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The FinTech-driven Approach to Financial Inclusion

A cross-sectional study of how Financial Inclusion furthers Sustainable Development in Sub-Saharan Africa

by

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Abstract

The UN 2030 agenda for sustainable development acknowledges the essential role of financial inclusion in achieving the Sustainable Development Goals (SDGs) and reducing inequality. African countries have made substantial progress in economic development and financial inclusion over the last two decades, yet there is still considerable need for further development. Financial Technology (FinTech) is a powerful force influencing the structure of financial services in Sub-Saharan Africa (SSA). Fintech is seen as a critical enabler of financial inclusion and viewed as a potential opportunity to deliver financial services to the millions of unbanked across the SSA region. This paper explores the relationship between fintech, financial inclusion, economic growth and income inequality for a panel of 16 SSA countries using data from the Financial Access Survey, the Global Findex database and the World Development Indicators for 2014 and 2017. This study introduces three new indices of financial inclusion for 16 SSA. The indices are used to assess the impact of fintech-driven financial inclusion on economic growth and income inequality. The results provide evidence that fintech-driven financial inclusion is significantly positively related with economic growth and that fintech-driven financial inclusion reduces income inequality.

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Glossary

ATM	Automated teller machine
CFI	Comprehensive Financial Inclusion
CV	Coefficient of Variation
FAS	Financial Access Survey
FDI	Foreign Direct Investment
FFI	Fintech-driven Financial Inclusion
Fintech	Financial Technology
GDP	Gross Domestic Product
IFI	Index of Financial Inclusion
IMF	International Monetary Fund
OLS	Ordinary Least Square
PCA	Principal Component Analysis
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
SWIID	Standardized World Income Inequality Database
TFI	Traditional Financial Inclusion
UN	United Nations
WB	World Bank
WDI	World Development Indicators
WGI	World Governance Indicators

1   Introduction

Over the last two decades, there has been a growing momentum and interest in the subject of access to financial systems. Policymakers, economists, and governments worldwide agree that financial inclusion plays a critical role in reducing poverty and creating opportunities for economic growth (Allen, Demirgüç-Kunt, Klapper, & Peria, 2012; Beck, Demirgüç-Kunt, & Levine, 2007; Demirgüç-Kunt & Klapper, 2012a; Sahay, Čihák, N'Diaye, Barajas, Mitra, Kyobe, Mooi & Yousefi, 2015). For instance, the UN 2030 agenda for sustainable development acknowledges the essential role of financial Inclusion in successfully implementing the Sustainable Development Goals (SDGs) and reducing inequality (SDG10) (Demir, Pesqué-Cela, Yener Altunbas & Murinde, 2020). Simply put, financial inclusion refers to a person's access to a bank account, savings, borrowing and payment services. According to the World Bank (2018), great strides have been made in recent years towards financial inclusion, and 1.2 billion adults have gotten access to accounts since 2011. However, 1.7 billion adults are still unbanked, and most of them are poor rural households (World Bank, 2018). Moreover, nearly all of the unbanked adults live in the developing world and women are overrepresented where 56 per cent of all unbanked adults are women (Demirgüç-Kunt, Klapper, Singer, Ansar, & Hess, 2018).

African countries have made a considerable progress in financial development and financial inclusion over the last two decades, yet there is still considerable need for further development. East African countries have led the world in innovative financial services based on mobile technology, which has helped to include large shares of the unbanked populations into the financials system (Mlachila, Montfort, Jidoud, Newiak, Radzewicz-Bak & Takebe, 2016). Recent data from the Global Findex Database (2018) show that 21 per cent of adults in Sub-Saharan Africa (SSA) have a mobile money account. Mobile money accounts are predominantly widespread in Kenya, where 73 per cent of adults have one and in Uganda and Zimbabwe, where about 50 per cent of adults have one, see figure 3 (Demirgüç-Kunt et al. 2018). Consequently, Financial Technology (FinTech) is a powerful force influencing the structure of financial services in SSA. Fintech is seen as a critical enabler of financial inclusion and viewed as a potential opportunity to deliver financial services to the millions of unbanked across the SSA region (Sy, Maino, Massara, Saiz & Sharma, 2019).

Although researchers have recognised the importance of fintech for financial inclusion, there is limited research that draws on financial theory to investigate how fintech can reduce financial exclusion and meet sustainable development (see Arner, Buckley, Zetzsche & Veidt, 2020; Demir et al. 2020; Sahay, von Allmen, Lahreche, Khera, Ogawa, Bazarbash, & Beaton, 2020; Sy et al. 2019). Whilst a large part of the literature has focused on how to measure financial inclusion (Amidžić, Massara, & Mialou, 2014; Camara & Tuesta, 2017; Honohan, 2008; Sarma, 2008; 2012; 2015; 2016; Wang & Guan, 2017), few studies have examined the

relationship between digital financial inclusion and economic growth in SSA (Anarfo, Abor, Osei & Gyeke-Dako, 2019; Demirgüç-Kunt & Klapper, 2012b; Nan, 2019) or the role of digital financial inclusion in reducing income inequality (Asongu, 2015; Asongu & Le Roux, 2017; Tita & Aziakpono, 2017).

This paper explores the relationship between fintech, financial inclusion, economic growth, and income inequality; drawing on previous studies from the three strands of literature mentioned above. First, by discussing 'how to measure financial inclusion' literature, this paper introduces three financial inclusion measures: one index to measure traditional financial inclusion, one to measure fintech-driven financial inclusion and one measure that covers indicators for both sectors (comprehensive financial inclusion). The construction of two indices, one digital and one traditional, allows for comparison and quantifies the difference in progress across the 16 SSA countries in the study. The second strand of literature relates to the relationship between financial inclusion and economic growth. Thus, this paper attempts to assess whether increased financial inclusion is associated with higher economic growth. The third and final strand of literature estimates the link between financial inclusion and income inequality. Correspondingly to the assessment on economic growth, the two indices are used to determine whether financial inclusion reduces income inequality and whether there is a difference between traditional and digital financial inclusion in the 16 SSA countries studied. The terms fintech and digital financial inclusion are used interchangeably throughout the paper.

1.1 Research Problem

The financial sector in SSA countries have been described as underdeveloped, risk-averse, vastly concentrated in urban areas, and skewed against the poor and women (Kuada, 2019). Additionally, regional inequality is an issue; as countries develop and becomes more economically integrated and industrialised, the distribution of economic activity becomes more unequal (Enflo & Rosés, 2015). Furthermore, the traditional banking sector has been unable (or unwilling) to tap into the large unbanked segments of populations across SSA, leaving them excluded without access to standard financial services. Financial inclusion is seen as a critical tool to enhance poor households capacity to absorb economic shocks, accumulate assets and invest in human capital, health, education and take advantage of investment opportunities in the economy (Beck, Demirgüç-Kunt, & Honohan, 2009). Hence, countries with higher financial inclusion can better stimulate growth and achieve poverty reduction than countries with weak financial systems and low financial inclusion. Yet, much of the evidence of a positive relationship between financial inclusion and economic growth lies within the individual and micro level, whilst there is less research on the relationship between financial inclusion and macroeconomic growth (Makina & Walle, 2019).

Additionally, the measures of financial inclusion have been imperfect. Until recently, very little data existed on the demand-side indicators of financial inclusion; consequently, previous studies have been biased, only looking at supply-side indicators (see Honohan, 2008; Amidžić, Massara, & Mialou, 2014). Hence, to accurately measure financial inclusion and the potential

effect it may have on economic growth and income inequality, a holistic measure that considers both the supply and demand side of financial inclusion is needed. If governments and policymakers globally put financial inclusion forward as the enabler of sustainable development and poverty eradication, the critical determinants of financial inclusion in SSA need to be assessed and understood.

1.2   Aim, Scope and Research Questions

The purpose of this study is to empirically assess whether fintech-driven financial inclusion leads to higher economic growth and less income inequality in SSA by a sample of a set of 16 countries[1].

The first part of the empirical assessment will be to construct three indices of financial inclusion in the 16 SSA countries. The second part of the analysis will assess the relationship between the dependent variable of economic growth, expressed as annual GDP growth, with the independent variables of fintech-driven financial inclusion (FFI) and traditional financial inclusion (TFI). The third part of the study will assess the relationship between the dependent variable of income inequality, expresses as the GINI index, with the independent variables of FFI and TFI. The control variables for both the economic growth and income inequality models will include variables characterised by the socio-economic conditions in the countries. This study seeks to answer the following questions:

1. What effects does fintech-driven financial inclusion have on economic growth in SSA between 2014 and 2017?

2. Does fintech-driven financial inclusion lead to higher economic growth than traditional financial inclusion in SSA countries between 2014 and 2017?

3. What effects does fintech-driven financial inclusion have on income inequality in the SSA countries between 2014 and 2017?

The three-hypothesis related to the research questions:

H1. Fintech-driven financial inclusion leads to positive impacts on economic growth in the SSA countries.

H2. Overall, fintech-driven financial inclusion leads to higher economic growth than traditional financial inclusion in SSA countries.

H3. Fintech-driven financial inclusion leads to less income inequality in SSA countries.

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[1] Benin, Botswana, Cameroon, Republic of Congo, Côte d'Ivoire, Ghana, Kenya, Namibia, Nigeria, Rwanda, Senegal, South Africa, Togo, Uganda, Zambia, Zimbabwe

1.3   Contribution

Although there is increasing research on the association between financial inclusion, economic growth and inequality, the literature still lacks a standard measure of financial inclusion. Despite the recent advances in providing measures for financial inclusion (see Camara & Tuesta, 2017; Sarma, 2015; Wang & Guan, 2017), the state of financial inclusion is constantly in flux. Hence, newly captured data assists in depicting the current state of financial inclusion. This may be more plausible in SSA than in many other regions globally, as the available data can be inferior and lacking. This paper will make four main contributions.

First, to the best of my knowledge, this is the first paper to construct three separate financial indices to provide evidence of a link between fintech-driven financial inclusion, economic growth and income inequality in the SSA region. The separate indices permit a distinctive comparison of the traditional contra fintech-driven determinants of financial inclusion, providing a nuanced picture of the most effective channels and instruments. Other financial inclusion measures (see Amidžić, Massara, & Mialou, 2014; Sarma, 2015; Wang & Guan, 2017) tend to only look at traditional financial inclusion indicators such as account ownership and access to automated teller machines (ATMs) or bank branches. A few studies on measuring financial inclusion includes measures of digital financial inclusion such as data on mobile and internet banking (Camara & Tuesta, 2017). Nevertheless, the digital financial inclusion indicators in Camara & Tuesta's (2017) study are combined with traditional indicators creating one index; thus, a comparison of traditional vis-à-vis fintech-driven financial inclusion is not possible.

Second, this study utilises the most recent data available from the IMF and the World Bank to calculate the index of financial inclusion (IFI) for both 2014 and 2017. The use of both traditional and digital indicators provides a more dynamic view of the workings of the financial system in SSA, illustrating that the financial inclusion indices are not consistent across the across country and time (see table 3). Moreover, the most recent data on financial inclusion captures the current role innovative fintech-driven financial services have played in the SSA region.

Third, the relationship between financial inclusion, economic growth and inequality is not yet well understood is because of lack of data availability (Demirgüç-Kunt, Klapper, & Singer, 2017). Until very recently, previous empirical studies examining financial inclusion, economic growth and inequality have mainly used supply-side data. Unlike these previous studies, I also use demand-side data; using both supply-side and demand-side data, I attempt to provide a more holistic and correct view of financial inclusion and how it affects economic growth and income inequality.

Finally, this paper analyses the role of fintech across the SSA region, where most previous studies have focused on East Africa. Additionally, this paper demonstrates that fintech rather than traditional financial tools may be more helpful in accelerating sustainable development in SSA countries.

1.4   Delimitations and Limitations

An initial sample of 46 SSA countries was analysed across 16 financial inclusion indicators. The final sample of 16 SSA countries was selected since the established parameter included countries with data across all of the 16 indicators for the years 2014 and 2017. Two exceptions were made for Kenya and South Africa, where data for one access indicator in 2017 was missing.

The major limitation of this study was missing data across the various indicators. There are several approaches to handlining missing data, which is discussed in more detail in section 4.3.3. Nonetheless, the missing data in South Africa and Kenya, was handled by following Svirydzenka's (2016) method and setting the values equal to the latest observation in 2014.

1.5   Outline of the Thesis

The rest of the paper is organised as follows. In chapter 2, the theoretical framework of financial inclusion and theoretical methods for constructing indices are discussed. In chapter 3, the relevant literature on fintech, financial inclusion and income inequality is reviewed. Chapter 4 describes the methodology and data used. In chapter 5, the results of the study are presented. Moreover, in chapter 5, the results are discussed, and policy implications are drawn. Finally, chapter 6 concludes the study.

2   Theoretical Framework

This chapter presents several concepts of financial inclusion and how it is measured. Section 2.1 summarises the definitions of financial inclusion, and section 2.2 covers the existing literature discussing the theoretical underpinning of how to measure financial inclusion.

2.1   What is Financial Inclusion?

Recently, a large body of literature has developed to assess the impact of financial inclusion on poverty reduction and sustainable economic development. Several studies define the concept in terms of financial exclusion, yet, financial inclusion and exclusion are two sides of the same coin explaining the broader context of social inclusion. Leyshon and Thrift (1996) discuss processes of financial exclusion, which disproportionately impact the more impoverished and more underprivileged segments of society. Other authors (Carbó, Gardener & Molyneux, 2005; Panigyrakis, Theodoridis & Veloutsou, 2002; Sinclair, 2001) discuss different dimensions of financial exclusion such as problems with access, price, conditions marketing and self-exclusion. Conversely, authors such as Demirgüç-Kunt, Klapper and Singer (2017) and Sarma (2008; 2012; 2015) directly discuss financial inclusion rather than exclusion. A range of studies has demonstrated that a lack of access to finance can lead to poverty and income inequality (Agyemang-Badu, Agyei & Duah, 2018; Beck, Demirgüç-Kunt & Levine, 2007; Demirgüç-Kunt & Levine, 2009, Demirgüç-Kunt, Klapper, Singer & Van Oudheusden, 2015; Park & Mercado, 2015). Simultaneously, the literature has illustrated that providing peoples with access to savings instruments increases savings (Aportela, 1999; Jamison, Karlan, & Zinman, 2014) and that access to credit positively influence employment, entrepreneurship, wages, growth, and income distribution (Demirgüç-Kunt & Levine, 2009; Chen, & Jin, 2017). Additionally, other studies assess the impact of financial inclusion on financial stability (Morgan & Pontines, 2014) and female empowerment (Bhatia & Singh, 2019).

