Unearthing digital financial services and financial inclusion: an empirical evidence from India

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Abstract: The present study aims at determining the role of information and communication technologies (ICTs), macroeconomic and demographic characteristics of individuals in advancing financial inclusion levels in India. Financial inclusion has been proxied by credit penetration, account ownership and digital financial services by key digital modes (i.e., mobile cellular subscriptions and internet penetration). The secondary data have empirically been analysed by using ordinary least squares estimation at the macro-level and employing logistic regression at the micro-level. The findings suggest that internet usage and mobile penetration rates have a positive association with financial inclusion in India. The study further discovers that individual characteristics and economic circumstances like education level, income level, age, gender, government transfers and saving behaviour are also likely to impact financial inclusion indicators in India. Unearthing a perfect balance between adopting an inclusive financial approach, pro-poor growth, and a technologically advanced infrastructure is indispensable for each facet that has an important role to contribute. Finally, the study recommends that such moves are not an end in themselves rather expected to shoulder the responsibility of creating new economic order in India via financial inclusion toolbox through sustainable development goals (SDGs).

Keywords: technology; financial inclusion; digital financial services; DFS; financial development; account ownership; logistic regression; India.

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1 Introduction

In the formal financial setup of the economy, an inclusive financial system demands active participation of all the segments of the economy that contribute towards its holistic growth and development. The significance of an inclusive financial system in the overall economic growth and development has been well documented in the literature. At the macro level, it has also been witnessed that an expanded access to financial services has a favourable impact on the stability of the financial system, the efficacy of monetary policy, poverty and inequality reduction (Imai et al., 2012). Therefore, the policy makers and regulators from all over the globe have been consistently insisting on considering financial inclusion (FI) a universal priority; and governments in both emerging and developed nations have been instituting measures to augment access and the use of financial services.

The previous studies on FI have identified various social, macroeconomic factors (Reserve Bank of India, 2008; Sarma and Pais, 2011; Demirgüç-Kunt and Klapper, 2013), individual-level characteristics (Fungáčová and Weill, 2015), structural factors as well as bank related characteristics (Love and Martínez Pería, 2014) that expressively determine the significance of FI in any nation. However, not many researchers and academicians have shed light on the role of *technological deepening*, *institutional as well as investment climate* in accelerating FI in the economies. It is believed that technological amenities can drive inclusion levels by bridging the infrastructural gap in delivering mobile financial services to the marginalised sections of the society (Diniz et al., 2012)

realising the equitable participation in the benefits have significant policy implications. In most of the countries, leading commercial banks have not been able to penetrate widely in rural and remote areas, apparently due to higher operating costs associated with it. However in recent years, the role of technology has increased manifold, and this has led to constant innovations in low-cost financial products and methods of financial service delivery like smart cards, internet banking, mobile banking, business correspondents and agents, postal-system delivery, etc. Some of the well-known examples include mobile payment and transfer service like M-PESA offered by mobile network operator Safaricom in Kenya¹ since 2007, the large-scale introduction of 'business correspondents' in Brazil and 'nofrills'/'basic savings bank deposit account' introduced in India since 2005. As a result, financial institutions have managed to ease the costs associated with poor clients and started recognising it as a business opportunity. Kpodar and Andrianaivo (2011) advocated that mobile phone diffusion has significantly spurred economic growth in African countries and a fraction of the positive impact of mobile phone rollout on growth has emanated from enhanced FI. Digital financial services (DFS) surfacing in major parts of the world foster growth at both the firm and country levels, validating a proposition that persistent growth is realisable owing to greater FI. Opportunities extended by DFS, such as internet and mobile penetration, can make it feasible for the population with restricted or no access to the formal financial sector to undertake financial transactions at a relatively cheaper cost and can also enable easy management of a large number of small transactions. In fact, it is quite evident that leveraging information and communication technology (ICT) intensifies the financial process that eventually leads to inclusiveness. Despite all efforts, globally, merely 62 percent of the adult population owns an account at a formal financial institution (Demirguc-Kunt et al., 2015). Undoubtedly, the world is gradually achieving the desired FI levels with the advent of mobile technology; however, the same remains questionable in the context of developing economies, and hence is posing serious concerns for the policy makers.



Figure 1 Overall DAI for selected countries (see online version for colours)

Source: Authors' representation of data sourced from the World Bank

To assess the global spread of digital technologies, the *Digital Adoption Index* (DAI) has been constructed as a part of the World Development Bank Report 2016: Digital Dividends. The index draws on original and established data to impart a worldwide, comprehensive depiction of technology diffusion across the three sections of the economy: businesses, people, and governments; varies between 0 and 1.

It is quite evident from Figure 1 that India is definitely not on par with its peer nations in terms of digital adoption and hence a substantial digital divide prevalently exists, relative to other nations. In terms of DAI components, India scores 0.49 for people, 0.25 for business and 0.77 for government. It indicates that the government and the people have been doing better in comparison to business digital adoption in the economy.

Figure 2 shows the prevalent use of mobile cellular telephone incomparable with the internet accessibility trend in India over the period 2000–2016.



Figure 2 Trends in DFS and credit penetration (2000–2016) (see online version for colours)

Source: Authors' representation of data sourced from ITU World Telecommunication/ICT Indicators database

Figure 2 depicts the growth in the usage of mobile phones, internet penetration rate and domestic credit to the private sector in India. It indicates that both internet and mobile cellular services experienced a lower usage trend prior to the year 2003. However, an exponential rise in the pattern of the mobile telephony relative to the internet after 2003 can be observed. The propagation of mobile Smartphone's with internet services as an auxiliary feature in the current scenario possibly plays a role in this escalation.

While there is an evidence of improved financial development in the latest decade (evident from the trend in domestic credit to the private sector, Figure 2), the size and coverage of formal finance in India has been observed far lesser than that of other economies. Strengthening the financial system and expanding its reach is vital, keeping in mind the current stage of development of the Indian economy. For these reasons, substantial benefits exist in investigating the role of *technological infrastructure* in FI levels in India. Furthermore, the existing literature has examined the various determinants of FI, and to the disregard of the significance of evolving role of *DFS*. However, this study bridges that gap in the literature by contributing to key contemporary finance issues considering the success story of the Kenyan mobile phone-based payments system M-PESA and the imminent potential of mobile banking in India.

