UNIVERSITY OF CAPE TOWN

Digital finance and welfare in Sub-Saharan Africa

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by

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DECLARATION

I, Lebogang Mphefo, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree at this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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ABSTRACT

This research investigates the reliability of measuring the effect of financial inclusion on welfare in Sub-Saharan Africa (SSA) using the traditional financial inclusion index, which encompasses traditional access to financial services but does not necessarily represent the marginalised, as the majority do not make use of formal financial services. It is from this narrative that the study derives three financial inclusion indices – traditional financial inclusion, digital financial inclusion and comprehensive financial inclusion – using the three-stage PCA methodology to establish the influence of financial inclusion on welfare, and to add to the debate on the appropriate approach to measuring financial inclusion in the region. The traditional financial inclusion index is derived from traditional banking variables (the ATM and the branch), while the digital financial inclusion index employs mobile banking variables and the comprehensive financial inclusion index is a combination of digital and traditional financial inclusion indices used to compute the overall financial inclusion index. Welfare is proxied by the human development index and an inequality-adjusted human development index to establish the effect of inequality on welfare and financial inclusion. The fixed-effect regressions were conducted on a panel of 41 sub-Saharan countries for the years 2011, 2014 and 2017, to explore the relationship between traditional financial inclusion and welfare, while the pooled OLS methodology was adopted to enable multi-regression of digital financial inclusion, comprehensive financial inclusion and welfare in 2017, due to mobile data limitations on the demand side. Unemployment and bank credit ratio were included in the models to support the rationalisation of the results in alignment with the literature. The empirical findings indicate that digital financial inclusion and education are the main factors for improving welfare, and not necessarily national income – which was the case previously in the financial development era – because the digital financial inclusion index is the most optimal approach to calculating financial inclusion in SSA. On average, the traditional financial inclusion index is lagging, while the comprehensive inclusion index mirrors the movement of the digital financial inclusion index, and therefore reflects the dominance of digital inclusion in the region. However, overall financial inclusion (represented by comprehensive financial inclusion) is insignificant to welfare; implying that financial inclusion is low and the depth of financial services available on digital platforms is not at a level of significance to impact welfare immensely.

Inequality-adjusted welfare has a significant and positive relationship with traditional and digital financial inclusion when regressed with education, but not with income. This implies

that with education, inequality can be overcome through financial inclusion to yield improved welfare.

This study also shows the use of mobile banking to be higher in medium to large-sized informal economies. Lastly, unemployment is significant and positively related to welfare through digital financial inclusion and education, due to opportunities created in the informal sector.

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ABBREVIATIONS

ATM	Automated Teller Machine
Findex	Financial Inclusion Database
Fintech	Finance Technology
GMM	Generalised Method of Moments
GNI	Gross National Income
HDI	Human Development Index
HDR	Human Development Report
ICT	Information and Communication Technology
IHDI	Inequality-adjusted Human Development Index
IMF	International Monetary Fund
ITU	International Telecommunication Union
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
SSA	Sub-Saharan Africa

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Financial development in an economy is directly connected to the growth of industry in the economy, which theoretically leads to a reduction in poverty and increases the level of equality in the economy. Financial development is measured by growth in size, revenues and stability of the financial system of the country (Umar Sambo et al., 2021). Cheng, Chien & Lee (2021) further highlighted that financial development is an expected result of any economic policy by a country. This can often lead to geographical disparities and inequality in the region, which must then be addressed through financial inclusion and other policies. Geographical disparities arise due to income-level differences among the population, regional inaccessibility, the terrain of the regions, and economic policy choices made by the people.

Financial inclusion has been defined to mean including access to different financial services by every section of the population, equitably and affordably. Financial inclusion aims to reduce economic discrimination in a population. It is often supported by the regulatory framework and policies of the country (Ozili, 2021). Research by Bakari & Ibrahim (2018) showed that several factors such as inflation, interest rate, political stability, mobile banking, commercial bank branches, income and government expenditure can impact the rate of financial inclusion in a country, which can impact the entire monetary and fiscal policy mechanism. The level of technological adoption in the population, and their willingness to adopt financial services also impact the level of financial inclusion in the country.

Around the world, financial inclusion has been measured by the development of specific tools which measure the accessibility, usage, and affordability of financial services. The current models have adopted the level of technological development and innovation required to measure inclusion. American and European countries have a higher rate of financial inclusion (Demirgüç-Kunt, Klapper & Singer, 2017).

On the other hand, Jahan (2019) and other scholars have stated that countries in the Asia-Pacific region have varying rates of financial inclusion, due to a variety of factors such as industrial development and government policies. Thus, it is important to consider the factors that are

individual toeach country. Financial inclusion in SSA has been impacted by both individual factors, such as the age and income of the individual, and macroeconomic variables, such as the development of financial institutions and the level of national income in the country. Policy development thus becomes a complex topic (Asuming, Osei-Agyei & Mohammed, 2019). To add to this, Shahriar, De Jong and Shazia (2022) stated that the monetary policy adopted by the SSA countries can determine the impact of financial inclusion. The government must regulate both the traditional banking institutions and digital finance to ensure there is a balance between economic and scientific development in the region.

Financial inequality or income inequality has been defined as the uneven and irregular distribution of income in society. Such inequality can occur in a specific section of the population or also showcase gender and educational perspectives. Income inequality can also be the result of government taxation and expenditure policies (Cihak & Sahay, 2020). In addition, other scholars have asserted that financial inequality can lead to instability in the economy, and also increase the level of exclusion of people from mainstream finance (Botta, Caverzasi, Russo, Gallegati & Stiglitz, 2021). Income inequality is caused both in the household sector and in the industrial sector through the development of an informal economy.

Around the world, income inequality has been based on certain similar factors, such as the income, gender and educational qualifications of the population. Any attempt made by the government to combat inequality must address the multidimensionality of the challenges posed by inequality. This also indicates the presence of nonlinear impacts on financial inclusion (Fouejieu, Sahay, Cihak & Chen, 2020). Similarly, a study conducted by Navarro & Skirbekk (2018) suggested that income inequality can lead to various religious and political conflicts, which can result in instability in the nation. Hence any form of government must attempt to ensure a reduction in inequality rates. This becomes a major determining factor for policy development in conflict nations such as those in SSA. Financial inequality has been widespread in the SSA region, caused both by the lack of financial institutions in the region and by government policies as well. This is a country-specific aspect, however, because the different economies have adopted individual policies to address the growing inequality in the region (Meniago & Asongu, 2018). Furthermore, Asongu and Odhiambo (2019) added that income inequality in the SSA region has led to lower levels of technological development, which has led to a rise in poverty and unemployment compared to other regions of the world. Thus, it must be the priority of government to improve the equality ratio.

Financial welfare relates to the sustainable development of the income level of the individual. It is a concept interconnected with the overall welfare of an individual, including both social and political perspectives. Financial welfare policies are usually developed by government through collaboration with private industry (Weber et al., 2021). In a similar vein, French & Vigne (2019) added that financial welfare is a relatively individual concept which can be influenced by the policies of the government. The inability of the public to manage their finances can lead to a reduction in the level of financial welfare, even in developed countries. Globally, financial welfare has been considered a result of the development of financial institutions and of the literacy level of a country's population. However, these factors have been slightly reduced in importance with the growth of digital financial services, which have reduced the traditional barriers to accessing and using banking services (Zhong & Jiang, 2021).

Around the world, financial welfare was affected by the coronavirus pandemic (COVID-19) (IMF, 2020). But though the COVID-19 period reduced income level and employment, on the other hand it did increase the use of digital financial services, which is now improving the financial inclusion rate in SSA (Klapper & Miller, 2021). The adoption of digital finance services by the countries in the SSA region has significantly improved the level of financial welfare. However, the informal economy and limited education prospects are acting as major barriers. Governments must focus on a variety of aspects rather than just encouraging financial welfare (N'dri & Kakinaka, 2020; Acheampong, 2019).