Despite several studies and empirical evidence on the importance of financial inclusion, more research should be conducted to further understand the extent of the financial sector in developing nations and the policies that foster inclusion. An essential topic amongst governments, policymakers and researchers is how to measure financial inclusion. Authors such as Amidžić, Massara and Mialou (2014), Demirgüç-Kunt and Klapper (2012a), Honohan (2008) and Sarma (2008; 2012; 2015; 2016) attempt to measure financial inclusion. Nevertheless, studies such as Honohan (2008) are problematic because they only investigate one dimension of financial inclusion, such as the number of bank accounts per capita. That leaves out other critical dimensions such as availability and usage, and the data can be biased as individuals may have more than one bank account.

As many of these studies show, financial inclusion can be assessed through various lenses and have different definitions. This study accommodates two classifications of financial inclusion; *traditional financial inclusion* and *fintech-driven financial inclusion*. This study will extend Sarma's (2008, p. 3) definition of financial inclusion "as a process that ensures the ease of access, availability and usage of the formal financial system for all members of an economy", to include the word digital access. The amended definition of financial inclusion will read: *'A process that ensures the ease of traditional or digital access, availability and usage of the formal financial system for all members of an economy'*. Traditional financial inclusion comprises a range of financial services such as savings, credit, transactions and insurance for individuals and enterprises. Whilst digital or fintech-drive financial inclusion captures the digital access and use of formal financial services through a mobile phone and computers (internet access) (Sahay et al. 2020). This definition underscores several dimensions of financial inclusion, incorporating accessibility (digital and traditional), availability, and usage of the financial system.

2.2   Constructing three Indices of Financial Inclusion

The first step to measure financial inclusion is to identify the indicators that measure accessibility and usage of financial services. This study takes a holistic approach to financial inclusion and addresses both the demand and supply-side factors, measuring indicators related to access, availability (supply), and usage (demand) dimensions.

Several methods have been used for measuring financial inclusion. The lack of harmonisation across measures means that there have been various approaches attempting to construct financial inclusion measures. Several researchers (see Sarma, 2015; Camara & Tuesta, 2017) have highlighted the problems with some of the measures built solely on supply-side indicators (e.g., Honohan, 2008; Amidžić, Massara, & Mialou, 2014). These measures tend to provide inaccurate readings of financial inclusion as supply-side indicators such as accounts or loans can overstate inclusiveness as one person can have several accounts. Moreover, another issue with constructing financial inclusion measures is assigning appropriate weights to the indicators and dimensions. For example, Sarma (2012) assign equal weight to all variables and dimension, assuming that all individual variables contribute equally to the index. Additionally, the weights seem to have been derived subjectively.

Other researcher attempts to assign weights to indicators through statistical methods using factor analysis (Amidžić, Massara, & Mialou, 2014), principal component analysis (Camara & Tuesta, 2017; Sahay et al. 2020; Yorulmaz, 2018) and coefficient of variation (Wang & Guan, 2017). Amidžić, Massara, and Mialou (2014) use the properties of their factor analysis model to derive the dimensions and weights scheme for their financial inclusion index. However, there are two main issues with their method. First, they only use supply-side indicators, which can provide biased results. Second, the factor analysis model determines which variables to be included in each dimension; hence, all available data for each country does not get utilised (Park & Mercado, 2015; Camara & Tuesta, 2017). The principal component analysis is a widely used

statistical method to obtain weights in the financial inclusion measure literature (see Camara & Tuesta, 2017; Sahay et al. 2020; Yorulmaz, 2019). The statistical technique utilises an orthogonal transformation to change a set of observations of potentially correlated variables into a set of linearly uncorrelated observations called principal components (Rafeeq, 2018).

Although the PCA methodology ensures multidimensionality and provide statistical weights, it is a complex methodology, and the results can be biased. Mishra (2007, p. 2) states that "PCA loadings are highly elitist", that is, highly correlated variables are preferred to poorly correlated variable irrespective of the contextual importance of the poorly correlated variable. He argues that PCA performs poorly at constructing comprehensive indices from variables where the system has not fully evolved to the extent that everything determines everything (highly inter-correlated systems). Moreover, he argues that developing economies have underdeveloped inter-correlated systems and that data drawn from these systems exhibit poor interdependence among different measures. Consequently, PCA does not fit these types of underdeveloped systems.

Another statistical method used for assigning weights is the coefficient of variation (CV). CV measures the variability of a series of values independently of the unit of measurement used for those values; the CV is the ratio of the standard deviation to the mean value (Abdi, 2010). CV is not a common statistical method used in financial inclusion measures; however, Wang and Guan (2017) utilise the method to calculate weights in their financial inclusion measure. This paper will use an adjusted version of Sarma's (2012) approach; the same financial inclusion dimensions of access, availability and usage will be used, however, with an extended list of indicators. Moreover, to circumvent subjectively assigning weights, this paper will use the same method as Wang and Guan (2017). Although Sarma (2016) incorporated digital access in a more recent measure of financial inclusion, I have decided to create three separate indices as I am interested in analysing the effectiveness of digital financial inclusion contra traditional financial inclusion. In figure 1, the overview of the three dimensions underpinned by 16 indicators is illustrated in a comprehensive financial inclusion diagram.

2.2.1   Access

The dimension of access is characterised by the fact that an inclusive financial system should have as many users as possible. They should have access "to accounts to receive income or transfers, savings accounts to store money safely and prudently, credit sources for personal or business borrowings, and insurance products to tide against bad times" (Sahay et al. 2015, p.8). Traditionally, the size of the 'banked' population is measured by the portion of individuals with a bank account. For many individuals having a bank account acts as an entry point into the formal financial sector. However, obtaining bank account data is challenging, particularly in developing nations. Hence supply-side data capturing the number of deposit accounts per 1000 adult is used as a proxy (Sarma, 2015).
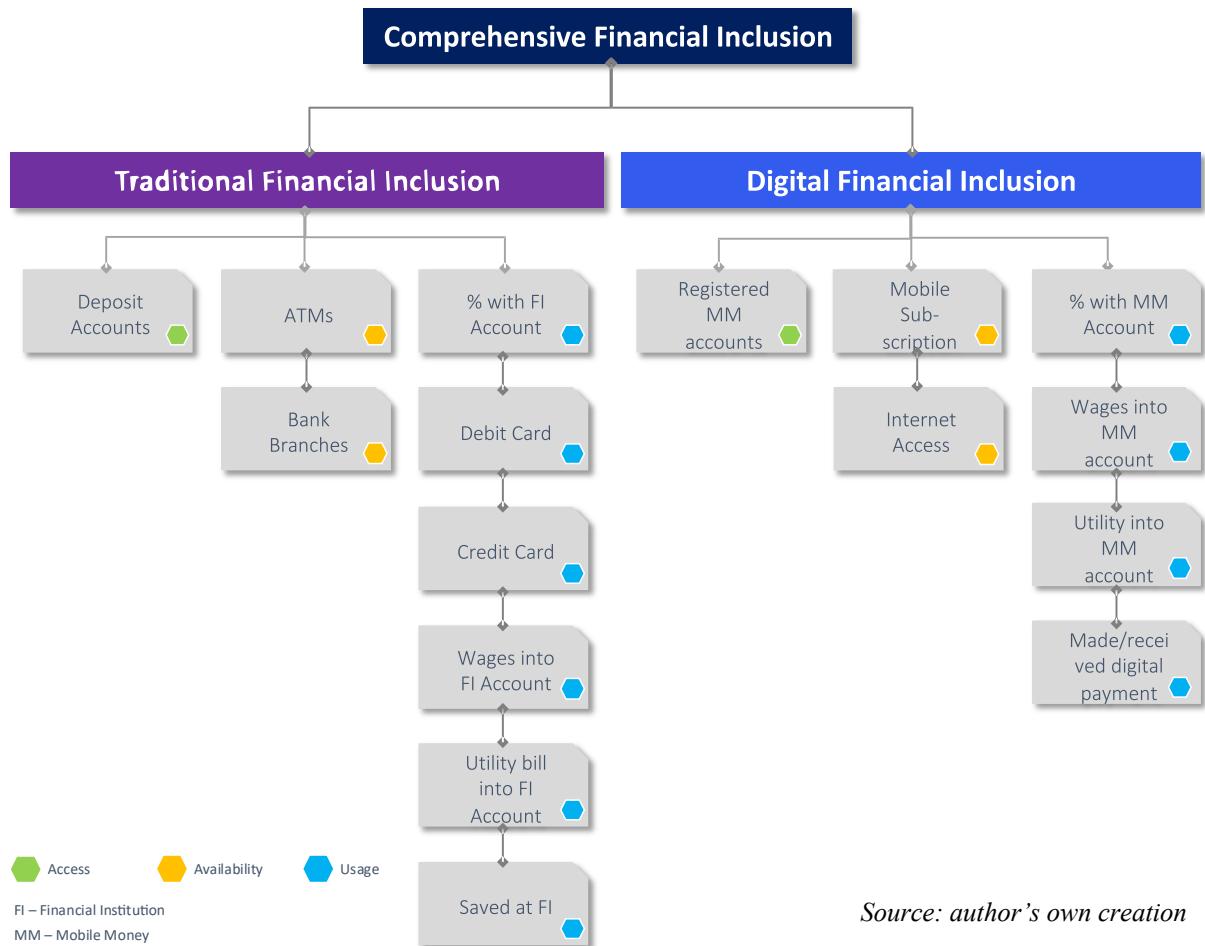
Figure 1 - Financial Inclusion Dimensions and Indicators

Globally, some 1.7 billion adults lack accesses to basic financial services without access to a financial institution or a mobile money provider, and virtually all of these unbanked adults live in the developing world (Demirgüç-Kunt et al. 2018). Nevertheless, with the rise of digital financial services, there is increasing potential to accelerate financial inclusion and access of the unbanked population. In SSA, mobile money accounts are growing at a fast pace. Instead of a brick-and-mortar bank branch, mobile money agents provide essential financial services, such as providing depositing and withdraws services. Supply-side data capturing the number of registered mobile money agents per 1000 adults serves as a proxy for the access of digital financial services (Sahay et al. 2020).

Number of depositors with commercial banks per 1000 adults

83   1 687

Number of registered mobile money accounts per 1000 adults

11   1 665
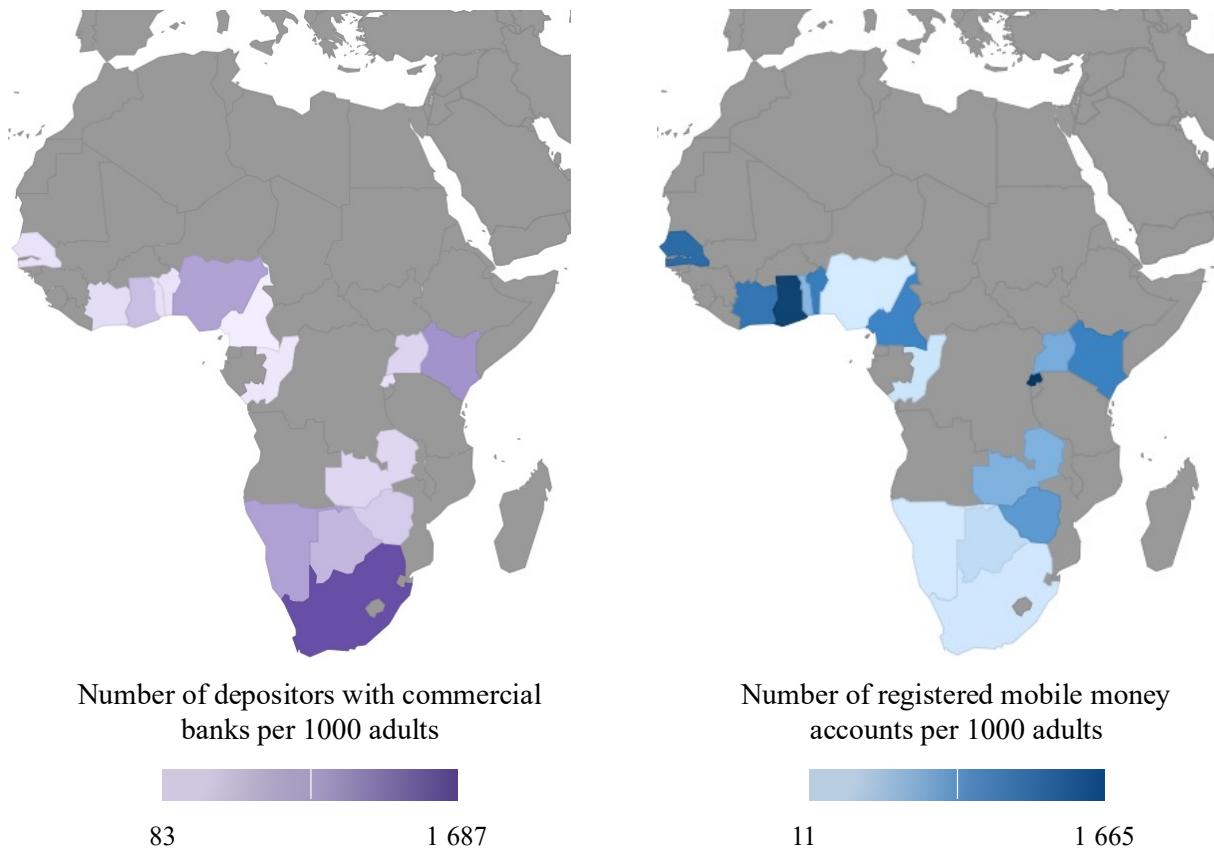
Source: author's own creation (Data IMF FASS)

Figure 2 - Access to financial services in 16 sub-Saharan countries in 2017

2.2.2 Availability

Another essential feature of an inclusive financial system is the availability of banking services. In most research, the availability of financial services is approximated by the number of bank branches per 1000 adults and ATMs per 1000 adults (Amidžić, Massara, & Mialou, 2014; Sarma, 2015; Wang & Guan, 2017). This study will use the same measures as a proxy for the availability of traditional financial services. However, a common practice within banks in advanced economies for the last 20 years has been to shut down local branches. This is a trend that is expected to continue, and although the contextual nature of the geographical location matters, there is widespread concern regarding the impact of local communities (Nguyen, 2014). Yet, what is the trend in developing nations where the availability of bank service traditionally has been low and limited? Sahay et al. (2020) argue that where traditional access to bank services (bank branches and ATMs) have been limited, fintech payments services tend to be supplied more. This may reflect the shift to digital services (e.g., mobile and online banking) by banks and it implies that fintech-driven financial inclusion tends to be higher where there is a gap or deficient existing supply of traditional financial services.