Till now, the discourse on FI was mostly based on the supply side data (number of bank accounts, bank branches, loan accounts, etc.) on FI indicators. With the recent availability of demand-side data (households' level of income, gender, education level of

household members, etc.), the contemporary studies have taken a new turn to provide a comprehensive information on FI status. The availability of novel datasets to gauge FI such as the Global Findex Database (World Development Bank) presents an innovative opportunity to mark a distinction between the use of financial services versus the access of services to individuals, and hence to dig deeper into the matter of FI, particularly in the context of India as the same has not been undertaken so far at the individual country-level.

The remaining paper is organised as follows. Section 2 discusses the existing literature review from three aspects – Subsection 2.1 briefs on the studies that relate FI and information technology, Subsection 2.2 sheds light on the linkage between FI and micro level determinants, and Subsection 2.3 entails studies that associate FI with macro level determinants. Objectives and rationale of the paper are listed in Section 3, followed by data sources and sample selection in Section 4. Section 5 narrates on the methodology adopted to test the data empirically, followed by empirical analysis in Section 6. The paper concludes with key policy implications in Section 7.

2 Review of related studies

2.1 FI and ICT

There is an existence of marginal literature that discussed the role of technology in furthering FI and financial development all over the globe. The same enables to identify the current gap that the current study attempts to address later in the sections. Kpodar and Andrianaivo (2011) contended that technological amenities such as mobile phones and internet access incentivise FI due to their efficacy in warranting optimal and efficient credit allocation. According to the studies conducted by Gelos and Roldós (2004) and Kpodar and Andrianaivo (2011), transaction and information technologies can suggest a way to overcome impediments in delivering sound credit administration to the underprivileged sections of the economy. Using generalised methods of moment (GMM), Kpodar and Andrianaivo (2011) discovered a positive association between mobile penetration and FI and further validated that mobile phone rollout considerably impels economic growth in African countries, as it fosters FI. ICT and mobile network amenities warrant improved flow of information, thus easing both information asymmetry and transaction costs of administering physical bank branches by the FIs (Donovan, 2012). Information flow further aids in lowering price volatility, which was pointed out as the positive economic impact of mobile telephony (Jensen, 2007). Diniz et al. (2012) asserted that ICT bridged the financial infrastructural gap for service providers as it extended branchless banking to those previously excluded from financial substructure, hence boosted FI. It can be herein claimed further that accessibility of information made viable by technology will tend to dispel any obscurities in the credit delivery mechanism, making it effortless for credit worthiness of possible borrowers to be established. Precisely, ICT helps shrink information asymmetry between lenders and creditors (Demirgüç-Kunt et al., 2008) as it ensures timely availability of information. The previous literature had empirically corroborated that nations with broader platform for information sharing have a tendency to achieve significant levels of FI as greater bank credits result (Djankov et al., 2007), entailing lesser financial accessibility restrictions among firms (Love and Mylenko, 2003) in such systems. In the context of low-income

countries in particular, improved access of information and transparent contract enforcement had been discovered to deepen the financial system (Demirgüç-Kunt et al., 2008; Djankov et al., 2007).

Rasmussen (2010) intimated that mobile technology has significantly bridged the gap in African economies such as Kenya (e.g., Safaricom's M-PESA) and South Africa (e.g., MTN mobile money). Donovan (2012) also documented that mobile money facility is regarded as an efficient channel of guaranteeing financial access to millions of people universally. Utility bills, internal and external fund transfers and various payments are all conducted via the technology (Jack and Suri, 2011; Kpodar and Andrianaivo, 2011). Triki and Faye (2013) also advocated how the benefaction of mobile technology in the financial sector in Africa has revolutionised the delivery of financial services and has warranted access to inexpensive, safe and reliable financial amenities, particularly for a majority of people who would have otherwise been 'unbanked'. Arun and Kamath (2015) also documented that technological innovations can play a crucial role in furthering the FI agenda, as it can greatly reduce costs and widen outreach. Bassant (2011) too proposed that commercial banks need to go for cost-effective options such as mobile banking, ATMs, and point of sale (POS) technology so as to attain holistic growth along with equality. Chatterjee and Anand (2017) conducted an empirical analysis to investigate the association between ICT development and FI using a panel of 41 countries over a period of 12 years. The results discovered ICT as a positive and significant determinant of FI. The study also highlighted how FI and ICT diffusion can together effectively reinforce and sustain the growth process in the economies.

2.2 FI and micro-level determinants

Till date, there are only a few studies that have sought to comprehend the determinants of FI by making use of the recently constructed Global Findex Database by World Bank (Demirgüç-Kunt and Klapper, 2012, 2013; Fungáčová and Weill, 2015; Allen et al., 2016; Zins and Weill, 2016; Ghosh and Vinod, 2017; Yangdol, 2017). A majority of these studies emphasised the role of individual characteristics to recognise those who are 'financially excluded' and those who are not. The existing literature has validated that individual characteristics such as gender, education, age, employment, and income level are significant factors in determining the likelihood of financial exclusion. Most of the previous studies documented that females have lower levels of FI in comparison to their male counterparts (Demirgüç-Kunt and Klapper, 2013; Zins and Weill, 2016). Ghosh and Vinod (2017) using disaggregated household-level data in India established that female-headed households are 8% less likely to access formal accounts and 6% less likely to access informal sources of finance as compared to households that are led by males. Also, they use 20% fewer cash loans in contrast to their male counterparts. They further contended that lower wage rates and poor levels of education are the factors inhibiting females' level of FI. Utilising the 2012 Global Findex on 98 developing nations, Demirgüç-Kunt and Klapper (2013) discovered a substantial gender gap existing in account ownership, formal saving and formal credit all over the globe. Demirgüç-Kunt and Klapper (2013) cited early marriages and violence against women as the prime reasons accounting for differences in the ownership of accounts between males and females. The study further pointed out difficulties in providing collateral, lower levels of financial literacy and business knowledge, the husband's unfavourable credit history to be the key reasons for such a gender gap in formal FI. Nevertheless, the presence of such

discriminations in informal financial services was found to be less evident. Undeniably, in some nations, women were more likely to use informal financial services. Aterido et al. (2013) examined this subject in nine African countries although did not discover substantial gender discrimination. Allen et al. (2016) also did not find a striking gender disparity in account ownership in their sample of 123 countries.

