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Inclusive Digitalization: A way towards sustainability & shared prosperity

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Abstract:

This study investigates whether, and to what extent, the inclusive digitalization of financial services contributes to economic growth. It explores the relationship between social inclusion, digital finance, and economic development. Using the Barro (1990) framework, the study develops panel data models to examine how inclusive digitalization—measured through per capita GDP growth—is influenced by the usage of digital financial services (DFS) like debit cards, credit cards, and digital payments.

A key contribution of this research is the creation of an Inclusive Digitalization Index, which captures the usage of these financial tools among four specific societal groups: the labor force, the poorest 40%, women, and rural populations. The study also conducts a comparative analysis between two income groups of countries—low and lower-middle income vs. high and upper-middle income—to assess the levels of social inclusion in DFS usage compared to overall DFS adoption.

The findings indicate that financial inclusion, when supported by Information and Communication Technology (ICT), has the potential to boost economic growth. However, in low- and middle-income countries, not all ICT-based financial services have an equally significant impact on development.

From a policy standpoint, the study highlights the need to tailor ICT-enabled financial services to the specific needs and economic contexts of different countries. It also emphasizes the importance of investing in awareness and education regarding the use of ICT in formal banking systems. Overall, the research underscores that inclusive access to DFS is crucial for harnessing the full benefits of digital technology in economic growth.

Key words: Financial Inclusion, Digitalization, financially excluded, Economic development, Panel Data, Policy Making, Regulation, Innovation, Least Developed Country, Technological Change.

JEL: G2, G28, G21, O16, O57

I. Introduction:

Financial inclusion aims to bring the “unbanked” population into the formal financial system, ensuring access to essential services like savings, credit, insurance, and payments (Hannig & Jansen, 2010). While traditionally viewed as access to formal credit, inclusion also involves digital alternatives such as mobile money, digital payments, and online banking (Demirguc-Kunt & Klapper, 2012). According to the World Bank (2017), financial inclusion refers to individuals and businesses accessing useful, affordable financial services delivered responsibly and sustainably.

A growing body of research (Levine, 2005; Beck et al., 2007; Demirguc-Kunt et al., 2018) shows that financial inclusion boosts economic growth, reduces poverty, and narrows income gaps. Information and Communication Technology (ICT) plays a pivotal role by enhancing efficiency, reducing transaction costs, and expanding access through telecommunication infrastructure (Pohjola, 2001; Vu, 2011; Pradhan et al., 2018a).

Digital Financial Services (DFS) include a wide range of services—such as debit/credit cards, mobile payments, online transfers, and digital wallets—delivered via digital channels (AFI Global). These services reduce the need for physical banking infrastructure, making financial access more widespread, especially in developing nations. Digital tools allow customers to perform transactions with ease, helping the poor manage finances better and access timely credit, ultimately improving their living standards (Suri & Jack, 2016; Burgess & Pande, 2005).

With nearly 50% of people in the developing world owning a mobile phone (World Bank, 2014), digital finance presents enormous opportunities. For small businesses and entrepreneurs, it facilitates smoother cash flow, financial planning, and scalability. Programs like Financial Diaries indicate that customized digital financial tools are more likely to be adopted by low-income users (ADB). Services offered by mobile providers often surpass the reach of traditional banks, making mobile phones potential "Swiss Army knives" of financial services (Banerjee, 2010).

Digital transformation in banking—driven by AI, machine learning, and mobile platforms—has streamlined operations and improved customer service. The spread of digital financial services can promote inclusive economic growth and macroeconomic stability by encouraging spending, investment, and saving.

According to McKinsey Global Institute, digital finance could add up to 6% to the GDP of emerging economies—roughly $3.7 trillion by 2025. Countries like Kenya have already made significant strides; for example, M-Pesa now serves 38% of mobile users (Economist, 2009). However, countries like India, where over 90% of transactions are still cash-based (Roy & Sinha, 2014), have significant potential for growth in DFS usage.

Yet, effective use of digital banking tools requires education, digital literacy, awareness, and trust in technology. Vulnerable sections—women, rural poor, and labor class (ILO, 1993)—need targeted policy support for meaningful inclusion. Despite its benefits, the inclusiveness of ICT-driven finance remains a challenge, demanding proactive strategies for awareness, security, and accessibility.

A more efficient, effective, and synergetic use of ICT is needed to successfully support economic development. But ICT is not properly utilized in various sections of the society, and then it will not be able to improve the growth process. Moreover, the literature acknowledges that both FI and ICT infrastructure can promote economic growth. When having a particular look on the development of socio-economy with regard to the different form of ICT the previous literature revealed that ICT puts dedicated attention to it directly by offering a corresponding fully-fledged service portfolio. In one hand Internet as well as mobile penetration is increasing in both developed and developing countries and this play a very important role in making ICT successful in facilitating FI, on the other hand the ICT enabled financial product can instigate people to spend more, thus money infuses in economy.

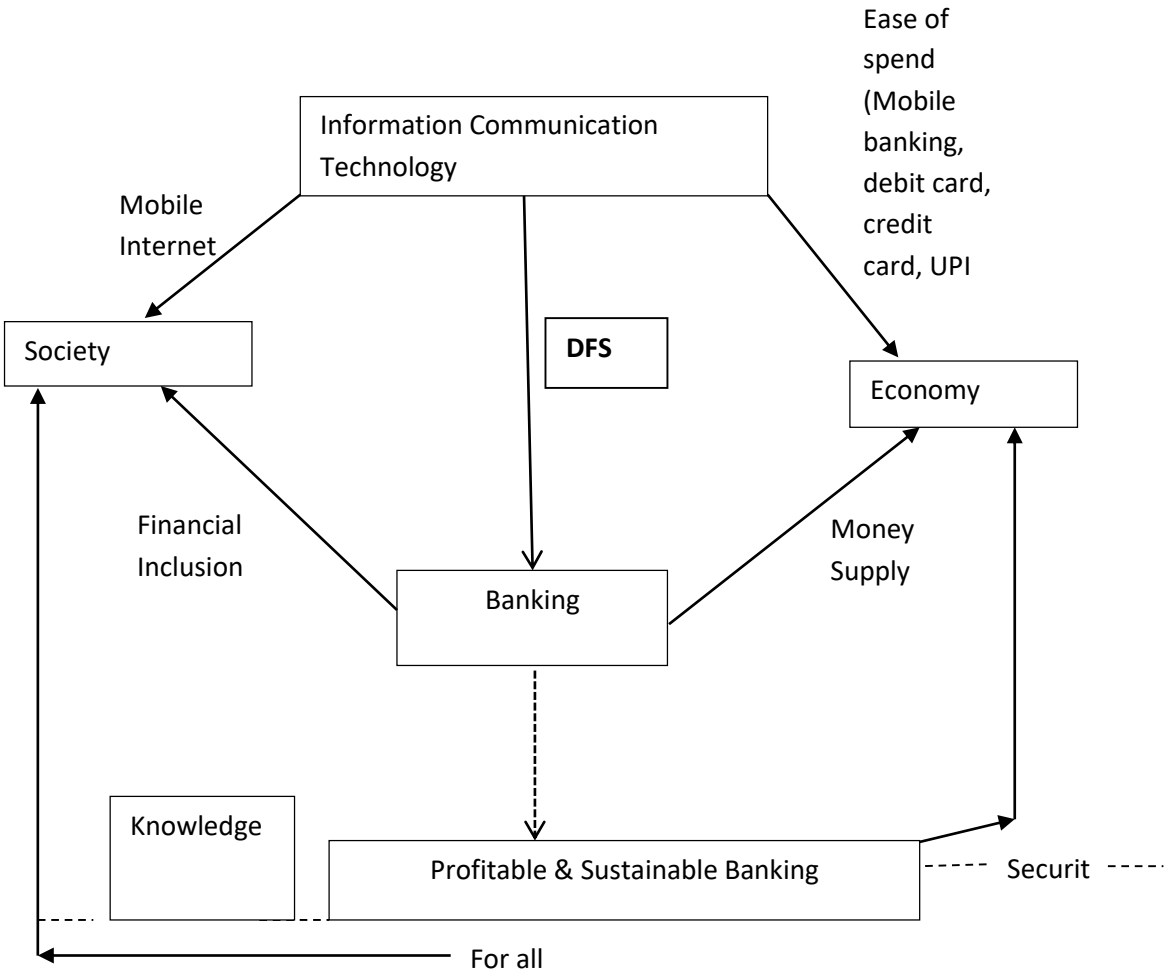


Figure 1:ICT and Socio-economic nexus Framework

Though the effect of financial innovation on economic growth has been noticed by different researchers in the literature in recent times but the role of ICT in digital financial services, financial inclusion, and economic growth in a holistic way across the countries is un-discussed. Moreover, the questions are already arising over the nature of social inclusion and economic growth nexus. Fig 1 defines how ICT penetrates to the economy and society through banking industry and the channels by which it impacts socioeconomic development of countries. ICT impacts both the economy and the society simultaneously. From economic perspective it increases money supply and strengthens the monetary base of a nation whereas from societal point of view impact of ICT reaches all sections of the society irrespective of their income classification. Literature review section discusses the channels (mainly debit credit cards and digital payment services) by which greater digital financial inclusion would result in faster economic growth. Hence the present study aims to develop the existing literature by incorporating these important aspects such as whether whether and to what extent inclusive digitalization leads to economic growth and sustainability. Inclusive growth and sustainability are interconnected and cannot be viewed as trade offs. The most common definition as put forth by the Brundtland Commission in 1987 says that "sustainable development meets the needs of present without compromising the ability of future generations to meet their needs". The issue that digitalisation, social inclusion and sustainability has been acknowledged globally (OECD, 2017; United Nations, 2015). Many researchers (Del Río Castro et al., 2021; Bansal, 2019; Melville, 2010) perceived the link between digitalisation and sustainability. Therefore, if inclusive digitalization along with process based financial innovation depicts a positive association with economic growth of countries then one can infer that economic growth due to financial innovation is inclusive as well as sustainable one.

