion indices in

[5] See Espinosa-Vega et. al, (2020) for an overview of the database.

[6] See Bazarbash and Beaton (2020) for developments in marketplace lending.

[7] The approach is similar to the methodology used in the existing literature on traditional financial inclusion (Sahay et. al., 2015b; Loukoianova et. al., 2018; Blancher et. al., 2019; and Camara and Tuesta, 2017). It is a statistical procedure which allows reducing the dimension of a large number of interrelated variables while preserving as much information in the data as possible.

existing literature. For instance, for digital financial inclusion, supply-side measures are represented by accessibility to digital infrastructure (i.e., mobile subscription and access to internet) and to mobile money agents, which are represented by accessibility to ATMs and bank branches is used for traditional financial inclusion. Similarly, demand-side measures encompass account holdings (mobile money for digital and at a financial institution for traditional financial inclusion index) and active use of the services (e.g., use of mobile money and financial institutions accounts, respectively, for payments and receipt of wages).[8]

Table 1. Selected Variables for Financial Inclusion Indices

Overall Financial Inclusion Index					
Traditional Financial Inclusion Index	**Data Source**	**Weight**	**Digital Financial Inclusion Index**	**Data Source**	**Weight**
Access[1]			**Access**		
Access to bank infrastructure		0.25	**Access to digital infrastructure**		0.125
Number of ATMs per 100,000 adults	IMF FAS		Mobile subscription per 100 people		
Number of Branches per 100,000 adults			% of population who has access to internet	ITU	
			Number of registered mobile money agents per 100,000 adults	IMF FAS GSMA Staff est.	0.25
Usage		0.25	**Usage**[2]		0.125
% of adults with a financial institution account	WB Findex		% of adults who has a mobile account	WB Findex	
% of adults who saves at a financial institution			% of adults who uses internet to pay		
% of adults with debit cards			% of adults who uses mobile phone to receive salary or wages		
% of adults who receives wages through a financial institution account			% of adults who uses mobile phone to make utility payments		
% of adults who uses a financial institution account for utility					

Note: 'Weight' is the weight of the variable in the overall index of financial inclusion

[1] For missing data from IMF's FAS on ATM per 100,000 adults and bank branches per 100,000 adults, we use proxy variables (i.e. ATM per 10,000 km2 and bank branches per 10,000 km2) to interpolate the missing data. When data on proxy variable is also not available, missing data is filled with the general past trend in the variable.

[2] The FAS includes annual data on Mobile Money transactions and volume, but the data is available for only a limited number of countries. These variables are therefore excluded to retain as many countries as possible in our sample.

In order to construct the digital financial inclusion index, we put together a novel dataset on the number of mobile money agents across countries from various data sources. Although regional aggregates and country-specific data on mobile money agents is available from the GSMA and IMF FAS respectively, this data is not complete (for instance, for 2017 the IMF FAS only has data for 22 countries in our sample). The missing data on the number of registered mobile money agents is supplemented by estimates based on various data sources, including mobile money service providers, GSMA, IFC Mobile Money Scoping country

[8] It should be noted that mobile-related variables have the same weights as traditional bank-related variables in the final index, as we are using weights coming from first principal component. This could lead to some bias in the final results in countries especially where DFSs have smaller presence compared to traditional financial services.

reports, and articles and reports including from the Consultative Group to Assist the Poor (CGAP).

IV. Indicators of Financial Inclusion: Stylized Facts

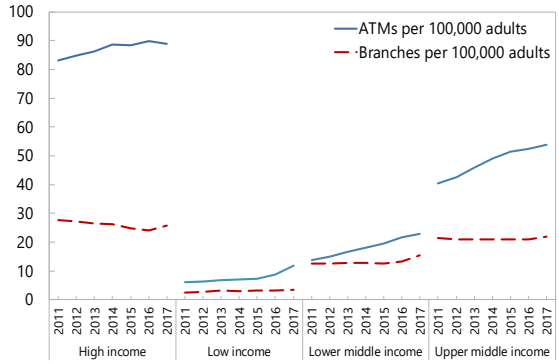
Despite significant improvements over time, a large gap remains in financial inclusion through services provided by financial institutions for low income countries (LICs).

- The access to financial institutions—measured by the number of ATMs per population—saw a notable jump over the last decade especially in middle income countries (Figure 1). However, the level remains low for LICs, with the number of ATMs per population at less than 1/10th of the global average. On the other hand, bank branches per population remained stable, and saw a decline on average in high-income countries.

- The share of adults with financial institutions account—a measure of the usage of financial services—saw more notable improvements across countries with different levels of development in the recent years, roughly doubling in lower middle-income and low-income countries in 2011-17 (Figure 2). The improvement for LICs is more pronounced in terms of broader account holdings, likely reflecting the spread of mobile money products in these countries.

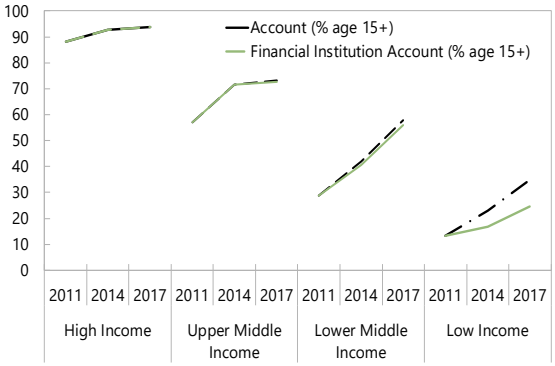
- Account holding does not always indicate actual use of financial services. More active measures of financial services use—the share of population that saved or borrowed from a financial institution—saw a more muted improvement (Figure 3).

Figure 1. ATM and branches per 100,000 adults (In percent, 2011 – 2017)



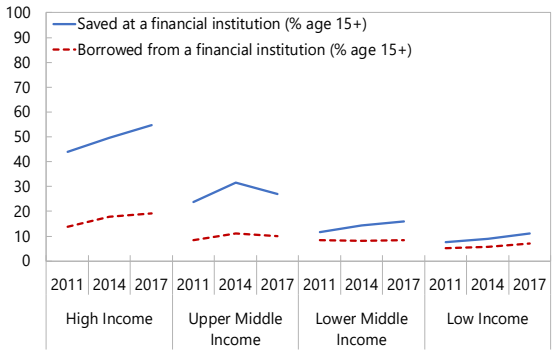
Source: IMF FAS Survey.

Figure 2. Population with an account (In percent, 2011 – 2017)



Source: Global Findex Database.

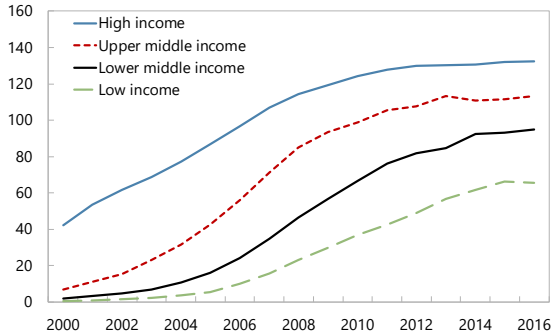
Figure 3. Population with saving and borrowing (In percent, 2011 – 2017)



Source: Global Findex Database.

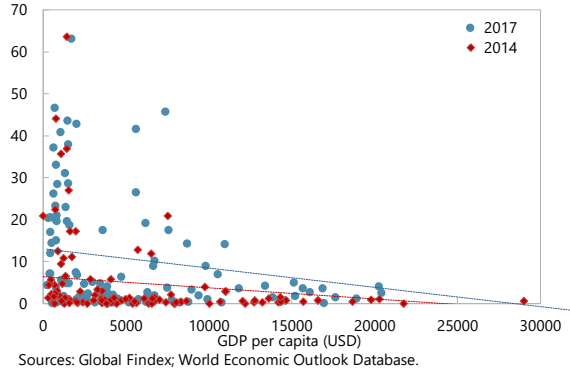
With significant improvement in access to technology over the last decade, there has been an increase in the use of technology in financial transactions. Mobile subscription increased sharply in LICs in mid-2000s, and mobile phone has become the main vehicle to access internet especially in countries with lower per capita income (Figure 4). This was in part enabled by the increased affordability of mobile phones, including smartphones.[9] As a result, the use of mobile phones for financial transaction increased: the use of mobile phone for sending or receiving domestic remittances has roughly doubled in lower middle income countries and LICs between 2014 and 2017, the two time periods for which the data is available (Figure 5). The share tends to be higher in countries with lower per capita income—about half of the population received or sent domestic remittances using mobile phones in LICs in 2017. The share of population using the internet to pay bills or make purchases has increased across all countries, as well, and tends to be higher in countries with higher per capita income (Figure 6).

Figure 4. Mobile subscription (per 100 inhabitants)



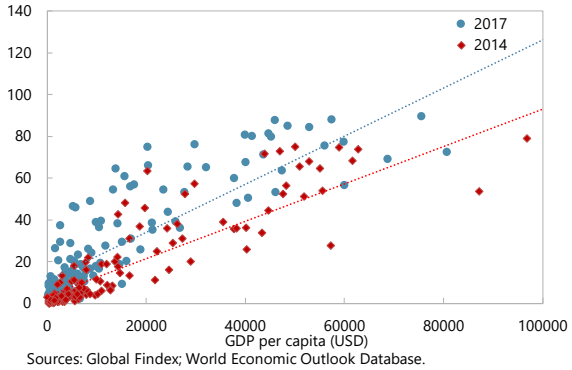
Source: ITU.