Age is another vital factor influencing the likelihood of being financially included. The prevailing studies advocated that younger people are more likely to be financially excluded (Fungáčová and Weill, 2015; Allen et al., 2016; Zins and Weill, 2016; Yangdol, 2017). They discovered that the older the individual is, the greater is the probability of owning a formal account, saving in a financial institution and borrowing from a financial institution since older people are more concerned about lack of money, distance, and other religious reasons. However, a nonlinear relationship was unearthed between age and FI, meaning that after reaching a certain age, such an influence is reversed. As far as income and education are concerned, the academic literature exhibits that richer and more educated individuals are more likely to be financially included (Fungácová and Weill, 2015; Allen et al., 2016; Zins and Weill, 2016). Apart from these factors, religion too may have an impact on FI (Demirgüç-Kunt and Klapper, 2013). The study employed a sample of 65,000 individuals in 64 economies and discovered Muslims to opt considerably less for formal account ownership and formal saving as compared to non-Muslims. There is a paucity of literature that has taken into account the role of macro-level determinants. One such exceptional study is by Allen et al. (2016) which demonstrated at the global scale that greater FI is significantly linked with high quality of institutions, decreased banking costs, closeness to financial institutions, efficient legal system, political stability, and stronger contract enforcement.

2.3 FI and macro-level determinants

The academic literature on FI has pinpointed primarily two factors that propel FI across nations (Naceur et al., 2015). First being structural factors, which govern the costs of delivering financial amenities to the inhabitants; and secondly, policy-related factors, which are instrumental in creating a supportive environment for FI. Chithra and Selvam (2013) conducted a study to examine inter-state variations in financial accessibility and employed a composite FI Index to gauge the same. They identified income, population, literacy levels, deposit and credit penetration having a significant link with FI. Siddik et al. (2015) explored the determinants of FI in Bangladesh exploiting a multi-dimensional index. The findings suggested that among the socio-economic factors, household size, rural population, literacy rate were significant factors influencing FI. Further, amongst the infrastructural variables, paved road networks, internet; and amid the banking variables, deposit penetration were uncovered to be the important factors contributing to FI. Evans and Adeoye (2016) adopted the dynamic panel data approach to document the determining factors of FI in Africa over the period 2005-2014. They found per capita income, literacy, broad money (% of GDP), access to the internet and Islamic banking presence and activity to be the major factors elucidating FI levels in Africa. Other studies established information availability, urbanisation, physical and electronic connectivity, adult literacy, income inequality levels, etc. to be crucial factors in shaping the extent of FI (Reserve Bank of India, 2008; Sarma and Pais, 2011). The studies contended that nations having low GDP per capita have relatively greater levels of

income inequality, poorer connectivity, lower literacy rates, inferior urbanisation levels, and hence appear to be more 'financially excluded' (Sarma and Pais, 2011; Demirgüç-Kunt and Klapper, 2013). Zulkhibri and Ghazal (2016) exploited panel data analysis to investigate the inter-linkages between FI, institutions, and governance in a sample of developing countries. The study established that governance has a positive impact on the individuals opening accounts and making saving in a financial institution, but then it has a negative effect on borrowing from a financial institution.

3 Objectives and rationale of the study

The study aims to provide a comprehensive overview of the levels of FI in India, specifically, in the backdrop of the impact of technological disruptions on reaching individuals who were otherwise financially excluded, mainly through increased access to DFS. Trend analysis exhibits a much rapid growth in mobile telecommunication services than FI in India, hence, proffering the opportunities this strand of ICT development has for speeding up FI through mobile financial services. The study is an attempt to present a *novel evidence* regarding the role of DFS such as mobile rollout and internet usage in advancing FI in India. It also investigates numerous factors influencing the access to finance at the individual level like demographic characteristics of the residents, etc. in the economy by utilising Global Findex Database. Moreover, the impact of macroeconomic indicators, qualitative indicators, freedom indexes, bank-related characteristics, government transfers, etc. on FI too has been studied so as to have an overview of inclusive growth at the bottom level in the country. For the said purpose, the study has been carried out both at the macro-level (for the period 2000–2016) as well as at the micro-level (on the basis of World Bank's latest Findex Database).

Indirectly, the proposition that ICT overcomes the problems of information asymmetry and lessens transaction cost essential for extensive FI has been set out to be tested. The prime motivation originates from a concern for those who are financially excluded, are outside the umbrella of formal financial services and hence may overlook opportunities to enhance their wellbeing. Moreover, focusing on a specific country reveals certain country-specific features and facts which may not be highlighted in cross-country studies (Demirgüç-Kunt and Klapper, 2013).

4 Data sources and sample selection

For the purpose of *macro-level analysis*, the national level macroeconomic indicators used in the study have been sourced predominantly from World Development Indicators (World Bank database). International Telecommunication Union's ICT statistics have been utilised to gather data on mobile cellular subscriptions and internet usage. The data on Index of Economic Freedom, Financial Freedom Index, and Property Rights Index has been extracted from the Heritage Foundation/Wall Street Journal. Financial Indicators such as bank concentration, banks' overhead costs (as % of total assets) have also been sourced from Global Financial Development Database (WDI). The macro dataset will cover the time period from 2000–2016 in India (see Table 1).