Though there are studies that have examined the relationship between welfare and financial inclusion, no other study has unpacked an optimal approach to financial inclusion by incorporating the digital dynamics of the region and the influence thereof on the overall welfare of the population. Therefore, in this study the computation of financial inclusion from the traditional financial inclusion index – which is considered appropriate for developed economies – is expanded with the intent of establishing an appropriate measure for SSA, since the dynamics and challenges of the SSA economies are different. The analysis of welfare is also extended to include inequality-adjusted education, life expectancy and national income, so as to present a more realistic view of welfare in a region with high levels of inequality, which previous studies confirm is positively related to growth in national income in SSA (Obeng-Odoom, 2015; Tita & Aziakpono, 2017) . The correlation between income and inequality drives a change in the empirical approach to investigating welfare and inclusion, because income is

also an indicator of the human development index, which represents welfare; but in the SSA instance, income is counter-effective to inclusion.

1.2 Problem Statement

In recent years, financial inclusion has included traditional methods of banking and digital finance services (Kandpal & Mehrotra, 2019; Lutfi et al., 2021; Ozturk & Ullah, 2022). Countries in the SSA region face unique challenges when addressing the need for financial inclusion; but they also have definite opportunities with the development of digital financial services in the region (Ajide & Dada, 2022; Nsiah, Yusif, Tweneboah, Agyei & Baidoo, 2021). Therefore, the multidimensionality of financial inclusion and high inequality necessitates constant investigation into the distinct challenges of countries in the region to enable precision in the development of policies. The research aims to investigate three different approaches to financial inclusion indices – namely traditional, digital and comprehensive inclusion – with the intent of understanding the relationship between multiple variables from an African perspective, and establishing the optimal approach to financial inclusion in the region to reduce exclusion and improve the financial welfare of citizens at the same time. The latter raised the opportunity for an investigation into the appropriate input variables representing the marginalised in order to measure financial inclusion in SSA, with the intent of circumventing the inadequacy in existing methodologies to enable the implementation of suitable measures for welfare to be optimised.

1.3 Research Questions and Scope

Primary Question

i. What is the interaction between financial inclusion, inequality and welfare in Sub-Saharan Africa?

Secondary Questions

ii. What is the impact of digital finance on education and income in the SSA region, considering different human development models?

iii. What is the impact of the informal economy on the growth of digital financial inclusion in SSA countries?

The empirical results of this study provide a true reflection of financial inclusion progress in Sub-Saharan Africa and its impact on welfare, where welfare is based on the human development index and inequality-adjusted human development index. This could guide policy decisions on the effective infrastructure investments required to drive financial inclusion, which for the in-depth analysis offered by this study is represented by three indices: traditional financial inclusion, digital financial inclusion, and comprehensive financial inclusion.

The study aims to:

a) examine the impact of financial inclusion on welfare dimensions in sub-Saharan countries with the influence of digital technology;

b) investigate the consequences of inequality on digital financial inclusion and welfare dimensions in sub-Saharan countries;

c) validate the influence of digital financial inclusion on SSA economies, factoring in the informality of their market structures.

1.4 Purpose and Significance of the Research

Financial inclusion is an important aspect of financial policy, which currently involves both traditional and digital tools of finance (Duvendack & Mader, 2020; Le, Chuc, & Taghizadeh-Hesary, 2019). The utilisation of digital finance tools has created new opportunities in the SSA region, but has also raised new challenges, in the form of technological development and public adoption rate (Aziz & Naima, 2021; Yang & Zhang, 2020). The current study has found a significant literature gap regarding the effectiveness of traditional, digital and comprehensive financial policies in the SSA region. Thus, the findings of this study will contribute to this domain on both theoretical and practical grounds, and help to inform governments on the optimal approach for achieving effective progress in financial inclusion.

Theoretically, this study will contribute to determining the effectiveness of different models used in research which can be used to measure the efficiency of government policies (Ali, Raza, Raza, Din & Ul Abidin, 2018; Asuming et al., 2019; Hickel, 2020). It will contribute to the existing literature by advancing knowledge on the impact of various factors (such as unemployment, credit availability, education and income level of citizens) on the level of financial inclusion in the SSA region, which has not been covered using different human development models. It will also help future scholars to understand the role played by the informal economy in the region, and how financial inclusion could be intensified in such economies. The study will also contribute practically to the development of better financial inclusion policies by governments in the SSA region, to improve welfare. This research will also outline in a practical way the challenges faced and the opportunities that have arisen after the adoption of digital finance on the continent, contributing to better policy development, particularly in countries with high inequality.

This study demonstrates the imprecision and impact of calculating a financial inclusion index with traditional financial services input variables, which do not necessarily represent the financial involvement of marginalised people. The mentioned approach of utilising traditional financial services input variables limits the regression significance of important factors such as unemployment and welfare, which are challenges that must be tackled to realise the socio-economic development required in SSA. Empirically, unemployment demonstrates one of the scenarios outlined above, where traditional financial inclusion has a positive correlation to welfare, while unemployment is insignificant (Ofori-Abebrese, Baidoo & Essiam, 2020; Sarma & Pais, 2008). This current research, therefore, highlights that regressions of digital financial inclusion expand the significance of financial inclusion on unemployment, inequality, education and poverty, all dominated by the poor (Abor, Amidu & Issahaku, 2018; Aker & Mbiti, 2010).

Focusing on the marginalised, this study demonstrates that welfare – measured by the human development index, with the variables Income, Life Expectancy and Education – is improved by education and life expectancy when regressed with digital financial inclusion; because over time, African economies have experienced high inequality with the growth of income, and therefore inequality and income variables have been proved to be positively related, in an SSA context (Tita & Aziakpono, 2017). Because the beneficiaries of inequality are also the dominant participants in traditional financial services, that makes the traditional financial inclusion index

an inappropriate measure for gauging welfare of the marginalised. Thus, this research observes a significant positive relationship between digital financial inclusion and education, life expectancy and unemployment, while the effect of income is insignificant.

1.5 Organisation of the Study

Chapter 1 documents the background to the study, and presents the problem statement together with the questions, research objectives and hypotheses. Chapter 2 presents a justification for the study, citing literature to substantiate the need for the study and the variables used to produce a model using regression analysis, and substantiates the statistical approach adopted. It also includes existing econometric and economic theory and frameworks to support and strengthen the model from an economics perspective of the variables specified. Chapter 3 presents the methodology and procedures used for data collection and analysis. Chapter 4 describes the analysis of the data and presents the results from the models proposed and used in the research. Chapter 5 concludes, stating the findings of the study, giving policy and project recommendations, and suggesting recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

“Financial development” refers to the overall development of economic conditions in a distributed and sustainable manner. “Financial inclusion” also refers to the accessibility and availability of financial services in an equitable manner to different sections of the population, especially those with a poorer socio-economicbackground. Development and inclusion often span different sectors, and also impact future generations. Financial inclusion is developed through the involvement of different agents, including government and private authorities. Financial inclusion requires the creation of new services and the transformation of existing traditional services (Dewi, Febrian, Effendi & Anwar, 2020). Digital finance has increased the scope of the financial ecosystem (Song, Su & Yang, 2022). It has helped to reduce the cost of business, and has also ensured that geographical barriers do not-retard the growth of financial inclusion in an economy. Digital finance aims to improve the financial existence of the population by bringing them into mainstream finance. However, it also brings to the fore newer challenges such as technological development and the reluctance of traditional banking institutions to accept newer technologies and further modify their products. Due to socio-cultural factors, the level of digital finance adoption is different in each country. In their study, Simatele and Kabange (2022) stated that the informal economy has a significant impact on overall poverty and financial inclusion in a country. Thus, countries around the world have started to develop unique policies to formalise the informal sector, while also attempting to ensure that the sector faces no adverse shocks during the transformation. This is done to sustain growth levels.

This chapter covers the literature of previous researchers regarding various aspects of financial development. Financial inclusion and the various opportunities and challenges faced in the SSA region have been discussed, including the various factors that contribute to digital finance and the opportunities it presents for SSA. The informal economy is a major part of the ecosystem in the SSA region, so it has various implications for the overall economy. This chapter also covers the various challenges of the informal economy in the SSA region, and the measures

currently being adopted by governments to address them. The theoretical framework for this study and its utilisation in the research are also discussed.

2.2 Theoretical Literature Review

Three distinct theories have been used by the researcher in this study, namely the theories of financial inclusion, digital finance and the informal economy. The literature on financial development provided context on the transition of finance ecosystems over time, allowing the researcher to evaluate the three theories in terms of fitness for purpose, both theoretically and quantitatively.