Figure 5. Sent or received remittances via mobile phone (In percent of population)



Sources: Global Findex; World Economic Outlook Database.

Figure 6. Used the internet to pay bills or make purchases (In percent of population)



Sources: Global Findex; World Economic Outlook Database.

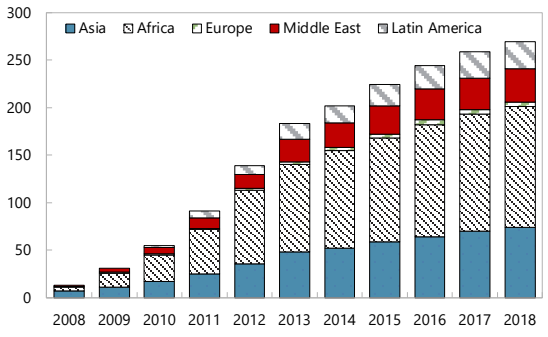
Rapid growth in mobile money service providers has enabled an increase in transactions and access to financial services via the mobile phone and internet. The number of mobile money operators has increased significantly over the last decade to over 250 in 2018 (Figure 7), and the number of active mobile money accounts almost tripled between 2013 and 2017 in lower-middle and low income countries (Figure 8).

The access to mobile money is also facilitated by mobile money agents, who support cash-in/cash-out transactions, peer-to-peer (P2P) transfers and bill payments. There are over 2.9 million active mobile money agents operating in 90 countries, and their cash-in/cash-out services account for 55 percent of the total value of mobile money transactions in 2017 (GSMA, 2017). This is roughly the same as the number of ATMs globally. They play an important role especially in countries with lower income per capita, where digital

[9] For example, in India, smartphones are available from US$20-30 and widely used.

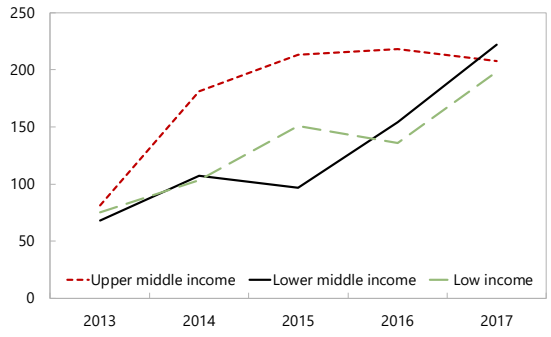
infrastructure is less developed and individual's access to mobile phone and internet is more constrained (Figure 10). With the spread of mobile money services, the value of mobile money transactions has reached sizable amount, ranging from around 20 percent of GDP in Bangladesh and Senegal, to over 140 percent of GDP in Zimbabwe (Figure 9).

Figure 7. Number of mobile money operations (2008 – 2018)



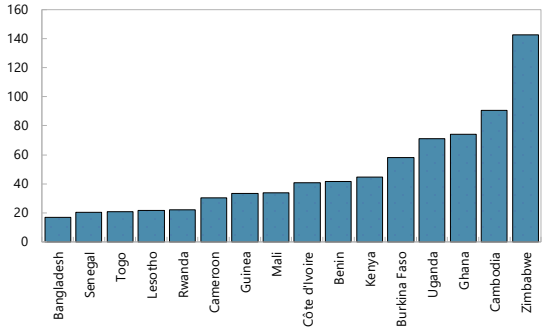
Source: GSMA Mobile Money Deployment Tracker.

Figure 8. Mobile money account (Active, per 1,000 adults)



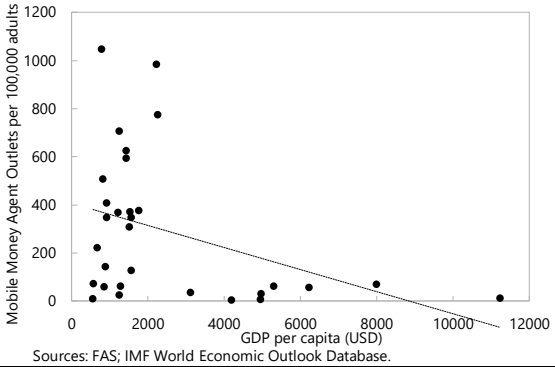
Sources: FAS and IMF staff caclulations.

Figure 9. Value of mobile money transaction, 2018 (In percent of GDP)



Source: FAS.

Figure 10. Mobile money agent outlets per 100,000 adults (2018)



Sources: FAS; IMF World Economic Outlook Database.

V. FINDINGS

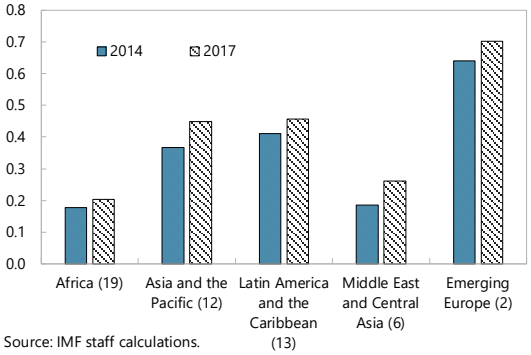
A. Traditional Financial Inclusion Index

Countries in Asia and the Pacific, Latin America and the Caribbean, and Emerging Europe in our sample, are found to have high degrees of traditional financial inclusion (Figure 11, Appendix Table II.8). Given that traditional financial inclusion is highly associated with the levels of GDP per capita, this likely reflects the levels of economic as well as financial development in these countries (Figure 12). Countries that rank high in traditional inclusion index in 2017 include Mongolia, China, Thailand, Brazil, Turkey, and Namibia. On the other hand, majority of the countries in the bottom quartile are in Africa.

Traditional financial inclusion index remained broadly unchanged between 2014 and 2017 for most countries in our sample (Figure 13). This reflects the slow-moving nature of the underlying indicators on access. In fact, the changes in underlying traditional access index is more concentrated around zero, compared to traditional usage index (Figure 14). However, some countries in Asia and the Pacific and Latin America and the Caribbean with mid- to

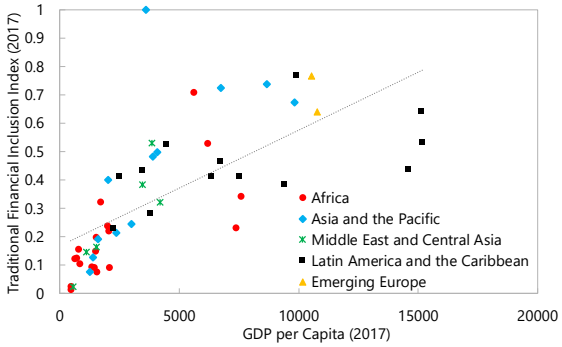
high-levels of traditional financial inclusion saw relatively large improvements in the index. On the other hand, countries with low levels of traditional financial inclusion (primarily in Africa) saw limited improvements. There were eight countries that experienced a decline in the levels of traditional financial inclusion (e.g., Nigeria and South Africa).

Figure 11. Traditional financial inclusion index



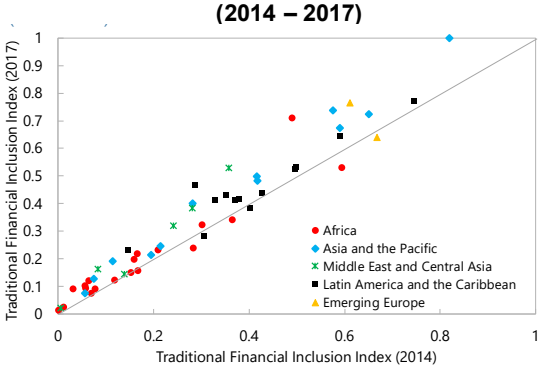
Source: IMF staff calculations.
Note: Number in bracket indicates the number of countries in the sample.

Figure 12. Traditional financial inclusion index and GDP per capita



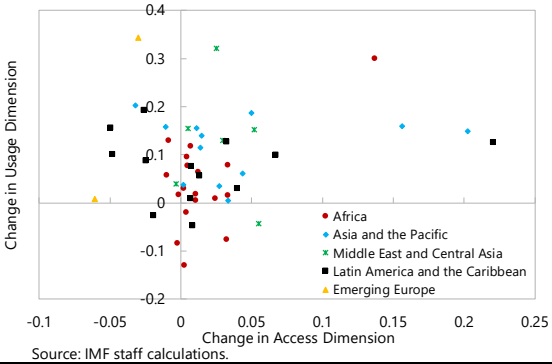
Sources: World Economic Outlook and IMF staff calculations.

Figure 13. Progress in traditional financial inclusion (2014 – 2017)



Source: IMF staff calculations.