Variables (symbol)	Definitions	Expected sign	Source	Previous studies
Financial inclusion (Fin Inc.)	Domestic credit to the private sector (as % of GDP)	NA	Financial Structure Database (World Bank)	Kpodar and Andrianaivo (2011), Demirgüç-Kunt and Klapper (2013), Alter (2015), Agyekum et al. (2016)
Per capita GDP growth (GDPpc_G)	GDP per capita growth (annual %)	+	World Development Indicators and International Financial Statistics	Kendall et al. (2010), Sama and Pais (2011), Chithra and Selvam (2013), Allen et al. (2014), Evans (2015), Alter (2015), Agyekum et al. (2016) and Sharma (2016)
Mobile subscription rate (Mobile_sqrt)	Mobile cellular subscriptions per 100 people	+	International Telecommunication Union	Kpodar and Andrianaivo (2011), Jack and Suri (2011), Alter (2015) and Agyekum et al. (2016)
Internet penetration (Internet_sq)	Individuals using the internet (% of population)	+	International Telecommunication Union	Kpodar and Andrianaivo (2011), Sarma and Pais (2011), Chithra and Selvam (2013), Alter (2015), Evans (2015) and Agyekum et al. (2016)
Economic Freedom Index (log) (LEFI)	Measure of countries' living standards, economic growth, and other indicators of social and economic well-being	+	Heritage Foundation	Zulkhibri and Ghazal (2016)
Institutional development (Inst_Devlopmnt)	Indicator measuring degree of a country's legal protection of private property rights and degree of enforcement of those laws	+	Heritage Foundation/ Wall Street	Kpodar and Andrianaivo (2011), Allen et al.(2014) and Alter (2015)
Bank concentration (Bank_Concentn)	Ratio of assets of three largest commercial banks to total commercial banking assets	I	Global Financial Development Database (WDI)	Law and Abdullah (2006), Kendall et al. (2010) and Demirgüç-Kunt and Klapper (2013)

 Table 1
 Description of selected variables at the macro-level

Variables (symbol)	Definitions	Expected sign	Source	Previous studies
Banks' overhead costs (as % of total assets) (BOC)	Indicator of inefficiency of financial intermediaries	I	Global Financial Development Database (WDI)	Kpodar and Andrianaivo (2011), Demirgüç-Kunt and Klapper (2013) and Alter (2015)
Financial Freedom Index (log) (LFFI)	Indicates financial efficiency as well as how independent from the government is the financial sector	+	Heritage Foundation/Wall Street	Zulkhibri and Ghazal (2016)
Govt. consumption (% of GDP) (Govt_Consumptn)	General government final consumption expenditure (% of GDP)	I	World Development Indicators (World Bank)	Kpodar and Andrianaivo (2011)
Gross primary completion rate (proxy taken for literacy rate) (GPCR)	Gross intake ratio to the last grade of primary education	+	World Development Indicators (World Bank)	Sarma and Pais (2011), Chithra and Selvam (2013), Allen et al. (2014) and Evans (2015)
Population density (Pop_G)	People per sq. km of land area	+	World Development Indicators (World Bank)	Kendall et al. (2010), Allen et al. (2014) and Alter (2015)
Source: Authors' owr	ı compilation			

Table 1 Description of selected variables at the macro-level (continued)

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Variables* (symbol)	Definition	Expected sign	Previous studies
Formal account (For_Acc)	Binary variable that takes the value of 1 if the individual has a formal account (it can be an account with a financial institution or mobile money account) and 0 otherwise.	NA	Demirgüç-Kunt and Klapper (2013), Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Formal saving (For_Sav)	Binary variable that takes the value of 1 if the individual has saved or set aside money using an account at a bank or another type of formal financial institution in the past 12 months, and 0 otherwise.	NA	Demirgüç-Kunt and Klapper (2013), Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Formal credit (For_Cred)	Binary variable that takes the value of 0 if the individual has borrowed any money from a bank or any other type of financial institution in the past 12 months and 0 otherwise.	NA	Demirgüç-Kunt and Klapper (2013), Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Account at financial institution (Acc_Fin_Inst)	Binary variable that takes the value of 1 if the individual owns an account at a bank or any other type of financial institution, such as credit union, cooperative, or microfinance institutions and 0 otherwise.	NA	Demirgüç-Kunt and Klapper (2013), Zins and Weill (2016) and Yangdol (2017)
Mobile money account (Mob_Mo_Acc)	Binary variable that takes the value of 1 if mobile phone-based services were found to be used to pay bills or to send or receive money and 0 otherwise.	NA	Demirgüç-Kunt et al. (2015), Zins and Weill (2016) and Yangdol (2017)
Female	Binary variable that takes the value of 0 if the individual is female and 0 otherwise.	-	Demirgüç-Kunt and Klapper (2013), Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016), Yangdol (2017) and Ghosh and Vinod (2017)
Age	Age in number of years of the individual	+	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Age squared (age ²)	Age in number of years, squared	_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)

 Table 2
 Description of selected variables at the micro-level

Note: *Global Findex Database (Demirgüç-Kunt et al., 2015) (World Bank).

Source: Authors' own compilation

Variables* (symbol)	Definition	Expected sign	Previous studies
Secondary education (Edu_2)	Binary variable that takes the value of 1 if the individual has completed secondary education and 0 otherwise.	+	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Tertiary education (Edu_3)	Binary variable that takes the value of 1 if the individual has completed tertiary education or more and 0 otherwise.	+	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Income: poorest (20%) (Income_q1)	Binary variable that takes the value of 1 if the individual belongs to the lowest income quintile and 0 otherwise.	_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Income: second (20%) (Income_q2)	Binary variable that takes the value of 1 if the individual falls in the second lowest income quintile and 0 otherwise.	_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Income: middle (20%) (Income_q3)	Binary variable that takes the value of 1 if the individual belongs to the middle income quintile and 0 otherwise.	_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Income: fourth (20%) (Income_q4)	Binary variable that takes the value of 1 if the individual falls in the second highest income quintile and 0 otherwise.	_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Internet usage (Int_Usg)	Binary variable that takes the value of 1 if the individual made any payments online using the internet and 0 otherwise.	+	Demirgüç-Kunt et al. (2015) and Agyekum et al. (2016)
Government transfers (Govt_trans)	Binary variable that takes the value of 1 if the individual, personally, received any government transfers (financial support like subsidies, contributions for educational or medical expenses, unemployment benefits, any kind of social benefits) in the past 12 months and 0 otherwise.	+	Yangdol (2017)
Saved	Binary variable that takes the value of 1 if the individual saved in the past year and 0 otherwise.	+/_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)
Borrowed	Binary variable that takes the value of 1 if the individual borrowed in the past year and 0 otherwise.	+/_	Fungáčová and Weill (2015), Zins and Weill (2016), Allen et al. (2016) and Yangdol (2017)

 Table 2
 Description of selected variables at the micro-level (continued)

Note: *Global Findex Database (Demirgüç-Kunt et al., 2015) (World Bank).