Literature Review:

II.a Financial Innovation, Inclusion, and Socio-Economic Development

Innovation is a key driver of long-term economic growth (Solow, 1956), and financial innovation has emerged as a crucial enabler of both economic stability and growth (Levine, 1997; IMF, 2006; Lerner & Tufano, 2011). Financial innovations—ranging from ATMs to mobile money and digital payments—have transformed traditional banking models, fostering efficiency, customer reach, and product diversity (Blach, 2011). Moody's Analytics (2016) estimates that electronic payments contributed $296 billion to the GDP of 70 economies from 2011 to 2015, equivalent to 2.6 million jobs annually.

While innovation enhances socio-economic outcomes, it also introduces risks to financial stability. The ultimate goal of digital finance is not just economic expansion but also poverty reduction and broader financial inclusion (UN, 2016). A well-developed financial system mobilizes savings, channels funds into productive investments, and promotes inclusive growth by enabling access to finance for marginalized populations (Levine, 2005; Beck et al., 2007).

However, financial access remains uneven. Vulnerable groups—rural populations, women, the poorest, and the labor class—face multiple barriers: geographical remoteness, affordability, lack of digital literacy, and socio-cultural inhibitions (Kempson & Whyley, 1999; Peake, 2012). These groups are often excluded due to structural (access), economic (price), or psychological (self-exclusion) barriers.

II.b ICT, Digitalization, and Economic Development

ICT has become a cornerstone of modern financial systems. Over the past three decades, it has enabled banks and financial institutions to expand services, reduce costs, and improve customer experience (Abubakar & Rasmaini, 2012; Castellacci & Tveito, 2018). ICT-driven platforms such as internet and mobile banking have revolutionized service delivery (Noyer, 2007), lowering operational costs and creating opportunities for financial inclusion.

Studies confirm ICT's role in enhancing productivity and service innovation (Andrianaivo & Kpodar, 2012; Czernich et al., 2011), yet few have directly examined its broader socio-economic implications, especially in cross-country contexts. Most research addresses either economic growth (Bojnec & Ferto, 2012) or ICT penetration (Pradhan et al., 2018c), but not the intersection of ICT infrastructure, financial innovation, and inclusive development across income-diverse economies.

II.c Financial Inclusion, Digital Finance, and Development Outcomes

Financial inclusion—defined as access to formal financial services by disadvantaged groups—has been linked to poverty reduction, economic resilience, and macroeconomic stability (Beck et al., 2007; Han & Melecky, 2013). Digital financial services (DFS), by expanding service outreach and lowering costs, are instrumental in advancing inclusion, especially among unbanked populations (Ozili, 2018; World Bank, 2014).

Thailand offers a success story where DFS expansion—via ATMs and ADMs—helped achieve 88% household financial inclusion (BOT, 2014). Digital inclusion also allows households to cope with income shocks and promotes personal financial security (Collins et al., 2009). Financial deepening, supported by DFS, has potential macroeconomic benefits, including more effective monetary policy and improved resource allocation (Cecchetti & Kharroubi, 2012; Creane et al., 2004).

However, findings vary across regions. Sassia and Goaied (2012) note a positive interaction between ICT and financial development only after a threshold level of ICT adoption is reached in MENA countries. This indicates that digital financial development may have conditional effects, varying by region and income level.

Research Gap and Need for Further Study

Despite significant literature on financial inclusion, digital finance, and ICT in isolation, existing studies fall short in analyzing the integrated impact of ICT-enabled financial innovation and inclusive digitalization on socio-economic development, especially in comparative cross-country contexts. Most research focuses on developed economies or specific national case studies, offering limited insights into the heterogeneous needs of developing countries.

There is limited empirical research comparing how digital financial services impact vulnerable sections across high- and low-income countries, particularly with respect to infrastructure readiness, user capability, and institutional support. Additionally, few studies examine the interplay between ICT penetration, financial innovation, and digital inclusion as a combined framework for promoting equitable growth.

This gap calls for a microscopic, comparative analysis of developed and developing countries to assess whether digital finance fosters inclusive socio-economic outcomes equitably. Given the heterogeneity of financial infrastructure, policy environments, and digital readiness, generalized conclusions could lead to misinformed policy recommendations. Thus, the need of the hour is to contextualize digital financial inclusion strategies through a comparative empirical lens.

II. Research Objectives:

According to most popular approach of financial innovation, it is classified as product, process[1] and institutional innovations/ financial system[2]. Process innovation is usually aimed at increasing the efficiency in the production process, and it is often associated with technological change. It is basically a new way of operating business through implementation of ICT, such as Automated Teller Machine (ATM), transaction facilities through cards and other methods, introduction of mobile banking, online banking, etc (Abor, 2005). As the types or the facilities that offers ATM or debit and credit cards are constantly going through innovation. From its initial unveiling as an engineering marvel, to its present-day iniquitousness, modern ATMs have innovated far beyond the traditional way of deposits, withdrawals, cash checks, and payments. They now play a role in digital banking and financial inclusivity as well (World Bank, 2021). Similarly, the use of credit and debit cards remain useful for manual as well as online payments. Mobile devices have become increasingly central to daily financial activities of human being. This call for continuous upgradation of mobile technology. Still, digital financial services are out of the reach of many people especially the countries like India, Bangladesh. Some people live in areas with little to no internet facilities which pose a big problem for rural habitants.

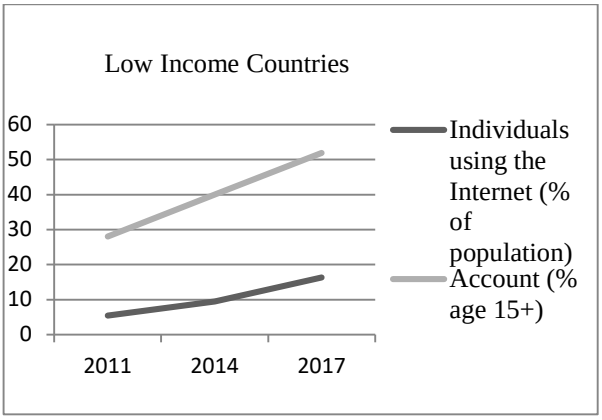
Therefore, the research does not differentiate traditional channels and digital channels of inclusion. Instead of that the research considers debit cards, credit cards and digital payment services as technological process related financial innovation. Some researchers have argued that usage of ICT has facilitated improvement in financial inclusion in developing and low-income countries around the world (Andrianaivo & Kpodar, 2012; Ozili, 2018). Financial inclusion is one of the characteristics of financial development and also an indicator of social development. Previous researches pointed out that the association between financial inclusion and ICT

[1] See Oslo Manual, 2005; Greenhalgh and Rogers, 2010; Allen and Yago, 2010; Pain, 2011

[2] See Llewellyn, 2009; Frame and White, 2004; Dan Awrey, 2013

use is theoretically positive; suggesting that improvement in internet usage could stimulate financial inclusion as well as economic growth. Fig 2, 3 and 4 shows the persistent rise of internet use among all group of countries over the years.

Therefore, to utilize ICT as a developmental tool we should understand the complex relationship between internet usage and financial inclusion. Not only that, we must be in a position to compare this relationship for different category of countries in terms of income as income category represents the degree of financial development.



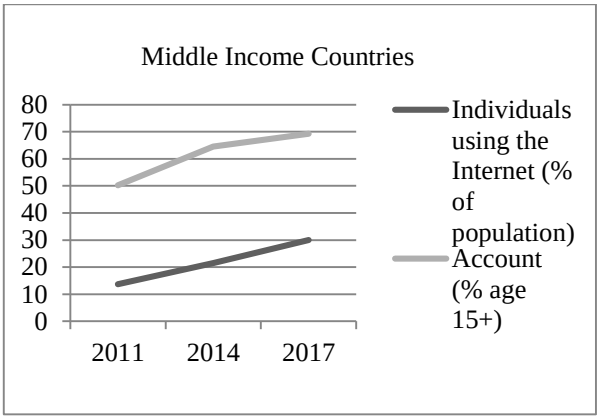


Fig 2: Authors' preparation (from World Bank dataset) Fig 3: Authors' preparation (from World Bank dataset)

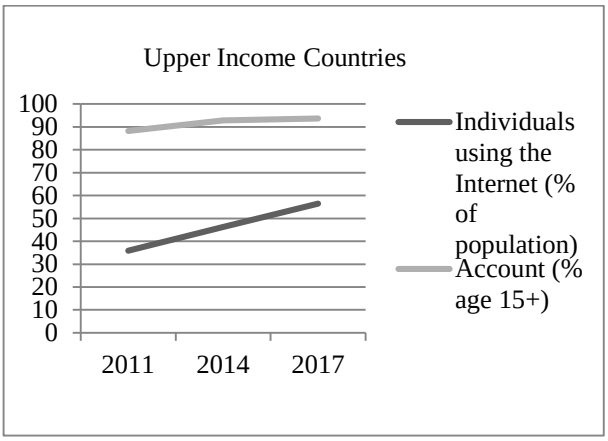


Fig 4: Authors' preparation (from World Bank dataset)

In the above picture it is clear that the percentage of account opening and individuals using internet both are rising over the years for each category of countries, but the rate of rise is not uniform for all. In low-income countries only 50 per cent of the country's total populations have bank account that implies half of the countries people are covered under formal finances so far but the percentage of individuals using internet is rising at a diminishing rate. Hence the gap between the no of account opened and internet used are gradually rising implying a divergent trend for low income nations. In case of middle-income countries, almost 60 – 70 percent of total populations have bank accounts among them 30 percent are using internet. Interestingly from Fig 2, it is noted that percentage of populations having accounts shows as mixed trend i.e., up to 2014 the rate of rise is steep then it is flat indicating a point of inflexion in 2014. Otherwise, the gap between the no of account opened and internet used remains constant (neither convergent nor divergent). Lastly in upper income countries the number accounts opened has reached almost near to 100 percent. No doubt it can be inferred that maximum number of countries population are having bank accounts and percentage of individuals using internet is also gradually rising over the years. So, the gap between these two is declining shows a convergent trend which is mostly desired from high income groups and sets an ideal example to be followed by others.

It is well known that financial development need everyone's participation and contribution, no one should be left behind i.e financial inclusion.

But the question is how to reach this? We have seen above that use of ICT is increasing day by day for each category of country. So, inclusiveness of digitalization should be the solution.

The main aim of the research is to access the inclusive digitalization and its economic impact of the nations based on the income groups such as high & upper middle income and low & lower middle-income countries. In order to reveal economic impact of inclusive digitalization the paper also tries to construct an inclusive digitalization index (based on the percentage of use of DFS out of total population) for the vulnerable sections or financially excluded sections of a country. The present research is extended to indicate the most significant factors of digital finance and the importance of inclusiveness of digital finance for the economic growth of the country in Barro(1990) framework.