"Financial inclusion" means providing accessibility to and the availability of financial services to all sections of the population. The affordability of the services is also important, as higher costs may retard adoption, even if such services are easily available. This theoretical model considers different prospects, from education to employment opportunities, in economies around the world (Kling, Pesqué-Cela, Tian & Luo, 2020; Senzu, 2022). The model has been used by researchers to identify the various factors impacting financial inclusion in the SSA region, and thus can add to an understanding of the prospects of financial inclusion.

The relationship between financial development and financial inclusion has been described by a "U-shaped" model. This is due to financial development in the earlier stages creating an income gap, and leading to the growth of only selected firms in each industry in the economy. This growth is evidenced by the inclusive and equitable distribution of wealth caused by a rise in education and employment levels. This theoretical model postulates that the migration of rural workers happens during the first phase, leading to equitable development in the second phase (Beck, 2000; Ozili, 2018; Tita & Aziakpono, 2017). The model has been used to describe the multidimensional concept of financial inclusion in different countries of the SSA region, which all face different socio-economic and political challenges.

"Digital finance" means providing traditional services to the general population in a digital manner. It covers most areas of the finance spectrum, with the only difference being the medium chosen for the delivery of each service. This theory connects digital finance with the overall development of people, and thus the societal models created through this theory connect with the digital application of financial services (Chen & Yuan, 2021; Yu & Tang, 2023). This theory

was used by the researcher to identify the various opportunities and challenges faced in promoting digital finance across the SSA region, as digital finance has played an important role in financial inclusion and the reduction of poverty in regions affected by low growth and high unemployment. This theory also focuses on distinct financial services and the challenges faced in making them digital. Since it covers the challenge aspect, it becomes necessary to determine the way society is influenced by political and economic factors regulated by the government. This theory will allow the researcher to connect digital finance with socio-cultural conditions in the SSA region, and thus develop a comprehensive analysis of the present situation.

The informal economy has a distinct regulatory and economic structure, which often operates in parallel with the formal ecosystem regulated by banking institutions and the government. Another important aspect is that it doesn't operate based on a centralised structure; rather, it develops multiple structures within itself which operate in the same country but with limited influence from the country's government (Huang, Xue & Wang, 2020). The theoretical model will help the researcher to identify the reasons behind the growth of the informal economy and the challenges faced by the government in the formalisation of the economy in the SSA region (Etim & Daramola, 2020). However, the informal economy is unregulated; it operates under the institutional culture. Studies on informal economy identified different aspects of society from different social models and has then established the relationships between different variables. It reflects the interconnectivity of factors as well as the distinct impacts of each factor on the informal economy, making it relevant to consider new attributes such as digital finance (Heredia et al., 2022). The social models ensured that the researcher could identify the sociocultural aspects of the informal economy, and the challenges that governments in the SSA region face when incorporating digital finance and growing financial inclusion.

The theoretical models were initially used to explain the scope of financial development, which has resulted in different activities such as financial inclusion and digital finance.

Asongu (2015) defined financial development as a framework, with financial depth, access, efficiency and stability as proxies for an efficiently functioning financial system facilitated through two components: financial institutions and financial markets. Depth is measured by money supply (M2, deposits, financial institution assets or credit) within financial institutions; access includes branches, bank accounts, and firms with credit; efficiency refers to profitability, net interest margin and lending-deposit spread; and lastly, stability is measured by liquidity

ratios, Z score and capital adequacy ratios Asongu (2015).. Theoretically, financial development is a driver of economic growth through efficient allocation of capital, ease of trading, better risk management, reduction of information asymmetries and transaction costs monitoring, and also enables products which households can use for security or investment diversification. Most importantly, it is acknowledged to reduce inequality and produce better welfare through financial inclusion (Naceur & Zhang, 2016).

Financial structure is an important factor in determining the level of financial development. Certain structures are more suited to ensuring development than others. A system with a sustainable stock market usually provides better chances of development than other financial institutions (Valickova, Havranek & Horvath, 2015). But some researchers disagree with this concept; they consider the legal environment of the country and other economic factors such as economic policy to be responsible for financial development. This theory assumes that financial structures develop after there has been sustainable development which attracts private citizens to the country, and also promotes the assumption that firms would not be able to grow faster, or that the economy would experience an abnormal growth rate, if financial structure is developed suddenly, with the assistance of foreign countries. A country must travel its own path of development; but external support may help in smoothing the process (Maksimovic, Beck, Demirgüç-Kunt & Levine, 2000; Valickova et al., 2015).

However, though financial development has improved in some countries in the SSA region, it did not translate into the expected equitable economic growth. Instead, the robust economic growth of 2005-2015 came with major challenges; inequality grew, and wealth concentration became visible in the majority of the industries and sectors over the entire region (Obeng-Odoom, 2015; Tita & Aziakpono, 2017). This growth has been described as rising wealth in the economy, with an increase in unemployment and poverty levels across the region (Obeng-Odoom, 2015; World Bank Group, 2020). South Africa, Nigeria and Zambia are examples where unemployment, inequality and poverty increased due to exclusive growth. Research conducted in SSA by the World Bank confirmed that an increase in income inequality is associated with more widespread poverty (World Bank Group, 2020). However, there have been where poverty decreased although inequality has increased; this occurs when growth in mean consumption is significantly large to offset rising inequality (Beegle, Christiaensen, Dabalen & Gaddis, 2016).

These examples demonstrate that improvement in financial development and economic growth alone are not necessarily a solution that will reduce poverty in a region with high inequality. For that reason, further investigations were conducted by scholars to substantiate how financial development can be enhanced to address the challenges experienced in SSA, since the region inarguably has weak financial systems and high levels of inequality (McIntyre, Obse, Barasa & Ataguba, 2018). From various studies it is clear that SSA generally has underdeveloped financial systems with illiquid stock exchanges (Beck, 2000; Demirgüç-Kunt & Klapper, 2012; Mengistu & Saiz, 2018; Valickova et al., 2015). With the exception of South Africa, African stock exchanges are small, measured by the ratio of market capitalisation to GDP – only 38% on average, as compared to 44% in all other developing economies and 62% in high-income economies (Demirgüç-Kunt & Klapper, 2012; Maksimovic et al., 2000). Researchers have argued that the development of stock markets will ensure the economic growth of the region by ensuring finance is accessible to the corporate sector (S. K. Acaravci, Ozturk, & Acaravci, 2009). However, several scholars have counter-argued that financial inclusion will ensure the growth of stock markets, demonstrating that the relationship is a complex one (Kodan & Chhikara, 2013). Over time, research has progressed; financial inclusion has been confirmed to be the financial development approach for sustainability (Thathsarani, Wei & Samaraweera, 2021).

A study by Mallick & Zhang (2019) identifies financial inclusion and financial development as two separate but highly correlated concepts. They define financial inclusion as a micro-level measurement of financial services usage by households and businesses, where relevant and affordable financial products are tailored to meet the payments, credit, insurance and savings requirements of their customers sustainably, while financial development is identified as the process of establishing efficient financial institutions with reduced transaction costs, easy access to and low cost of information, enforcing contractual obligations in a competitive market (Mallick & Zhang, 2019). Though described by Mallick and Zhang (2019) as the micro-level measurement of financial services, financial inclusion has a macroeconomic effect – it is a tool for achieving sustainability and inclusive economic growth with poverty reduction and increased income equality and employment, in both developing and advanced countries (Omar & Inaba, 2020).

Inclusive development and financial inclusion have become popular topics in meetings between global players (World Bank Group, 2020). A study by Asongu & Odhiambo (2019) referred

to quality growth, inequality and poverty as measurements of inclusive development, which can be improved by financial inclusion. The effectiveness of financial inclusion is dependent on other factors to reduce poverty and income inequality (Omar & Inaba, 2020; Cámara & Tuesta, 2014). Thus, though there are different models for estimating the level of inclusion, it is generally agreed that inequality between different sections of the population is the major challenge in the SSA region. It requires dedicated effort from both government and financial institutions to address the existing differences and ensure sustainability in the region by promoting financial inclusion (Regional et al., 2019). Scholars are investigating the conditions of existence and correlation between variables to understand the role of and extent to which financial inclusion, particularly in SSA, can tackle welfare and inequality challenges. This explains the need for this study and for further investigation into economies such as those of South Africa, Namibia and Botswana, where though the financial systems are mature, education and inequality levels have not satisfactorily improved welfare and reduced poverty to the expected levels.