Figure 14. Progress in traditional financial dimension (2014 – 2017, positive refers to better inclusion)

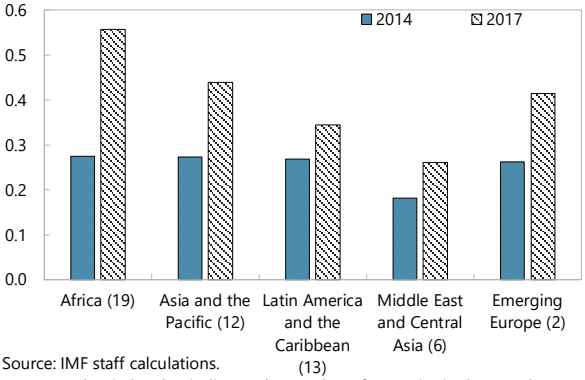


Source: IMF staff calculations.

B. Digital Financial Inclusion Index

Countries in Africa and Asia and the Pacific regions in our sample are found to have high degrees of digital financial inclusion compared to other regions (Figure 15, Appendix Table II.8). African countries, led by Ghana, Kenya and Senegal, account for majority of the countries with the top quartile of the index in 2017, as well as China, Bangladesh and Malaysia. Countries in Latin America and the Caribbean rank around the middle, with Dominican Republic, Chile and Argentina among the highest for the region.

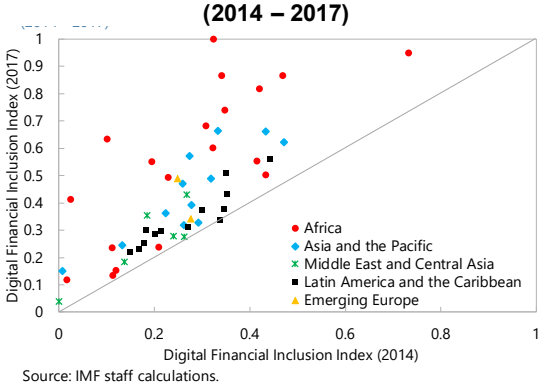
Figure 15. Digital financial inclusion index



Source: IMF staff calculations.
Note: Number in bracket indicates the number of countries in the sample.

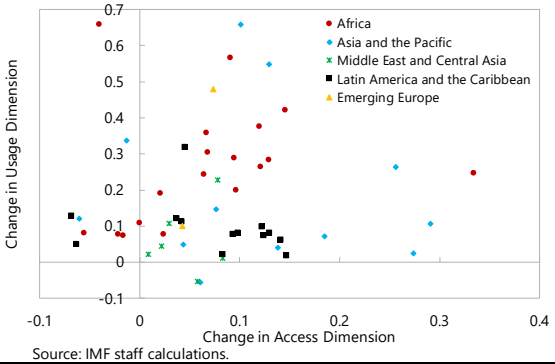
Most countries saw an increase in digital financial inclusion index between 2014 and 2017, and the improvement was particularly large in African countries (Figure 16).[10] Ghana, Benin, and Senegal were among the highest gainers. On the other hand, the index level did not see significant increase for some of the countries in Latin America and the Caribbean, and Middle East and Central Asia. Most countries saw an increase in both the access and usage dimensions, while for a small number of countries, the improvement was driven by the increase in usage (Figure 17).

Figure 16. Progress in digital financial inclusion (2014 – 2017)



Source: IMF staff calculations.

Figure 17. Progress in digital financial dimension (2014 – 2017, positive refers to better inclusion)



Source: IMF staff calculations.

Comparing digital and traditional financial inclusion indices, two clusters of countries stand out where either digital or traditional inclusion is dominant (Figure 18). The group with high digital inclusion index and low-to-medium traditional inclusion index mostly consists of African countries (e.g., Ghana, Kenya, Senegal, Uganda, and Rwanda), where fintech could be filling the gap in the availability of services provided by financial institutions. This is not surprising given the high adoption of mobile money in many East African countries. On the other hand, the group with high traditional inclusion index and medium digital inclusion index includes Brazil, Romania, Panama and Guatemala, likely reflecting the relatively high level of banking sector development and penetration. However, there are exceptions such as China and Malaysia, where both traditional and digital financial inclusion are found to be high in comparison to other countries in the sample. The results also point to significant differences in digital financial inclusion outcome within a geographical region, especially in Africa (such as Ghana versus Nigeria) and Asia (such as Bangladesh versus Myanmar). These trends indicate that the experience across countries are varied: in some case, digital services complement traditional services (those with relatively higher per capita income), while in others digital services are substituting traditional services (those with relatively lower per capita income).

C. Comprehensive Financial Inclusion Index

Incorporating digital financial inclusion indicators in the overall measure of financial inclusion gives a more realistic estimate of differences in financial inclusion across countries

[10] Digital inclusion improved in all countries except Panama.

(Table 2).[11] Incorporating digital financial inclusion index significantly improves the ranking of comprehensive financial inclusion for countries with high digital but low traditional inclusion (the cluster of countries indicated by red circle in Figure 18). On the other hand, countries with well-developed bank infrastructure and high bank penetration but low adoption of fintech see declines in their overall rankings (those indicated by purple circle in Figure 18). This means that people in countries that have similar levels of traditional financial inclusion (as typically captured in existing literature) indeed could have very different experiences in accessing and using financial services when digital measures of inclusion are taken into account. For example, Kenya, Botswana and Jordan rank similar in terms of traditional financial inclusion index (Figure 19). While Botswana remains at a similar rank in terms of comprehensive financial inclusion index, Kenya ranks in the top group and Jordan around the bottom 1/3 of the countries in our sample. Similarly, Uganda ranks among the top quartile and Togo in the bottom quartile in the comprehensive measure, while both Uganda and Togo are in the bottom quartile in terms of traditional financial inclusion.

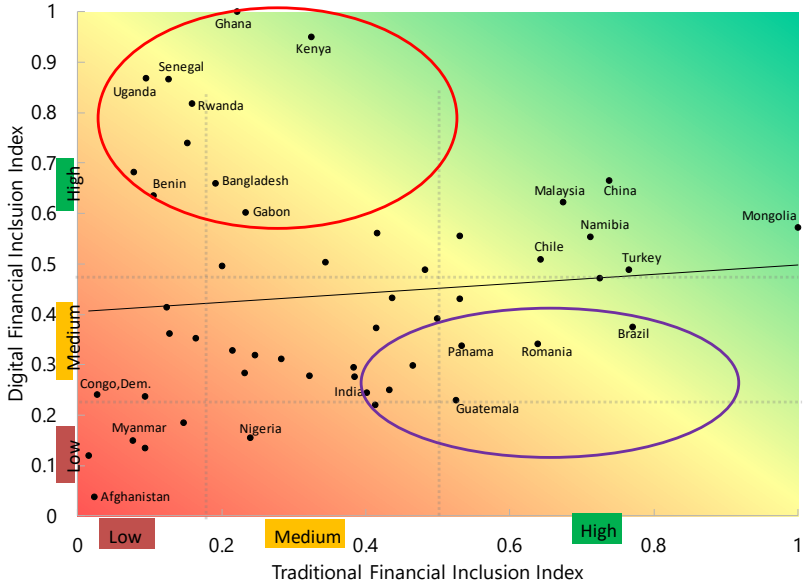
Table 2. Comprehensive Financial Inclusion Index Ranking and Quartile

Quartile	Country	Ranking	Quartile	Country	Ranking
4th Quartile	Mongolia	1	2nd Quartile	Colombia	27
	China	2		Benin	28
	Kenya	3		Peru	29
	Malaysia	4		Guatemala	30
	Ghana	5		Zambia	31
	Namibia	6		Bolivia	32
	Turkey	7		Mexico	33
	Thailand	8		Tunisia	34
	Chile	9		India	35
	Brazil	10		Honduras	36
	South Africa	11		Jordan	37
	Uganda	12		El Salvador	38
	Rwanda	13		Philippines	39
3rd Quartile	Senegal	14	1st Quartile	Togo	40
	Dominican Republic	15		Vietnam	41
	Indonesia	16		Pakistan	42
	Romania	17		Nicaragua	43
	Armenia	18		Cambodia	44
	Zimbabwe	19		Nigeria	45
	Sri Lanka	20		Cameroon	46
	Bangladesh	21		Mauritania	47
	Argentina	22		Congo, Democratic Republic of	48
	Panama	23		Congo, Republic of	49
	Botswana	24		Myanmar	50
	Gabon	25		Madagascar	51
	Cote d'Ivoire	26		Afghanistan	52

Source: IMF staff calculations.

[11] See Appendix II for a complete list of ranking of countries according to their scores in the comprehensive, traditional, and fintech-driven financial inclusion, as well as breakdown by component.

Figure 18. Traditional versus Digital Financial Inclusion Index, 2017



Note: High, medium and low refers to countries that are at the 75th percentile or above, 25th to 75th percentile and below 25th percentile of the index respectively.
Source: IMF staff calculations.