Finally, the paper also tries to ascertain whether digital innovation or DFS leads to financial inclusion or not. Here digital innovation is same as DFS but it is a part of Financial Technology or fintech. Fintech is utilized to help companies, business owners, consumers to operate their financial operation and many other purposes. Fintech includes different industries such as education, retail banking, general banking, FMCG etc. Here the paper mainly concentrates on technology-based innovation channels generally accessible to each class of the society. Hence, DFS can be regarded as subset of "fintech". To do so the paper performs a cluster analysis on the basis of the use of overall DFS by nations and by vulnerable groups within the nations. Hence the paper prepares a comparative analysis of overall penetration of DFS and its reach among the vulnerable sections or financially excluded sections.

III. Data Description and Variables

IV.A *Source of Data:*

The research is of a dynamic and multiregional structure and was conducted on the target sample based on the longitudinal study of World Bank and FINDEX (Financial Development Index) database. The paper considers 121 countries (49 lower and lower middle-income countries and 72 high and upper middle-income countries) over the time period 2011, 2014 and 2017 to explore the complex relationship of digitisation, economic growth and social inclusion. The major problem of this study is limited data period only for 2011, 2014 and 2017[3] and for limited countries. Dataset regarding financial inclusion variables i.e., for the use of credit card, debit card transaction, use of mobile phone to pay bills, digital payments etc of the countries are not regular before 2011. Hence, we cannot extend our analysis before 2011. The dataset has been taken from World Bank (Global Findex) survey which is available for the year 2011, 2014 & 2017 only. Digitalizations are classified under three major categories i.e., Debit Card, Credit Card, and digital payment.

To address the first objective of the paper i.e. to estimate the impact of digitalization over economic growth GDP per capita is considered as independent variable and Debit Card ownership, Credit Card ownership, and digital payment percentages[4] are considered as dependent variables. Three control variables are also used to assess the relationship between multiple variables.

The explanatory variables are of two types; control variables (Private credit by deposit money banks and other financial institutions to GDP, General government final consumption expenditure, Population growth) and Digital finance variables (Debit Card, Credit Card and Digital payment). Secondary data is taken from World Bank database.

Second part of this paper mainly focused on social inclusion through digitalization and economic growth nexus. For this GDP per capita is considered as independent variable and Debit Card social impact index, Credit Card social impact index, and digital payment social impact index are considered as dependent

[3]Data on use of credit card, debit card transaction, use of mobile phone to pay bills, digital payments etc of the countries are not regular before 2011. Hence, we cannot extend our analysis before 2011. The dataset has been taken from World Bank (Global Findex) survey which is available for the year 2011, 2014 & 2017 only.

[4]Due to unavailability of datasets for the year 2011 in World Bank database, Interpolation method has been used to get the values of digital payments and all its components.

variables. The indices have been calculated considering labour force, women, poor and rural penetration of those products. Same control variables are also used and secondary data is taken from FINDEX (Financial Development Index) database.

IV.B *Variables:*

Dependent Variable

Data taken from World Bank database and for detailed definition see Table A.1 in appendix.

Growth rate GDP per capita is the dependent variable which indicates the economic development of a country. Many researchers (Jerven, 2013; Sarma & Pais, 2011; Chatterjee, A. 2020; Baluch and Ariff, 2007) have taken into account GDP as a measure of economic performance based purely on economic activities in the formal sector.

Independent Variable:

- Financial Innovation and Inclusion variables

Parameters taken from World Bank FINDEX (Financial Development Index) database are of two types as defined in the study. The first set reflecting total use of Digital Payment Services (DFS) such as use of debit cards, credit cards and digital payments as proportion of total population are taken as financial innovation (defined by debit card ownership, credit card ownership and digital payments) variables in the Model. The second one reflecting the use of Digital Payment Services (DFS) such as use of Debit Card, Credit Card, and Digital payment by 4 classes namely labour force, women, poorest 40% and rural sections are taken as inclusive digitalization variables in the Model to measure their effect on economic development of the nations. There have been Plethora of research studies on the use of electronic modes of payment or transaction services and its impact on economic growth (Ishida, 2015: Lee & Brahmasrene, 2014; Rohman & Bohlin, 2014; Shahiduzzaman & Alam, 2014; Pradhan, Arvin, Norman, & Bele, 2014; Bacache, Bourreau, & Gaudin, 2013; Bojnec & Ferto, 2012; Sarma & Pais, 2011; Bouras, Giannaka, &Tsiatsos, 2009). It is evident in many research that ICT infrastructure is a leading growth enabler in developing as well as developed nations. Not surprisingly, many developing nations are working hard to incorporate ICT infrastructure to catch up rapidly with the developed economies (Bankole, Osei-Bryson, & Brown, 2013; ASEAN, 2011; Kooshki & Ismail, 2011; Bollou, 2010; Shirazi, Gholami, & Higon, 2009; Kuppusamy, Raman, & Lee, 2009; Thompson & Garbacz, 2008; Jorgenson & Vu, 2005). Hence in this current research we have taken ICT enabled financial innovation variables and also the use among different segments which definitely entails the inclusiveness of those services. Detailed description of variables are provided in Appendix Tables A.2

The identified parameters are as follows:

- *Other Control variables:*

The main role of control variables is to control the impact of any other variable which may influence the dependent variables other than the main independent variables. Thus, in order to measure economic impact of DFS and inclusive digitalization, some of economic indicators have been incorporated as control variables. For definition of the variables see Table A.3 in Appendix. Regression equations are used in many studies to measure to estimate the effect of ICT enabled DFS and inclusive digitalization on the economic growth by controlling a number of macroeconomic factors. The paper mainly follows Barro (1990) endogenous growth theory model (which is discussed under methodological section) that incorporates three macroeconomic factors as control variable these are k= private capital growth, l= population growth, d= general government expenditure. According to several researchers (Popov 2018; Leaven et al., 2015; Levine et al. 2000; Levine, 2005; King and Levine, 1993a) Private capital growth is proxied by Private credit by deposit money banks and other financial institutions to GDP that measures financial development or financial depth of countries. Evidence from cross-country panel regressions shows a causal relationship between financial depth measures and long run economic growth that implies greater depth leads to these better outcomes. However, financial inclusion should be linked to financial depth because if a country able to mobilizes a large amount of funds, it

can be used for the welface of large section of the society by providing services. Another control variable is general government expenditure (as incorporated in Barro, 1990 model) which is proxied by General government final consumption expenditure (GFCF) as proportion of GDP consists of all the current expenditures of the government for the purchase of goods and services, including compensation for employees (World Bank 2020). According to some researchers (Chatterjee, A. 2020; Devarajan, Swaroop, and Zou 1996) it is a growth determinant factor that indicates a higher GFCF will boost the economic growth of any country. Finally, the population growth indicator which is widely used in many studies (George Tsetsekos 2000; Czernich et al., 2011; Sarma & Pais, 2011; Kumar, 2013; Pradhan, Mallik & Bagchi, 2018; Chatterjee & Das, 2019; Chatterjee A, 2020) to control the effect on economic growth. In this line of research, Allen et al. (2014) pointed out that population density holds the highest degree of importance for financial development and financial inclusion in anywhere.

IV. Methodology:

V.A *Construction of Inclusive digitization index:*

According to World Bank Global Findex Database, 2017 there are several classes of people who are using Digital Payment Services such as Debit Card, Credit Card, and Digital payment but the paper has selected 4 classes[5] namely labour force, women, poorest 40% and rural sections in order to construct Debit Card societal impact index, Credit Card societal impact index, and digital payment societal impact index using Principal Component Analysis Method. We have constructed a comprehensive societal impact index of all DFS channels for each of the 121 countries (49 lower and lower middle-income countries and 72 high and upper middle-income countries) over the time period 2011,2014 and 2017. We have constructed these indices to understand the impact of digital inclusion on the economic growth in a cross-country set. The indicators are combined into three sub-indices based on the weights assigned using principal component analysis (PCA). Thus, the paper has constructed 3 indices for debit cards, credit cards and digital payments to understand the impact of digital inclusion in a comprehensive way especially for the "vulnerable Section" i.e., labour force, women, poorest 40% and rural sections. The indices are considered as explanatory variables in the model. If the use of debit card, credit cards and digital payment services percolates to the "vulnerable sections" then only we can justify the objective of inclusive digitalisation. A comprehensive measure should be able to incorporate information on several dimensions of digital inclusion. It should incorporate those classes of people who are presumed to be vulnerable section of the society and unable to reap the benefit of digital transactions. Moreover, it should be easy and simple to compute and should be comparable across countries and across the year. Therefore, Principal component analysis (PCA) is used for the construction of Digital Inclusion indices following the methodologies used by Camara and Tuesta (2017), Svirydzenka (2016) & Sahay et al (2015a,b). PCA is the most scientific methods of index construction in the presence of at least three variables, especially when variables may have multi-collinearity problem. In the present research, the variables, considered for construction of three digital inclusion indices, are highly correlated. Factor analysis is done across the countries at a particular time period. Weights of the inclusion variables are calculated during factor analysis. Endogenous weights are used to construct multi-dimensional indices such as Debit Card societal impact index, Credit Card societal impact index, and digital payment societal impact index.

There are two commonly used approaches to constructing composite indices: Among non-parametric[6] and parametric methods of constructing composite indices the paper has selected parametric method. However, there are two parametric analyses commonly used for indexing: PCA and Common Factor Analysis. According to Steiger, 1979, PCA is preferred over Common Factor Analysis as an indexing strategy[7]. A good composite

[5] According to ILO's definition these classes represents "vulnerable" section of society.

[6] Non parametric methods assign the importance of indicators by choosing the weighs exogenously as developed by researchers' own intuition.

[7] because it is not necessary to make assumptions on the raw data, such as selecting the underlying number of common factors. Particularly, PCA is better when set of variables are correlated.

index should be the combination of all factors considered to built an index but that should not be biased towards one or more of these indicators. Thus, the search is for the best weighted combination of use of digital financial services by the vulnerable sections such as labour force, women, poorest 40% and rural sections that define our underlying structure of construction of 3 indices namely Debit Card societal impact index, Credit Card societal impact index, and digital payment societal impact index.