Financial inclusion is an important concern for people around the world; however, it is hard to construct a mathematical model defining financial inclusion. The two major reasons are the multidimensionality of various concepts, and the complex relationships between the variables. Traditional econometrics and the randomness of variables are used by researchers to define these relationships. This has led to each country adopting a different model, according to the needs and expectations of the population (Demir, Pesqué-Cela, Altunbas & Murinde, 2020; Honohan, 2007; Mallick & Zhang, 2019; Matekenya, Moyo & Jeke, 2021; Ofori-Abebrese et al., 2020; Okoli & Tewari, 2020; Sarma & Pais, 2008). However, every model takes into account the limitations of the traditional finance system in serving the needs of poor people in their economy.

The SSA region is made up of countries with different socio-economic conditions; thus it is important to understand the complexities of financial inclusion, as every country has a different social policy and every government has different objectives. The socio-economic condition of a country is influenced by the quality of governance, which is acknowledged to be vital in achieving crucial socioeconomic development results (Fagbemi, Nzeribe, Osinubi & Asongu, 2021). “Undesired socioeconomic conditions” refers to factors impacting social and economic standing, such as poor education, poor health, poverty, unemployment, religious discrimination, political unrest and corruption. A study by Asongu and others (2021) confirmed institutional

issues in many countries in SSA to be the reason for their poor socioeconomic conditions; there is also a lack of effective governance for promoting the required socioeconomic conditions. Other research has suggested that lack of institutional development and political challenges in the economy highlight different aspects of the relationship. This implies that unless conditions are improved, no measures of financial inclusion will ensure a reduction in income inequality. This is a major challenge for both firms and policymakers, who must work in the ecosystem defined by political variables but still ensure sustainable development to meet the needs of the people (Sawadogo & Semedo, 2021). However, in some countries in the region financial inclusion brought changes in other aspects of the economy, including the social and political structure of the country (Sawadogo & Semedo, 2021). The problem could be eliminated by good governance and public institutions making the government more transparent and accountable, to ensure overall growth in a controlled ecosystem. Changes in government policy must take sociocultural aspects into account, and not adopt the principles of western countries and other institutions in the world directly (AFDB, 2019). This study contributes to the body of knowledge in this area by observing countries such as Mauritius, with the lowest poverty rate in SSA (less than 10%) and low inequality, to provide strategic insights for addressing these problems in other SSA countries.

According to a study by Sawadogo and Semedo (2021), SSA countries demonstrated a 69.6% probability of being classified as countries where financial inclusion does not significantly impact income inequality because of quality of institutions; this category included Côte d'Ivoire, Cameroon, Congo Republic, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Niger, Nigeria, Rwanda, Senegal, Sao Tome and Principe, Eswatini, Seychelles, Tanzania and Zimbabwe. Those with a 30.4% chance of realising the desired outcome, where financial inclusion reduces income inequality, were Benin, Burkina Faso, Botswana, Cabo Verde, Namibia, Uganda and Zambia (Sawadogo & Semedo, 2021). There's a thought-provoking alignment between the two studies which emphasises the need for analysis of inclusive growth and financial inclusion that’s is cognisant of weak public institutions, inequality, and poor financial systems (Sawadogo & Semedo, 2021; Tita & Aziakpono, 2017). A study by Allen (2014) validated this analysis, in that GDP per capita and institutional development (measured by the KKM index) were positively related to financial development and financial inclusion.

The limited access to banking in SSA countries contributed to the concentration of wealth and to poor people becoming more dependent on traditional services, which led to the growth of the informal economy (Tita & Aziakpono, 2017). The business ecosystem in the economy and digital services determine the level of financial inclusion. The banks also impact financial inclusion, through various tools which determine the rate of savings and investment in the economy. However, the impact of the banking system is limited, as it is constrained by the legal ecosystem and political structure of the country. But seven factors simultaneously and considerably impact financial development and inclusion: total bank accounts, total loans given, availability of institutions throughout the country, level of savings and investment in the -country, customer perceptions, and government policies, both economic and general (Tita & Aziakpono, 2017). In addition to these, the lack of adequate information in the population regarding the different credit schemes, banking tools and financial systems impacts the level of financial inclusion, especially in the remote regions of SSA (Tita & Aziakpono, 2017).

The alignment of financial inclusion and financial development defined by Mallick and Zhang (2019) is employed in a sub-Saharan African study by Abeka and other scholars (2021), in which financial development was investigated through studying telecommunication investment. Mobile money has transformed the accessibility and usage of financial services in SSA (World Bank Group, 2016). According to the World Bank, eight out of 10 people in the developing economies own a mobile phone. SSA leads the world in the adoption and penetration of mobile money (Sy, Maino, Massara, Saiz & Sharma, 2019). Therefore, mobile technology has great potential for extending the reach of formal banking systems in countries where most of the population remains unbanked (or informally banked) but owns a mobile phone (Allen et al., 2014; Demir, Pesqué-Cela et al., 2020). Mobile banking entails utilising mobile phones to facilitate the payment of bills and to receive or send money; and when money flows, more entrepreneurs have better access to the capital they need, therefore stimulating economic growth (Asongu, Governance & Roux, 2017; Asongu & Odhiambo, 2019).

Financial technology (fintech) organisations are at the core of digital finance; they help governments solve problems which can't be addressed by traditional banking institutions (Demir, Pesqué-Cela et al., 2020; Gosavi, 2018). In their study, Salampasis and Mention (2018) described fintech as "providing technology-based solutions and services to the financially excluded individuals around the globe, enabling entrepreneurial and innovative business models leading to social value and long-lasting impact". Digital finance provides solutions to

problems that traditional finance institutions face, such as high transaction costs and the inability to provide services to remote and vulnerable sections of the country (Demir, Pesqué-Cela et al., 2020; Moro-Visconti, Rambaud & Pascual, 2020; Suryono, Budi & Purwandari, 2020). Technological development has led to the broadening of the user base, by providing basic economic functions such as payment to shops as well as complex functions such as international transfers. This has also helped migrants. The growth of digital finance has been strongly affected by the increase in the number of mobile phones in the region. This has ensured that people with even the most basic infrastructure can also address their financial challenges (Okoli & Tewari, 2020).

Digital finance has also reduced the effectiveness of traditional banking institutions. The rise in the number of fintech companies has reduced the control that banking institutions have on the money supply. This is evident in developing countries around the world, where such institutions are challenging the banking regulations but still operate within the legal system of the country (Asongu, 2016). The development of digital finance has also affected the accepted definitions of inclusion and exclusion, by including various additional services in their domain. Currently, in fact, banks can be regarded as a threat to financial inclusion if they do not promote digital services to their customers swiftly and efficiently (Asongu, 2016). However, this also has major implications for the general population, because they must then access the knowledge and skills which will enable them to use digital services (Asongu & Odhiambo, 2019).

Access to financial services does not necessarily translate to usage, according to the Global Findex database; 760 000 of those with access do not use their accounts (Demir, Pesqué-Cela, Altunbas & Murinde, 2020). Accessibility to the services will not translate to inclusion if the public is not willing to use such services due to factors including their socio-cultural attributes as well as government perception towards such services (Demirgüç-Kunt & Klapper, 2012). But public adoption of a new system is directly related to the growth of digital financial services in the economy. The government should promote digital finance in its policies and programmes wherever it is applicable (Asongu & Odhiambo, 2019; Demir, Pesqué-Cela et al., 2020). The public must also have sufficient knowledge regarding the utility of the services, especially in lower financial inclusion areas (Romer, 1990; Zhao, 2020). This brings us to the importance of education, which has been discussed before. Adequate education is a major factor in ensuring people's willingness to utilise digital services (Zhao, 2020). Some researchers have connected the growth of education to the growth of innovation, which is then used by entrepreneurs to

challenge the problems faced by traditional banking institutions (Asongu, Governance & Odhiambo, 2019).