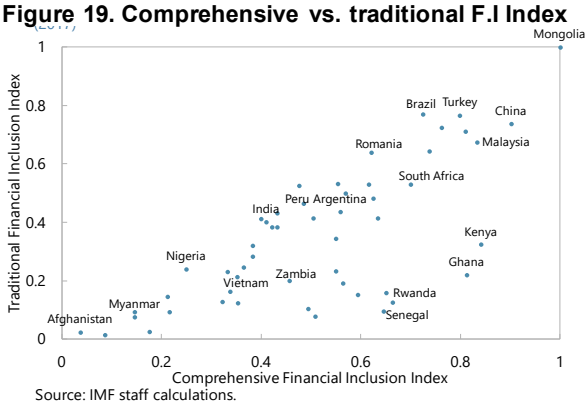
Comprehensive financial inclusion index indicates that financial inclusion has increased between 2014 and 2017 for most of the 52 EMDEs in the sample (Figure 20 and 21). The index improved the most in Africa on average, whereas the progress was been the slowest in Latin America. Both traditional and digital indices saw improvement for most countries in the sample: some countries saw a sharper improvement in digital inclusion (e.g., Ghana, Benin, Senegal), while improvement is more notable in traditional inclusion in others (e.g., Namibia, Mongolia, Peru).[12]

In some countries, improvement in financial inclusion is entirely driven by fintech (Figure 22). Most countries saw improvements in both traditional and digital financial indices between 2014 and 2017. There are, however, eight countries[13] where the increase in digital inclusion index was accompanied by a fall in traditional inclusion index. Sub-components of traditional index indicate that this is driven more by the fall in demand (usage) rather than the access (supply) in all but two (Zimbabwe and Romania). This could reflect substitution by technology-related financial services away from traditional financial institutions, and/or banks themselves shifting towards technology-based delivery of services as opposed to physical presences.

[12] The index computation does not allow for direct comparison between the level of and the magnitude of change in digital financial inclusion index score and the traditional financial inclusion index score. However, the sign of the change gives sense of the direction, and within each type of index, one can compare these scores and the relative significance of the change across the countries in the sample.

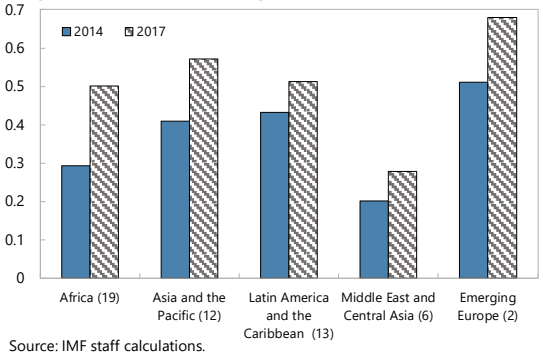
[13] Botswana, El Salvador, Mexico, Nigeria, Romania, Rwanda, South Africa, and Zimbabwe

Figure 19. Comprehensive vs. traditional F.I Index



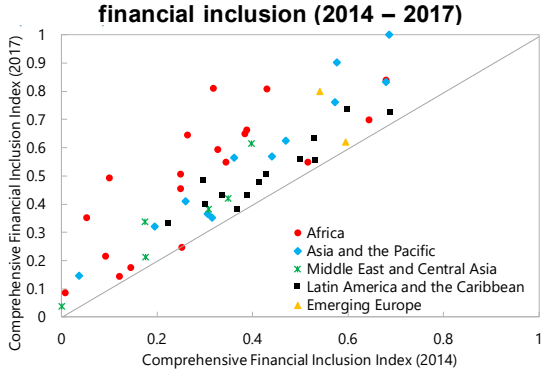
Source: IMF staff calculations.

Figure 20. Comprehensive financial inclusion by region (1 indicates higher financial inclusion)



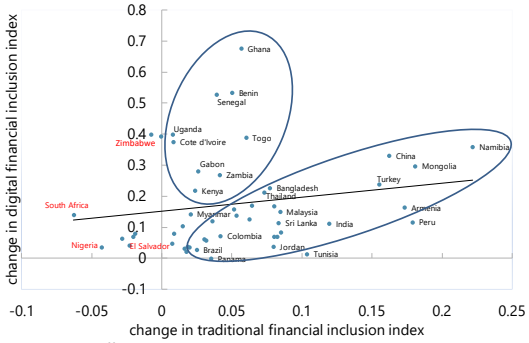
Source: IMF staff calculations.

Figure 21. Progress in comprehensive financial inclusion (2014 – 2017)



Source: IMF staff calculations.

Figure 22. Changes in financial inclusion indices (from 2014 – 2017)



Source: IMF staff calculations.

VI. CONCLUSION

This paper relies on a broad set of indicators to build a new measure of digital financial inclusion. This is used to identify countries where DFSs have played a significant role in expanding both the access to and usage of financial services to a wider population. We take advantage of the new data and expanded coverage of the World Bank's Global Findex Database on usage of mobile money and online financial services, and the IMF FAS data series on access to mobile money accounts, and supplement it by data on access to mobile money agents put together using various data sources. Three-stage principal component analysis (PCA) is employed to determine the weight on each indicator, where the first stage computes the access and usage sub-indices; the second stage then combines these sub-indices into traditional and digital financial inclusion indices, and a weighted combination of these forms a comprehensive measure of overall financial inclusion at the third stage.

Our indices indicate that most of the 52 EMDEs in our sample saw improvements in digital financial inclusion between 2014-17, particularly in countries in Africa and Asia and the Pacific on average. Comprehensive financial inclusion, taking into account both traditional and digital measures, improved in most of the countries over the same period, however in some countries, the improvement was entirely driven through digital means. Incorporating digital financial inclusion indicators in the overall measure of financial inclusion gives a more accurate estimate of differences in financial inclusion across countries.

While there are challenges in constructing the index, mainly due to data coverage limitations, it serves as an important step towards measuring financial inclusion more comprehensively than before and should aid researchers in analyzing the relationship between digital financial inclusion and economic outcomes. We strive to continue improving the digital financial inclusion indices by addressing some of its limitations as new data becomes available.

REFERENCES

Amidžić, G. A. Massara, A. and A. Mialou (2014). "Assessing Countries' Financial Inclusion Standing – A new Composite Index," IMF Working Paper WP/14/36, International Monetary Fund, Washington, D.C.

Aslan, G., C. Deléchat, M. Newiak, and F. Yang (2017). "Inequality in Financial Inclusion and Income Inequality." IMF Working Paper 17/236, International Monetary Fund, Washington, D.C.

Bazarbash, M. and K. Beaton (2020). "Filling the Gap: Digital Credit and Financial Inclusion." IMF Working Paper WP/20/150, International Monetary Fund, Washington, D.C.

Beck, T., A. Demirgüç-Kunt, and M. S. Martinez Peria. (2007). "Reaching Out: Access to and Use of Banking Service across Countries." Journal of Financial Economics 85: 234-66.

Berkmen, P., K. Beaton, D. Gershenson, J. Arze del Granado, K. Ishi, M. Kim, E. Kopp, and M. Rousset (2019), "Fintech in Latin America and the Caribbean: Stocktaking," IMF Working Paper 19/71, International Monetary Fund, Washington, D.C.

Blancher, N., and others (2019). "Financial Inclusion of Small and Medium-Sized Enterprises in the Middle East and Central Asia." IMF Departmental Paper No. 19/02, International Monetary Fund, Washington, D.C.

Camara, N., and D. Tuesta (2017). "Measuring financial inclusion: a multidimensional index," *Bank of Morocco – CEMLA – IFC Satellite Seminar at the ISI World Statistics Congress on "Financial Inclusion"*

Dabla-Norris, E., Y. Deng, A. Ivanova, I. Karpowicz, F. Unsal, E. VanLeemput, and J. Wong (2015). "Financial Inclusion: Zooming in on Latin America," IMF Working Paper 15/206, International Monetary Fund, Washington, D.C.

Demirguc-Kunt, A., L. Klapper, and D. Singer (2013). "Financial Inclusion and Legal Discrimination Against Women: Evidence from Developing Countries." Policy Research Working Paper 6416, The World Bank Group, Washington, D.C.

Espinosa-Vega, M., K. Shirono, H.C. Villanova, E. Chhabra, B. Das, and Y. Fan (2020). "Measuring Financial Access: 10 Years of the IMF Financial Access Survey." IMF Departmental Paper No. 20/02, International Monetary Fund, Washington, D.C.

Honohan, P. (2008). "Cross-Country Variation in Household Access to Financial Services." Journal of Banking and Finance 32: 2493-500.

International Monetary Fund (2018). "The Bali Fintech Agenda." IMF Policy Paper, International Monetary Fund, Washington, DC.

International Monetary Fund (2019). "Fintech: The Experience So Far," IMF Policy Paper, International Monetary Fund, Washington, D.C.

Jack, W., and T. Suri (2011). "Mobile Money: The Economics of M-Pesa," NBER Working Paper 16721

Jack, W., and T. Suri (2014). "Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution," *American Economic Review* 2014, 104(1): 183-223

Jolliffe, I.T. (1986). "Principal Component Analysis and Factor Analysis." Springer, New York

Loukoianova, E., Y. Yang, and others (2018). "Financial Inclusion in Asia-Pacific," IMF Departmental Paper No. 18/17, International Monetary Fund, Washington, D.C.