Moreover, with the changing landscape of financial services and new technological advances availability of financial services can be measured in other ways. Fintech technologies such as

mobile money accounts have broadened the possibilities of financial availability. The massive growth and penetration rate of mobile technology are transforming mobile phones into pocket-banks in SSA and providing countries with affordable costs and an effective way of including large parts of the populations excluded from formal financial service (Asongu, 2015). Accordingly, mobile phones and internet access are used as a proxy for digital financial availability (Sahay et al. 2020).

2.2.3   Usage

The usage dimension focuses on the frequency and consistency of financial services. With data from the Global Findex database, indicators with a focus on the usage of payments, digital payments, savings, credit and debit cards can be assessed. Camara and Tuesta (2017) argue that broad access and high usage of formal financial services do not necessarily mean that a system is inclusive per se and that the use of financial services can depend on socio-economic factors such as GDP per capita or human capital. Financial inclusion dimensions such as usage need to be assessed holistically, together with other factors such as availability of infrastructure (ATM or internet access) and other socio-economic factors. Nevertheless, as seen in figure 3 below, the percentage of adults with a financial institution or mobile money account greatly varies across the SSA region. West African economies are performing the worst, except Ghana, Côte d'Ivoire and Senegal, where the share of adults with a mobile money account surpassed 30 % in 2017. Several measures are used as proxies for usage dimension, see figure 1.
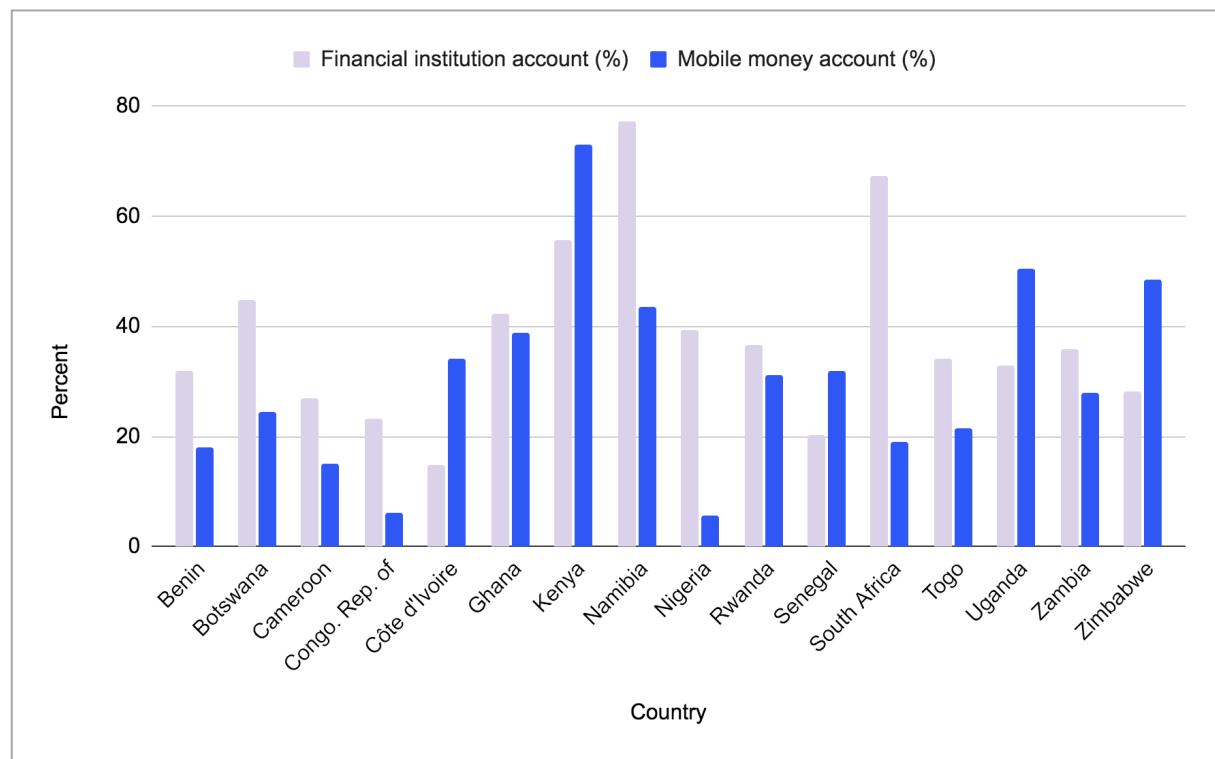
Source: author's own creation (Data Global Findex)

Figure 3 - Bank account vs mobile money account in 16 sub-Saharan countries in 2017

3   Literature review

The role of financial systems in economic growth has widely been discussed and assessed by economists. Although a large body of literature has established a positive link between financial sector development and economic growth at the micro as well as macro-level (Beck, Levine, & Loayza, 2000; King & Levine, 1993; Levine, 2005), more research needs to be conducted into the breadth of financial systems and the extent to which members of society has access to and use financial services (Beck, Demirgüç-Kunt, & Peria, 2007).

Per the research questions, this literature review will focus on fintech, financial inclusion, economic growth, and inequality. Section 3.1 discuss the concept of fintech and digital financial services. Section 3.2 deliberate on fintech and financial inclusion in SSA, discussing the existing literature on the effects of mobile money on financial inclusion in SSA countries. Section 3.3 discuss the literature on financial inclusion and economic growth in SSA. Finally, section 3.4 will review the literature on financial inclusion and inequality, concluding the section with a discussion on the effects of fintech-driven financial inclusion on income inequality.

3.1   What is Fintech?

Fintech is used to describe new technology that seeks to deliver improved and new uses of financial services (Popescu, 2019). Sahay et al. (2020) argue that the emergence of fintech is changing the financial services landscape. They contend that fintech disrupts traditional financial services delivered by financial institutions predominately built on cash transactions and face-to-face interactions. With the development of digital platforms which can offer a range of financial products (new and or existing) accessible from mobile phones or computers, the need for traditional services is reduced. However, OECD (2020) raise questions of whether fintech companies and services are replacing banks and other financial institutions. Whether they induce healthy competition, enhance efficiency in markets or rather cause disruption and financial instabilities? Navaretti, Calzolari, Mansilla-Fernandez and Pozzolo (2017) argue that fintech companies will not replace banks in their most essential functions. Yet, they enhance competition in financial markets, provide services that traditional institutions do less efficiently or not, and widens the pool of users of financial products and services.

Gomber, Koch, and Siering (2017) discuss fintech companies as organisations with new business models built on internet related technologies (e.g., cloud computing, mobile internet) providing financial services (e.g., money lending, transaction banking) that tend to promise more flexibility, security, efficiencies and opportunities than established financial services. Moreover, the innovator can be a start-up (e.g., Branch a Nigerian mobile lending app), an

established ICT company (e.g., Vodaphone and Safaricom with M-pesa) or an established financial service provider (e.g., Societe Generale). Arner et al. (2020) argue that fintech comprises five major areas, finance and investment, operations and risk management, payments and infrastructure, data security and monetisation and customer interfaces. This paper will only focus on the payments and infrastructure area as the focus of the study is in SSA, where the driving force of fintech mainly have been centred around the internet and mobile payments. Moreover, one common issue with financial inclusion studies is data availability. Out of the five fintech areas, financial inclusion indicators on the internet and mobile subscription and digital payments services are available. Data on crowdfunding, insurance or digital financial advice is very limited or non-existing.

3.2   Fintech and Financial Inclusion in SSA

The World Bank's 2017 Findex report shows that 69 per cent of adults globally own an account, meaning that 515 million adults have access to financial tools. This is a continuation of the upward trajectory since the Global Findex database first was released in 2011 (Demirgüç-Kunt et al. 2018). Much of the recent advances have been driven by digital payments, government policies and new financial services accessed through the internet and mobile phones. Moreover, the power of fintech-driven financial inclusion is demonstrated most convincingly in SSA, where 21 per cent of adults now have a mobile money account, which is almost a twofold increase since 2014 and the highest adaption rate in the world. Moreover, while mobile money has mainly been adopted in East Africa, data from 2017 shows that it has spread to other regions such as West Africa (Demirgüç-Kunt et al. 2018). However, the number of unbanked adults is still disproportionately high in developing and emerging economies. Financial inclusion is essential to improving the livelihoods of the disadvantaged and poor. Providing low-income households with access to payments, insurance, savings, and credit helps them manage their financial obligations and build a better future contributing to broader economic growth, development, and poverty reduction (Arner, Buckley & Zetzsche, 2018).

Mlachila et al. (2016) discuss SSA as a sizable but spare population, noting that traditional bank intermediaries do not reach remote areas. The cost of their services tends to be too steep for low-income households and small enterprises. They argue that the recent surge in mobile money in several SSA countries has been enabled by a substantial increase in mobile phone subscriptions. This is reinforced by the expansion of network coverage and technology to support financial services. Additionally, the declining prices of mobile phones and an increasing variety of mobile payments and banking innovations have also contributed to the expansion of fintech-driven financial inclusion. Sy et al.'s (2019) study on fintech in SSA countries illustrates that by 2015 mobile money accounts surpassed traditional deposit accounts in 17 countries, including some of the largest economies such as South Africa, Kenya and Tanzania. However, it is essential to emphasise the sizeable difference across the region, with East Africa leading the adoption and usage of mobile money.

Several empirical analyses utilising financial access survey data reveals the economic impacts the widespread adoption of mobile phones as communications tools has had on the adoption of mobile money. The studies assess the impact M-Pesa, *a money transfer system operated by Safaricom*, has had on Kenya (Jack & Suri, 2014; Mbiti & Weil, 2011; Shem, Misati & Njoroge, 2012; Yermack, 2018). Jack and Suri (2014) assess the economic effect of M-Pesa on households in Kenya, and their findings show that M-Pesa facilitates trade and increases household savings. They argue that because of the cheaper transaction costs, M-Pesa improves investment and allocation of human and physical capital, it allows households to spread risk and positively affects peoples ability to share risks. Moreover, they argue that M-Pesa could empower women with less bargaining power, especially in poorer segments of the population. Thus, M-Pesa has had an important role in accelerating financial inclusion and achieving inclusive growth in Kenya.

Sy et al. (2019) argue that the advancement and success of mobile payments in East Africa, compared to other SSA countries, are due to the preferred telecom regulatory model adopted in the region. In this framework, telecom companies work with financial regulators to set up the infrastructure for mobile money. They postulate that the bank-led model promoted in other SSA countries proved less successful in attracting users. Moreover, one of the largest impediments to more rapid fintech-driven financial inclusion appears to be the electrical and communications infrastructure in many SSA countries, which has limited and unreliable access to broadband internet connections and mobile phones (Yermack, 2018).

Another important aspect to consider when evaluating the possibilities of fintech challenging traditional financial services is the regulatory and supervisory challenges to consumer protection and financial stability. Buckley and Malady (2015) argue that regulatory frameworks need to respond to mobile money in two ways. First, regulators need to take an '*enabling approach*' that involves policies and activities that help mobile money grow safely. Second, regulators should adopt a '*proportionate approach*', that is, implementing policy and regulation that does not stifle the development of the fintech-driven financial sector. For instance, know your customer and anti-money laundering regulations is essential for banking and payments services to prevent bad actors from exploiting the system. However, these processes can be fairly onerous and time-consuming and exclude large populations (as some countries do not have wide ID card schemes) (Buckley & Malady, 2015). Consequently, regulators need to perform a risk-benefit analysis as with certain segments of the populations it may be a question of dollar transactions (Lal & Sachdev, 2015). Hence, the rules need to be proportional to the actual underlying risk.

Furthermore, Sahay et al.'s (2020) report on fintech and financial inclusion found several key factors that may facilitate or inhibit financial inclusion. They found that digital finance is accelerating financial inclusion even where traditional financial inclusion decreases and that fintech-driven financial inclusion is positively related to growth. Moreover, they discuss that safely developing digital financial inclusion lies within a mixture of factors, where rapid financial inclusion without appropriate regulation and financial literacy can lead to financial instability. New digital practices, cybersecurity risks and incorrect lending practices by unregulated institutions can increase system vulnerabilities and jeopardise trust in the financial system. They also argue that unequal access to digital infrastructure, limitations to financial and

digital literacy and lightly regulated fintech institutions could create new risks to financial inclusion.

3.3   Financial Inclusion and Economic Growth in SSA

African countries have experienced positive growth in access to financial services in recent decades. In some countries, the deepening of the financial sector has led to more credit availability for individual and enterprises, and mobile money products have helped broaden access to financial services (Demirgüç-Kunt & Klapper, 2012b). Nevertheless, the financial system of many African countries remains underdeveloped compared to other developing economies, and there are many challenges in the work of constructing a more financially inclusive system in Africa (Demirgüç-Kunt & Klapper, 2012b). Many economists have conducted empirical research illustrating that financial development is an essential factor for a country's economic growth (Beck, Levine, & Loayza, 2000; King & Levine,1993; Levine, 2005; Madsen & Ang, 2016).

Research examining the relationship between SSA and economic growth has found a positive association between financial sector development and economic growth (Mlachila et al. 2016; Murinde, 2012). Similarly, several studies assessing the relationship between finance and growth in SSA found the relationship positive and causal in one or both directions (Ahmed, 2010; Akinlo & Egbetunde, 2010; Fowowe, 2011; Odhiambo, 2008). Moreover, Nan's (2019) difference-in-differences analysis of SSA countries illustrates that when mobile money is widely adopted, it positively affects a country's economic growth. In contrast, other studies argue that the financial sectors in SSA countries do not play an essential role in economic growth, partly because they are highly underdeveloped (Demetriades & James 2011; Gries, Kraft, & Meierrieks, 2009). However, a recent comparative study by Sulemana and Dramani (2020) investigate the effect of financial sector development on economic growth between the Economic Community of West African States (ECOWAS) and Southern African Development Community (SADC) regions. Their results show a positive but insignificant effect of financial sector development on ECOWAS regions, whilst for SADAC, the results were positive and statistically significant. The authors attribute the results to a relatively underdeveloped financial sector of the ECOWAS region and a relatively more developed financial sector in the SADAC region.