Let us consider the following equation.

$$FII = \omega_1 V_{1i} + \omega_2 V_{2i} + \omega_3 V_{3i} + \omega_4 V_{4i} + \omega_5 V_{5i} + \omega_6 V_{6i} \ldots\ldots\ldots\ldots (i)$$

where subscript i denotes the countries $\omega_{1,\ldots,}\omega_6$ denotes weights of use of debit card or credit card or digital payments by labour force, women, poorest 40% and rural sections. Table 4, 5 and 6 gives the weight structure of Debit Card societal impact index, Credit Card societal impact index, and digital payment societal impact index respectively.

Construction of index involves Academic software STATA 10.0 and hence respective weights of the variables have been calculated with this PCA method. In the next step, the academic software STATA is used to find out the factor loading of each variable. Important components are determined from cumulative values given in the corresponding table that explains maximum proportion of the model. Then in the next step eigen values of that component have been taken for the respective variables and then square values of each eigen values are to be calculated. Then column total for each component (sum of the square eigen values) have been done. After that the square of eigen values of the variables are divided by the column total and by this one can calculate component values for all the variables. To determine the final weight of all variables in the final stage, the maximum values among the components are selected for all variables followed by multiplication with the corresponding component weight. Now the component weight is calculated by the sum of eigen values of each component. Final step involves the multiplication of the weight and the corresponding standardised value of a given time, which depicts the Inclusive digitisation Index for Debit Card, Credit Card, and Digital payment services.

V.B *Cluster Analysis*

At first, the Cluster analysis is performed for inclusive digitalisation indices[8] and for DFS variables[9] across 11 countries. Accordingly, four clusters have been formed with relatively homogeneous groups. Justification of cluster formation has been made based on the differences of mean value of identified parameters.

- Under inclusive digitalisation indices:

a) Cluster 1 (Low mean value): represents use of DFS by vulnerable section across low and lower middle-income group of countries

b) Cluster 2 (High mean value): represents use of DFS by vulnerable section across high and upper middle-income group of countries

- DFS by total ownership (i.e., total use of Debit cards, credit cards, digital payments)

c) Cluster 1 (Low mean value): represents total ownership of debit cards, credit cards and digital payments across low and lower middle-income group of countries

a) Cluster 2 (High mean value): represents total ownership of debit cards, credit cards and digital payments across high and upper middle-income group of countries

Before that, normality test for all parameters of inclusive digitalization has been performed. Large significance values (>.05) of all the independent variables indicate that the observed distribution corresponds to the theoretical distribution. The value of significance indicates that all the independent parameters are normally

[8] i.e., use of Debit Card, Credit Card, and Digital payment by the "vulnerable section" (which incorporates labour force, women, poorest 40% and rural sections)

[9] i.e., percentage of population having Debit cards out of total population (which is defined as debit ownership rate), percentage of population having credit cards (credit card ownership rate) out of total population and percentage of population using digital payments out of total population.

distributed. Cluster analysis is done basically to make a comparative analysis of inclusive digitalisation and process based financial innovation on economic performance between high income and low income group of countries.

V.*C Panel Data Analysis:*

Throughout the literature review, we could not find any empirical study exploring the impact of DFS on financial inclusion and economic development for cross country comparison. The use of mobile phone and Internet services has increased rapidly in every country during the past decade. Their use has helped to enhance financial inclusion largely. On this line this paper intends to evaluate the impact of overall digital finance and inclusive digitalization on economic growth of a nation in a multiple regression using panel data analysis method. Financial inclusion is a multidimensional concept that includes various factors affecting accessibility and usability of financial products and services. Most of the researchers have used just a few dimensions to measure the degree of financial inclusion. A few studies have created an index of financial inclusion using different financial dimensions and methodologies (Chakravarty and Pal 2013; Chattopadhyay 2011; Sarma 2015; Lenka and Bairwa 2016). We have considered only the part of financial inclusion which is addressed by ICT.

- *Theoretical Framework*

The paper has considered an explicit endogenous growth model developed by Barro (1990). Here in this particular model new variable have been introduced i.e., DFS variables and inclusive digitalisation indices. In Barro (1990) endogenous growth theory model level of technology has been considered along with k= private capital growth, l= population growth, d= general government expenditure to determine the change in technology and its effect on economic growth in long run. However present research replaces the level of technology in Barro model by DFS(as proxy of financial innovation) variables and inclusive digitalisation indices. Control variables in the research remains same as used in Barro (1990) framework. In order determine the degree of impact of financial innovation and inclusive digitalization on economic growth, the model can be written as y=f(k,l,d,h), where k= private capital growth, l= population growth, d= general government expenditure, $h_1(h_2)$= DFS variables or inclusive digitalization indices .

The panel data analysis is done for two major group of countries such as low & lower middle-income countries and high- and upper-income group of countries. The paper constructs a panel structure consisting of 121 countries over the time period 2011, 2014 and 2017.

In this framework, the panel estimation can be applied using a fixed-effects model (FEM) which incorporates individual-specific (time-invariant) effect (αi) and time-specific (individual-invariant) effect (δt):

$$y_{it} = \beta_{0+}\beta_1 X_{it} + \alpha_i + \delta_t + \epsilon_{it} \dots\dots (ii)$$

In Equation (ii), y_{it} represents endogenous variable for the i^{th} country at t^{th} period. β_0 is the intercept term and X_{it} is the matrix of exogenous variables. β_1 is the vector of associated parameters. $\alpha_i$is the individual-specific time-invariant effect, and δ_t is the time-specific individual invariant effect. $\epsilon_{i,t}$ is usual stochastic disturbance term following normal distribution with mean 0 and variance σ^2. The dependent variable for i^{th} country and t^{th} period is explained by a set of exogenous variables, some unobservable individual-specific (α_i) and time-specific (δ_t) factors.

The country specific effect $\alpha_i$may or may not be correlated with other explanatory variables. In a fixed effect model,α_i is correlated with other control variables whereas in a random effect model, α_i is stochastic. There are two tests used for appropriate model selection, Breusch-Pagan test and Hausman test, while the former helps in distinguishing between simple pooled regression and random effect model, the latter helps in distinguishing between fixed effect model and random effect model.

The linear estimable relationship is given by equation (i), for i^{th}contry in t^{th} period can be written as

Model 1:

$$y_{it} = \alpha_i + \beta_1 Private\ credit\ by\ deposit\ money\ banks\ and\ other\ financial\ institutions\ to\ GDP_{it} + \beta_2 General\ government\ final\ consumption\ expenditure\ growth_{it} + \beta_3 Population\ growth_{it} + \beta_4\ Debit\ card\ ownership\ (\%\ of\ total\ population)_{\ it} + \beta_5 Credit\ card\ ownership(\%\ of\ total\ population)_{it} + \beta_6 Made\ or\ received\ digital\ payments\ in\ the\ past\ year(\%\ of\ total\ population)_{it} + \varepsilon_{it} \quad \text{.....(i)}$$

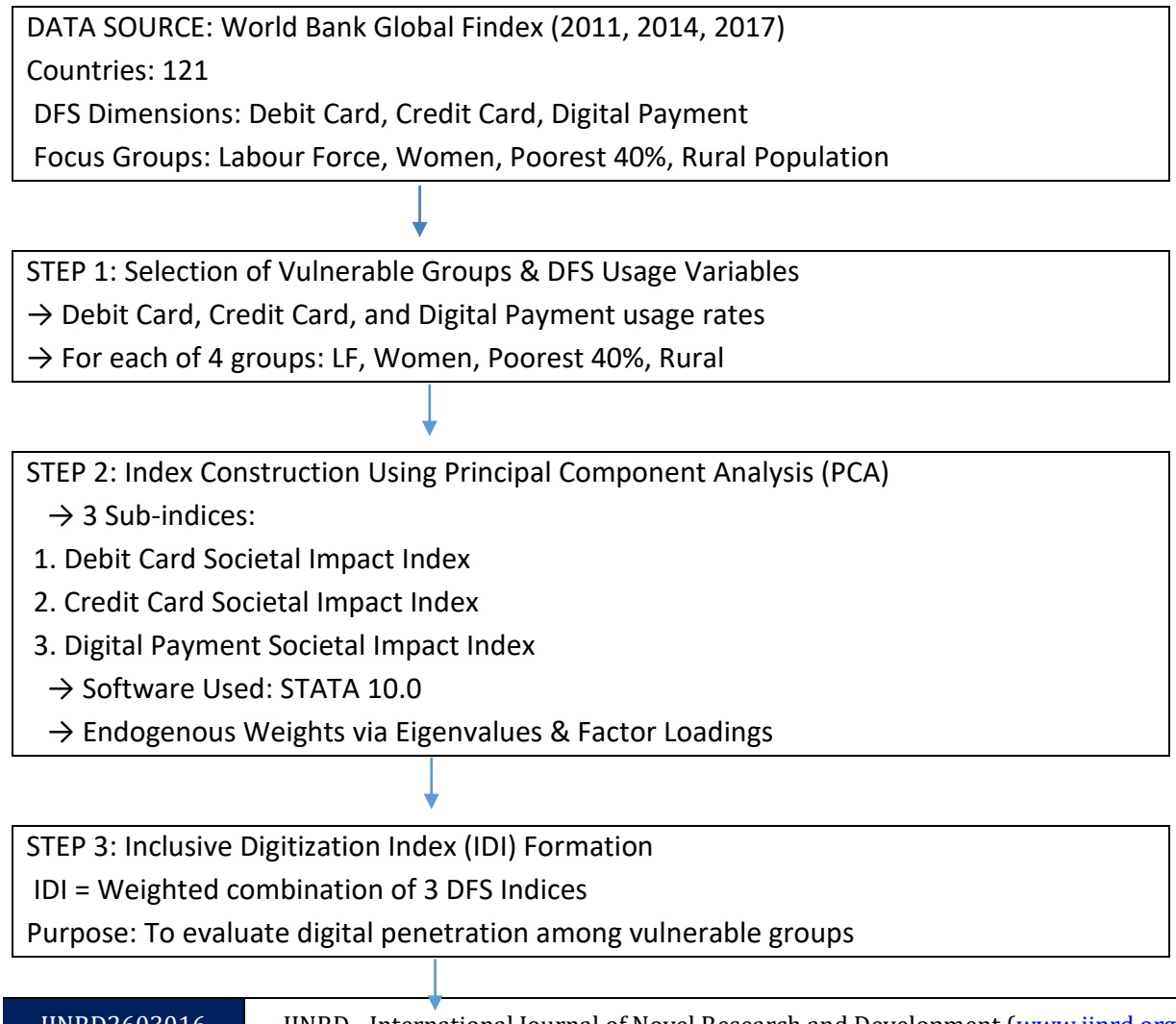
Model 2:

$$y_{it} = \alpha_i + \beta_1 Private\ credit\ by\ deposit\ money\ banks\ and\ other\ financial\ institutions\ to\ GDP_{it} + \beta_2 General\ government\ final\ consumption\ expenditure\ _{it} + \beta_3 Population\ growth_{it} + \beta_4 Debit\ Card\ societal\ impact\ index\ _{it} + \beta_5 Credit\ Card\ societal\ impact\ index_{it} + \beta_6 Digital\ Payment\ societal\ impact\ index_{it} + \varepsilon_{it} \quad \text{.....(ii)}$$

Countries (cross-sectional units) are indexed by *i*= 1,.....,121for the time period 2011, 2014 and 2017, indexed by *t*=2011,2014,2017.