Source: Authors' own compilation

For *micro-level analysis*, the study used World Bank's 2014 Global Findex Database. The survey was carried out by Gallup, Inc., in collaboration with its annual Gallup World Poll. It provides individual-level data on FI, based on a survey of adult individuals covering over 142 countries for the year 2014. It provides a large number of indicators on FI, enabling to assess the extent of account penetration, the use of financial services, the purposes and motivations, the alternatives to formal finance, etc. It also provides micro-level information such as gender, age, income and education of respondents – that will be mainly used in our estimations. Only India has been considered in our analysis, covering a sample of 3,000 adult individuals in the year 2014. The data on individual characteristics, their economic circumstances and their active mobile phone and internet usage to make financial transactions is extensively utilised in this study in an attempt to investigate factors that are associated with the level of FI, denoted by individuals' access to formal financial services, formal savings, and formal credit (see Table 2).

5 Methodology

In order to provide the empirical estimations, the study has applied *ordinary least squares* (OLS) model at the macro-level and *logistic regression* model at the micro-level.

OLS is a statistical method for estimating the unknown parameters in a linear regression model:

 $yi = \beta 0 + \beta 1xi + \mu i$

where $\beta 0$ represents the value of y when x is 0; $\beta 1$, the slope coefficient measures the change in y due to a unit change in x and μ is the error term.

It minimises the sum of squared vertical distances between the observed points in the dataset, and the points predicted by the linear approximation (http://wiki.ubc.ca/OLS_ estimators). In other words, it handles the relationship between y_i and x_i in a way such that the conditional mean function is stated as: $E(y_i/x_i) = xi'\beta$ and the resultant estimator ($\hat{\beta}$), which should fulfil the basic assumption underlying the classical regression model is expressed as follows:

$$\hat{\beta} = \min_{\beta \in \mathbb{R}} \sum \left(E(yi \mid xi) - xi'\beta \right)^2$$

where $\hat{\beta}$ is the estimator that minimises the conditional mean function in the above equation. The estimator, which is the sum of the error squared, is assumed to be best linear unbiased estimator (BLUE) in the Gauss-Markov sense (Cameron and Trivedi, 2005). Accordingly, it is presumed that the model has only linearity in parameters, but has also an error term, which is both homoscedastic as well as serially uncorrelated.

Logistic regression has been applied to micro-level data/ individual-level data with a dichotomous outcome variable. Since it is known that the error follows a binomial distribution, logistic serves as an apt link function (Gujarati and Porter, 1999). As a link function, logit transforms the original $F(\pi; 1, 0)$ using maximum likelihood estimation (MLE) procedure in such a way that the estimates $\hat{\pi}$ behave as continuous. In this manner, the logit function scatters the outcome variable over the whole range of numbers. Logit function is specified as:

$$F(\pi) = \log[\pi/(1-\pi)]$$

where π is the probability of 'occurrence of an event' or 'success'; and $[\pi / (1 - \pi)]$ is the odds of an event occurring.

Commonly, the logistic model expressed as a probability can be stated as:

$$Pr(\pi)ob(y = 1/x) = \frac{e^{(\beta X)}}{1 + e^{(\beta X)}}$$

where π is that probability of occurrence of an event; the *y*, which denotes the likelihood of FI, is a dummy variable assuming binary values described as: $y = \{1, \text{ if individual is financially included (i.e., owns an account) 0, if otherwise}\}$. The *X*'s are the explanatory or controlled variables; the β 's are the coefficient estimations and are nothing but the logarithmic transformed odd ratios of the logistic regression, assuming to have a linear relationship with the outcome variable.

5.1 Econometric model specification (for macro-level analysis)

$$FI_t = \beta_0 + \beta_1 TI_t + \beta_2 X_t + \varepsilon_t$$

5.1.1 Variables in OLS model

- Dependent variable: FI denotes FI and is proxied by domestic credit to the private sector (as % of GDP) because it is found to be significantly linked with, and hence a vital measure of, FI (Demirgüç-Kunt and Klapper, 2013). Earlier, narrower but direct measures such as number of deposits per head and number of loans per head were thought to be considered as indicators of FI and were later dropped due to the non-availability of data for an ample period of time.
- Independent variable: The key IVs are ICT indicators, i.e., mobile phone penetration
 and internet usage per 100 inhabitants denoted by *TI_t*. National level indicators such
 as macroeconomic variables (MEV) like GDP per capita growth, population density,
 government consumption, economic freedom indicator (EFI), financial freedom
 indicator, gross primary completion rate, bank concentration (quantified by the ratio
 of assets of three largest commercial banks to total commercial banking assets),
 Banks' overhead costs (as % of assets) to account for the inefficiency of financial
 intermediaries, property rights index to account for the level of institutional
 development, act as appropriate control variables in the macro-model and are
 denoted as *X_t*.

5.2 Econometric model specification (for micro-level analysis)

 $FI_i = \beta_0 + \beta_1 TI_i + \beta_2 X_i + \varepsilon_i$

5.2.1 Variables in logistic regression model

• Dependent variable: Following the previous study of Demirgüç-Kunt and Klapper (2013), the study attempts to use three main indicators of FI: *formal account, formal saving* and *formal credit*. These indicators are converted into binary variables to

indicate whether or not an individual possesses a formal financial account, whether or not an individual saved using a formal financial institution in the past 12 months (formal saving) and whether or not an individual borrowed from a formal financial institution in the past 12 months (formal credit). These binary variables are then used as the main dependent variables in a regression framework. Therefore, the methodology used in this paper is a logit estimation model which is also known as binary dependent variable model. It tries to model the probability of a binary variable taking value 1 (indicating a 'yes') and 0 otherwise as a function of the explanatory variables. FI_i measures the likelihood of inclusion and *i* depicts one given individual.