Loukoianova, E., Davidovic, S., C. Sullivan, and H. Tourpe (2019). Strategy for Fintech Applications in the Pacific Island Countries" IMF Departmental Paper No. 19/14, International Monetary Fund, Washington, D.C.

Lukonga, I. (2018). Fintech, Inclusive Growth and Cyber Risks: Focus on the MENAP and CCA Regions. IMF Working Paper No. 18/201, International Monetary Fund, Washington, D. C.

Sahay, R., M. Čihák, P. N'Diaye, A. Barajas, S. Mitra, A. Kyobe, Y.N. Mooi, and S.R. Yousefi (2015a). "Financial Inclusion: Can It Meet Multiple Macroeconomic Goals?" IMF Staff Discussion Note 15/17, International Monetary Fund, Washington, D.C.

Sahay, R., M. Čihák, P. N'Diaye, A. Barajas, R. Bi, D. Ayala, Y. Guao, A. Kyobe, L. Nguyen, C. Saborowski, K. Svirydzenka, and S.R. Yousefi (2015b). "Rethinking Financial Deepening: Stability and Growth in Emerging Markets." IMF Staff Discussion Note 15/08, International Monetary Fund, Washington, D.C.

Sahay, R., U. Eriksson von Allmen, A. Lahreche, P. Khera, S. Ogawa, M. Bazarbash, and K. Beaton (2020). "The Promise of Fintech: Financial Inclusion in the Post COVID-19 Era." IMF Departmental Paper No. 20/09, International Monetary Fund, Washington, D.C.

Sarma, M. (2012). "Index of Financial Inclusion—A measure of financial sector inclusiveness", Competence Centre on Money, Trade, Finance and Development Working Paper No. 07/2012, Berlin

Sy, A. N., R. Maino, A. Massara; H. Perez-Saiz; P. Sharma. (2019). "Fintech in Sub-Saharan African Countries: A Game Changer?" IMF Departmental Paper No. 19/04, International Monetary Fund, Washington, D.C.

Tarazi, M.; and P. Breloff (2010). "Nonbank E-Money Issuers: Regulatory Approaches to Protecting Customer Funds." CGAP Focus Note No. 56629.

World Bank (2013). “Global Financial Development Report: Rethinking the Role of the State in Finance.” Washington, D.C.

APPENDIX I: COMPOSITION OF VARIOUS FINANCIAL INCLUSION INDICES

	Coverage	Methodology	Data Source	Access	Usage	Other Dimensions
Sarma (2012)	94 countries; 2004 - 2010	UNDP Approach: weighted geometric average using equally weighted dimension indices	FAS	(1) bank branches per 100,000 population; (2) ATMs per 1000,000 population	(1) bank accounts per 1000 population	Credit and Deposits as a % of GDP
World Bank (2013)	2011	Equal Weights	Findex; others	(1) bank branches per 100,000 adults; (2) % of market capitalization outside of top 10 largest companies; (3) % of value traded outside of top 10 traded companies; (4) government bond yields; (5) ratio of private to total debt securities; (6) Ratio of private to total debt securities (domestic); (7) ratio of new corporate bond issues to GDP	(1) bank accounts per 1000 population; (2) % of firms with line of credit (all firms); (3) % of firms with line of credit (small firms); (4) Accounts at a formal financial institution (% age 15+)	
Camara and Tuesta (2014)	82 countries; 2011	Two-stage PCA	Findex; FAS	(1) bank branches per 100,000 population; (2) ATMs per 1000,000 population; (3) ATMs per 1000 sq km; (4) bank branches per 1000 sq km	(1) % of adults who hold at least one financial product; (2) saved at a financial institution in the past year (% age 15+); (3) loan from a financial institution in the past year (% age 15+)	Barriers to financial inclusion
Sahay et al (2015b) & Svirydzenka (2016)	176 countries; 1980 - 2013	PCA	FAS; others	(1) bank branchers per 100,000 adults; (2) % of market capitalization outside of top 10 largest companies; (3) % of value traded outside of top 10 traded companies; (4) total number of debt issuers (domestic & external, nonfinancial & financial corporation)		
Dabla-Norris et al (2015)	Houshold dimension; 104 countries; 2011 & 2014	Equal Weights	Findex		(1) accounts at a formal financial institution (% age 15+); (2) Saved at a financial institution in the past year (% age 15+); (3) loan from a financial institution in the past year (% age 15+); (4) has a credit card (% age 15+); (5) has a debit card (% age 15+); (6) ATM is the main mode of withdrawal (% with an account, age 15+)	
	SMEs dimension; 104 countries; 2011 & 2014	Equal weights	Enterprise Survey		(1) % of firms with a bank loan/line of credit; (2) % of firms with a checking or savings account; (3) % of firms using banks to finance investment; (4) % of working capital financed by banks; (5) collateral needed for a loan in % of loan amount; (6) % of firms not needing a loan; (7) % of firms identifying cost of finance as a major constraint	
	Access dimension	Equal Weights	FAS	(1) bank branches per 100,000 population; (2) ATMs per 1000,000 population; (3) ATMs per 1000 sq km; (4) bank branches per 1000 sq km		
Sahay et al (2015a)	Financial Institution dimension			(1) bank branches per 100,000 population; (2) ATMs per 100,000 population		Efficiency; depth
	Financial Markets dimension			(1) % of market capitalization outside of top 10 largest companies; (2) total number of debt issuers		Efficiency
Mialou et al (2017)	31 countries; 2009 - 2012	Weighted geometric average; weights derived from factor analysis	FAS	(1) ATMs per 1000 sq km; (2) ODC branches per 1000 sq km	(1) total number of resident household depositors with ODCs per 1000 adults; (2) total number of resident household borrowers with ODCs per 1000 adults	
Loukoianova, Yang et al (2018)	163 countries	See Mialou et al (2017)	FAS	(1) bank branches per 100,000 population; (2) ATMs per 1000,000 population; (3) ATMs per 1000 sq km; (4) bank branches per 1000 sq km		
	88 countries	See Mialou et al (2017)	FAS	(1) bank branches per 100,000 population; (2) ATMs per 1000,000 population; (3) ATMs per 1000 sq km; (4) bank branches per 1000 sq km	(1) bank depositors per 1000 adults; (2) bank borrowers per 1000 adults	
	870 countries	See Mialou et al (2017)	FAS	(1) ATMs per 1000 sq km; (2) bank branches per 1000 sq km	(1) bank depositors per 1000 adults; (2) bank borrowers per 1000 adults	
Blancher et al (2019)	Household	PCA	Findex; FAS	(1) bank branches per 100,000 population; (2) ATMs per 100,000 population	(1) accounts at a formal financial institution (% age 15+); (2) saved at a financial institution in the past year (% age 15+); (3) loan from a financial institution in the past year (% age 15+); (4) saved any money last year (% age 15+); (5) has a credit card (% age 15+); (6) has a debit card (% age 15+)	
	SME	PCA	Enterprise Survey		(1) % of firms with a bank loan/line of credit; (2) % of firms with a checking or savings account; (3) % of firms using banks to finance investment; (4) % of firms using banks to finance working capital; (5) % of investments financed by banks; (6) % of working capital financed by banks	

Source: IMF staff.

APPENDIX II: CONSTRUCTION OF THE FINANCIAL INCLUSION INDEX

1. Approach and Coverage: We introduce a new comprehensive financial inclusion index, focused on payments services. We collate fourteen indicators, falling under two types of financial inclusion: traditional and digital, described in detail below. We further distinguish between the two different dimensions of financial inclusion, access and usage, within each type. This distinction is important, as higher access to financial services increases the likelihood of but does not necessarily imply a higher level of financial inclusion, if they are not actually used. The indicators are combined into two sub-indices (traditional and digital) and a final index (comprehensive) of financial inclusion, based on the weights assigned using principal component analysis (PCA). The index covers 52 emerging market and developing economies (EMDEs), spanning across two years – 2014 and 2017 – for which data on all the fourteen indicators in publicly available (Appendix Table II.1).

Appendix Table II.1. Breakdown of Countries by Region

Asia and the Pacific	Africa	Latin America and the Caribbean	Middle East and Central Asia	Emerging Europe
Bangladesh	Benin	Argentina	Afghanistan	Romania
Cambodia	Botswana	Bolivia	Armenia	Turkey
India	Cameroon	Brazil	Tunisia	
Indonesia	Congo, Democratic Republic of	Chile	Jordan	
Malaysia	Congo, Republic of	Colombia	Mauritania	
Mongolia	Cote d'Ivoire	Dominican Republic	Pakistan	
Myanmar	Gabon	El Salvador		
Philippines	Ghana	Guatemala		
Sri Lanka	Kenya	Honduras		
Thailand	Madagascar	Mexico		
Vietnam	Namibia	Nicaragua		
China	Nigeria	Panama		
	Rwanda	Peru		
	Senegal			
	South Africa			
	Togo			
	Uganda			
	Zambia			
	Zimbabwe			

2. Data: Data to construct the indices is obtained from the following sources: World Bank Global Financial Inclusion ("Global Findex") database, IMF's World Economic Outlook (WEO), IMF's Financial Access Survey (FAS), International Telecommunication Union (ITU) and GSMA's mobile money database. The variables are selected to represent two different aspects of financial inclusion in payments—access and usage—while keeping in mind the goal of retaining a wide range of countries.