Where y_{it} is a i^{th} country's growth rate of GDP per capita (Constant 2005 USD) indicator.β_1 toβ_6 denotes corresponding coefficients for the respective explanatory variables and moderating variables. ε_{it} is the random disturbance term. The DFS variables considered in model 1 are given use of DFS as proportion of total population where as in model 2 inclusive digitalisation indices are taken as explanatory variables. Thus, technology variables or main explanatory variables considered under model 1 and 2 are free from GDP. Therefore, the problem of reverse causality doesn't arise in the analysis.

Fig 5: Flow Chart



STEP 4: NORMALITY TEST ON VARIABLES
→ Large p-values (> 0.05) ; Normal Distribution Confirmed

↓

STEP 5: CLUSTER ANALYSIS ON IDI & DFS USAGE
→ Clustered across 11 countries into 4 groups
→ Based on mean values of inclusive DFS usage
→ Differentiation by income level (Low vs High Income)

↓

STEP 6: PANEL DATA ANALYSIS (FEM)
Dataset: 121 countries × 3 years (2011, 2014, 2017)
Two Models:
→ Model 1: Uses raw DFS ownership variables
→ Model 2: Uses constructed DFS indices (IDI components)
Controls: Private credit/GDP, Govt. expenditure, Population growth
Endogenous growth framework: Modified Barro (1990) Model

↓

STEP 7: MODEL SELECTION TESTS
→ Breusch-Pagan Test (Pooled vs RE)
→ Hausman Test (RE vs FE)
→ Final Estimation with Fixed Effects Model (FEM)

↓

FINAL OUTCOME: IMPACT OF INCLUSIVE DIGITIZATION
→ On GDP per capita growth across countries
→ Comparative analysis across income groups

V. Analysis and Findings:

Table1: Descriptive Statistics of Various Indicators of Inclusive Digitalization Index

Year	2011	2014	2017
Socio-index of debit-card			
Number of Observation	72	72	72
Mean	0.36	0.28	0.31
Std. Dev	0.21	0.13	0.13
Min	0.02	0.01	0.03
Max	0.74	0.5	0.5
Socio-index of Credit-card			
Number of Observation	72	72	72
Mean	0.17	0.13	0.14
Std. Dev	0.14	0.1	0.1
Min	0.01	0.01	0
Max	0.56	0.38	0.41
Socio-index of Digital Payment			

Number of Observation	72	72	72
Mean	0.37	0.29	0.5
Std. Dev	0.22	0.13	0.18
Min	0	0.01	0.012
Max	0.76	0.5	0.75

Source: Authors' calculation

Data Exploration & Inter-country comparison: The present section depicts the descriptive statistics of inclusive digitalisation indices to provide a comparative analysis of the importance of inclusive digitalisation variables among the vulnerable groups across 121 countries. Table 1 shows descriptive statistics of three indicators of inclusive digitalization: debit card societal impact scores, credit card societal impact score and digital payment impact score. In case of debit card and digital payments mean and standard deviation are rising over time. In case of credit card mean and standard deviation both are low over the years. This implies that use of credit card still very low across 121 countries. The reason may be the high interest charged on the use of credit cards which reduces its receptibility. However, use of digital payments is becoming emerging mode of transactions across the countries. Digital mode of transactions reduces cost and risk of handling cash, increases transparency and improves hassle-free mode of monetary transactions among vulnerable sections of the nations. In 2011 Use of debit card, credit card and digital payments were high in Netharlands, Israel, Sweden respectively where as they were low in Gabon, Algeria, Iraq respectively. In 2014 Netharland, Canada, Denmark showed high vales for debit card, credit card and digital payments respectively, however Iraq, Algeria and again Iraq showed the low values respectively. In 2017 high values prevailed for debit card, credit card and digital payment were Sweden, Canada, Denmark respectively and low prevailed in Iraq over the years.

The paper has considered use of debit cards, credit cards and digital payments as financial innovation variables. The present section depicts a comparative analysis of use of debit cards, credit cards as well as digital payment services across the nation.

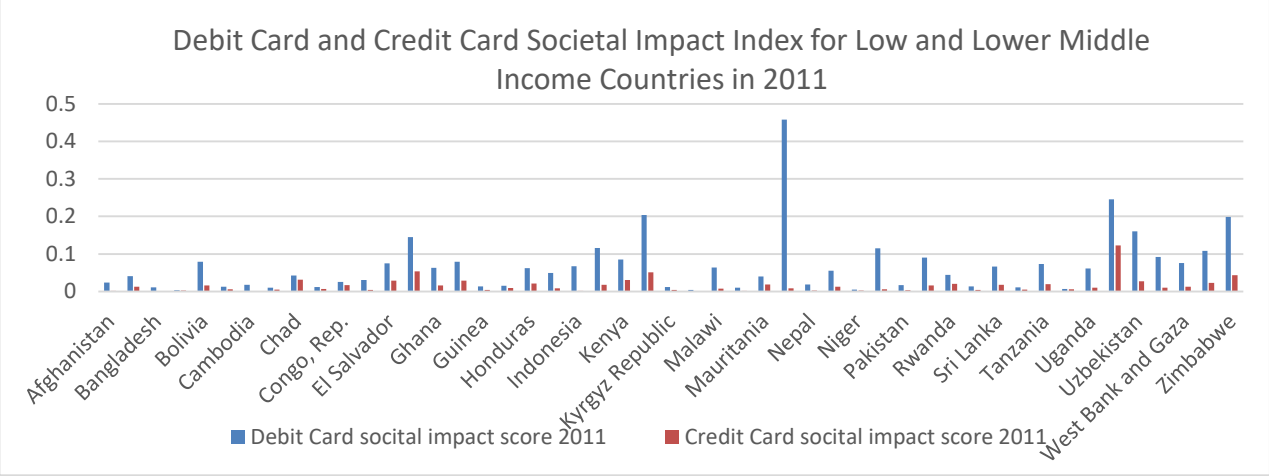


Fig 5: Debit Card and Credit Card Societal Impact Index for Low and Lower Middle Income Countries in 2011

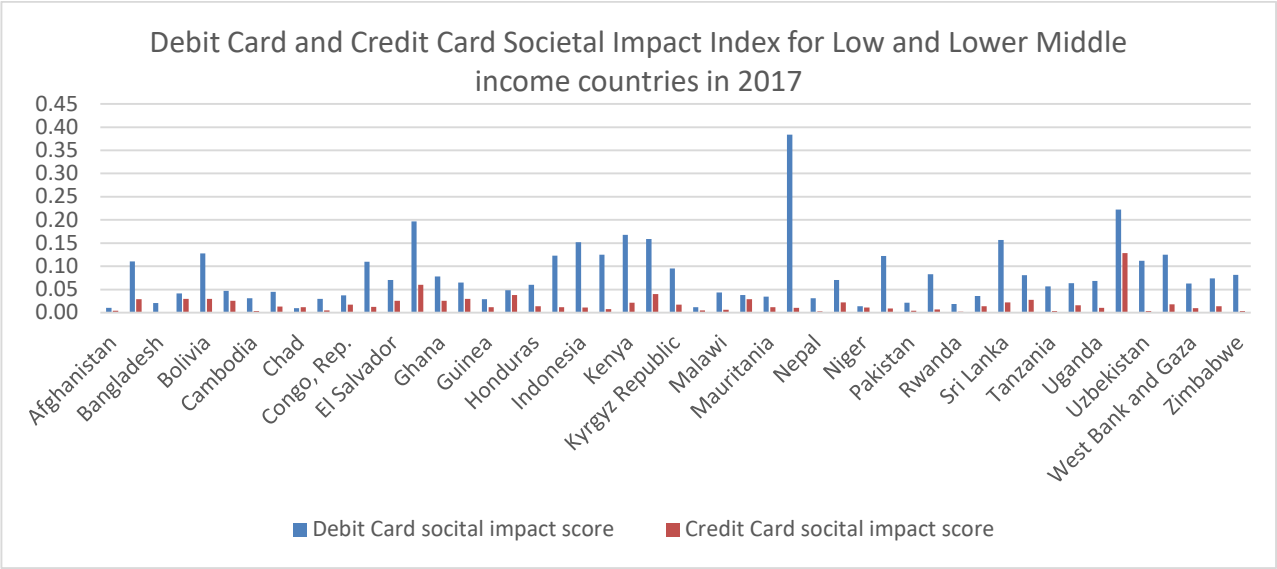


Fig 6: Debit Card and Credit Card Societal Impact Index for Low and Lower Middle Income Countries in 2017

Fig 5, 6, 7 & 8 shows a comparison between use of debit as well as credit cards among different sections (Labour class, poorest 40%, Women and rural section) of the society across the global countries. It is found from fig 5 & 6 that the use of debit cards has increased among the excluded sections across nations from 2011 to 2017 however, use of credit cards remains very insignificant among low and lower middle groups. Only less than 10 percent of the vulnerable sections of low and lower idle income countries nations are having credit card facilities. Mongolia shows the highest in terms of use of debits cards and Ukraine shows the lowest for credit cards both in 2011 & 2017.