• Independent variables: The main IVs are *TI_i*, capturing *technological infrastructure*, i.e., mobile and internet penetration rates and *X_i* denotes control variables in the micro-level model and includes demographic characteristics such as gender, age, income, education of the individuals, government support, savings or borrowings in the past year, etc. *Gender* is a dummy variable equal to one if the individual is a female and zero otherwise. *Age* defined as the number of years (age) and *squared age* (age²) so as to consider possible nonlinearity in the relation between age and FI have been considered in the estimations.

The *income levels* are categorised into five quintiles, 20% poorest, second 20%, third 20%, fourth 20% and lastly the richest 20%. Income is accounted for by considering four dummy variables, each equal to one if the individual's income is in a given quintile, ranging from the first (poorest 20%) to the fourth (fourth 20%). The omitted dummy variable is for the fifth income quintile. *Education level* includes primary, secondary and tertiary levels of education. The study considers two dummy variables for education, equal to one if the individual has completed secondary education or tertiary education. The omitted dummy variable is for primary education completion. *Government transfers* capture if the individual, personally, received any government transfers (financial support like subsidies, contributions for educational or medical expenses, unemployment benefits, any kind of social benefits) in the past 12 months. *Saved* denotes whether the individual saved in the past year or not.

6 Analysis of the data

6.1 Results of macro-level analysis using OLS estimation

Table 3 summarises the estimation results based on macro dataset from the year 2000 to 2016 in India. There are a several notable results that surface from our analysis. We obtain strong support for significant association of DFS, i.e., mobile cellular subscriptions and internet penetration rates, with FI proxy in all the model specifications, which is in line with the contemporary study in Ghana (Agyekum et al., 2016). *Mobile cellular subscription* is positively correlated with FI in all the models, suggesting the favourable impact of extensive adoption of mobile network subscriptions on the financial development (Kpodar and Andrianaivo, 2011; Alter, 2015). The reason behind the same can be attributed to the fact that ICT affects service provision via the supply of credit information, which overcomes obstacles relating to information asymmetries and the transaction costs of providing financial services, thereby leading to deeper inclusion in

the financial system. The *internet penetration rate*, which encapsulates the number of population having accessibility to the world wide web, surprisingly indicates a somewhat ambiguous relationship with FI across all the models in macro analysis, which is contradictory with the robust positive relationship discovered in the micro-level analysis and also with the previous studies (Sarma and Pais, 2011; Chithra and Selvam, 2013; Evans, 2015). The macro-level investigation uses internet usage rate over time, with no clear-cut linkage to use of financial transactions unlike the micro-level analysis, which pertains to specific information related to internet usage for making financial transactions. The reason behind the inverse relationship in the above two models can even be due to internet security issues in India.

 Table 3
 Regression results of macro-level analysis

Explanatory variables	(1) Fin Inc.	(2) Fin Inc.	(3) Fin Inc.
OLS	OLS	OLS	
GDPpc_G	0.2635 (0.2544)	0.4009*** (0.0609)	1.2951 ** (0.4843)
Mobile_sqrt	3.2706* (0.6705)	2.0604*** (0.3069)	5.8853*** (0.0392)
Internet_sq	-0.0155** (0.1506)	-0.0082** (0.0009)	0.0338** (0.0126)
LEFI	3.9124*** (0.4998)		
Bank_Concentn	0.9434*** (0.5142)	0.3837*** (0.0794)	
BOC	-2.7988 (0.6440)	-4.7747*** (0.6592)	-2.0317** (0.3331)
LFFI		-1.6596** (0.6248)	-1.2497** (0.2296)
GPCR			0.4852*** (0.3148)
Govt_Consumptn	-0.0635*** (0.1674)		-1.2738** (0.5698)
Pop_G		0.5289*** (0.7566)	
Inst_Devlopmnt			0.2924** (0.8905)
Constant	1.1148*** (0.7556)	-0.7809*** (0.3664)	0.8581** (0.6388)
R-squared	0.9812	0.9999	0.9957
Adj R-squared	0.9648	0.9995	0.9872
Root MSE	0.6941	0.1728	0.1091
No. of observations	16	9	13
<i>F-stats</i>	59.79	20.13	117.01

Notes: 1 ***signifies 1%, **5% and *10% level of significance (***p < 0.01,

***p* < 0.05, **p* < 0.1).

2 Standard errors in parentheses.

3 The compositional governmental EFI, voice and accountability, control of corruption are all found insignificant individually with the FI proxy.

4 Other macroeconomic variables like unemployment, inflation are found to be insignificant in multiple regression specifications.

Source: Author's regression results based on OLS, STATA 13 testing

Though *GDP per capita* is found to have an expected sign, i.e., positive, but surprisingly it is not significant in all the models, indicating even greater economic growth cannot spur FI in India in the light of current development stage of the country. This result is in conflict with the studies conducted by Sarma and Pais (2011), Chithra and Selvam (2013) and Evans (2015). *Economic Freedom Index* is found to be significant, with index of economic freedom having a positive impact on the FI in the model tested, thereby

implying that and competitive markets generate open more а cost-effective allocation of resources across the nation at large and encourage productive potential across individuals or firms to avail economic opportunities on an equitable basis. While the impact of *Financial Freedom Index* on FI is negative and significant, thereby hinting towards the challenges that the country might be facing with respect to measures of financial freedom. This is somewhat similar to the results found by Zulkhibri and Ghazal (2016) who found the mixed results with respect to the impact of freedom indexes on FI.

Also, gross primary completion rate is found to be positive and significant in the extended model, signalling that as literacy of the people goes up, FI deepens and grows further (Allen et al., 2014; Evans, 2015). The *population density* turned out to be positive and significant in the model tested, establishing a direct link between population density and FI proxy, which is in line with the study by Allen et al. (2014) in Africa, which states that it is easier for financial institutions to multiply savings when a greater proportion of potential depositors have easy access to them.