Technological progression is a representation of human capital; the two are complementary and interconnected, one cannot have one without the other. This is in line with the growth models used by Romer (1990), where advancement in technology is deemed to be the outcome of direct investment linked with human capital (Zhao, 2020). Countries with educated citizens normally enjoy a high rate of financial inclusion (Amendola, Boccia, Mele & Sensini, 2016). The literature shows that the level of education in SSA is relatively lower than in other regions in the world and creates major problems (Asongu et al., 2019; Zhao, 2020). Falling school enrolment and completion rates are reflective of the problem, and are thus an immediate priority for government (Regional et al., 2019). Thus, there is a need to improve the education system worldwide, and especially in SSA; the literature emphasises that a basic level of education and literacy is important for increasing financial inclusion through digital finance. Various researchers have argued that increasing the education level of poor and marginalised sections of the population can cause a major shift in the financial inclusion curve, in a positive direction (Zhao, 2020). This is important because the public is expected to have the general skills and knowledge required to utilise various digital tools (Asongu & Odhiambo, 2019). Education improves the ability to access different tools, which then helps to improve the rate of financial development in the economy (Matekenya et al., 2021; Sarma & Pais, 2008).

Rural regional studies have shown that people with limited access to education are more prone to exclusion from mainstream finance – even after government intervention – than people who already have a basic level of education; however, this relationship is now also observed in major urban settings and towns around the world (Matsebula & Yu, 2020). But financial inclusion alone cannot solve the problems in the economy; it must be done through various tools to ensure sustainable and equitable growth in the longer run (Demirgüç-Kunt & Klapper, 2012; Shipalana, 2019). Research by Tita & Aziakpono (2017) on the general equilibrium model indicated that the marginalised having direct access to financial services is not the most optimal channel for reducing poverty and income inequality and improving welfare; rather, the impact of access to finance can be vividly demonstrated through the indirect labour market channel, where investment by the poor through financial services is used to pay for the education of their children; in this way, future generations have a better chance of securing a decent job or becoming an entrepreneur, to break the poverty cycle and improve welfare. This model implies

that progression towards financial inclusion should ultimately lead to an increase in education with the possibility of decent jobs to curb unemployment.

Level of unemployment can also have an impact on the growth of digital finance in the economy, affecting poverty and inequality reduction. Government should focus on growing industry, which would promote the growth of the economy and act as a motivator for the adoption of financial services (Ofori-Abebrese et al., 2020; Sarma & Pais, 2008). During the COVID-19 pandemic, which posed a major threat to the economy, the growth of fintech organisations ensured the development of the economy and an increase in inclusion. In some areas of the world it also helped to reduce the gaps in financial inclusion caused by gender- and race-based discrimination (Sahay et al., 2020).

However, the traditional strategies of digital finance as an inclusion tool are not progressing to the extent expected in SSA. Firstly, there is a lack of proper infrastructure to support internet penetration across the region. Secondly, the banking industry is affected by a monopolistic market which prevents new entrants, and the current banking institutions have limited interest in expanding to the rural regions of the country (OECD, 2020). Furthermore, banks in an economy also compete for access to more clients and towards improving their financial position (Bakar & Sulong, 2018). To sustain themselves, banks may encourage practices that improve their financial position but negatively impact financial inclusion (Parlour, Rajan & Zhu, 2020). Banks can utilise their financing ability to influence the level of innovation in the economy, indirectly impacting many sectors as well as the financial development of the country (Hellwig, 1998). An accessible and affordable banking system is required to ensure the country can provide sustainable resources to entrepreneurs, who promote the growth of the economy by increasing employment (Demirgüç-Kunt & Klapper, 2012; Intermediation, Laeven, Levine & Michalopoulos, 2015). In the current system, the banks are more inclined to finance based on available resources, reducing the ability of poor people to grow financially with formal credit (Demirgüç-Kunt & Klapper, 2012). Thus, the traditional banking institutions can still impact the level of financial inclusion, by controlling the level of finance available in the economy. Government must create a balance between traditional banks and fintech organisations (Tita & Aziakpono, 2017); given the growth in internet availability, government has an enormous opportunity to ensure financial inclusion by adopting the strategy of direct interference in the banking sector (Asongu & Roux, 2017).

Inequality reduces the chances of growth, which leads to more inequality, thus creating a vicious cycle (Nanziri, 2017). There is also a correlation between financial inclusion and the ability to access finance, demonstrated in various studies (Honohan, 2007). An agricultural economy has different challenges to an economy that is transitioning into a more industry-based economy. It is true that certain agricultural societies have also accessed digital finance, but this has required a high level of dedication from government and the traditional banking institutions. Studies have also suggested that the age of the population, the jobs they perform, and the communities to which people belong also impact the level of adoption of different technological services in the economy. The credit accessible to the fintech organisations also impacts the level of digital finance, as they require capital to run their operations. Thus, multiple factors influence the level of digital finance, without even being directly connected to the general population (Amendola et al., 2016). However, some researchers have argued that access to credit is not an adequate measure for gauging financial access, because lacking a formal mortgage would prevent people accessing credit facilities even from traditional finance institutions (Amendola et al., 2016).

Some researchers have suggested that the gradual development of physical branches along with the expansion of digital services will ensure financial inclusion is covered, with digital finance growth. This would help in the gradual development of every sector of the economy (Bakar & Sulong, 2018). However, this method has not been particularly beneficial for the growth of digital finance institutions in developing countries (Shipalana, 2019). The IMF has suggested this is due to unbalanced growth, which is fuelled by competition. A proper plan is essential, for the growth of banking institutions and of the economy (Sahay et al., 2020). However, this has changed the models by which financial inclusion was being measured. The traditional modelsdid not accommodate the utilisation of digital tools for certain financial services traditionally delivered only by physical banking institutions (Demir, Pesqué-Cela et al., 2020). The functions of saving funds and accessing finance at different interest rates for varying periods are both being provided to customers through entirely digital applications that are available even on mobile phones. Technological inclusion has also ensured that geographical challenges are not a barrier to growth, which ensures the rural regions of a country can also be connected to mainstream finance (Demir, Pesqué-Cela et al., 2020). However, borrowing facilities have been minimally used in most underdeveloped and relatively poor countries. This is important to consider, as such countries would need to implement more targeted policies (Demir, Pesqué-Cela et al., 2020; Gosavi, 2018).

Digital financial services, especially through mobile applications, offer a solution to this major crisis in the SSA region. These services are often run by companies that receive financial assistance from foreign markets to ensure they are not affected by monopolistic competition in the countries in which they operate (World Bank Group, 2016). SSA currently leads the world in the pace of adoption of such mobile services (Sy et al., 2019). These application providers have a major chance to grow, due to the growth in the smartphone-using population as well as the lack of traditional banking institutions in the region (Allen et al., 2014; Demir, Pesqué-Cela et al., 2020). Digital banking services were developed initially to allow customers to pay for services in the region, but are gradually expanding to cover all the financial services of traditional banking institutions, including providing long-term finance to entrepreneurs (Asongu et al., 2019; Asongu & Roux, 2017). The prime example in SSA is Kenya, where the growth of technology-based payments has led to positive growth in the economy. Currently, a variety of services – including payment of bills, insurance and international fund transfers – can be done through mobile applications, throughout the country (Tita & Aziakpono, 2017).

Tito and Aziakpono (2017) state that mobile banking is popular among the poor due to its simplicity and to the low cost of basic transactions, such as payments. But unlike Kenya, most African countries (such as Ethiopia, Morocco, Nigeria, Mozambique, Rwanda and Zambia) are still in stage 1 of developing digital financial services, with basic transaction account access to conduct payments (Pazarbasioglu et al., 2020). Therefore, products that stimulate financial depth, such as credit facilities and investments, are not yet available on digital platforms due to technological advancement being in its infancy in most SSA countries; interestingly, however, the poor opt for informal methodologies to bridge the gap rather than utilising the traditional financial institutions such as banks (Nanziri, 2017). But the major challenge in the region is instability in the development of internet infrastructure, which has led to varying rates of adoption around the targeted countries (Asongu & Roux, 2017).