2.1 Access to payments services:

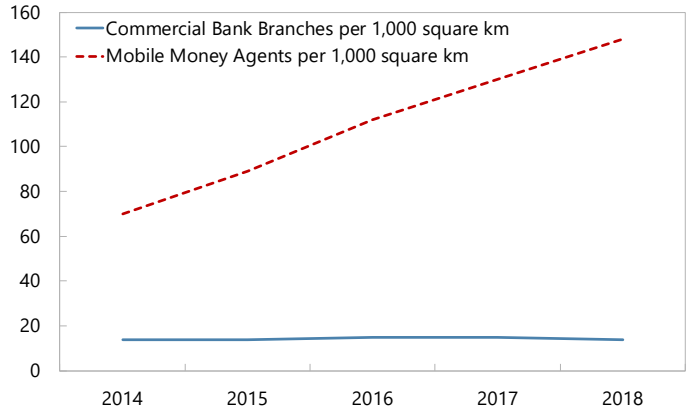
- *Traditional financial services*: We construct the access dimension of traditional financial inclusion (traditional access index) using two indicators—ATMs (per 100,000 adults) and commercial bank branches (per 100,000 adults)—available from the IMF's FAS database.

- *Digital financial services:* The access dimension of digital payments (digital access index) is represented by access to digital infrastructure and access to mobile money agents (per 100,000 adults), both of which are essential for mobile money, mobile banking, and the internet to function as new channels to access financial services. Access to digital infrastructure is composed of the share of individuals who have access to a mobile phone and access to the internet, the data for which is available from ITU.

  In addition to digital infrastructure, mobile money agents play a key role in facilitating access to mobile money financial services, by providing cash-in and cash-out services, converting physical cash to digital value and vice-versa, and for onboarding new customers. The presence of mobile money agents in rural and hard-to-reach areas has been instrumental in increasing access to financial services in many markets (Appendix Figure II.1).

The data on mobile money agents' density primarily draws on country-specific data from IMF's FAS which has data for 38 countries in our sample starting in 2009 until 2018. To fill in the many missing datapoints in the FAS and for the remaining 14 countries in our sample, we put together publicly available data from websites of these country's respective mobile money service providers, IFC mobile money reports, and news articles. Overall, sum of mobile money agents across the country-specific data in each region is checked against the regional aggregate data that is publicly available from the GSMA to ensure consistency.[14] The point-in-time data collected for each country is used to estimate time series for 2013-17, based on the real GDP growth and adjusted for the year of the launch of services.

Appendix Figure II.1. Mobile Money Agents and Bank Branches Density



Source: GSMA

2.2 Usage of payments services: The usage data is based on the Global Findex, which provides useful data on the usage aspects of financial inclusion in 2011, 2014 and 2017.

[14] The GSMA has aggregate data for the following regions: Europe and Central Asia, Middle East & North Africa, Sub-Saharan Africa, East Asia & Pacific, South Asia, Latin American & Caribbean, spanning from 2011 to 2018.

- *Traditional financial services*: To measure the extent of usage of traditional payments services (traditional usage index), we use the following indicators: percentage of individuals who have an account at a financial institution, percentage who use this account for wage transfers and utility payments, percentage who save at a financial institution, and people who have a debit card.

- *Digital financial services*: The extent of usage of digital payments (digital usage index) is measured using the following indicators: percentage of individuals who have a mobile account, percentage who use internet to pay, percentage who use mobile phone to receive salaries or wages, and percentage who use mobile phone to make utility payments.

Lack of comprehensive data on the usage of digital payments requires us to limit our sample size to 52 countries, and to two years 2014 and 2017.

Appendix Table II.2. Selected variables for constructing financial inclusion indices

Overall Financial Inclusion Index					
Traditional Financial Inclusion Index	**Data Source**	**Weight**	**Digital Financial Inclusion Index**	**Data Source**	**Weight**
Access[15]			**Access**		
Access to bank infrastructure		0.25	**Access to digital infrastructure**		0.125
Number of ATMs per 100,000 adults Number of Branches per 100,000 adults	IMF FAS		Mobile subscription per 100 people % of population who have access to internet	ITU	
			Number of registered mobile money agents per 100,000 adults	IMF FAS GSMA Staff est.	0.25
Usage		0.25	**Usage**[16]		0.125
% of adults with a financial institution account	WB Findex		% of adults who have a mobile account	WB Findex	
% of adults who save at a financial institution			% of adults who use internet to pay		
% of adults with debit cards			% of adults who use mobile phone to receive salary or wages		
% of adults who received wages through a financial institution account			% of adults who use mobile phone to make utility payments		
% of adults who use a financial institution account for utility					

Note: 'Weight' is the weight of the variable in the overall index of financial inclusion

[15] For missing data from IMF's FAS on ATM per 100,000 adults and commercial bank branches per 100,000 adults, we use proxy variables (i.e. ATM per 10,000 km^2 and bank branches per 10,000 km^2) to interpolate the missing data. When data on proxy variable is also not available, missing data is filled with the general past trend in the variable.

[16] FAS also includes annual data on mobile money transactions and volumes. However, it is not comprehensive in terms of its country coverage which is why we do not include it in our index.

The dataset is then trimmed by the 2nd and 98th percentile to avoid having extreme values driving the highest and lowest scores. Appendix Table II.3 reports the summary statistics of the selected variables for the traditional financial inclusion index and digital financial inclusion index. The correlation matrix is in Appendix Table II.9.

Appendix Table II.3. Summary statistics of selected variables for the indices

	Obvs.	Mean	Standard Deviation	Range
Access (Traditional)				
ATM per 100,000 population	104	32.17	29.49	109.31
Bank branches per 100,000 population	104	11.47	7.84	32.66
Usage (Traditional)				
Account at a F.I. (%)	104	40.57	21.25	75.56
Saving at a F.I. (%)	104	15.31	9.34	35.52
Debit card (%)	104	24.87	18.25	65.05
F.I account for wages (%)	104	7.03	6.15	25.35
F.I account for utility (%)	104	6.27	6.42	25.02
Access (Digital)				
Mobile subscription per 100 ppl.	104	105.16	31.03	130.48
Internet (%)	104	33.00	18.76	66.26
Usage (Digital)				
Mobile account (%)	104	11.11	13.63	50.42
Use internet to pay (%)	104	8.11	7.77	35.82
Mobile for wages (%)	104	1.81	2.73	11.59
Mobile for utility (%)	104	3.22	4.25	18.50
Mobile Money Agents				
Registered mobile money agents	104	138.14	192.72	743.52

Note: F.I. is financial institutions.

3. Weighting of variables: A three-stage principal component analysis (PCA) is used to construct the comprehensive financial inclusion index for each country.[17] Financial inclusion in itself is unobserved, and is determined by an interaction between a number of variables discussed above. To compute a quantitative measure of financial inclusion in each country, we assume that behind a set of correlated variables, there is an underlying latent variable 'financial inclusion'. PCA helps quantify the importance of each variable to describe the variability in the dataset.

In the first stage of the PCA, we estimate the two sub-indices: 'access' and 'usage', separately for traditional and digital financial inclusion. In the second stage, we estimate the traditional and digital financial inclusion indices by using the access and usage dimensions, computed in the first stage, as explanatory variables. In the third stage we compute the

[17] PCA is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables (see Jolliffe, 1986).

comprehensive financial inclusion measure by using the two types of financial inclusion, estimated in stage two, as explanatory variables.

The purpose of dividing the overall set of financial inclusion into various sub-indices is the following: 1) the various sub-indices provide disaggregated information on financial inclusion, which is useful for policy analysis; and 2) since the sub-indices contain highly inter-correlated indicators, we estimate the sub-indices first, rather than estimating the overall index in one stage with all the indicators at the same time. This is a preferred strategy because PCA is biased towards the weights of indicators which are highly correlated with each other (Camara and Tuesta, 2017). Applying the three-stage PCA helps minimize this problem.

3.1 First-stage PCA

In the first stage, the sub-indices for 'access' and 'usage' categories in both traditional (FI_T^a, FI_T^u) and digital component (FI_F^a, FI_F^u) are constructed based on selected variables listed in Table 1.

Access component (FI_T^a) of traditional financial inclusion is determined by: ATMs per 100,000 population (X_1) and bank branches per 100,000 population (X_2); whereas the usage component (FI_T^u) is determined by: percentage of adults with a financial institution account (Y_1), percentage of adults who saves at a financial institution (Y_2), percentage of adults with debit cards (Y_3), percentage of adults who received wages through a financial institution account (Y_4), and percentage of adults who use a financial institution account to make utility payments (Y_5).

$$(FI_T^a)_{it} = \sigma_1(X_1)_{it} + \sigma_2(X_2)_{it} + d_{it}$$

$$(FI_T^u)_{it} = \theta_1(Y_1)_{it} + \theta_2(Y_2)_{it} + \theta_3(Y_3)_{it} + \theta_4(Y_4)_{it} + \theta_5(Y_5)_{it} + n_{it}$$

where *i* denotes the country and $t \in (2014, 2017)$ corresponds to each of the two years. The total variation in the access and usage dimensions is represented by two orthogonal parts: variation due to the explanatory variables and variation due to error, $d(i)$ and $n(i)$ respectively. If the model is well specified, then E(e) = 0 and E(μ)= 0, and the variance of the error term is relatively small compared to the variance of the latent variables, the latter being 'access' and 'usage' of traditional payment services, respectively.