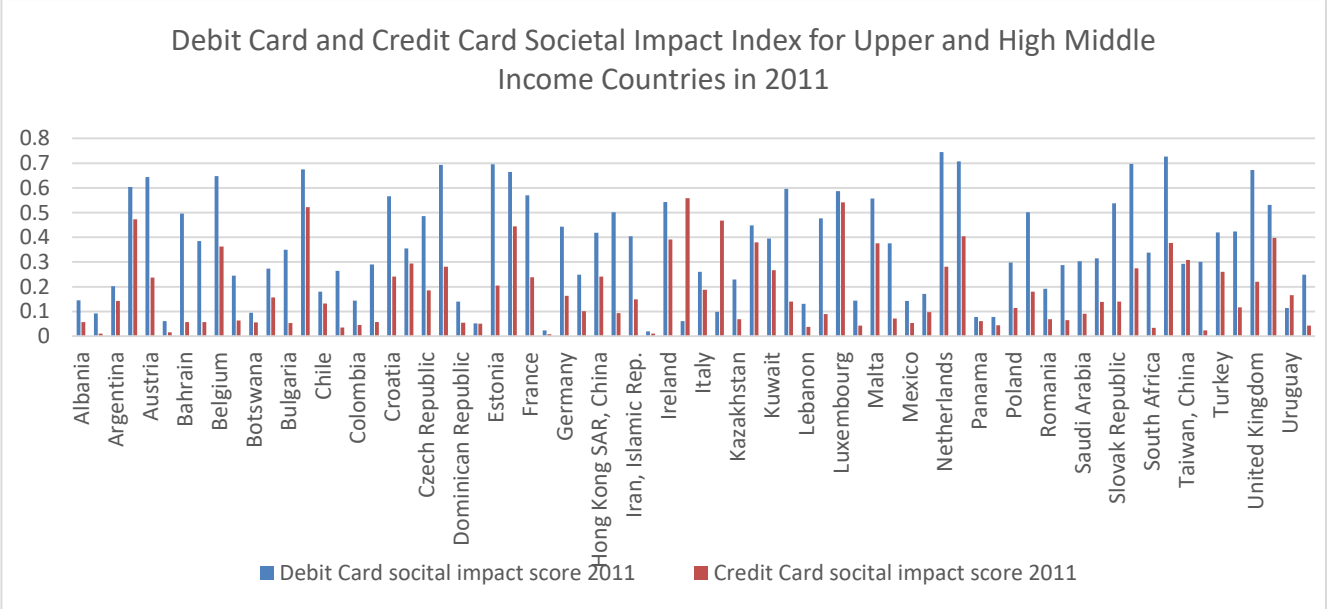


Fig 7: Debit Card and Credit Card Societal Impact Index for Upper and High Income Countries in 2011

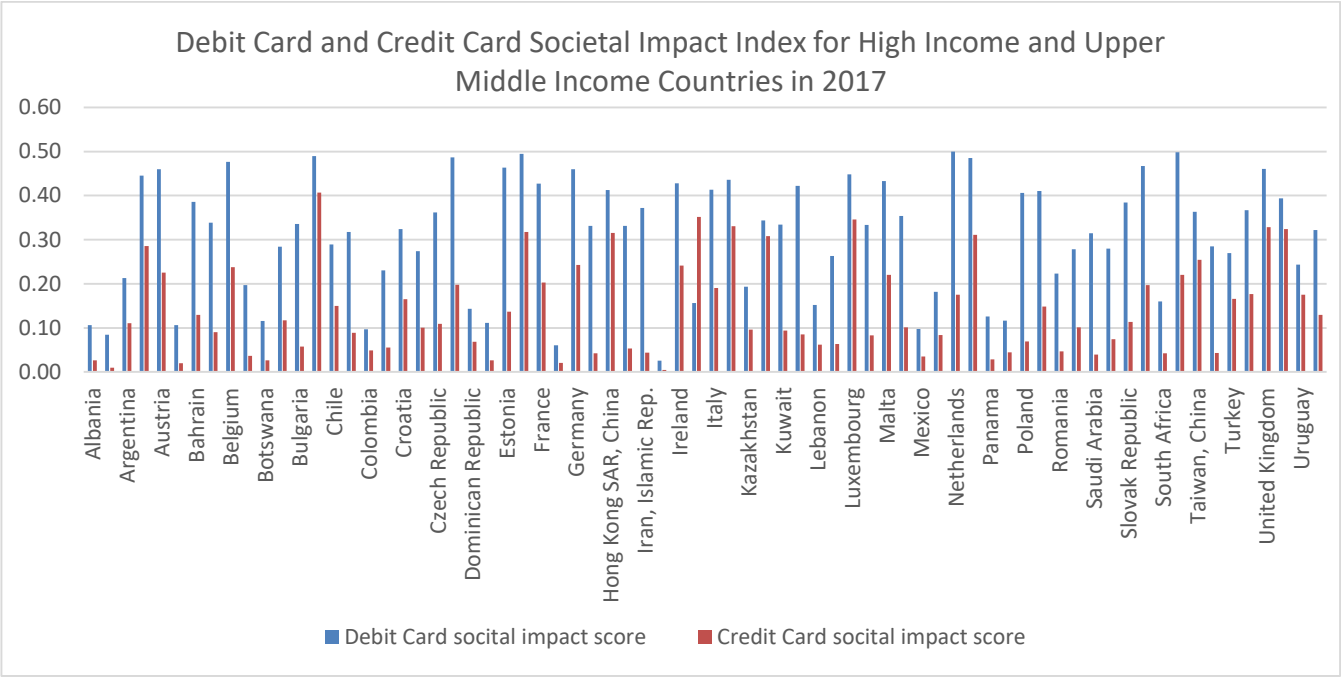


Fig 8: Debit Card and Credit Card Societal Impact Index for Upper and High Income Countries in 2011

From fig 7 & 8 it is seen that more or less 50% of population are having debit cards among the excluded sections across upper and high income groups. However, it is found that use of debit cards has decreased among the excluded sections of upper and high income groups like Australia, Austria, Bahrain, Belgium, Canada, Croatia, Denmark, Estonia and many more countries. That implies almost most of the population among high and upper income groups are included within formal financial system. Therefore, the percentage of use of cards has decreased from 2011 to 2017. Almost 20 percent of the excluded section of upper and high income group countries are using credit card facilities. It is true that over the time excluded sections across different income groups are gradually being include within formal financial system, however use of credit cards remains very low world-wide.

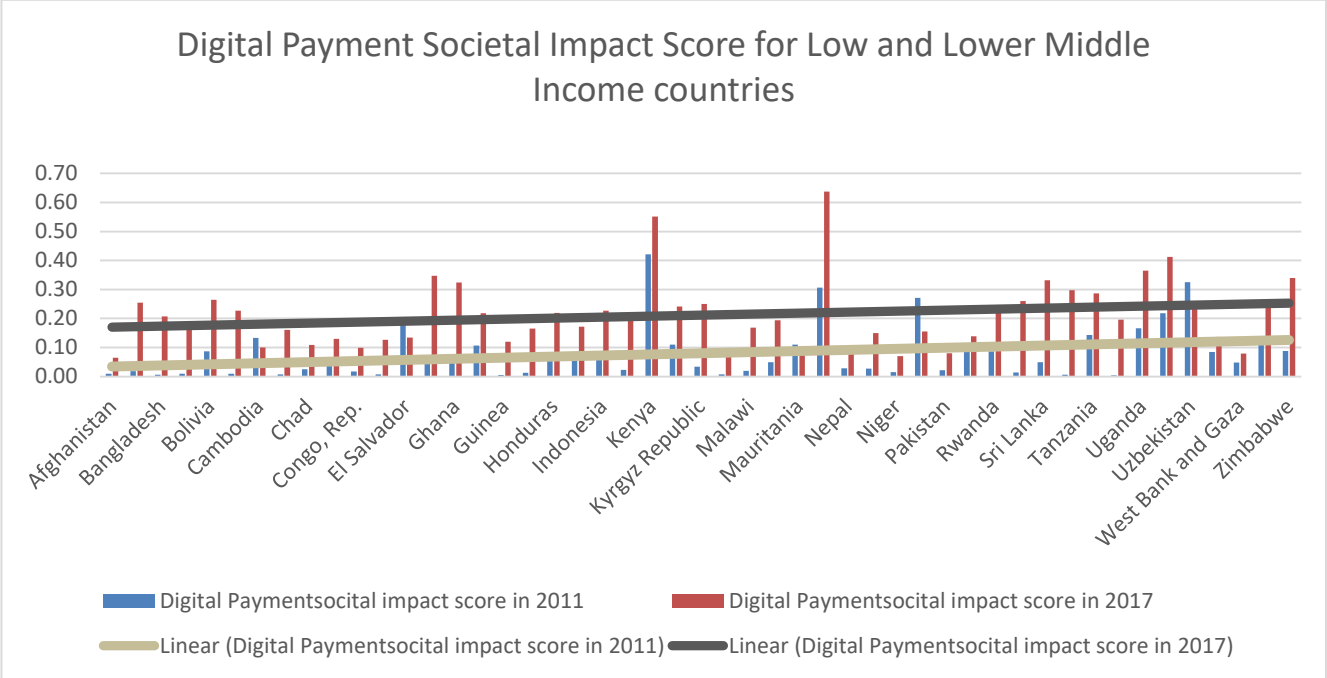


Fig 9: Digital Payment Societal Impact Score for Low and Lower Middle Income countries in 2011 and 2017