The regulatory ecosystem and the government of Kenya have been major examples of collaboration between government and fintech institutions to grow financial inclusion (Lewis, Villasenor & West, 2017). The Kenyan government has achieved a more than 80% adoption rate for different financial services through its digital applications, which is one of the highest rates globally. The Kenyan government utilised the COVID-19 pandemic as an opportunity to promote complex financial services to a population already using digital services, as well as

promoting basic services to vulnerable populations. The programme provided various services, from making bill payments to the repayment of loans (Sahay et al., 2020). This is a major lesson for other countries in SSA that still have very low levels of digital penetration. It would make sense for them to adopt the Kenyan system, as it is a country in the same region, facing many of the same challenges (Sarma & Pais, 2008).

The informality of economies is incorporated in the study as a moderating factor, because the economy in any country is dependent on both the formal and the informal sector; proper consideration must be given to both sectors by researchers (Allen et al., 2014). Thus the informality of economies in SSA is used by the researcher of this study to elaborate on observations made. Asongu (2013) agrees that the informality of economies cannot be ignored. A study on inclusive growth conducted by Amponsah, Agbola and Mahmood (2021) in SSA concluded that informality and financial inclusion are key to achieving inclusiveness, which will reduce poverty. However, it should be highlighted that though informality reduces poverty, it is unlikely to impact inequality in circumstances such as South Africa's where there is high unemployment (Cassim, Lilenstein, Oosthuizen & Steenkamp, 2015). Approximately 85.8% of the employed population in Africa works in the informal sector; in SSA, about two-thirds of total employment is in the informal sector (Mothobi, Gillwald & Aguera, 2020). Hypothetically, this means that job creation in SSA with wages in the informal sector contributes to inclusive growth and welfare. It is from this perspective that this research considers it beneficial to contextualise the above with an analysis of digital financial inclusion in economies in the region, ranging from most informal to least informal. This will establish whether informality drives the use of mobile money and drives inclusion, as mobile banking is observed to be stimulating the relationship between financial inclusion and the informal economy (Kelikume, 2021).

The IMF has stated that the informal economy in SSA is the largest in the world and has a revenue level on par with other countries having higher income levels. This represents a unique opportunity for government (Medina et al., 2017). Another interesting aspect is that some of the major economies in SSA are primarily oil exporters. They contribute much to the official GDP, but are also the major informal sector in the economy, operating with the help of the political ecosystem (Medina et al., 2017). According to the same study, oil-exporting countries with weaker political institutions have major informal economies closely aligned with the industry (Medina et al., 2017). If the industry is the biggest contributor to the country's revenue,

politically it becomes harder for the government to initiate major programmes for formalisation in this sector. The agricultural economy, on the other hand, is becoming more formal due to policies adopted by the European nations who are the major customers of the SSA countries. Thus the informal economy is not only growing, but changing in nature as well.

The informal sector in Africa includes large sections of the population who are not members of mainstream finance, whether voluntarily or otherwise. There are several reasons: cultural factors, the impacts of colonial racism, and the general unwillingness of the public (Makina, Fanta, Mutsonziwa, Khumalo & Maposa, 2015; Omar & Inaba, 2020; Shipalana, 2019). Studies have also highlighted suboptimal financial institutions and weak public institutions (including government) as major reasons behind the unprecedented growth of the informal sector (Sawadogo & Semedo, 2021; Tita & Aziakpono, 2017). The continued existence of colonial-era financial regulations in many SSA countries has led to the growth of the informal sector, as formal-sector institutions were often not provided with enough resources and opportunities to grow. This has caused the vulnerable section of the population to shift away from the government and organised sector (Tita & Aziakpono, 2017). Another challenge faced by governments is that they are not able to correctly estimate the assets of the public, which would help in the development of adequate schemes (Allen et al., 2014).

Digital finance was regarded as a major instrument for helping to create better economic opportunities. However, it also fuelled the growth of the informal sector, by providing easier-to-use tools to manage transactions. The major challenge faced in this context is not the limited availability of internet infrastructure, but the loopholes in the process which have allowed the development of the informal sector by putting the formal organisations in a disadvantageous position. Government must take steps to ensure the accessibility of digital finance within the broader spectrum of financial inclusion under the government, not in parallel with other banking institutions. Lack of adequate education and proper job opportunities are major factors causing significant disadvantages to the economy, more so than the existing informal sector, which is also a challenge (Beegle et al., 2016). Therefore, instead of eliminating informality, which might increase unemployment and negatively impact welfare and poverty, governments should allocate adequate funds to improve the functioning of the informal sector, because the development of the informal economy is positively correlated with poverty reduction (Amponsah et al., 2021; Cassim et al., 2015; Kelikume, 2021).

The traditional financial systems and institutions threaten the ideology of achieving inclusion in the informal sector, as they are not well equipped to meet these challenges. It requires effective collaboration among different stakeholders – including the government and corporate organisations, along with society in general. A study by Beck & Hoseini (2014) on the manufacturing sector in India confirmed that banks or formal financial institutions can reduce informality by removing barriers to entry into the formal economy; however, financial deepening had no impact at all on firms within the informal sector. In contrast, an investigation by Njangang, Nembot and Ngameni (2020) confirmed that governments can reduce the informality of economies by improving financial development through formal financing channels such as micro-credit, therefore higher levels of financial development might lead to a contraction of the informal economy. However it should be noted that formalising economies in SSA might be counter-effective in terms of improving welfare or poverty levels, because research has indicated that informality is a result of poor (or lack of) education (Cassim et al., 2015; Mothobi et al., 2020).

However, studies in some South Asian nations have noted that the informal economy is as big as (if not bigger than) the formal economy in that region. This presents a huge untapped opportunity for the government to promote financial inclusion (Thathsarani et al., 2021). Since this sector usually expands to most other industries, the formalisation must happen without interrupting the business procedures under which it is being done. This would ensure the existing economic situation is not lost in the attempt to secure a better financial position in the future (Thathsarani et al., 2021). Government must adopt a more comprehensive approach, under which the use as well as the challenges to both digital finance and financial inclusion, must be taken into account both the formal and the informal sector. This would ensure that the government is already taking steps to ensure financial inclusion before the formalisation is completed (Cámara & Tuesta, 2014). Time frames should also be considered before making any plans involving the informal sector. Firstly, policymakers must realise that it is not easy to change such structures within a limited period. This creates complexities that disturb the role played by the informal market in the economy, slowing down the rate of financial development. Such schemes must be developed over a long period, with proper focus on the role played by the financial institutions and the informal sector.

2.3 Empirical Literature

In the 2016 analysis conducted by the IMF (Naceur & Zhang, 2016), middle-income countries such as South Africa, Mauritius and Cabo Verde were shown to have expanded financial development beyond the banking sector over time, while oil-producing countries such as Angola, Congo Republic, Gabon, Cameroon, Equatorial Guinea, Nigeria and Chad had low financial development, because offshore investment is normally the source of funding for the oil production process and therefore the industry remains self-financed. Financial development can be described by a framework with proxies of financial depth, access, efficiency and stability for an efficient functioning financial system, facilitated through two components: financial institutions and financial markets (Asongu, 2015). However, though financial development has improved in some SSA countries, this has not translated into the expected equitable economic growth in the region.

Financial inclusion creates the possibility of ensuring sustainable growth, spread equally over and fulfilling the needs of various sections of the population, even in the presence of an imperfect credit market. The adoption of innovative systems which utilise digital technology has been the priority of governments in SSA, due to the ability of the digital ecosystem to solve the problems faced by traditional institutions across the region (Asongu et al., 2017). This necessitates the study of financial depth through telecommunication or mobile banking advancement, which is where countries such as Kenya bridge the knowledge gap (Beck & Hoseini, 2014). It is therefore the intent of this research to empirically investigate how financial inclusion can address the setbacks of financial development from an SSA perspective, where challenges such as inequality, unemployment, lack of education and poverty can be interrogated to substantiate observations in informal economies.