Similarly, for dimensions of digital financial inclusion, the access component (FI_F^a) is determined by mobile subscription per 100 people (K_1) and percentage of population with access to the internet (K_2). The usage component (FI_F^u) is determined by percentage of adults with a mobile account (P_1), percentage of adults who use internet to pay (P_2), percentage of adults who use a mobile phone to receive wages (P_3), and percentage of adults who use a mobile phone to make utility payments (P_4).

$$(FI_F^a)_{it} = \rho_1(K_1)_{it} + \rho_2(K_2)_{it} + u_{it}$$

$$(FI_F^u)_{it} = \tau_1(P_1)_{it} + \tau_1(P_2)_{it} + \tau_3(P_3)_{it} + \tau_4(P_4)_{it} + v_{it}$$

For each dimension-related sub-indices, PCA produces linear combinations of the underlying variables to generate principal components. Principal components are ordered so that the first component accounts for the largest possible amount of variation in the explanatory variables. The first principal component, PC_1, explains more than 70 percent of the explanatory variables' total variation (Appendix Table II.4).

Appendix Table II.4. First-stage PCA: Cumulative variance explained by principal components

Access (Traditional)		**Access (Digital)**	
PC_1	0.7982	PC_1	0.7884
PC_2	1.0000	PC_2	1.000
Usage (Traditional)		**Usage (Digital)**	
PC_1	0.7759	PC_1	0.7495
PC_2	0.8986	PC_2	0.9311
PC_3	0.9623	PC_3	0.9774
PC_4	0.9849	PC_4	1.0000
PC_5	1.0000		

To calculate the sub-indices for each country and year, underlying explanatory variables (x) and their respective absolute loadings (L) are needed. In the equation, the explanatory variables are standardized such that standard deviation equals to 1 and mean equals to 0. The absolute loadings are taken from the first principal component (Table 5: column 3). The index score (PC_{score}) is hence defined as:

$$PC_{score} = \sum_{i=1}^{n} L_i x_i$$

where PC_{score} equals to the sum of all standardized explanatory variables, denoted by x, weighted by absolute loadings of each variable (L). n specifies the number of explanatory variables within each category. The index scores are then normalized between 0 (lowest) and 1 (highest) across all countries and both years within each category, using a global min-max procedure across all countries and both years – 2014 and 2017:

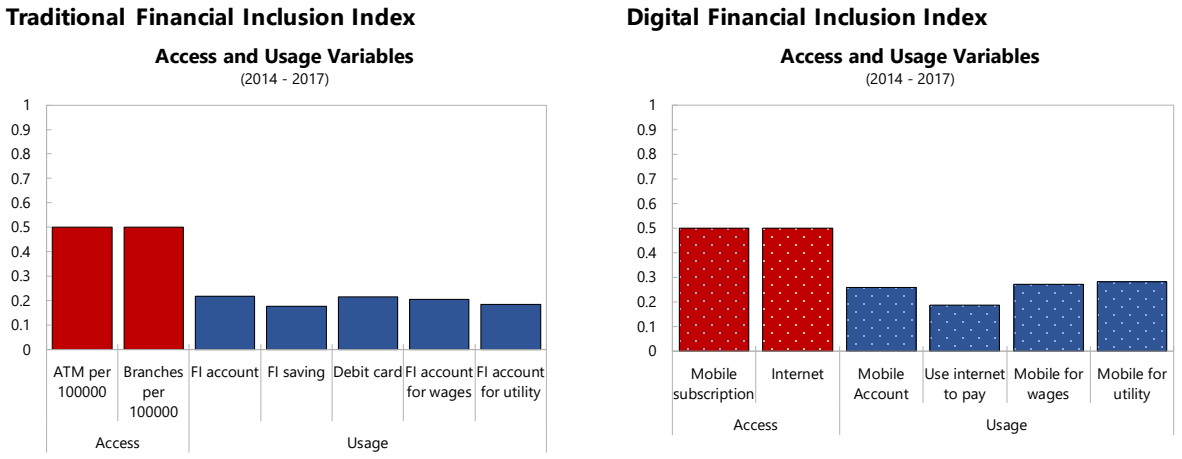
$$x_{normalised} = \frac{x - x_{min}}{(x_{max} - x_{min})}$$

Appendix Table II.5. First-stage PCA: Loadings

Access (Traditional)						
	Notation	PC_1	PC_2			
ATM per 100,000 population	X_1	0.7071	0.7071			
bank per 100,000 population	X_2	0.7071	-0.7071			
Usage (Traditional)						
	Notation	PC_1	PC_2	PC_3	PC_4	PC_5
Account at an F.I (%)	Y_1	0.4842	0.1934	0.0217	-0.5796	-0.6259
Saving at an F.I (%)	Y_2	0.3954	0.7556	0.2523	0.4328	0.1473
Debit Card (%)	Y_3	0.4820	-0.0465	-0.3747	-0.3772	0.6948
F.I account for wages (%)	Y_4	0.4551	-0.3382	-0.5087	0.5736	-0.3012
F.I account for utility (%)	Y_5	0.4120	-0.5245	0.7326	0.0735	0.1140
Access (Digital)						
	Notation	PC_1	PC_2			
Electricity (%)	K_1	0.7071	0.7071			
Internet (%)	K_2	0.7071	-0.7071			
Usage (Digital)						
	Notation	PC_1	PC_2	PC_3	PC_4	
Mobile account (%)	P_1	0.5130	-0.4231	0.5674	0.4857	
Use internet to pay (%)	P_2	0.3722	0.8911	0.1412	0.2181	
Mobile for wages (%)	P_3	0.5356	-0.1541	-0.7974	0.2315	
Mobile for utility (%)	P_4	0.5580	-0.0575	0.1496	-0.8142	

To know the relative importance of each explanatory variable in the sub-indices, we can derive the weighting, which is the percentage contribution of each variable to the sub-indices, from the loadings results in the first principal component. Weightings are shown in Appendix Figure II.2.

Appendix Figure II.2. First stage principal components analysis: Weights



Note: FI in the chart refers to financial institution.

3.2 Second-stage PCA

A second stage PCA then combines these access and usage sub-indices derived in the first stage, separately into the index for traditional and digital financial inclusion.

$$(FI_T)_{it} = \beta_1 (FI_T^a)_{it} + \beta_2 (FI_T^u)_{it} + e_{it}$$

$$(FI_F)_{it} = \alpha_1 (FI_F^a)_{it} + \alpha_2 (FI_F^u)_{it} + \mu_{it}$$

$\propto$ and β are the weights assigned to each sub-component (Appendix Figure II.3, left chart).

Note that for the digital financial inclusion index, the digital access variable 'mobile money agents (per 100,000 adults)' is added at the second stage PCA, as opposed to including it in the first stage with the other digital access variables. The mobile money agent density is negatively correlated with the access to internet and mobile subscription (Appendix Table II.9), which is consistent with its role in facilitating access to digital payments services to those who don't have access to digital infrastructure themselves. As a result, including it in the first stage PCA assigns a negative weight to mobile money agents. This would imply that higher accessibility to mobile money agents leads to lower access to DFSs, which is counter-intuitive.

Appendix Table II.6. Second and Third-stage PCA: Cumulative variance

Traditional financial inclusion index		Digital financial inclusion index[1]	
PC_1	0.8448	PC_1	0.5435
PC_2	1.0000	PC_2	1.0000
Overall Financial Inclusion Index			
		PC_1	0.6083
		PC_2	1.0000

[1]Mobile money agents (per 100,000 adults) are added in this stage.

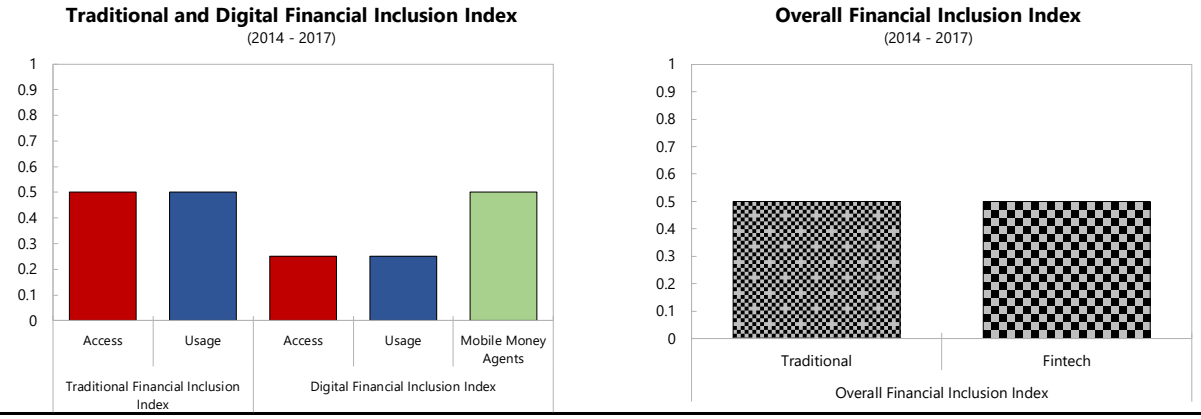
3.3 Third-stage PCA

Finally, the comprehensive financial inclusion index (FI) is computed by applying PCA on the traditional and digital financial inclusion indices, in the last stage, where ω is the weight assigned to each of the two subcomponents (Appendix Figure II.3, right chart).

$$FI_{it} = \omega_1 (FI_T)_{it} + \omega_2 (FI_F)_{it} + \omega_{it}$$

Similar to the sub-indices, overall financial inclusion index is normalized between 0 and 1.