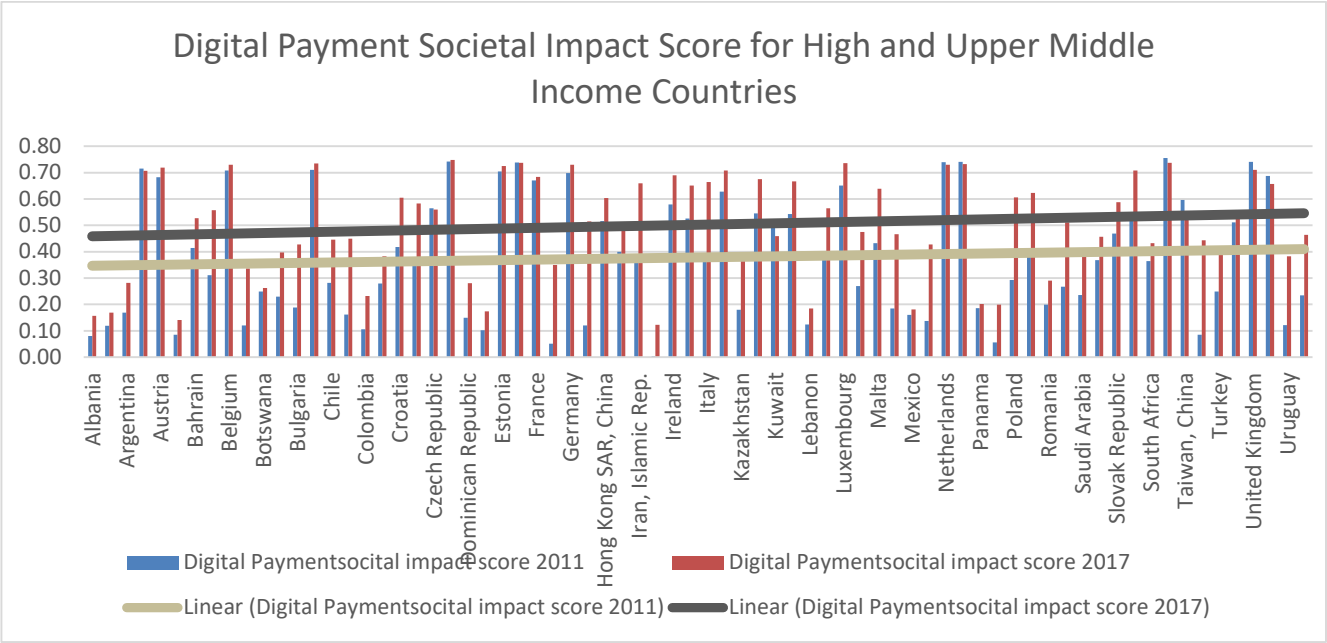


Fig 10: Digital Payment Societal Impact Score for High and Upper Middle Income countries in 2011 and 2017

Fig 9 and 10 represents a comparison between upper and low middle income countries. It is found that use of digital payment modes is gradually gaining importance over the time across the countries. Almost 60-70 percent population (which was 20-30 percent in 2011) from vulnerable section of high and upper groups are now using digital payment facilities, whereas it is still around 20-30 percent (which was below 10 percent in 2011) among low and lower middle groups in 2017. More than 60 percent population of financially excluded sections of Mongolia are now using digital payments in 2017 where as in 2011 Kenya was the player among low and lower middle group. Among upper and high income groups Sweden shows the highest value in 2011 whereas finally excluded sections of Canada shows the highest in 2017.

From graphical representations it can be concluded that digital payment scores show the highest values than debit and credit card scores, which definitely implies that digital payment modes are the most inclusive than debit and credit cards. Therefore, formal financial institutions especially banks should think over emphasizing digital payment services than any other modes for better financial inclusion.

Analysis- Stage I:

This section analyses the respective weights calculated while constructing inclusive digitalization index for debit card, credit cards and digital payment services. To know the relative importance of each explanatory DFS variables among the "vulnerable section" we have shown the weight structure, which is the percentage contribution of each variable to the sub-indices, from the loadings results in the principal component.

Table 2: Debit Card societal impact weights

	Debit Card societal impact weights			
Year	**Debit card ownership, in labour force**	**Debit card ownership, female**	**Debit card ownership, income, poorest 40%**	**Debit card ownership, rural**
2011	0.24642	0.25199	0.253289	0.005617
2014	0.00122	0.25015	0.000611	0.251649
2017	0.00166	0.25047	0.000751	0.250972

Table 3: Credit Card societal impact weights

	Credit Card societal impact weights			
Year	**Credit card ownership, in labour force**	**Credit card ownership, female**	**Credit card ownership, income, poorest 40%**	**Credit card ownership, rural**
2011	0.00263	0.24959	0.250684	0.250384
2014	0.00021	0.25149	0.000267	0.250185
2017	0.00095	0.25095	0.000377	0.250149

Table 4: Digital Payment societal impact weights

	Digital Payment societal impact weights			
Year	**Digital payments in the past year, in labour force**	**Digital payments in the past year, female**	**Digital payments in the past year, income, poorest 40%**	**Digital payments in the past year, rural**
2011	0.00381	0.25276	0.250763	0.247775
2014	0.00277	0.25059	0.000998	0.250995
2017	0.00164	0.24991	0.249611	0.251011

In order to calculate inclusive digitalization indices respective weights are tabulated and mentioned in Tables 2, 3 & 4. For each dimension-related sub-indices, PCA denotes linear combinations of the inclusive digitalization 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 explains more than 70 percent of the explanatory variables' total variation. In equation (i), explanatory variables are standardized so that standard deviation equals to 1 and mean equals to 0. The absolute loadings are taken from the first principal component.

The index score is defined as:

$$PC_{Score} = \sum_{i=1}^{n} w_i v_i$$

where PC_{Score} equals to the sum of all standardized explanatory variables, denoted by v, weighted by absolute loadings of each variable (w). 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 for the years 2011, 2014, 2017.

$$V_{normalized} = \frac{v - v_{min}}{v_{max} - v_{min}}$$

From the weight structure as provided in above tables, in the initial year 2011, penetration of debit card[10] was quite satisfactory among female population, labour class and poorest population of a nation. However, it is observed that uses of debit card are losing its importance day by day among labour class and poor section. Rural base of a nation remained untapped in this regard from the very beginning but as a whole debit card usage by the "vulnerable sections" rises over the years where as the use of credit cards doesn't gained

[10]As the data for digital payment services for 2011 is not available in World Bank Findex database so interpolation method is used to calculate the entire data set for the year 2011 as per the requirement of the data analysis.

popularity as debit cards among all sections. However, female population among others considers credit card as an important means of transactions. At the initial year of digitalization banks and financial intermediaries somehow tried to push the poorest and female customer base towards taking digital financial services by having a compulsory debit card and credit card at the time of opening up a bank account. The successful functioning of Microfinance institutions across the nations (mostly in low and lower middle-income countries) calls for women participation having a compulsory bank account in order to get loans. That may be the reason behind rising importance of digital financial services among female population across the nations over the year. However, the poorest sections (i.e., 40% of the population) are giving importance to the digital mode of payments over the years rather than the debit cards credit cards as the data shows in Table 2, 3 and 4.

Though the importance of digital payment services rises day by day among the poorest section of the society as it incorporates NEFT or RTGS data reveals that the policies and motive of popularising card facilities among the poor section are not adequate. According to Bansal (2014) financial illiteracy of the rural people is the main tool to overcome this situation. Though financial institutions like banks, microfinance organizations etc are providing their services in rural areas focusing on including them under formal financial system but education remains the main hindrance. Interestingly it should be worthwhile to mention that use of DFS shows a very slow penetration among the labour class people over the years. On other side use of debit and credit cards are low among the poorest sections over the years.

Analysis- Stage II:

Panel data analysis is done to evaluate the impact of overall digital finance and inclusive digitalization on economic growth of a nation in a multiple regression framework for two major group of countries such as low & lower middle-income countries and high and upper-income group of countries. The following Table 5 analyses the impact of DFS on per capita income growth of a nation.

Table 5: Impact of DFS on per capita income growth of a nation

Dependent variable	**High and upper middle income[11]**		**low and lower middle income[12]**	
Growth rate GDP per capita (Constant 2005 USD)	Coefficient	Probability	Coefficient	Probability
Private credit by deposit money banks and other financial institutions to GDP	-0.011676	0.007	-0.0568908	0.362
General government final consumption expenditure	0.2373451	0.000	0.0782877	0.000
Population growth	-0.9600066	0.000	-1.343059	0.000
Total Debit card ownership	-0.2305251	0.868	**6.309**	**0.026**

[11] In case of High and upper middle-income countries, breusch-pagan test (Prob> chi2 = 0.2050) confirms that simple pooled regression model is appropriate for this analysis.

[12] In case of low and lower middle income, breusch-pagan test (Prob> chi2 = 0.3102) confirms that simple pooled regression model is appropriate for this analysis.

Total Credit card ownership	0.9979683	0.485	**-22.35476**	**0.001**
Total digital payments in the past year	0.9499142	0.574	-0.1032993	0.959
R square	0.2424		0.3419	

- ***Model 1: Impact of DFS on per capita income growth of a nation***

Result presented in Table 5 for Model 1 shows that total use of DFS i.e., use of debit cards, credit cards and digital payments in high and upper middle-income countries does not have any significant impact on per capita income growth, whereas in case of low and lower middle-income countries, use of debit cards shows a positive significant association and use of credit cards has a negative significance on economic growth. That means, promoting debit card is quite beneficial in terms of per capita income growth in low and lower middle-income countries. Technology is lowering costs by maximizing economies of scale. Use of debit card increases the speed, security and transparency of transactions for low and middle-income group of countries. Governments in emerging economies could collectively save at least $110 billion annually as digital payments reduce leakage in public expenditure and tax revenue (as reported by McKinsey Global Institute analysis). However according to some researchers (Bridges and Disney 2010; Norvilitis, Szablicki and Wilson 2003) in low and lower middle income countries because of too much debt and high interest charges due to the use of credit cards reduces the purchasing power of the people that in turn leads to a negative impact on per capita income growth. Consumer spending drives our economy forward, and when people are using their credit cards, the economy isn't growing because debt is significantly associated with depression and reduces well-being of the society. Not only for low and middle-income economies, it must be remembered that one of the most notable factors leading up to the financial crisis of 2008 was the effect of credit card overuse and that was the preconditions for Eurozone crisis or European debt crisis in 2009. Now apart from these here in this particular framework it is seen that Private credit by deposit money banks and other financial institutions to GDP is negatively related with per capita growth rate for high and upper middle-income countries. Empirical evidences shows that Private credit by deposit money banks and other financial institutions to GDP —the measure of financial depth most often used in the literature—is an ambiguous and imprecise measure of overall financial development and has inconsistent association with economic growth. Beck and colleagues (2000, 2006), Levine and colleagues (2000) and some others showed in their studies that financial development varies positively with countries' level of economic development and helps reduce poverty and inequality (Demirguc-Kunt and Levine, 2011). Aghion and co-authors (2005), Mastenandco-authors (2008) suggest that financial depth can help accelerate income convergence, but may have no effect on long-run growth. Loayza and Ranciere (2006) and Ranciere& colleagues (2008) suggest that the effect of financial deepening could be negative in the short-run due to its pro-cyclicality, at times resulting in crises, but remains positive in the long run. Growth of general govt final consumption expenditure is positively related with economic growth of both income categories of countries (High and upper middle income and low and lower middle income). Government expenditure stimulates aggregate demand of nations hence raises per capita income irrespective of income categories. It is found in many research (Ahituv, A. 2001; Kelley, A.C. 1985; Musambachime, M. 1990 etc) that decline in population growth improves economic growth over the last two decades. This trend is persistent because of the world-wide decline in fertility, increase in life expectancy, and improvements in universal education over the last three decades. Hence it is obvious that population growth always will be negative contributor on per capita income growth irrespective of income categories of countries (High and upper middle income and low and lower middle income).