There is no universally accepted definition of financial inclusion, particularly from a quantitative perspective, since the concept is multidimensional in nature and multiple indicators or variables provide insight into financial inclusion. Most studies on this topic utilise the traditional econometric models: OLS (Ordinary Least Squares), IV (Instrumental Variables), fixed effects, random effects and GMM (Generalised Method of Moments), which assume consistency in the effects of financial inclusion distribution (Demir, Pesqué-Cela et al., 2020; Honohan, 2007; Mallick & Zhang, 2019; Matekenya et al., 2021; Ofori-Abebrese et al., 2020; Okoli & Tewari, 2020; Sarma & Pais, 2008). The impact of financial inclusion on welfare has

been shown to be weak in SSA by studies that have used the OLS technique on a sample of cross-sectional sub-Saharan data from the Global Findex to estimate the effect of financial inclusion on welfare (Ofori-Abebrese et al., 2020; Tita & Aziakpono, 2017). Though the econometric approach of both these studies was aligned, the variables utilised to explain welfare and financial inclusion were different, Ofori-Abebrese (2020) adopted the human development index (income, education and unemployment) as a proxy to represent welfare –` the same approach as Amendola and Zhang (2016) – and used the financial inclusion index, which followed the Sarma (2008) approach to determining the access, availability and usability dimensions of the financial inclusion index through the traditional banking variables ATM and branch.

Ofori-Abebrese (2020)showed 29 out of 33 sampled SSA countries to have low levels of financial inclusion, with a positive impact on welfare (proxied by education and income) while unemployment was insignificant. The current study analyses and validates the significance of unemployment using the mobile banking variables, which differentiates this study from previous studies. Tita & Aziakpono (2017) adopted the banking institution variables to gauge income inequality (Gini) which was used to analyse the level of inclusion in SSA, and showed an increase in income inequality when access to financial services is limited to a few individuals. It is therefore imperative to also evaluate the access of the masses to digital financial services, and how that impacts inequality and financial inclusion.

Seven explanatory variables – account ownership, account use for business, electronic payments, loans from formal financial institutions, formal loans for school fees, health insurance and formal savings – were used in the analysis to examine the effect of financial inclusion on inequality, which hypothetically should ultimately impact welfare (Tita & Aziakpono, 2017). The correlation analysis achieved the following results: only three variables (account use for business, electronic payments and savings) had a positive relationship with income inequality, which contradicts other studies. This might be due to limited financial inclusion widening inequality, moral hazard and information asymmetry, or to banks holding back money and failing to support economic growth. While health insurance and loans for school fees had a negative but insignificant relationship with income inequality, and were hypothetically in line with SSA financial infrastructure challenges, access did not translate into credit availability, due to information asymmetry and moral hazard (Tita & Aziakpono, 2017).

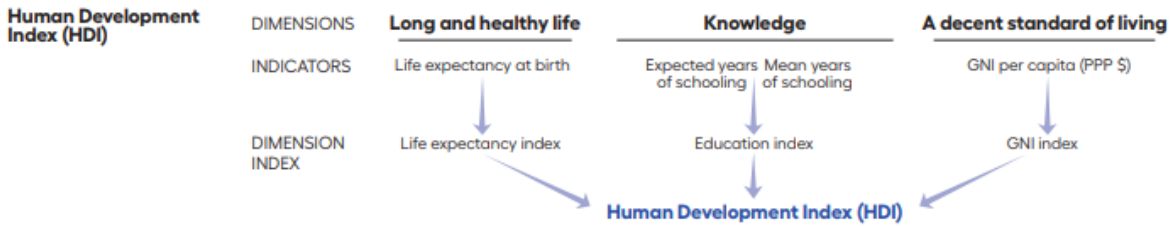
The research by Sarma & Pais (2008) adopted the same OLS regression equation approach as the studies mentioned above; it was a cross-country empirical analysis with a data sample of 49 countries, and it demonstrated that there are low levels of financial inclusion in SSA. Sharma & Pais's (2008) methodology was that accessibility, availability and usage dimensions were represented by traditional bank variables (branches, ATMs, bank accounts and transactions) to compute the financial inclusion index and identify macro factors associated with financial inclusion, and it showed human development (HDI) and financial inclusion to be positively related, resulting in a decrease in inequality when the level of inclusion rises. The study further found the human development variable education to be positively related to financial inclusion, while level of unemployment was found to be insignificant. As expected, rural populations in SSA seem to be unlikely to experience financial inclusion because of traditional banking access restraints, facilitated mainly by infrastructure limitations.

Financial inclusion alone does not reduce poverty or improve welfare significantly; therefore additional developmental initiatives, or factors such as education, per capita income and infrastructure development, are equally or more important (Demirgüç-Kunt & Klapper, 2012; Shipalana, 2019). Shipalana (2019) agrees with Matsebula & Yu (2020), who concluded that households headed by educated older individuals had a higher financial inclusion index, while those in rural areas with low real per capita income and no education were more likely to be completely excluded financially or discriminated against by banks. As a result, inequality manifests due to unequal access to finance, which as expected impacts consumption of goods and services (Nanziri, 2017). Research has proved that there is a correlation between inequality and household access to finance (Honohan, 2007).

Another study on welfare and financial inclusion, focusing on South Africa, utilised a cross-sectional dataset to compute well-being index and wealth index; OLS regression results were analysed to establish welfare disparities between users of formal financial services and non-users (Nanziri, 2017). The findings showed that users of formal financial services have better welfare than non-users, and the disparities were driven by income and education (Matsebula & Yu, 2020; Nanziri, 2017; Ofori-Abebrese et al., 2020). Figure 1 below briefly explains the human development index (HDI) of a country, defined as a measure of human development by the United Nations Development Programme (UNDP) and the Human Development Report (United Nations Development Programme UNDP, 2020).. The HDI is used to determine

welfare in three dimensions of human development, namely access to knowledge, long and healthy life, and a decent standard of living.

Figure 1: Human Development Index Variables



Source: United Nations Development Programme

The standard of living is the gross national income (GNI) measure in US dollars and is used as income in the calculation; it is made up of the income of a country plus aid and remittances, but excluding income from abroad.

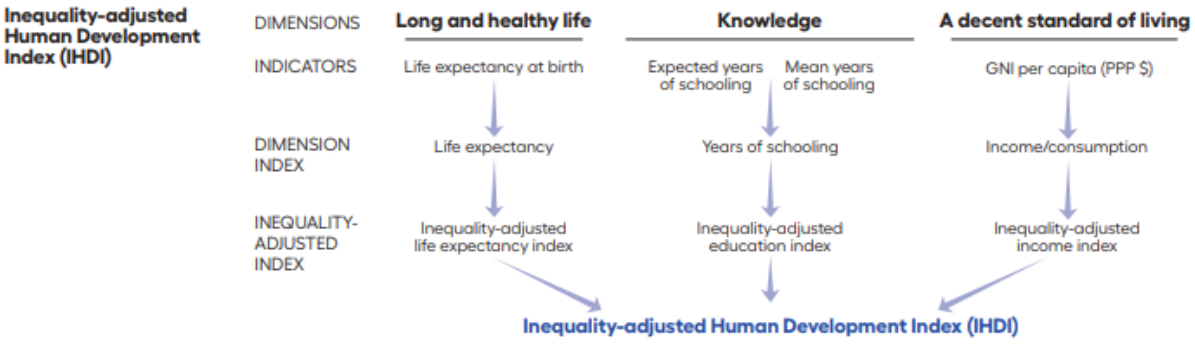
Knowledge is education, measured by mean years of schooling.

Life expectancy at birth is the assessment of a long and healthy life, calculated in years.

Unemployment is included in the welfare calculation because it is expected to affect welfare negatively; and in most developing countries, unemployment affects the income of many households, which implies that consumption of goods and services is limited. Unemployment is the proportion of the labour force that is eligible for and seeking work. It is a measure of total unemployment as a percentage of the total labour force.

Inequality is included in the welfare calculation due to the significance of its impact on welfare, which is highlighted vividly in the literature review. In this research, the inequality variable is a key component for determining a more realistic view of welfare, especially in developing countries such as South Africa, an upper-middle-income country where welfare is not improving (Regional et al., 2019). This variable adds a different element to the studies done previously on welfare and financial inclusion (Ofori-Abebrese et al., 2020; Sakyi, Bonuedi, & Opoku, 2018). By incorporating inequality, the researcher is calculating IHDI as displayed in Figure 3 below, which is a calculation of HDI discounted for inequalities (Conceição, 2020). Inequality "steals" human development; thus an increase in inequality results in an increase in losses of human development. The difference between HDI and IHDI reveals a loss in human development as a consequence of inequality.