Financial sector development plays an essential role in SSA because of its implications for economic growth but also affects financial inclusion. Anarfo et al.'s (2019) empirical study finds evidence of reverse causality between financial inclusion and financial sector development in sub-Saharan Africa, implying that financial inclusion and financial sector development reinforces each other. Although this paper does not empirically investigate the link between financial sector development and financial inclusion, it is essential to understand the effect financial sector development has on financial inclusion and how it is associated with economic growth. Anarfo et al. (2019) argue that there is a tripartite relationship between financial development, financial inclusion, and economic growth. They state that it is

imperative for policymakers in SSA to understand the trilateral relationship to put the economies on steadfast economic growth and development paths. An effective financial system drives economic growth by providing credit, savings, payment, and risk management products to individuals and enterprises with a wide range of needs. Financially inclusive economies allow wide-ranging access to financial services by making customised financial services available at an affordable price without rigorous documentation, especially to the poor or other disadvantaged groups within the economy (Babajide, Adegboye, & Omankhanlen, 2015). Moreover, several studies suggest that financial sector development and improved access to finance may accelerate economic growth along with a reduction in income inequality and poverty (Anand & Chikara, 2013, Tita & Aziakpono, 2017; Park & Mercado, 2015).

3.4   Inequality and Financial Inclusion

Several theoretical and empirical studies have focused on the relationship between finance and income inequality. Beck, Demirgüç-Kunt and Levine (2007) studied the impact of financial development on the poor by estimating the relationship between finance and changes in income distribution and poverty level. They found that financial development helps the poor and that greater financial development lowers income inequality by stimulating the incomes of the poor to grow faster than average per capita GDP. Kim's (2016) study found that income inequality strongly reduces economic growth in low-income countries and that financial inclusion improves the association between income inequality and economic growth. Hence, the reduction in income inequality through financial inclusion changed the positive relationship between income inequality and economic growth into a negative one.

Nevertheless, the studies on financial inclusion, poverty and income inequality have shown mixed results. Park and Mercado's (2015) study on financial inclusion, poverty and income inequality found that financial inclusion significantly reduces poverty and income inequality. Park and Mercado's (2018a) paper analysing 176 economies, including 37 from developing Asia, shows a significant relationship between higher financial inclusion and lower poverty rates for the full sample. However, they find a significant relationship between higher financial inclusion and lower-income inequality for the full sample, but not for developing Asia. On the other hand, Park and Mercado's (2018b) study on 151 economies finds that high- and middle-high-income economies with high financial inclusion have significantly lower poverty. In contrast, no relation exists for middle-low and low-income economies. Moreover, they did not find similar results for income inequality; that is, they found no significant effect of financial inclusion on income inequality.

Conversely, Agyemang-Badu, Agyei and Duah's (2018, p. 13) study on financial inclusion, poverty and income inequality in 48 African countries found that GINI per capita "exerts significant effect on financial inclusion". However, the study results are somewhat vague, and without a detailed methods section, one finds it difficult to assess the empirical steps taken. Furthermore, Tita and Aziakpono (2017) analyse the relationship between various aspects of financial inclusion and inequality in SSA, determining which aspects of financial inclusion have

the greatest effect on income inequality. Their results show that formal account use for business, digital payments, and formal savings positively relates to income inequality. Although most studies on financial inclusion and income inequality attempt to analyse the effects of the relationship, Tita and Aziakpono (2017) study made a major contribution by examining different elements of financial inclusion.

Moreover, several studies have shown that ICT and fintech can play an important role in reducing income inequality. Asongu and Le Roux's (2017) study of a panel of 49 SSA countries found that mobile, internet, and broadband penetration positively impacted inclusive growth using the inequality-adjusted human development index measure. Asongu (2015) empirical study of 52 African countries found that mobile penetration is good for the poor. They argue mobile phones have a positive income-redistributive effect, and that "transforming cell phones into pocket-banks in Africa" increases financial access (p.14). A recent study by Demir et al. (2020) put forward new evidence that financial inclusion is a key channel through which fintech reduces income inequality directly and indirectly. Studying a panel of 140 countries, they find that fintech is an important driver of financial inclusion and that financial inclusion reduces inequality at all quantile levels of inequality distribution. Although, its effects are more prominent in higher-income countries.

3.5   Chapter Summary

In chapter 2 the definition of financial inclusion was discussed and the definition was evolved to include traditional and digital access. This paper defines financial inclusion as: *'A process that ensures the ease of traditional or digital access, availability and usage of the formal financial system for all members of an economy'*. Moreover, in chapter 2 the theoretical framework for constructing financial inclusion indices was discussed, and the indicators for the dimension of access, availability, and usage were described.

In this chapter, the literature on fintech, financial inclusion, economic growth and income inequality has highlighted several important trends and facts. For example, a growing body of literature shows that fintech positively affects financial inclusion in SSA and that digital finance is accelerating financial inclusion even where traditional financial inclusion is decreasing (Sahay et al. 2019). Moreover, this chapter also bring up relevant literature on financial inclusion and economic growth in SSA, discussing key topics such as financial sector development and the tripartite relationship between financial development, financial inclusion, and economic growth (Anarfo et al. 2019).

Furthermore, previous research about the relationship between finance and income inequality has found mixed results. Some studies find that financial inclusion reduces income inequality whilst others does not find a significant link. Nevertheless, studies on the effect of fintech on financial inclusion and income inequality show that fintech can play an important role in reducing income inequality.

4 Methods and Data

This study seeks to explore traditional and fintech-driven determinants of financial inclusion and the effects on economic growth and income inequality in SSA. To test the three hypotheses, an index of financial inclusion was constructed and then tested in two separate OLS models. The first model builds on Sahay et al. (2020) model of assessing the impact of financial inclusion on economic growth; the second model draws on Čihák and Sahay (2020) estimation model to answer whether greater financial inclusion means lower inequality within countries.

This chapter describes the methods, data and robustness checks conducted in this study. Section 4.1 outlines the method used to construct the financial inclusion indices. Section 4.3 describes the model outlines and three regressions equations. Finally, Section 4.4 discusses the data sources, the descriptive statistics, the sensitivity and robustness checks conducted, and the data limitations.

4.1 Financial Inclusion Index

To construct the three financial inclusion indices, I adapt a combination of the approaches by Sarma (2012) and by Wang and Guan (2017). The first step is to create dimension indices (dimensions access, availability and usage) for each country in a particular year.

The dimension index for the i dimension, d_i, is computed using this formula:

$$d_{ij} = w_{ij} \frac{A_{ij} - m_{ij}}{M_{ij} - m_{ij}}$$

(1)

Where
w_{ij} = weight of indicator j in dimension i, $0 \leq w_{ij} \leq 1$
A_{ij} = actual value of indicator j in dimension i.
m_{ij} = minimum value of indicator j in dimension i.
M_{ij} = maximum value of indicator j in dimension i.

The proposed indices take values between 0 and 1, zero signifying lowest financial inclusion and 1 signifying complete financial inclusion. Formula 1 allows for $0 \leq d_{ij} \leq 1$, that is, the higher value of d_{ij} the higher the countries achievement in dimension i.

For each dimension i, formula (1) is initially applied to each of the indicators, the IFI in dimension i is calculated as in formula (2), where the index of financial inclusion for country

i is then measured by the normalized inverse of Euclidean distance of point d_i computed in formula (1) from the ideal point i which is equal to 1.

$$IFI_i = 1 - \frac{\sqrt{w_{i1}^2 (1 - d_{i1})^2 + w_{i2}^2 (1 - d_{i2})^2 + \cdots + w_{in}^2 (1 - d_{in})^2}}{\sqrt{w_{i1}^2 + w_{i2}^2 + \cdots + w_{in}^2}} \qquad (2)$$

Where
w_{i1}^2 = the weight of indicator 1 in dimension i, squared
d_{i1} = the computed value of indicator 1 in dimension i

Furthermore, the weights of the indicators, w_{ij}, are determined in accordance with Wang and Guan's (2017) method; they compute the weight with a statistical technique called the coefficient of variation (CV). The coefficient is outlined as the ratio of the standard deviation to the mean value. The weight of every indicator is defined as the part of its CV to the sum of all indicator CVs numerically. Formula (3) illustrates the calculation

$$w_{ij} = \frac{V_{ij}}{\sum j \, V_{ij}} \qquad (3)$$

Where
w_{ij} = weight of indicator j in dimension i.
V_{ij} = the CV of dimension i.
$\sum j$ = the sum of all coefficient of variation all indicators in dimension i.

The final IFI is calculated using the formula in equation (4) as specified by Wang and Guan (2017).

$$IFI_i = 1 - \frac{\sqrt{w_1^2(1 - IFI_1)^2 + w_2^2(1 - IFI_2)^2 + w_3^2(1 - IFI_3)^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2}} \qquad (4)$$

Where
w_1 = the weight of dimension 1 (access)
w_2 = the weight of dimension 2 (availability)
w_3 = the weight of dimension 3 (usage)

4.2 OLS Regression

4.2.1 Financial Inclusion and Economic Growth

To answer hypothesis 1 and 2, I first run a cross-country ordinary least square (OLS) regression following Sahay et al.'s (2020) method. The method is devised to relate the initial 2014 traditional and fintech-driven indices to the subsequent period of economic growth, from 2014 to 2017.

$$\gamma(i)_{2014-17} = \beta_0 + \beta_1 FI(i)_{T,2014} + \beta_2 FI(i)_{F,2014} + \beta_3 X(i)_{2014} + \varepsilon(i)$$

(5)

Where γ is real GDP growth over the period, i is the 16 sub-Saharan African countries, X is a vector of the control variables and ε is the error term. $FI(i)_{T,2014}$ is the TFI index in 2014. $\beta_2 FI(i)_{F,2014}$ is the FFI index in 2014. The control variables related to the initial period includes:

- Degree of economic development - log of GDP per capita
- Government consumption as a percentage share of GDP
- Foreign direct investment inflow (FDI) as a percentage share of GDP
- Inflation - annual percentage change in consumer prices
- Level of financial depth - log of domestic credit as a percentage share of GDP

However, since I want to investigate the relationship between the change in financial inclusion over time with the subsequent economic growth, Sahay et al.'s (2020) method is adjusted to a pooled cross-country ordinary least square (OLS) estimation. All variables included in the modified model (6) are time series variables. Since the previous year's values may significantly influence the dependent variable (GDP) the economic model must consider the lag effects in the data. Consequently, all independent variables are lagged. Due to data limitations, the level of financial inclusion is assumed to be at the same level as 2014 for 2015 and 2016.

$$\gamma(i)_{2014-17} = \beta_0 + \beta_1 FI(i)_{T,t-1} + \beta_2 FI(i)_{F,t-1} + \beta_3 X(i)_{t-1} + \varepsilon(i)$$

(6)

Where γ is log of real GDP growth over the period, i is the 16 sub-Saharan African countries, X is a vector of the control variables and ε is the error term. $FI(i)_{T,t-1}$ is the lagged TFI index over the period. $\beta_2 FI(i)_{F,t-1}$ is the lagged FFI over the period. All of the control variables are lagged and logged they include:

- Degree of economic development - logged GDP per capita (t-1)
- Logged government consumption as a percentage share of GDP (t-1)
- Logged Foreign direct investment inflow (FDI) as a percentage share of GDP (t-1)
- Logged Inflation - annual percentage change in consumer prices (t-1)
- Level of financial depth - logged domestic credit as a percentage share of GDP (t-1)

4.2.2   Financial Inclusion and Inequality

To answer hypothesis 3, a pooled cross-country ordinary least square (OLS) estimation will be run, following Čihák and Sahay (2020) model. I will investigate whether greater financial inclusion leads to lower income inequality throughout 2014 to 2017. To measure income inequality, I will use the most common measure used as a proxy in the literature, the GINI index. Which measures deviations from a perfectly equal distribution of income on a scale from 0 to 1. Čihák and Sahay's (2020) model have slightly been modified to include the financial inclusion indices and different covariates.

$$lnINE_{it} = \beta_0 + \beta_1 FI_{T,it} + \beta_2 FI_{F,it} + \beta_3 X_{it} + \varepsilon_{it}$$

(7)

Where *INE* stands for income inequality and measured using the natural logarithm of the GINI index over the period of 2014 to 2017, $FI_{T,it}$ stands for TFI index and $FI_{F,it}$ stand for FFI index, i is the 16 sub-Saharan African countries, t is time, X is a vector of the control variables and ε is the error term. I draw on the literature discussed in the literature chapter as well as Čihák and Sahay (2020) for the selection of the control variables and they include:

- Degree of economic development - logged GDP per capita
- Government consumption as a percentage share of GDP
- Inflation - annual percentage change in consumer prices
- Level of financial depth - logged domestic credit as a percentage share of GDP
- Rule of law - as a proxy for institutional quality
- Population – the growth rate of the total population to express changes in demography

4.3   Data

This study relies on several data sources to compute the financial inclusion index and conduct regressions on socio-economic factors related to economic growth, inequality, and financial inclusion. The first part of this sub-section discusses the data sources. The second part discusses the dependent and independent variables used in the study and a presentation of the descriptive statistics. Finally, the limitations of the data and the robustness tests conducted are discussed.

4.3.1   Financial Inclusion Data Sources

Goel and Sharma (2017, p.952) states, "any endeavour to measure the level of financial inclusion should take into consideration as many dimensions as possible that affect the inclusion". Hence, to capture the different characteristics of financial inclusion, 16 indicators across the span of access, availability and usage dimensions were included. The intention was to include as many countries as possible. Yet, due to data availability constraints, the sample

contains 16 countries with available data across the 16 financial inclusion indicators being investigated, see table 1.

The financial inclusion data is drawn from three sources, IMF's Financial Access Survey (FAS), the World Bank's Global Financial Inclusion (Global Findex) database and the World Bank's World Development Indicators (WDI). The World Bank's Global Financial Development Database and G20 Financial Inclusion Indicators were also cross-referenced to confirm data across several indicators.