Further, the results as expected discovered banks' overhead costs (as % of total assets) to be negatively associated with FI, thereby suggesting that lesser the costs of financial intermediation and greater the banks' operational efficiency, higher will be the degree of FI. High ratios tend to escalate the fixed costs of extending loans and maintaining accounts as well as lowering interest payments on savings and other deposits, therefore restricting FI. This finding is in line with Kpodar and Andrianaivo (2011) and Alter (2015). Bank concentration again is a measure of financial inefficiency in a way that it can lead to oligopolistic behaviour. In addition to increasing the costs of providing financial services, high levels of bank concentration might also inhibit lending to individuals if concentration is associated with a lack of competitive incentives to assess the quality of borrowers with relative riskier characteristics. Hence, the positive impact of bank concentration may appear counterintuitive at first sight, but it can be supported by the suboptimal banking market environment in emerging economies and is consistent with Law and Abdullah (2006) in the context of low-income and middle lower-income countries. However, the result is contradictory with the previous studies such as Kendall et al. (2010) and Demirgüç-Kunt and Klapper (2013). As has been witnessed in the previous studies (Kpodar and Andrianaivo, 2011), the negative and significant coefficient of government consumption expenditure in the current study too depict that greater government consumption expenditure can dampen financial development and hence can lessen FI. The variable institutional development is positive and significant, implying that good institutions can actually enhance FI in the economy (Allen et al., 2014; Alter, 2015). Lastly, we conducted model diagnostics for validation (using linktest and ovtest) and to examine if the models are correctly specified. The Ramsey reset test for the extended model finds no evidence of omitted-variables bias, and hence no additional variables are required (i.e., p-value of 0.299). It implies that at the 5% level of significance, we are 95% confident the model is properly specified.

6.2 Results of micro-level analysis using logistic regression

Table 4 displays the results and the marginal effects for the logit regression estimations for the main indicators of FI in India. Columns (1), (2), and (3) have formal account, formal saving and formal credit as the dependent variables. Columns (4) and five depict

the results for distinct regressions by separating formal account into account at financial institution [column (4)] and mobile money account [column (5)], as the dependent variables. Only one of the DFS, i.e., internet penetration formed part of the results estimation for analysing the impact of technological deepening on FI in India since mobile penetration rate was found to be a perfect predictor for the outcome variable and hence had to be dropped out of the analysis.

The results that surface from the analysis suggest that all individual characteristics have a significant relationship with FI. Being a female significantly reduces the probability of having a formal account (account at a financial institution or mobile money account) and also the probability of using a financial institution to save and borrow. The result is consistent with the previous studies such as Zins and Weill (2016) and Yangdol (2017). Age is found to be positive and significantly associated with all the indicators of FI, thereby implying that the older the individual is, the higher is the probability of having a formal account, saving in financial institution and borrowing from a financial institution. Age^2 depicts a significant negative and nonlinear relationship with all the indicators of FI, suggesting that after a certain age, the probability of being financially included decreases (also referred to as 'generational effect'). The results are similar to the ones found in Fungáčová and Weill (2015) and Allen et al. (2016). Education (both Edu 2 and Edu 3, i.e., dummy variables for secondary education and tertiary education) is positively and significantly related with formal account and formal saving, but no significant and positive relationship is observed concerning formal credit. This infers that compared to those individuals who have completed primary or less, those with secondary or tertiary education are more likely to have a formal account and are more likely to save at a financial institution (Zins and Weill, 2016; Yangdol, 2017). Furthermore, as can be seen from columns (1), (2) and (3), the marginal effects of Edu 3 (individuals who have completed tertiary education or more) is higher than Edu 2 (individuals who have completed secondary education) throughout, signifying that in case of individuals with tertiary education or more, the probability of owning an account increases by 31% and the probability of saving at a financial institution increases by 12.72%. The results found that greater *income* is associated with higher FI. Dummy variables for income (Income q1, Income q2, Income q3 and Income q4) are all significantly negative for formal account and formal saving with larger coefficients for income quintile dummies indicating lower income. This result is consistent with that of Demirgüc-Kunt and Klapper (2013) and Fungáčová and Weill (2015) who discovered that income is positively related to FI. However, no relationship was found as far as formal credit is concerned. The main variable of our study internet usage shows a robust positive and significant correlation with all the three indicators of FL i.e., formal account, formal saving and formal credit. The use of internet services in financial transactions raises the chances of being financially included as ICT permits the previously unbanked to carry out financial transactions through the internet facility (Kpodar and Andrianaivo, 2011; Agyekum et al. (2016). It has been observed that internet penetration augments the credit allocation process, leading to wider FI. Furthermore, ICT services guarantee a smooth flow of information and hence mitigate both information asymmetry and transaction costs of providing financial services to the marginalised section of the society. The variable govt. transfers is found to have a positive and significant relation with formal account and formal saving (Yangdol, 2017), but not so in case of formal credit. This indicates that individuals who received financial support like subsidies and other aids from the government were more likely to have an account and have saved at a financial institution.

Also, those individuals who saved and borrowed in the past year (from any source - formal or informal) are more likely to be financially included than those who did not save or borrow (Yangdol, 2017).