The following section (Table 6) analyses the impact of inclusive digitalization on per capita income growth for both income groups.

Table 6: Impact of inclusive digitalization on economic growth

Dependent variable	**High and upper middle income[13]**		**low and lower middle income[14]**	
Growth rate GDP per capita (Constant 2005 USD)	Coefficient	Probability	Coefficient	Probability
Private credit by deposit money banks and other financial institutions to GDP	-.0120906	0.003	-.0170678	0.203
General government final consumption expenditure	.2582669	0.000	.071932	0.000
Population growth	-.9556842	0.000	-1.306075	0.000
Debit card societal impact index	-.2283297	0.893	**14.26896**	**0.001**
Total Credit card societal impact index	1.030491	0.625	**-44.53243**	**0.000**
Total digital payments in the past year	1.672389	0.254	.2127623	0.929
R square	0.2424		0.3419	

- ***Model 2: Impact of inclusive digitalization on economic growth***

The results in this model 2 show similar results as in Model 1. The use of DFS among different social groups (that represents vulnerable section of the society) which are taken to construct debit card societal impact index, credit card societal impact index and digital payments societal impact index does not have any significant on the economic growth in high and upper middle group of countries. However, Debit card societal impact index has a significant positive impact on per capita GDP growth of low and lower middle-income group countries where as credit cards societal impact index has a significant negative impact on per capita GDP growth for low and lower middle-income group of countries. The reason is already discussed under model 1 that indicates the problem of increased debt among social the social groups due to not payment of the credit amounts. In graphical representation we have come across certain facts that digital payment modes in recent years i.e., in 2017 are mostly accepted modes across the vulnerable sections than debit cards and credit cards, however the impact on economic growth remains insignificant. If we consider lag impact on economic growth, then there may be a different result for digital payments. Later we will definitely extend the present analysis by incorporating latest data as well as lag impacts. Apart from this among other control variable Private credit by deposit money banks and other financial institutions to GDP has a negative significance for high and upper middle group of countries, General government final consumption expenditure has positive significance for both group of countries and population growth has a negative significance for both group of countries on per capita GDP growth (as discussed in previous result section). It is quite obvious that the magnitude of

[13] In case of High and upper middle-income countries, breusch-pagan test (Prob> chi2 = 0.1680) confirms that simple pooled regression model is appropriate for this analysis.
[14] In case of low and lower middle income, breusch-pagan test (Prob> chi2 = 0.9062) confirms that simple pooled regression model is appropriate for this analysis.

association among other control variable with the dependent variable must be same because both the framework is using same model (Barro, 1990) but the magnitude of debit card in societal context is higher compared to the overall count of debit card. That implies not only the significance of debit card but also point out the importance of inclusiveness of the same among the vulnerable section of the society.

VI. Conclusion and policy implications:

Economic development is usually a long journey, but there is no doubt that digital finance can speed up the movement.

Digitizing the finance has multiplier effect on economic growth for many countries but without the inclusion it will lose the degree of impact on economic growth. Reports studied for different countries shows a strong correlation between financial inclusion and DFS especially for the use of debit card transactions.

This study examines the effect of adopting digital payments on economy of a country and also explores the scope of "digitalization for all" concept. The result put together gives us an important policy direction towards what can enable the country to increase cashless payments.

The results indicate that the deployment of technology for digital payments has positive effect on economic growth of a country. The study gives emphasis to the inclusion of DFS for getting maximum benefit of technology. Government should take effective measures in creating awareness and also making suitable policy of card less payment among all the vulnerable section of the society. The study also fortified with an interesting finding, an essential input for policy makers in this regard, is the positive impact of debit card transactions and a huge negative impact of credit card transactions on per capita growth of GDP in low and lower middle-income group of countries. Knowing this, policymakers, in close coordination with merchants, can encourage widespread use of debit card mode of transactions rather than promoting credit cards in low and lower middle-income countries. It is also true that after reaching a threshold level of digital payments services, it does not have any significant impact on economic growth of countries (as found here for high and upper middle-income countries). Use of debit card is increasing the speed, security and transparency of transactions for people with low incomes hence easy to handle for labour class, female population, poorest section and rural population. Moreover, it is justified to say that impact of using debit cards increases as the penetration rises. It also satisfies the financial inclusion objectives that is enabling the unbanked vulnerable sections or financially excluded sections i.e., rural, labour class female and poorest sections into the formal banking system. However, use of credit cards may put the customers in an obligation to pay financial intermediaries or banks out of their future earnings. It involves costly interest charges which may hurt low and lower middle-income group of countries badly. Use of credit cards does not get such momentum over the period of time hence the study showing a negative impact on GDP growth for low and lower middle-income group of nations. Undoubtedly, consumers' ability to finance new purchases can help the economy as a whole, but this effect has its limitations. If the cardholders need to incur too much debt, they will end up having less spending ability, which can hurt the economy specifically to the vulnerable sections or financially excluded sections of low and lower middle-income countries but doesn't have significant impact on economic growth for high and upper middle-income groups.

VII. Limitation and Scope of Future Study:

This study, while comprehensive, has certain limitations. Firstly, the construction of the Inclusive Digitization Index relies solely on data from the World Bank Global Findex Database, which is available only for the years 2011, 2014, and 2017. This limits the temporal continuity and may not capture recent developments in digital financial inclusion. Secondly, the study focuses only on four vulnerable groups—labour force, women, poorest 40%, and rural population—excluding other marginalized segments such as the elderly, differently-abled, and informal sector workers. Additionally, while PCA is a robust method, it is sensitive to input selection and standardization, potentially affecting the index outcome.

The scope for future research includes extending the dataset to include more recent years and additional waves of Findex data as they become available. Researchers could also explore non-parametric techniques or machine learning models to capture non-linear relationships between digital finance and inclusion. Further studies could incorporate country-specific policy variables, digital literacy, infrastructure readiness, and trust in financial institutions to enhance index robustness. Additionally, micro-level (household or regional) analysis may provide deeper insights into how digital financial services impact economic outcomes at the grassroots level. Cross-sectoral analysis linking health, education, and digitization may also enrich future investigations.

Statements and Declarations

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Competing Interests
The authors declare that there are no competing interests in publishing this manuscript

Availability of data and materials
The data set have been extracted from Reserve Bank of India database.

Code availability
STATA10

Author's Contributions
The co-authors made a significant contribution at all stages of the research process and in preparation of the manuscript.

Availability of data and materials:
FINDEX (Financial Development Index) database
World Bank Database

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Appendices:

Appendix 1

Table A 1: Dependent Variable

Growth rate GDP per capita	Annual percentage growth rate of GDP per Capita based on constant local currency. Aggregates are based on constant 2010 U.S dollar. GDP per capita is gross domestic product divided by midyear population

Table A 2: List of Independent Variable

Total Debit card ownership	The percentage of respondents who report having a debit card
Credit card ownership	The percentage of respondents who report having a Credit card
Made or received digital payments in the past year	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills, sending or receiving remittances, receiving payments for agricultural products, receiving government transfers, receiving wages, or receiving a public sector pension directly from or into a

	financial institution account or through a mobile money account in the past 12 months
Debit card ownership, in labor force	The percentage of respondents who report having a debit card, in labor force
Debit card ownership, female	The percentage of respondents who report having a debit card, female
Debit card ownership, income, poorest 40%	The percentage of respondents who report having a debit card, income, poorest 40%
Debit card ownership, rural	The percentage of respondents who report having a debit card, rural
Credit card ownership, in labor force	The percentage of respondents who report borrowing any money using a credit card, in the past 12 months, in labor force
Credit card ownership, female	The percentage of respondents who report borrowing any money from using a credit card, in the past 12 months, female .
Credit card ownership, , income, poorest 40%	The percentage of respondents who report borrowing any money using a credit card, in the past 12 months, income,
Credit card ownership, rural	The percentage of respondents who report borrowing any money using a credit card, in the past 12 months, rural
Made or received digital payments in the past year, in labor force	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills, sending or receiving remittances, receiving payments for agricultural products, receiving government transfers, receiving wages, or receiving a public sector pension directly from or into a financial institution account or through a mobile money account in the past 12 months, in labourforce.
Made or received digital payments in the past year, female	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills, sending or receiving remittances, receiving payments for agricultural products, receiving government transfers, receiving wages, or receiving a public sector pension directly from or into a financial institution account or through a

	mobile money account in the past 12 months, female .
Made or received digital payments in the past year, income, poorest 40%	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills, sending or receiving remittances, receiving payments for agricultural products, receiving government transfers, receiving wages, or receiving a public sector pension directly from or into a financial institution account or through a mobile money account in the past 12 months, income, poorest 40% .
Made or received digital payments in the past year, rural	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills, sending or receiving remittances, receiving payments for agricultural products, receiving government transfers, receiving wages, or receiving a public sector pension directly from or into a financial institution account or through a mobile money account in the past 12 months, rural

Table A 3: List of Control variables

Private credit by deposit money banks and other financial institutions to GDP.	Claims on the private sector by deposit money banks and other financial institutions divided by GDP
General government final consumption expenditure	Annual percentage growth of general government final consumption expenditure based on constant local currency. Aggregates are based on constant 2010 U.S dollars. General government final consumption expenditure (general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation.
Population growth	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t,

	expressed as a percentage population is based on the de facto definition of population, which counts all residents regarding of legal status or citizenship.