Table 1 - Data Sources for Financial Inclusion Indices

Traditional Financial Inclusion	Source	Fintech-driven Financial Inclusion	Source
Access			
Number of depositors per 1,000 adults	IMF FASS	Number of registered mobile money accounts per 1,000 adults	IMF FASS
Availability			
Number of ATMs per 100,000 adults	IMF FASS	Mobile subscriptions per 100 people	WB WDI
Number of branches per 100,000 adults		% of individuals using the Internet	
Usage			
% of adults with financial institution account	WB FINDEX	% of adults with mobile money account	WB FINDEX
% of adults with debit card	"	% of adults received wages through a mobile phone	"
% of adults with credit card	"	% of adults paid utility bills using a mobile phone	"
% of adults received wages into a financial institution account (%)	"	% of adults paid made or received digital payments in the past year (%)	"
% of adults paid utility bills using a financial institution account (%)	"		
% of adults saved at a financial institution	"		

The Global Findex database is relatively new and contains over 200 indicators on the demand-side indicators of financial inclusion, that is, data collected from the perspective of users of financial services. The indicators are constructed with survey data from interviews with randomly selected adults aged 15 and above (Demirgüç-Kunt & Klapper, 2012a). The first survey year is 2011; however, for SSA countries, indicators for the year 2011 was close to non-

existent. In this study, indicators from 2014 and 2017 are used. The FAS database provide data on more than 150 indicators on the supply-side of access and use of financial services. It is a database with annual coverage with historic data from 2004 (the database was launched in 2009), the data is sourced directly from financial service providers. Both demand and supply-side data are fundamental when measuring financial inclusion to obtain a holistic view of an economy's financial inclusion (Espinosa-Vega, Shirono, Villanova, Chhabra, Das & Fan, 2020). However, the collection of demand-side data is costly compared to supply-side data due to it being more resource-intensive and time-consuming. In some cases, demand-side data have low response rates, and it is also gathered relatively infrequently. On the other hand, supply-side data is collected at a relatively low administrative cost and tend to be collected at a higher frequency (Espinosa-Vega et al. 2020). The WDI is the World Bank's primary collection of development indicators, gathered from officially recognized international sources.

4.3.2 Data Sources for Dependent and Independent Variables

To analyse the link between financial inclusion and economic growth, it is essential to understand the factors that influence the development of a financial system and affect economic growth. Similarly, there are socio-economic factors that affect the level of income inequality in an economy. The relationship between financial inclusion and income inequality is relevant because income distribution can influence savings decisions, allocation of resources and incentives to innovate (Levine, 2005). Hence, variables that may affect economic growth, financial sector development, financial access, and income inequality are considered. The factors used in the empirical analyses are the various financial inclusion indices, GDP growth rates, GDP per capita, GINI index, the inflation rate, inflows of foreign direct investments, the rate of government expenditure, the rule of law estimate (captures the extent to rules of society is abided by), the population growth rate. See table 3 in Appendix 2 for the description of the variables.

The financial development and control variables are from the World bank's WDI, and the measure on the rule of law is from the World Bank's World Governance Indicators (WGI). Adeleye, Osabuohein and Bowale (2017) point out that the WGI database has been criticised for biases. It is not entirely free of errors, yet it is still the best data sets available for cross-country studies. The Gini Index is drawn from Standardized World Income Inequality Database (SWIID; Solt, 2019). One key concern regarding the GINI index measure is the issue of variation and comparability across countries and years. Solt's (2019) database tries to deal with this issue by aiming to maximise the comparability of income inequality and preserve the widest possible coverage across countries and over time - the database comprises thousands of reported Gini indices from hundreds of published sources. The index ranges from 0 (perfect income equality) to 1 (perfect income inequality). Hence countries with an index closer to 0 are more equal than the ones closer to 1.

Table 2 presents the summary statistics of the variables used in the OLS estimations, the panel data used is balance and contains variables for the years 2014 and 2017. CFI was lowest in Togo in 2014 at 0.101 and highest in Namibia in 2017 at 0.714. Annual GDP growth was found lowest in Congo in 2016 with a negative 10% growth and highest in Rwanda in 2015

with an 8.85% increase in annual GDP Growth. As measured by the GINI index, income inequality was lowest in Kenya in 2014 and highest in Namibia in 2014.

Table 2 - Descriptive Statistics

Variables	N	Mean	SD	Min	Max
CFI	64	0.309	0.178	0.101	0.714
TFI	64	0.331	0.248	0.0945	0.990
FFI	64	0.296	0.205	0.0782	0.918
GDP growth	64	3.820	3.331	-10.19	8.857
GINI Index	64	0.504	0.0801	0.410	0.707
GDP per capita	64	2.356	1.969	570.9	7 893
Inflation	64	4.655	5.013	-2.431	17.87
Dom. Cred	64	25.84	15.78	11.14	68.24
FDI	64	3.783	6.616	-1.032	39.44
Gov. Exp	64	14.80	5.527	4.403	27.90
Rule of law	64	-0.404	0.535	-1.431	0.643
Pop. Growth	64	2.433	0.548	1.256	3.750

Notes: N stands for the number of observations. Mean is the arithmetic average. Std. Dev. Is the standard deviation. Min is the minimum value. Max is the maximum value. CFI is Comprehensive financial inclusion, TFI is traditional financial inclusion, FFI is Fintech-driven financial inclusion. GDP Growth and per capita is measured in current US$

4.3.3   Data limitations

The supply-side and demand-side data has its limitation, and the biggest issue with conducting the financial inclusion index was dealing with missing data. There are several approaches to handling missing data. The OECD Handbook on Constructing Composite Indicators (OECD, 2008) has a chapter on data imputation covering methods such as single imputation, unconditional mean imputation and multiple imputations. However, my approach to dealing with missing data is partly to follow Svirydzenka's (2016) treatment of missing data. In those instances where data was not available across the 16 indicators for both years, I treated the data as truly missing. The country was excluded from the index; this was important for the comparability of indices from 2014 to 2017.

Moreover, in two cases, data is missing for one indicator in 2017 (South Africa and Kenya). I follow Svirydzenka (2016) method and set the values equal to the latest observation in 2014. The same approach was taken for the OLS panel regressions where the level of financial inclusion was assumed to be at the same level as 2014 for 2015 and 2016. In cases where GINI data was missing for a particular year in the SWIID database, the same approach to set the value to the previous year was taken. Moreover, there are no institutional controls in the growth

models; this may affect the link between financial inclusion and economic growth as the model is not controlling for countries with different institutional frameworks. Similarly, due to the small sample, it was pertinent not to divide the sample. However, dividing the sample of economies in terms of the level of income may give different results. For example, Park and Mercado (2018b) divided their sample of 151 economies into high- and middle-high-income and assessed the link between financial inclusion, poverty and income inequality.

4.3.4   Robustness and Model Testing

To ensure the robustness of the models and analysis, several strategies have been employed. Firstly, a '*stepwise*' approach to analysis was applied, by adding the control variables in a stepwise order the robustness of the models was tested, these various controls are discussed in the results chapter. Secondly, the financial inclusion and growth model was estimated without logged variables. The results can be seen in estimation (1) in table 4 in Appendix 2. Thirdly, Alter and Yontcheva (2015) argue that countries with larger populations and higher population densities are likely to have more developed financial services due to economies of scale in the costs for financial agents and processes. Three variables controlling for the influence of population demographics, population growth, population density and dependency ratio was added to the economic growth (estimation 2) and income inequality (estimation 3) in table 4 in Appendix 2. Hence, testing whether the added population variables affect the signs and statistical significance of the models is a good robustness test. Finally, the financial inclusion and income inequality model was estimated using lags, see estimation 4. The results are similar to the results reported in table 5 and 6 (results chapter) in terms of sign and statistical significance.

Moreover, to instil confidence in my results, several assumptions need to be met. The aim is for my models to be BLUE; that is, the models should be linear in their parameters, unbiased, and have the least variance among its class of linear unbiased estimators (Kennedy, 2008). To test the normality of model (6) I conducted the Jarque-Bera test for normality. The test result shows that the p-value is greater than 0.0127, which means that the null-hypothesis of a normal distribution is rejected at a 5 % significance level. However, the graphical test illustrates that the residuals are normally distributed. The quantiles in the qnorm graph (in Appendix 2) indicate left skewness. Moreover, the results of the Jarques-Bera test of normality for model (7) ($p>0.178$) indicates that we can accept the null-hypothesis of normality. To test for multicollinearity, correlation tests were run, the results in Appendix 2 show that the models do not suffer from multicollinearity. Finally, to test the assumption of homoscedasticity, the Breusch-Pagan rather than the White test was run. The Breusch-Pagan test is designed only to detect linear forms of heteroskedasticity. The results show that model (6) does suffer from heteroskedasticity ($p>0.000$), whilst model (7) does not. Hence, for model (6), to solve heteroskedasticity, I ran the estimations with robust standard errors.

4.4   Chapter Summary

In this chapter the methodology for how to construct a financial inclusion index and three OLS regressions are discussed. Moreover, the data sources used to construct the indices and the other variables are presented and the descriptive statistics are discussed. Moreover, the strategy for dealing with data limitations such as missing data is elaborated on. Finally, the robustness and model tests conducted are discussed and the results are presented.

5   Results

This chapter presents the results of the study in three sections. In section 5.1, the financial inclusion indices and the rankings of the 16 SSA countries are presented and discussed. In section 5.2, the main results from the econometric assessment of the relationship between financial inclusion and growth, are discussed. Finally, section 5.2 will be dedicated to the econometric evaluation of the relationship between financial inclusion and income inequality.

5.1   Financial Inclusion Index Scores for 2014 & 2017

The IFI captures data from various financial inclusion indicators into a range between 0 and 1, where 0 signifies complete financial exclusion and 1 indicates complete financial inclusion. Sarma (2011) defines high financial inclusion countries as those with a value between 0.5 and 1, and medium financial inclusion countries have a value between 0.3 and 0.5, and the low financial inclusion countries have values below 0.3. Table 3 presents three newly constructed financial inclusion indices for 16 sub-Saharan African countries for the separate years 2014 and 2017. The index is constructed so that for each given dimension, the min and max values are taken. Hence the index might change for different points in time and if the number of countries included changes. Thus, the index is constructed dynamically and is highly relative to the prevailing situations in the economies included in the index. For example, in table 3, South Africa's high value of 0.99 (TFI in 2014) is vastly dependent on the other countries included in the index.

In table 3 Kenya is in the top five countries for each of the three IFIs and ranks number 1 for FFI both in 2014 and 2017. Botswana and South Africa are interesting cases as they ranked high in the CFI in 2014, yet they performed worse in 2017. Nevertheless, they are still in the top five ranking economies. Both Botswana and South Africa's strong rankings are driven by high scores in the traditional index rather than the digital. Another interesting economy is Namibia, which had a CFI score of 0.43 during 2014 ranking as number 4, whilst in 2017 it has the highest score of 0.71 and ranked number 1. In both the digital and traditional IFI, Namibia improves from 2014 to 2017. The reverse is true for Nigeria, which had poorer performance in all indices between 2014 and 2017 and moves from a medium to a low financial inclusion country. Several west African economies such as Togo, Republic of Congo, Benin, and Cameroon consistently are ranked as low financial inclusion countries with rankings below 0.22. In economies such as Rwanda, Uganda and Côte d'Ivoire, the increase in digital financial inclusion coincides with the fall in the traditional index, suggesting that mobile payments replace cash transactions.

Table 3 - The three indices of Financial Inclusion for 16 SSA Countries

Index of Financial inclusion - scores and rankings for countries (2014 and 2017)

Comprehensive Financial Inclusion					Traditional Financial Inclusion					Fintech-driven Financial Inclusion				
Country	2014	Rank	2017	Rank	Country	2014	Rank	2017	Rank	Country	2014	Rank	2017	Rank
Kenya	0.68	1	0.68	2	South Africa	0.99	1	0.66	2	Kenya	0.92	1	0.87	1
Botswana	0.59	2	0.43	4	Botswana	0.69	2	0.48	4	Botswana	0.50	2	0.35	10
South Africa	0.57	3	0.55	3	Namibia	0.64	3	0.96	1	Uganda	0.45	3	0.48	3
Namibia	0.43	4	0.71	1	Kenya	0.55	4	0.57	3	South Africa	0.39	4	0.40	6
Uganda	0.36	5	0.33	8	Nigeria	0.46	5	0.35	6	Côte d'Ivoire	0.26	5	0.36	9
Nigeria	0.31	6	0.28	9	Zambia	0.29	6	0.35	5	Namibia	0.26	6	0.52	2
Zambia	0.27	7	0.38	5	Uganda	0.27	7	0.23	9	Zimbabwe	0.24	7	0.47	4
Rwanda	0.25	8	0.26	10	Rwanda	0.25	8	0.19	13	Zambia	0.23	8	0.39	7
Ghana	0.22	9	0.38	6	Ghana	0.22	9	0.34	7	Rwanda	0.23	9	0.37	8
Zimbabwe	0.21	10	0.34	7	Rep. Congo	0.17	10	0.15	14	Ghana	0.18	10	0.43	5
Côte d'Ivoire	0.21	11	0.19	15	Zimbabwe	0.16	11	0.25	8	Nigeria	0.17	11	0.15	15
Rep. Congo	0.15	12	0.14	16	Côte d'Ivoire	0.13	12	0.09	16	Senegal	0.12	12	0.32	11
Senegal	0.13	13	0.22	12	Benin	0.12	13	0.22	10	Cameroon	0.11	13	0.22	13
Benin	0.12	14	0.22	13	Senegal	0.12	14	0.15	15	Benin	0.11	14	0.21	14
Cameroon	0.12	15	0.21	14	Cameroon	0.11	15	0.19	12	Rep. Congo	0.10	15	0.11	16
Togo	0.10	16	0.23	11	Togo	0.10	16	0.20	11	Togo	0.08	16	0.25	12

Notes: Number of depositors with commercial banks per 1,000 adults (Access) missing for 2017 in Kenya, replaced with 2014 number
Number of registered mobile money accounts per 1,000 adults (Access) missing for 2017 in South Africa, replaced with 2014 number
The rankings for each year is independent from previous years

Source: estimations made by author

Hence, the results show that there is considerable variations between the SSA countries and that large economies such as Nigeria, Botswana and South Africa, which are heavily reliant on traditional financial inclusion, are performing worse in 2017 contra 2014.