Dependent variables	For_Acc	For_Sav	For_Cred	Acc_Fin_Inst.	Mob_Mo_Acc
Explanatory variables	(1)	(2)	(3)	(4)	(5)
Female	-0.1236***	-0.0585***	-0.0218**	-0.1269***	-0.0112**
	(0.0169)	(0.0132)	(0.0093)	(0.0169)	(0.0056)
Age	0.0249***	0.0089***	0.0037**	0.0248***	0.0005
	(0.0027)	(0.0024)	(0.0017)	(0.0027)	(0.0009)
Age ²	-0.0002***	-0.0001***	-0.0000*	-0.0002***	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Edu_2	0.1771***	0.0373**	-0.0019	0.1807***	0.0132*
	(0.0189)	(0.0162)	(0.0107)	(0.0189)	(0.0072)
Edu_3	0.3103***	0.1272***	-0.0279*	0.3152***	0.0018
	(0.0268)	(0.0328)	(0.0151)	(0.0266)	(0.0096)
Income_q1	-0.0983**	-0.1282***	0.0048	-0.0578**	-0.0252^{***}
	(0.0294)	(0.0137)	(0.0192)	(0.0294)	(0.0058)
Income_q2	-0.0794***	-0.1253***	0.0262	-0.0791^{***}	-0.0098
	(0.0264)	(0.0138)	(0.0175)	(0.0264)	(0.0071)
Income_q3	-0.0633***	-0.0567***	0.0089	-0.0959***	-0.0206***
	(0.0253)	(0.0158)	(0.0150)	(0.0253)	(0.0059)
Income_q4	-0.0503**	-0.0521***	0.0210	-0.0468*	-0.0079
	(0.0259)	(0.0156)	(0.0156)	(0.0259)	(0.0065)
Int_Usg	0.2302***	0.1834***	0.0240*	0.1959*	0.3859***
	(0.0751)	(0.0606)	(0.0268)	(0.0768)	(0.0697)
Govt_trans	0.1876***	0.0913***	0.0167	0.1910***	0.0416***
	(0.0277)	(0.0267)	(0.0173)	(0.0277)	(0.0141)
Saved	0.1930*** (0.0181)		0.0777*** (0.0106)	0.1935*** (0.0181)	0.0152*** (0.0060)
Borrowed	0.0191* (0.0171)	0.0709*** (0.0133)		-0.0216 (0.0171)	0.0080 (0.0056)
Observations	3,000	3,000	3,000	3,000	3,000
Pseudo R ²	0.1398	0.0916	0.0629	0.1412	0.2516
Log likelihood	-1,770.7034	-1,219.0975	-713.0193	-1,769.704	-297.3209
Predicted probability (at mean values)	0.559	0.165	0.071	0.556	0.029

Results of logit estimation (marginal effects) for micro-dataset Table 4

Notes: 1 Logit marginal effects are tested using Stata 13. 2 ***signifies 1%, **5% and *10% levels of significance (***p < 0.01,

***p* < 0.05, **p* < 0.1).

Source: World Bank Global Findex Database 2014 for India

Now, when we estimate the regressions separately for accounts at financial institution [column (4)] and mobile money account [column (5)], we find that gender (being female) has a negative relation with both types of formal account, similar to the other main indicators of FI. Age also has a similar effect, i.e., positive up to certain age and then negative (Age^2 is negatively related) in case of account at financial institution but no so in case of mobile money account. Education (both Edu 2 and Edu 3, i.e., dummy variables for secondary education and tertiary education) has positive relationship with account at financial institution but no clear-cut relation with mobile money account. Again, similar to the main indicators of FI, the marginal effects for Edu 3 are higher than Edu 2, only for account at financial institution. Individuals' income level does not exhibit any clear relation with both account at financial institution and mobile money account. Internet usage, the prime variable of our study is found significantly positive with both account at financial institution and mobile money account. Government transfers have a positive impact on both account at financial institution and mobile money account. Those who saved in the past year have higher likelihood of FI unlike those who borrowed in the past year. Lastly, for logit estimations, the model diagnostics were conducted (using linktest, fitstat and Hosmer and Lemeshow's test) to examine the overall fit of the model.

7 Conclusions and policy implications

FI has been recognised as one of the predominant pillars of the global development agenda. FI fosters growth through a broadening of the financial system and *technology* can be a key catalytic agent for deeper FI. The study attempts to establish the significant role technological deepening, macroeconomic and financial indicators, individual characteristics and economic circumstances play in furthering FI in India, with theoretically wider applicability which can be generalised to other developing countries. At the macro-level analysis, the study finds mobile penetration rate, Economic Freedom Index, population density, bank overhead costs (% of total assets), government consumption expenditure, gross primary completion rate and institutional development to have a significant influence on FI in India. To sum it up at the micro-level analysis, the study observes that being a man, richer, more educated, older to a certain extent, well-supported by the government and critically having good internet access and usage favour access to formal financial services in India with a particular influence of education and income. This finding highlights the view that policies favouring FI should target certain groups of the population like women and young people in the country.

The study recommends that as DFS are made affordable and accessible to individuals who were previously 'unbanked,' the adoption can grow at a much rapid pace. Leveraging the opportunities that technology proffers through mobile phone platform and internet usage can reduce transaction and information costs, widen scale, and deepen the spread of financial services and hence can be critical to attaining universal and complete FI. However, holistic FI is more likely when policy regulators, donors, and relevant industry participants collectively come together to build a technologically conducive environment. It is likely to be unsuccessful if practiced in isolation. Hence, unearthing a perfect balance between adopting an inclusive financial approach, pro-poor growth, and a technologically advanced infrastructure is indispensable since each facet has an important role to play. Focusing on the noticeable trade-offs in evolving modes of rendering financial services to the marginalised are vital to attain inclusive and pro-poor growth as

the urge towards inclusion made viable by the mobile network services does not differentiate along income, status, education or age category lines. Furthermore, ICT growth can be instrumental in bringing about numerous macroeconomic benefits like economic growth, employment, and financial system stability through reduced information asymmetry and can prove to be transformational especially when it comes to developing countries.

Bridging the gap between demand-supply side constraints and digital awareness also remain at the centre of such services so as to include poor in the digital space. In this scenario, the future Indian economy promises rapid growth that necessitates the people to be digitally literate and technologically equipped to start with. More government-to-person (G2P) and person-to-all (P2ALL) initiatives could be developed similar to direct benefit transfers (DBTs) and other transfer payments. The stakes are high that constantly urge towards policy leadership and coordination among private and public players so as to push the digital way forward. Thus, 'digital financial literacy' needs to be reinforced along with technological deepening towards holistic inclusive growth. Additionally, the think-tanks need to be vigilant in monitoring the legal and regulatory technology (Regtech) framework that is predictable, fair and technology-neutral. Finally, the study recommends that such moves are not an end in themselves rather expected to shoulder the responsibility of creating new economic order in India via FI toolbox through sustainable development goals (SDGs).

The study can further have critical policy implications for the governments of emerging markets as an amplified investment in the ICT sector can be a plausible avenue to shrink carbon emissions, lower air pollution levels and hence pave the way for lowcarbon economies in the world. An empirical investigation may further be undertaken to validate the statistical significance of the argument herein.

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Notes

1 In Kenya, active bank accounts have multiplied by more than four times between 2007 and 2012.