Appendix Figure II.3. Second- and third-stage principal components analysis: Weights



5. Results: Table 8 shows the ranking of countries in the sample according to the value of the overall financial inclusion index, traditional financial inclusion index and digital financial inclusion index. Summary statistics of the overall financial inclusion index and financial inclusion sub-indices are included in Appendix Table II.7 below.

Appendix Table II.7. Summary Statistics of Financial Inclusion Indices

No. of countries	Category	Observations	Mean	Standard Deviation	Min	Max
Traditional Financial Inclusion Index						
52	Access	104	0.296	0.233	0	1
52	Usage	104	0.34	0.247	0	1
52	Traditional	104	0.324	0.226	0	1
Digital Financial Inclusion Index						
52	Access	104	0.527	0.267	0	1
52	Usage	104	0.196	0.218	0	1
52	Digital	104	0.349	0.204	0	1
Comprehensive Financial Inclusion Index						
52	Overall	104	0.433	0.216	0	1

Appendix Table II.8. 2017 Ranking: Financial Inclusion Indices

Ranking in 2017	Comprehensive	Index	versus s2014	Traditional	Index	versus 2014	Digital	Index	versus 2014
1	Mongolia	1.00	1	Mongolia	1.00	0	Ghana	1.00	15
2	China	0.90	6	Brazil	0.77	0	Kenya	0.95	-1
3	Kenya	0.84	1	Turkey	0.77	2	Senegal	0.87	10
4	Malaysia	0.83	-1	China	0.74	5	Uganda	0.87	-1
5	Ghana	0.81	25	Thailand	0.72	-1	Rwanda	0.82	2
6	Namibia	0.81	12	Namibia	0.71	6	Zimbabwe	0.74	5
7	Turkey	0.80	3	Malaysia	0.67	1	Cote d'Ivoire	0.68	12
8	Thailand	0.76	1	Chile	0.64	-1	China	0.66	7
9	Chile	0.74	-3	Romania	0.64	-6	Bangladesh	0.66	-3
10	Brazil	0.72	-9	Panama	0.53	0	Benin	0.64	38
11	South Africa	0.70	-6	South Africa	0.53	-5	Malaysia	0.62	-9
12	Uganda	0.66	10	Armenia	0.53	8	Gabon	0.60	5
13	Rwanda	0.65	10	Guatemala	0.53	-2	Mongolia	0.57	11
14	Senegal	0.65	22	Sri Lanka	0.50	1	Dominican Republic	0.56	-10
15	Dominican Republic	0.63	-3	Indonesia	0.48	-1	South Africa	0.55	-7
16	Indonesia	0.62	-1	Peru	0.47	9	Namibia	0.55	21
17	Romania	0.62	-10	Argentina	0.44	-4	Chile	0.51	-7
18	Armenia	0.62	2	Bolivia	0.43	3	Botswana	0.50	-13
19	Zimbabwe	0.59	10	Dominican Republic	0.42	-2	Zambia	0.50	13
20	Sri Lanka	0.57	-4	Colombia	0.41	-2	Indonesia	0.49	-2
21	Bangladesh	0.56	4	Honduras	0.41	1	Turkey	0.49	9
22	Argentina	0.56	-8	India	0.40	5	Thailand	0.47	7
23	Panama	0.55	-12	Tunisia	0.38	5	Argentina	0.43	-14
24	Botswana	0.55	-11	Mexico	0.38	-8	Armenia	0.43	2
25	Gabon	0.55	2	Botswana	0.34	-6	Togo	0.41	24
26	Cote d'Ivoire	0.51	14	Kenya	0.32	-2	Sri Lanka	0.39	-4
27	Colombia	0.51	-10	Jordan	0.32	2	Brazil	0.37	-15
28	Benin	0.49	19	El Salvador	0.28	-5	Colombia	0.37	-8
29	Peru	0.49	6	Philippines	0.25	1	Cambodia	0.36	4
30	Guatemala	0.48	-11	Nigeria	0.24	-4	Pakistan	0.35	8
31	Zambia	0.46	8	Gabon	0.23	0	Romania	0.34	-8
32	Bolivia	0.43	-4	Nicaragua	0.23	5	Panama	0.34	-18
33	Mexico	0.43	-12	Ghana	0.22	1	Vietnam	0.33	-12
34	Tunisia	0.42	-8	Vietnam	0.21	-2	Philippines	0.32	-6
35	India	0.41	2	Zambia	0.20	0	El Salvador	0.31	-10
36	Honduras	0.40	-2	Bangladesh	0.19	4	Peru	0.30	3
37	Jordan	0.38	-5	Pakistan	0.16	4	Mexico	0.29	-3
38	El Salvador	0.38	-14	Rwanda	0.16	-5	Nicaragua	0.28	-2
39	Philippines	0.36	-6	Zimbabwe	0.15	-3	Jordan	0.28	-8
40	Togo	0.35	9	Mauritania	0.15	-2	Tunisia	0.28	-13
41	Vietnam	0.35	-10	Cambodia	0.13	2	Bolivia	0.25	-1
42	Pakistan	0.34	2	Uganda	0.13	-3	India	0.25	2
43	Nicaragua	0.33	-2	Togo	0.12	2	Congo, Dem. Rep. of	0.24	-8
44	Cambodia	0.32	-2	Benin	0.11	4	Cameroon	0.24	3
45	Nigeria	0.25	-7	Senegal	0.10	1	Guatemala	0.23	-4
46	Cameroon	0.22	2	Congo, Republic of	0.09	-4	Honduras	0.22	-4
47	Mauritania	0.21	-4	Cameroon	0.09	2	Mauritania	0.18	-4
48	Congo, Dem. Rep. of	0.18	-3	Cote d'Ivoire	0.08	-4	Nigeria	0.15	-3
49	Congo, Republic of	0.15	-3	Myanmar	0.08	-2	Myanmar	0.15	2
50	Myanmar	0.15	0	Congo, Dem. Rep. of	0.03	0	Congo, Republic of	0.13	-4
51	Madagascar	0.09	0	Afghanistan	0.02	0	Madagascar	0.12	-1
52	Afghanistan	0.04	0	Madagascar	0.01	0	Afghanistan	0.04	0

Note: 'versus. 2014' refers to the respective country's change in ranking compared to 2014. Green shade suggests improvement in ranking from 2014 to 2017, whereas red shade indicates deterioration in country's ranking.

Appendix Table II.9. Correlation Matrix: Explanatory Variables

Variables	ATM per 100,000 pop	Bank per 100,000 pop	Account at an F.I	Saving at an F.I	F.I account for utility	F.I account for wages	Debit card	Mobile Subscription	Internet	Mobile Account	Using Internet to pay	Mobile for utility	Mobile for wages	Mobile money agents
Traditional Financial Inclusion: Access														
ATM per 100,000 population	1													
Bank per 100,000 population	0.532	1												
Traditional Financial Inclusion: Usage														
Account at a F.I.	0.7	0.536	1											
Saving at a F.I.	0.428	0.231	0.793	1										
F.I account for utility	0.58	0.509	0.687	0.406	1									
F.I account for wages	0.714	0.489	0.791	0.518	0.72	1								
Debit card	0.801	0.513	0.891	0.672	0.701	0.884	1							
Digital Financial Inclusion: Access														
Mobile subscription	0.5589	0.3176	0.4093	0.3044	0.2757	0.3883	0.4494	1						
Internet	0.638	0.272	0.529	0.257	0.406	0.641	0.608	0.5728	1					
Digital Financial Inclusion: Usage														
Mobile Account	-0.151	-0.194	0.121	0.243	0.208	0.118	0.112	-0.1664	-0.12	1				
Using internet to pay	0.526	0.185	0.599	0.432	0.697	0.751	0.711	0.2988	0.624	0.343	1			
Mobile for utility	0.0254	-0.039	0.272	0.303	0.381	0.302	0.295	-0.0041	0.0475	0.858	0.552	1		
Mobile for wages	0.111	0.0624	0.32	0.321	0.492	0.356	0.338	0.0041	-0.01	0.792	0.496	0.826	1	
Mobile money agents	-0.375	-0.208	-0.109	-0.028	-0.104	-0.21	-0.258	-0.3003	-0.303	0.553	-0.103	0.367	0.368	1

Sources: IMF staff calculations.