Moreover, although fintech-driven financial inclusion has increased, the adoption of mobile money varies across the studied countries. In figure 4 it is illustrated that TFI has been fairly stagnant with a 1-point average increase over the period, whilst FFI has increased by a 10-point average. The high accumulation of FFI is driven by Kenya, Uganda, Zimbabwe, Senegal and Côte d'Ivoire, where the share of adults with a mobile money account is larger than the share with financial institution accounts (see figure 3).
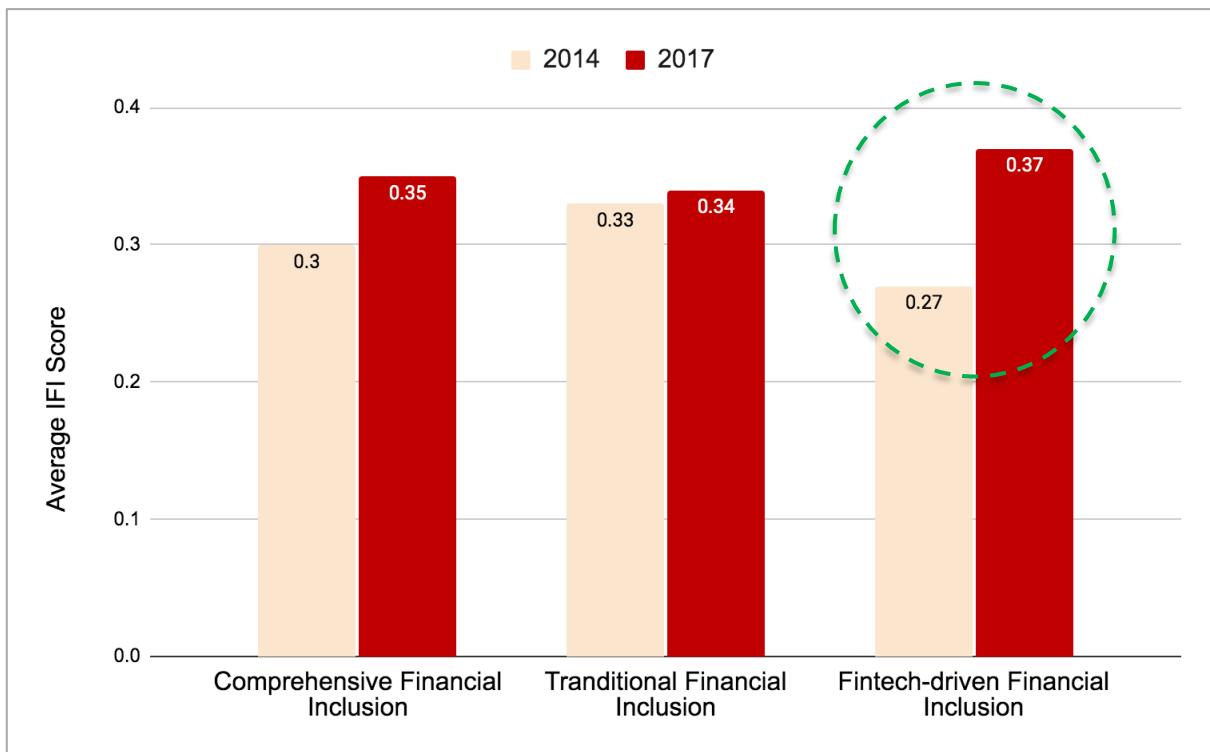
Source: author's own creation

Figure 4 - Average score of financial inclusion across 16 SSA countries

5.2   The effects of Financial Inclusion on Economic Growth

This empirical study found that between 2014 and 2017, financial inclusion had a positive effect on economic growth. The results in table 4 follow Sahay et al.'s (2020) model of computing a standard cross-country OLS regression model to identify the impact of fintech-driven financial inclusion on economic growth. The model assesses the initial level of traditional and digital financial inclusion and the control variables in 2014 to subsequent average economic growth.

Although the results show a positive correlation between fintech-driven financial inclusion and economic growth, the results are only significant in estimation 2. A one-unit increase in FFI is associated with a 0.176 unit increase in average GDP growth at a 10 % significance level. Surprisingly, when including variables for the degree of financial development, financial depth, and other control variables, FFI loses its significance. In estimation (5) in table 4, the association becomes a negative one. Sahay et al. (2020) got more convincing results with a significant positive correlation between FFI and economic growth. However, they looked at a larger timespan and a larger sample of countries across different regions in the world.

Table 4 - GDP Growth and Initial Financial Inclusion (Model 5)

Variables	(1)	(2)	(3)	(4)	(5)
	Dependent variable – Average Real GDP growth rate (2014 – 2017)				
CFI 2014	0.082		0.070		
	(0.096)		(0.137)		
TFI 2014		-0.077		-0.257	-0.982
		(0.077)		(0.165)	(0.495)
FFI 2014		0.176*		0.166	-0.046
		(0.094)		(0.096)	(0.160)
GDP per capita log			-0.052	0.006	0.200
			(0.031)	(0.042)	(0.117)
Inflation			0.004	0.006	0.009
			(0.005)	(0.004)	(0.006)
Gov. Exp			0.005	0.003	-0.022
			(0.006)	(0.006)	(0.020)
FDI			-0.007	-0.008	-0.005
			(0.006)	(0.006)	(0.008)
Dom. Cred log			0.004	0.056	0.369
			(0.067)	(0.070)	(0.229)
Region					
West Africa					-0.268
					(0.162)
South Africa					-0.085
					(0.089)
Central Africa					-0.228
					(0.128)
Constant	-0.020	-0.019	0.304	-0.214	-1.859
	(0.033)	(0.029)	(0.251)	(0.370)	(1.033)
Observations	16	16	16	16	16
R-squared	0.050	0.212	0.476	0.627	0.783

Notes: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. CFI is Comprehensive financial inclusion, TFI is traditional financial inclusion, FFI is Fintech-driven financial inclusion. GDP Growth and per capita is measured in current US$. Inflation, consumer prices (annual %). General government final consumption expenditure (% of GDP). Foreign direct investment, net inflows (% of GDP). Domestic credit to private sector by banks (% of GDP). SSA region dummies in estimation 5.

In order to conduct a deeper analysis of the relationship between financial inclusion and economic growth and assess the change in financial inclusion over the period, I modified Sahay et al.'s (2020) model to a log-log model including lags. I will be using a pooled OLS estimation where the control variables remain unchanged but will be lagged to ensure that the lag effects in the economy are captured. The results are considerably different to the results in table 4. In table 5, fintech-driven financial inclusion is significantly positively correlated to economic growth across all estimations. The results show that FFI is significantly positively associated with economic growth even when other determinants of financial inclusion are not included, see estimation (2) and (3). For example, in estimation 2, a 1% increase in FFI, leads to a 0.565% increase in economic growth at a 1 % significance level. Furthermore, one can conclude that when control variables such as the level of economic development and financial depth are included, FFI reaps greater growth benefits. For example, in estimation 5, a 1% increase in FFI, leads to a 0.805% increase in economic growth at a 1% significance level.

Table 5- GDP Growth and Change in Financial Inclusion (Model 6)

Variables	(1)	(2)	(3)	(4)	(5)
	Dependent variable – Logged GDP Growth (POOLED OLS)				
CFI log $(t-1)$	-0.335*			0.499**	
	(0.181)			(0.230)	
TFI log $(t-1)$		-0.833***	-0.694**		-0.937***
		(0.248)	(0.303)		(0.308)
FFI log $(t-1)$		0.565***	0.511**		0.805***
		(0.200)	(0.222)		(0.207)
GDP Capita log $(t-1)$			-0.154	-0.362**	-0.007
			(0.168)	(0.137)	(0.137)
Gov. Exp log $(t-1)$				0.130	0.212
				(0.438)	(0.315)
FDI log $(t-1)$				0.426*	0.304
				(0.219)	(0.190)
Inflation log $(t-1)$				-0.352***	-0.107
				(0.113)	(0.087)
Dom. Cred log $(t-1)$				-0.300	0.035
				(0.258)	(0.208)
Constant	0.842**	0.967***	2.218*	5.402***	0.577
	(0.316)	(0.194)	(1.306)	(1.352)	(1.721)
Observations	41	41	41	34	34
R-squared	0.083	0.325	0.336	0.513	0.679

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
CFI is Comprehensive financial inclusion, TFI is traditional financial inclusion, FFI is Fintech-driven financial inclusion. GDP Growth and per capita is measured in current US$. Inflation, consumer prices (annual %). General government final consumption expenditure (% of GDP). Foreign direct investment, net inflows (% of GDP). Domestic credit to private sector by banks (% of GDP).

Furthermore, traditional financial inclusion is significantly negatively associated with economic growth. In estimation 5, with a 1% increase in traditional financial inclusion, lead to a 0.937% decrease of economic growth at a 1% significance level. In estimation 4, the combined effect of traditional and fintech-driven financial inclusion is estimated. A 1% increase in comprehensive financial inclusion results in a 0.499% increase in economic growth at a 5% significance level.

5.3   The effects of Financial Inclusion on Income Inequality

Studies on financial inclusion and income inequality have found mixed results, some studies found a negative relationship whilst others found no significant effect of financial inclusion on income inequality. However, using the newly constructed index of TFI, figure 5 illustrates that there is a positive relationship between traditional financial inclusion and income inequality.
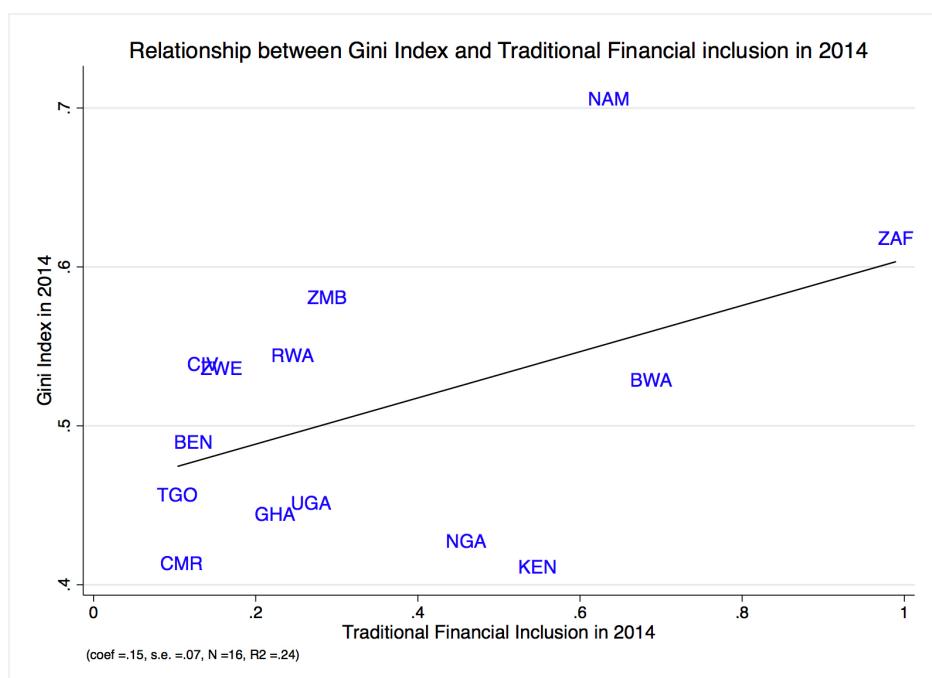

Source: author's own creation

Figure 5 - Correlation Between Traditional Financial Inclusion and Income Inequality

Economies such as South Africa, Botswana, and Namibia have a high GINI index, indicating greater income inequality whilst also scoring high on TFI. In contrast, with the newly constructed fintech-driven financial inclusion index figure 6 illustrates the opposite - a negative

relationship between income inequality and digital financial inclusion. These correlation results are quite singular, showing the importance of studying the determinants of financial inclusion in SSA.
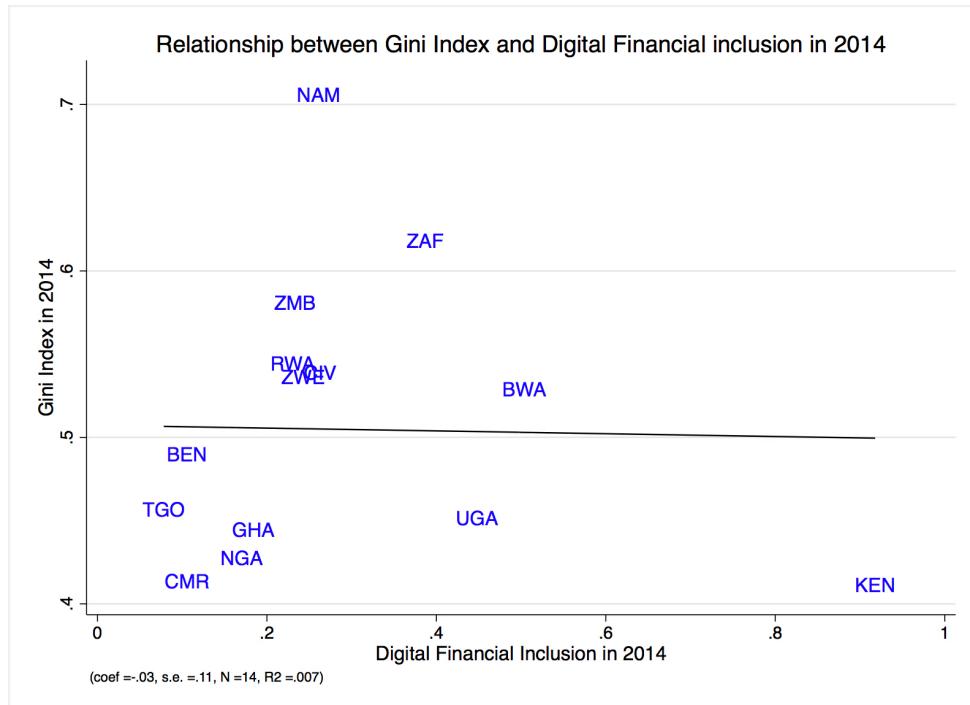
Source: author's own creation

Figure 6 - Correlation Between Fintech-driven Financial Inclusion and Income Inequality

Thus, to further test these relationships, a pooled cross-country ordinary least square (OLS) estimation was run and the striking but not surprising results in table 6 show that traditional financial inclusion is associated with higher income inequality, whilst fintech-driven financial inclusion has the opposite effect; that is, fintech-driven financial inclusion reduces income inequality.

In estimation 2, I simply assess the two measures of financial inclusion with income inequality. The result can be interpreted as follows; a unit increase in TFI is associated with a 49.6% (exp 0.403) -1) increase in income inequality at a 1% significance level. A unit increase in FFI is associated with a 23.4% (exp -0.267) -1) decrease in income inequality at a 1% significance level over the studied period. The positive relationship between TFI and income inequality and the negative relationship between FFI and income inequality remains robust after several sensitivity tests. I first control for macroeconomic variables such as log of GDP per capita, government expenditure, inflation and domestic credit (estimation 4).

Unexpectedly, government expenditure is positively associated with the growth of income inequality. A unit increase in government expenditure results in 1.9% (exp 0.019) -1) increase in income inequality. However, there is a negative relationship between domestic credit and income inequality, a unit increase in domestic credit results in a 9% (exp -0.095) -1) decrease

in income inequality. In estimation 5 two additional control variables are added (population growth and rule of law), the results show that rule of law is significantly positively associated with income inequality. As shown in estimation 4 and 5, adding control variables does not alter the initial results (estimation 2), which suggests that the effectiveness of financial inclusion on reducing income inequality depend not only on itself but also on other factors.

Table 6 - Income Inequality and Financial Inclusion in 16 SSA countries (Model 7)

Variables	Dependent variable – Logged Gini 2014 -2017				
	(1)	(2)	(3)	(4)	(5)
CFI	0.237**		-0.009		
	(0.104)		(0.109)		
TFI		0.403***		0.336**	0.332**
		(0.078)		(0.133)	(0.127)
FFI		-0.267***		-0.159*	-0.175**
		(0.094)		(0.085)	(0.081)
GDP per capita log			0.033	-0.013	-0.028
			(0.029)	(0.032)	(0.035)
Gov. Exp			0.020***	0.019***	0.020***
			(0.004)	(0.004)	(0.004)
Inflation			-0.001	-0.002	-0.005
			(0.003)	(0.003)	(0.003)
Dom. Cred log			-0.078*	-0.095**	-0.136***
			(0.044)	(0.046)	(0.047)
Rule of law			0.085**		0.088***
			(0.033)		(0.031)
Pop. Growth			0.003		-0.009
			(0.042)		(0.039)
Constant	-0.770***	-0.751***	-0.963***	-0.646**	-0.334
	(0.037)	(0.030)	(0.348)	(0.273)	(0.400)
Observations	64	64	64	64	64
R-squared	0.077	0.306	0.580	0.575	0.631

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Pooled OLS estimation. CFI is Comprehensive financial inclusion, TFI is traditional financial inclusion, FFI is Fintech-driven financial inclusion. GDP per capita is measured in current US$. General government final consumption expenditure (% of GDP). Inflation, consumer prices (annual %). Domestic credit to private sector by banks (% of GDP). Population growth (annual %). Rule of Law: Estimate.

5.4 Discussion

To facilitate the discussion, this section is split it into two sub-sections. Section 1 will discuss the results related to financial inclusion and economic growth, and section 2 will discuss the results related to financial inclusion and income inequality.

5.4.1 Fintech-driven Financial Inclusion drives Economic Growth

This study supports the first hypothesis that fintech-driven financial inclusion leads to positive impacts on economic growth in the SSA countries. The findings are consistent with Van, Vo. A., Nguyen and Vo. D. (2021), who found a positive relationship between financial inclusion and economic growth. Similar findings were also reported by Inoue and Hamori (2016), who found that financial access has a statistically significant and robust effect on increasing economic growth in SSA. Additionally, the results support the second hypothesis; that fintech-driven financial inclusion leads to higher economic growth than traditional financial inclusion.

Although the studies reported in table 7 may have used slightly different method and measures of economic growth the results show that financial inclusion leads to increased economic growth. Despite the studies not having separated traditional and fintech-driven financial inclusion we can compare the results. Van et al.'s study found that a one unit increase in financial inclusion leads to a 5 % increase in GDP growth, this was the strongest result of the studies listed in the summary. However, their study included a larger sample of high and low economy countries. Moreover, the results of this study show that a 1 per cent increase in fintech-driven financial inclusion leads to a 0.8 % increase in annual GDP growth which is higher than the results from Anand and Chhikara (2013) and partly higher than the results from Sethi and Acharya (2017), see table 7.

Nevertheless, the result that traditional financial inclusion has significantly negative relationship with economic growth was not expected. Yet, the result is partly supported by Sahay et al. (2020), who found that traditional financial inclusion does not contribute to economic growth. The explanation to their findings was that the effect from traditional financial inclusion had already been reaped prior to the period assessed in the analysis. In contrast, the positive impact of digital financial inclusion has only just started. However, Sahay et al. (2020) have a larger sample of 52 emerging markets and developing countries; thus, their results may not be entirely comparable with this study.

Another possible explanation for the negative relationship between traditional financial inclusion and economic growth is that out of the 16 SSA countries, my newly constructed financial inclusion data show that the countries with the highest traditional financial inclusion had a particularly bad performance in economic growth over the period. For example,

Botswana, Namibia, Nigeria and South Africa. Meanwhile, West African economies with the lowest financial inclusion scores, such as Benin, Cameroon, Côte d'Ivoire, Senegal and Togo performed well with average GDP growth of 5.9%, see figure 6.

Table 7- Summary of Financial Inclusion and Economic Growth Studies

Author(s)	Estimation and testing procedures used	Countries and period(s)	Results
Van et al. (2021)	Log-linear regression – they use the real per capita GDP as the representative variable of economic growth.	124 countries 2004 - 2015	A 1 unit increase in Financial inclusion leads to a 5 % increase in GDP Growth.
Sarma (2016)	Vector auto-regression regression. The GDP per capita is the dependent variable and financial access measured in terms of availability of bank branches and ATMs are the independent variables.	India 2004 - 2013	A 1 per cent increase in several geographic/ demographic indicators would raise the GDP per capita to nearly 2-4 per cent
Anand and Chhikara (2013)	Log-linear regression. Human development index (HDI) taken as a proxy of development.	49 countries 2007	A 1 per cent increase in the financial inclusion led to on an average 0.034 per cent increase in the value of HDI.
Sethi and Acharya (2017)	Panel time-fixed effect model. They use the real per capita GDP as the representative variable of economic growth.	31 countries 2004 - 2010	A 1 percent Increase in the level of financial inclusion leads to 0.22 per cent (in fixed effect) to 2.59 per cent (in time fixed effect) increase in real per capita GDP of an economy.
This study	Log-log regression. Dependent variable annual GDP growth, independent variables traditional and fintech-driven financial inclusion	16 countries 2014 - 2017	A 1 per cent increase in fintech-driven financial inclusion leads to a 0.8 % increase in annual GDP growth at a 1 % significance level. A 1 per cent increase in traditional financial inclusion leads to a 0.94 % decrease in annual GDP growth at a 1 % significance level.

It is difficult to explain the results yet; it is hard to argue that countries such as Republic of Congo, Benin and Togo already have *'reaped'* the benefits of traditional financial inclusion when their financial inclusion scores are very low. These findings raise intriguing questions regarding the nature of financial inclusion in SSA.
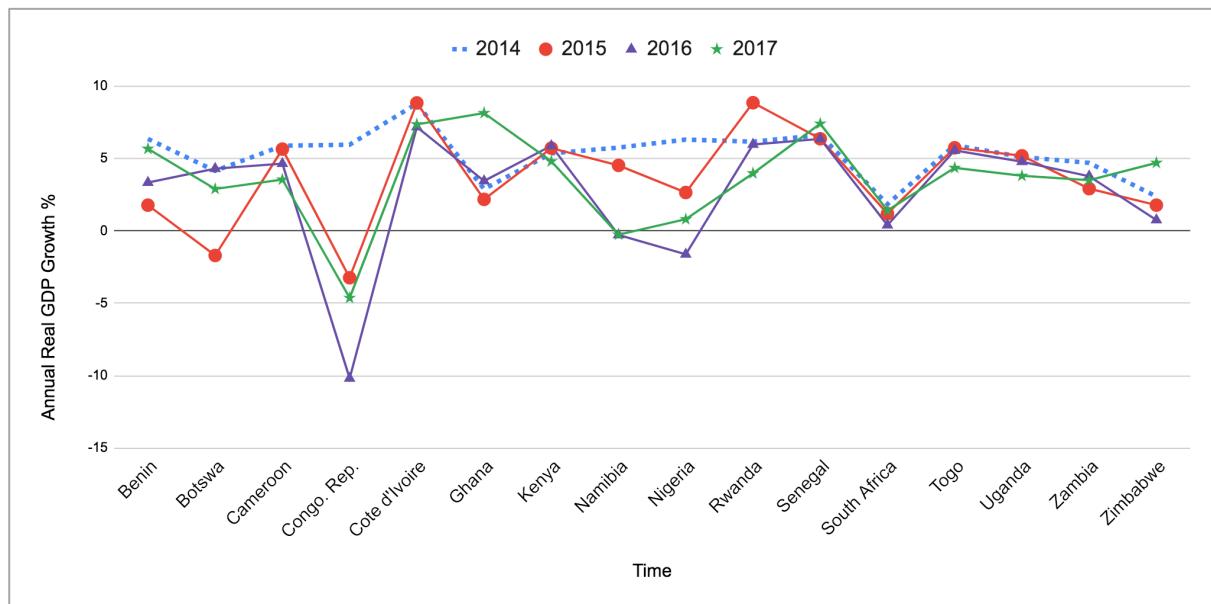
Figure 7 - Annual GDP Growth between 2014 and 2017 in 16 SSA Countries

Most studies agree that financial inclusion has a positive relationship with economic growth. Yet, as the results of this study show, it is essential to study the determinants of financial inclusion. This combination of findings provides some support for the conceptual premise that the financial sectors in West African countries have become deeper but not more accessible. The World Bank (n.d.) states that financial depth has a strong statistical link to long-term economic growth and closely related to poverty reduction. Hence, an implication of this is that traditional financial inclusion may not be the optimal policy instrument for increasing financial inclusion. Demirgüç-Kunt and Klapper (2012b) argue that some of the barriers to formal account ownership in SSA are costs, distance and documentation. Many people living in rural areas cite that the distances to a bank and insufficient documentation are barriers to opening a bank account. The other side of the coin is that poor infrastructure and communications, and heavy bank regulation, also restrict the geographical expansion of bank branches (Demirgüç-Kunt & Klapper, 2012b).

Anarfo (2018, p. 446) argues that the tripartite relationship between financial inclusion, financial sector depth and economic growth "appears to have escaped the knowledge of empirical researchers" and that, as a result, there is a limited understanding of the relationship. Hence, this is an important topic for further research. Moreover, policymaker and government should consider that financial inclusion and financial sector depth are complementary and design policies and strategies that assure the accessibility of finance to all members of society.

The findings of this study correspond with some of the policy recommendations suggested by Tita and Aziakpono. They argue that for growth to *'trickle-down'* to the grassroots level, universal financial inclusion should be prioritised as a development and poverty alleviation strategy by all SSA countries with a focus on fintech servicers such as mobile and agent banking to reduce high transaction costs. Moreover, they argue that M-Pesa in Kenya has demonstrated that financial inclusion of the rural poor is possible and that there is a need to re-think the current rural banking model. That is, the Kenyan model is worth emulation as it has proven that previously excluded rural areas can have safe and reliable access to savings and credit facilities.

5.4.2   Fintech-driven Financial Inclusion leads to less Income Inequality

As discussed in the literature review chapter, studies on financial inclusion and income inequality have found mixed results. Similarly, this study also found mixed results with important implications for reducing income inequality. First, the results demonstrate that fintech-driven financial inclusion leads to less income inequality in SSA; thus, hypothesis three was supported. Second, the result shows that traditional financial inclusion leads to higher income inequality. This finding is not consistent with the results obtained by other recent cross-country studies. For instance, Park and Mercado (2018b) also found mixed result, yet, contrary to this study, they did not find a significant positive link between financial inclusion and income inequality. Their results showed no significant association between financial inclusion and income inequality in middle and low-income economies. They argue that this may be since middle-low and low-income economies have features of their economies that impeded the effect of financial inclusion on income inequality. A possible explanation of the results is that in the countries with high traditional financial inclusion, the income distribution is quite unjust and that poor people may still largely be excluded from the financial sector.

Moreover, another unexpected result is that government expenditure is positively associated with the growth of income inequality, this result is not consistent with much of the literature. Guzi and Kahanec (2018) argue that expansion of the public sector and redistributive policies may reduce income inequality. However, another possible explanation may be that contrary to advanced economies where the cost of getting the public expenditure wrong is much higher (Lindert, 2004), developing nations spend less on public expenditure as a share of GDP hence it is less costly to get it wrong. Thus, one of the questions is whether the government expenditure in the 16 SSA countries is well distributed? Does increases in government expenditures or social transfers reach the poor? These are questions unanswered by this paper but might be an important topic for future research.

Furthermore, the result implies that rule of law tends to worsen income distribution in SSA countries. This finding is consistent with Omar and Inab (2020), who suggest that institutional reforms make the informal economy ineffective, which creates higher additional costs for the poor at the early stages of development while benefiting those in the formal sector, causing higher income inequality. However, enhanced institutional quality eventually leads to improving the efficiency of the whole economy and thus reduces income inequality.

In constructing two indices of financial inclusion, the findings of this study suggest that fintech drives financial inclusion in SSA. Due to the limited number of studies that have split

financial inclusion into traditional and digital financial inclusion indicators, it is hard to find comparable findings. However, the findings of Demir et al.'s (2020) study also suggest that fintech-driven financial inclusion have a negative association with income inequality. The result of this study provides some important policy implications. This study has shown that fintech-driven finance can be a powerful tool in reaching the unbanked. Policy choices such as whether using a telecom regulatory model or a bank-led model can determine whether you can attract users or not (Sy et al. 2019). Thus, the policy choices need to support fintech and digital financial services to help economies leapfrog to higher levels of development. Moreover, an investment in fintech must coincide with investments in infrastructure, telecommunications, appropriate (consumer protection) regulations and the increased availability of financial service.

5.5   Chapter Summary

The results in this chapter indicate that fintech-driven financial inclusion has a higher IFI score than traditional financial inclusion (see figure 4). Moreover, fintech-driven financial inclusion has a positive effect on economic growth whilst traditional financial inclusion has a negative effect on economic growth. Together these results provide important insights into the importance of the determinants of financial inclusion. Similar results were shown in the testing of the relationship between financial inclusion and income inequality. Where fintech-driven financial inclusion had a negative effect on income inequality whilst traditional financial inclusion had a positive effect. Thus, countries with higher traditional financial inclusion also had higher income inequality. In the discussion section the striking results are discussed and I attempt to explain the negative relationship between traditional financial inclusion and economic growth by referring to previous literature and my newly constructed data.

6   Conclusion

Theory suggests that financial inclusion accelerates economic growth and reduces income inequality, yet this study shows that the determinants of financial inclusion matter. This empirical research aimed to examine the impact of fintech on financial inclusion by constructing two separate measures to assess traditional and digital financial inclusion. This study has shown that fintech is a crucial enabler of financial inclusion and mobile financial services; thus, fintech-driven financial inclusion has the greatest potential to include the unbanked into the formal financial system.

The second aim of this study was to investigate the effects of fintech-driven financial inclusion on economic growth and income inequality by using a panel of 16 SSA countries with data from the FAS and Global Findex database across the years 2014 and 2017. Specifically, I examined whether fintech-driven financial inclusion led to economic growth and whether the association was more substantial than traditional financial inclusion. Surprisingly, the result showed that traditional financial inclusion had a negative rather than a positive association with economic growth in SSA. These findings will be of interest to policymakers and governments devising policies to bringing unbanked populations into the formal financial system. Evidence from successes stories such as Kenya demonstrated that financial inclusion of the rural poor is possible and that there is a need to re-think the current rural banking model in SSA that have low financial inclusion scores.

Furthermore, the investigation of the relationship between financial inclusion and income inequality has shown that countries with high fintech-driven financial inclusion also have lower income inequality than countries with high traditional financial inclusion. The pooled OLS regression analysis revealed that traditional financial inclusion is significantly positively related to income inequality. Hence, countries with high scores of traditional financial inclusions also tend to have a more unequal income distribution. An important area for future research is regional inequality, as SSA countries become more developed and incur structural change regional inequality might become exacerbated (Enflo & Rosés, 2015).

Three main conclusions can be drawn from the findings of the study. First, fintech-driven financial inclusion is a better strategy than traditional financial inclusion to bring the poor and rural populations into the financial system. Second, fintech-driven financial inclusion can contribute to economic growth in SSA. Third, fintech-drive financial inclusion reduces income inequality.

With financial Inclusion increasingly being seen as an essential tool in the implementation of the sustainable development goals the finding of this study contributes to the financial inclusion literature. It sheds light on the role of fintech-driven financial inclusion in promoting inclusive, sustainable development. The insights gained from this study lays the groundwork for future research into the determinants of financial inclusion and the various ways in which fintech may support a balanced sustainable development.

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Appendix 1 – Constructing an Index

Data sources

To construct the financial inclusion indices data from IMF and the World Bank was combined into one database in excel. Key variables related to access, availability and usage was investigated across 48 sub-Saharan African Countries. Across all of the variables listed in the table there were only 16 countries with data in both traditional and digital indicators.

Moreover, in the Findex database which is used for most usage variables data for the year 2011 was very scarce, hence the reference years will be 2014 and 2017.

Step 1.

Calculate traditional IFI for 2014
Apply formula (1) to each country and each of the 9 indicators. The formula normalizes the indicators and transforms the value of each indicator to between 0 – 1.

Step 2.

Calculate the coefficient of variation for each of the 9 indicators. Each indicator should have a CV which is then divided by the total CV of all 9 indicators to get the weight for each indicator.

Sep 3:

In step 3 I calculate the IFI for each dimension, that is the IFI for dimension access, dimension availability and dimension usage.

Step 4:

In step 4 we calculate the actual IFI, by calculating the weight of each dimension and the IFI for the three dimensions.

Appendix 1 – Descriptive Statistics of Index Indicators

Appendix Table 1 - Descriptive statistics Traditional Financial Inclusion

Summary of indicators composing the Traditional Financial Inclusion index

	Year 2014							Year 2017						
	Min	Max	Mean	St dev	CV	w_{ij}	w_{1-3}	Min	Max	Mean	St dev	CV	w_{ij}	w_{1-3}
Access							0.12							0.11
No. of depositors per 1.000 adults	66.57	1 614.57	0.24	0.28	1.15	0.12		82.98	1 686.7	0.28	0.27	0.99	0.11	
Availability							0.26							0.26
No. of ATMs per 100.000 adults	1.98	14.77	0.35	0.29	0.84	0.09		1.90	10.48	0.45	0.29	0.65	0.07	
No. of branches per 100.000 adults	3.58	65.50	0.19	0.31	1.63	0.17		3.98	70.43	0.20	0.33	1.64	0.19	
Usage							0.62							0.62
Financial institution account (%)	11.35	68.77	0.36	0.32	0.89	0.09		14.77	77.34	0.37	0.27	0.71	0.08	
Debit card ownership (%)	0.51	13.46	0.22	0.29	1.36	0.09		0.73	15.38	0.27	0.25	0.92	0.11	
Credit card ownership (%)	2.27	54.87	0.32	0.32	1.00	0.10		4.70	65.08	0.27	0.25	0.92	0.11	
% of adults received wages into account	1.92	26.27	0.26	0.29	1.10	0.11		3.04	29.18	0.26	0.28	1,06	0.12	
% of adults paid utility bills using account (%)	0.18	12.17	0.23	0.29	1.26	0.13		1.52	16.24	0.31	0.30	0.97	0.11	
% of adults saved at a financial institution	5.19	32.73	0.43	0.36	0.83	0.09		5.31	34.44	0.34	0.28	0.82	0.09	

Appendix Table 2 - Descriptive statistics Fintech-driven Financial Inclusion

Summary of indicators composing the Fintech-driven Financial Inclusion Index

	Year 2014							Year 2017						
	Min	Max	Mean	St dev	CV	w_{ij}	w_{1-3}	Min	Max	Mean	St dev	CV	w_{ij}	w_{1-3}
Access							0.15							0.15
No. of MM accounts per 1,000 adults	14.86	456.17	0.34	0.38	1.11	0.15		10.50	1164.6	0.40	0.33	0.81	0.15	
Availability							0.23							0.27
Mobile subscriptions per 100 inhabitants	55.18	163.29	0.35	0.28	0.79	0.11		60.6	155.23	0.41	0.29	0.73	0.14	
Percentage of individuals using the Internet	5.7	49.00	0.3	0.26	0.86	0.12		7.47	56.17	0.40	0.28	0.70	0.13	
Usage							0.62							0.57
Mobile money account (%)	1.41	58.39	0.37	0.31	0.84	0.12		5.61	72.93	0.42	0.27	0.64	0.12	
% of adults received wages through mobile	0.24	7.01	0.22	0.3	1.33	0.19		1.45	12.00	0.38	0.27	0.70	0.13	
% of adults paid utility bills using mobile (%)	6.9	69.12	0.37	0.3	0.81	0.11		17.81	78.96	0.42	0.27	0.64	0.12	
% of adults made or recived digital payments in past yr	0.14	18.56	0.17	0.25	1.44	0.2		1.00	37.10	0.21	0.23	1.04	0.20	

Appendix 2 – Description of Variables used

Appendix Table 3 - Description of Variables

Variables	Description	Source
Financial inclusion Indices (CFI, TFI FFI)	Measure of financial inclusion. Ranges between 0 (complete financial exclusion) to 1 (complete financial inclusion).	IMF FAS, WB GLOBAL FINDEX, WB WDI, see table 1
GINI Index	Measure of income inequality. Ranges between 0 (perfect equality) and 1 (perfect inequality).	SWIID
GDP growth	Annual percentage growth rate of GDP at market prices based on constant local currency.	WB WDI
GDP per capita	Gross domestic product divided by midyear population.	"
Gov. exp	General Government Final Consumption Expenditure (% Of GDP) General government final consumption expenditure includes all government current expenditures for purchases of goods and services. It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation.	"
Inflation	Inflation, consumer prices (annual %). Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	"
Dom. Cred	Domestic credit to private sector by banks refers to financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	"
FDI	Foreign direct investment are the net inflows of investment in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.	"
Ruel of Law	Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Ranges from –2.5 (very weak) to +2.5 (very strong).	WB WGI
Pop. Growth	Annual population growth rate expressed as a percentage.	WB WDI

Appendix 2 – Robustness checks

Appendix Table 4 - Robustness checks

Variables	(1) GDP Growth	(2) GDP Growth	(3) GINI (ln)	(4) GINI (ln)
TFI (t-1)	-15.736***	-19.009***		0.610***
	(5.086)	(6.241)		(0.211)
FFI (t-1)	6.077**	7.181**		-0.291***
	(2.459)	(2.720)		(0.102)
TFI			0.264*	
			(0.137)	
FFI			-0.157*	
			(0.084)	
GDP per capita (t-1)	0.000	0.001		-0.000*
	(0.000)	(0.001)		(0.000)
Gov. Exp (t-1)	-0.241**	-0.199		0.023***
	(0.113)	(0.124)		(0.005)
FDI (t-1)	-0.325***	-0.327***		-0.002
	(0.075)	(0.078)		(0.003)
Inflation (t-1)	0.120	0.138		-0.007
	(0.093)	(0.110)		(0.004)
Dom. Cred (t-1)	0.156***	0.170**		-0.006**
	(0.054)	(0.076)		(0.002)
Pop. Growth		0.504	-0.050	
		(1.459)	(0.056)	
Dependency R.		-0.013	0.004	
		(0.103)	(0.003)	
Pop. Density		0.007	0.000	
		(0.005)	(0.000)	
GDP per capita log			0.017	
			(0.048)	
Gov. Exp			0.020***	
			(0.004)	
Inflation			-0.004	
			(0.003)	
Dom. Cred			-0.090	
			(0.055)	
Rule of law			0.094**	0.093**
			(0.037)	(0.037)
Constant	5.979***	3.851	-1.074*	-0.945***
	(1.332)	(8.126)	(0.614)	(0.057)
Observations	48	48	64	48
R-squared	0.595	0.629	0.649	0.586

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Testing model 6 for normality of residuals, the null-hypothesis of normal distribution at a 5 % significance level is rejected (jarque-bera test). However, running graphical test (qnorm and histogram) one can see that the data is not perfectly distributed, yet it is acceptable

Model 6

```
. jb6 e
Jarque-Bera normality test:  8.829 Chi(2)  .0121
Jarque-Bera test for Ho: normality: (e)
```

.

Model 7

```
. jb6 e1
Jarque-Bera normality test:  3.452 Chi(2)  .178
Jarque-Bera test for Ho: normality: (e1)
```
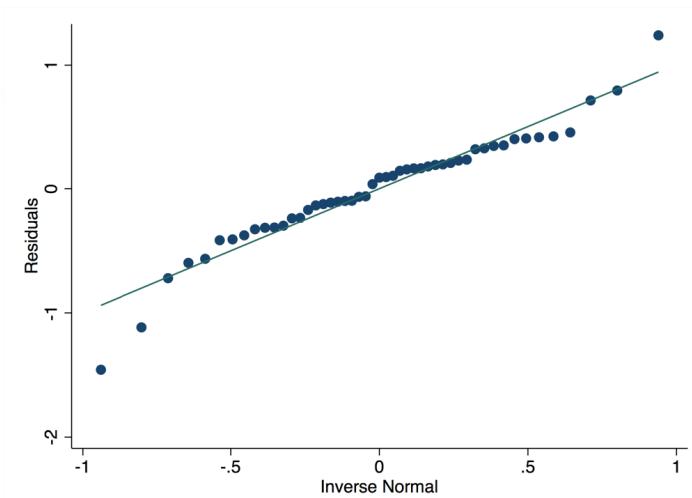

Appendix Table 5 - Correlation Matrix (Model 6)

Variables	GDP G. (log)	CFI (log)	TFI (log)	FFI (log)	Gov Exp. (log)	GDP per capita (log)	FDI (log)	Inflat. (log)	Dom. Cre (log)
GDP Growth (log)	1								
CFI (log)	-0.299*	1							
TFI (log)	-0.490***	0.918***	1						
FFI (log)	-0.0325	0.887***	0.640***	1					
GDP per capita (log)	-0.413**	0.482***	0.639***	0.203	1				
Gov Exp. (log)	-0.0664	0.206	0.308*	0.108	0.387**	1			
FDI inflow (log)	0.277	-0.312*	-0.283*	-0.270	-0.202	0.113	1		
Inflation (log)	-0.344*	0.560***	0.588***	0.390**	0.177	-0.144	0.162	1	
Domestic credit (log)	-0.272	0.441**	0.526***	0.295*	0.458***	0.696***	-0.354*	-0.0497	1

*p<0.05 ** p<0.01 *** p<0.001 / *Gov Exp. = Government consumption as a % of GDP

Appendix Table 6 - Correlation matrix (Model 7)

Variables	Gini (log)	CFI (log)	TFI (log)	FFI (log)	Gov Exp. (log)	GDP per capita (log)	Inflat. (log)	Dom credit (log)	Rule of law	Pop Growth
Gini (log)	1									
CFI (log)	0.277*	1								
TFI (log)	0.463***	0.882***	1							
FFI (log)	-0.00546	0.860***	0.539***	1						
Gov Exp. (log)*	0.691***	0.294*	0.441***	0.0635	1					
GDP per capita (log)	-0.0943	-0.0316	-0.169	0.142	-0.258*	1				
Inflation (log)	-0.0750	0.281*	0.290*	0.154	-0.271*	-0.177	1			
Domestic credit (log)	0.482***	0.583***	0.740***	0.320*	0.670***	-0.0236	-0.0864	1		
Rule of law	0.401**	0.509***	0.545***	0.306*	0.248*	0.155	0.301*	0.450***	1	
Population Growth	-0.477***	-0.423***	-0.568***	-0.157	-0.659***	0.0979	0.0674	-0.597***	-0.209	1

*$p<0.05$ ** $p<0.01$ *** $p<0.001$
*Government consumption as a % of GDP

Model 6

```
. vif

    Variable |      VIF     1/VIF
-------------+----------------------
  ln_trad_lag |    9.69    0.103223
 ln_dom_cre~g |    4.68    0.213650
 ln_inflati~g |    3.97    0.251678
 ln_gov_con~g |    3.62    0.276188
   ln_fdi_lag |    2.81    0.356119
   ln_dig_lag |    2.76    0.362106
  ln_gdp_cap~g |    2.47    0.405012
-------------+----------------------
     Mean VIF |    4.29
```

Model 7

```
. vif

    Variable |      VIF     1/VIF
-------------+----------------------
     trad_ifi |    8.76    0.114141
   gdp_capita |    5.39    0.185504
   dom_credit |    4.48    0.223246
     pop_growt |    2.88    0.346694
 gov_consum~p |    2.59    0.385666
    ruleoflaw |    2.05    0.488843
    inflation |    1.95    0.512664
      dig_ifi |    1.91    0.522505
-------------+----------------------
     Mean VIF |    3.75
```

Model 6

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of ln_gdp_growth

        chi2(1)      =     18.23
        Prob > chi2  =    0.0000

.
```

Model 7

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of gini_ln

        chi2(1)      =      2.20
        Prob > chi2  =    0.1381
```