Figure 2: Human Development Index Variables - Inequality Adjusted



***Source**: United Nations Development Programme*

A cross-country research study by Nanda and Kaur (2016) was conducted on 68 developing countries from 2004 to 2018, with the intent to construct a modified HDI as a measure of socioeconomic development inclusive of the Financial Inclusion Index, or what is referred to as financial vitality (financial availability and access for all); this is a different approach to other studies on financial inclusion and welfare. For the current study the comprehensive Sarma & Pais (2008) approach was adopted to calculate the financial inclusion index, with three dimensions (banking penetration, availability and usage) used as input to derive a modified HDI including financial inclusion as the fourth dimension; the new index is normalised to ensure the range will be between 0 and 1 (Nanda & Kaur, 2016). The traditional banking variables used to calculate the financial inclusion index include the number of deposit accounts (per 1 000 adults) as penetration; number of bank branches (per 1 000 persons) and number of ATMs (per 1 000 persons) for availability; and volume of outstanding credit and deposit as a percentage of GDP for usage.

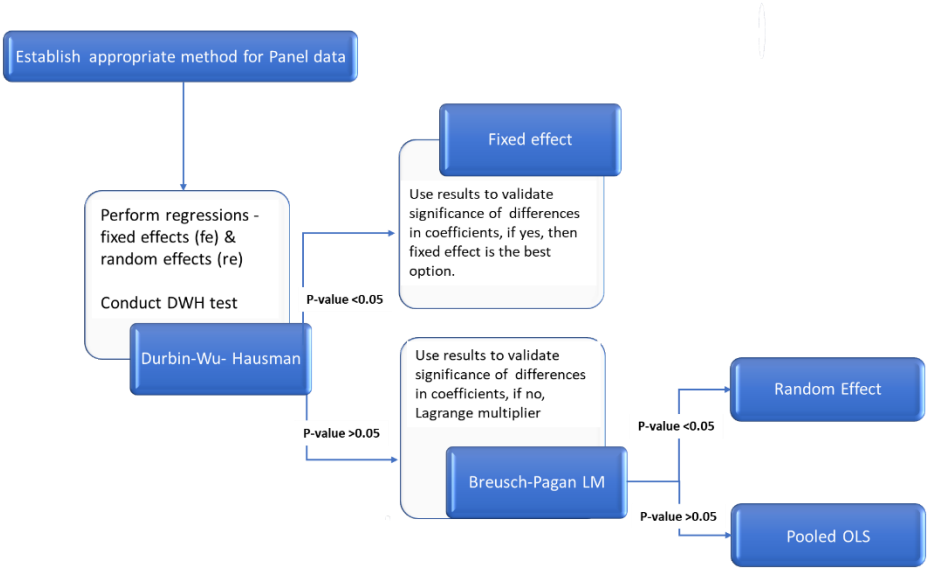
The panel regression analysis revealed a strong unidirectional correlation between HDI and the Financial Inclusion Index; also, the income level of the countries is shown to move alongside the extent of the financial inclusion. For example, Lebanon, Ireland, Japan, Switzerland, Estonia, Malta, Seychelles, Spain, Malaysia, Belgium, the Netherlands, Mauritius and Korea demonstrated high levels of inclusion; these are mainly countries classified as high-income or medium-income OECD countries (Nanda & Kaur, 2016). As expected from the financial inclusion hypothesis used in multiple studies, HDI inclusive of the Financial Inclusion Index improves socio-economic development (Asongu & Roux, 2017; Ofori-Abebrese et al., 2020; Sarma & Pais, 2008). The indices used in the study were macro, to enable comparative analysis

between countries; however, this limited the analysis to country-specific information (Nanda & Kaur, 2016).

To improve the accuracy of estimations in a study, the panel data approach is applied with a limited number of time series observations, because it allows a greater degree of freedom. For this reason, Matekenya and others (2021) adopted this methodology when investigating the direction of the relationship between financial inclusion and human development in SSA, with time series observations of 14 years. As alluded to by Roodman (2006), the rule states that n (number of individuals) could be greater than 100; however, number of periods should be minimised to less than 10 ideally, but not greater than 15 when estimating dynamic models using panel data. Panel data (also known as longitudinal data, or cross-sectional time-series data) should have at least two dimensions: the time series indicated by *t*, and the cross-sectional dimension represented by a subscript *i* (Zulfikar, 2018). Longitudinal data can model common and group behaviours, which enables the researcher to analyse economic investigations that cannot be probed through cross-sectional or time-series data sets; this approach to data produces a large number of data points, and reduces collinearity between explanatory variables (Davidson & Hsiao, 1987). Lillo & Torrecillas (2018) describes panel data as a statistical tool for which models are created using numerous variables across identified times; this differs from pure cross-sectional analysis, which focuses on the analysis of several individuals at a specific point in time, and pure time-series methodology, which relates to the analysis of the same variable across time.

The three main modelling analyses for panel data are OLS, fixed effects and random effects; however, a study by Mallick & Zhang (2019) pointed out that the OLS approach does not cater for endogeneity in financial inclusion, resulting in biased and inconsistent estimations. Therefore, to establish the optimal model technique to be utilised for panel data research in this study, the process illustrated in Diagram 1 was adopted following research by Asongu and others (2017) to validate normality in the data; then autoregression model estimations are conducted for the random effects model and fixed effects model of panel data. In an attempt to choose between the random effects and fixed effects models, the Hausman test is modelled, with a null hypothesis for random effects being the preferred method, while the alternative is fixed effects if the p-value is less than 0.05 (Asongu et al., 2017).

Diagram 1: Analysis Methodological Framework of Panel Data



***Source**: Author's Diagram*

The GMM technique is an estimation method used when the researcher has opted for the panel data approach but runs into endogeneity problems. Other studies have looked into informality and financial inclusion using the GMM approach for analysis, and have described the informal economy index as a multi-dimensional concept that cannot be explained by a single variable (Amponsah et al., 2021; Kelikume, 2021). The motivation for using the GMM approach in the studies mentioned above is to deal with variation in the scale of variables, which could result in error correlation and heteroscedasticity (OLS is not ideal in such circumstances); and also to eliminate issues of reverse causality and biasedness, which might be caused by the omission of independent variables (Amponsah et al., 2021; Kelikume, 2021). However, the strategy of this paper is to incorporate the influence of economic informality, particularly in SSA, through data selection and categorisation of countries to elicit the possibility of this factor stimulating the need or use of mobile banking and the depth of financial inclusion, considering the weak existing formal financial services in the region.

Another study, by Cámara and Tuesta (2014), applied the PCA approach to panel data to derive the financial inclusion index, where weights assigned to the three financial inclusion dimensions (usage, barriers and access) were endogenously derived using two-stage principle component analysis to minimise biased results with highly correlated indicators. The three sub-indices (access, usage and barriers) have highly correlated variables; hence the sub-indices are

computed first, rather than the overall FI index with all variables at the same time. Stage one is an estimation of the three sub-indices, which in stage two are used as explanatory variables in the regression model to estimate the overall FI index. Besides the PCA approach, it should be noted that the research by Cámara & Tuesta (2014) expanded the dimensions from just usage and access by including barriers, which they defined as a measurement of involuntary financial exclusion perceived by those excluded from formal financial services. This approach is therefore more comprehensive, as it investigated financial inclusion from the supply and the demand side, in both developing and developed economies. To achieve both viewpoints, supply and demand, the strategy of this research considered the data selection and sources of the two dimensions; the demand-side data was sourced from the World Bank's Global Findex (financial inclusion data), while the supply-side data was extracted from the IMF Financial Access Survey.

The financial inclusion index as a composite index is sensitive to weight assignment, and a subjective execution would dramatically impact the results, as described by Sarma & Pais (2008); thus, the parametric method is preferred for research over the non-parametric method, where the weights are assigned exogenously as perceived by the researchers (Cámara & Tuesta, 2014). The usage variables represent individuals with an account, a loan, or savings; while access includes ATM and branch. Lastly, barriers listed are distance, affordability, documents and trust. The outcome of the study specified access to financial services as the most effective proxy for measuring financial inclusion, which is highly correlated with the explanatory variables education, per capita GDP, financial stability and efficiency (Cámara & Tuesta, 2014). Developing countries with significant government development or social funds pay-outs such as Thailand and Mongolia seemed to have a higher level of financial inclusion than some of the developed countries such as Sweden and Ireland, due to payment transactions initiated by the government. However, in general, developed countries have high financial inclusion levels, as expected.

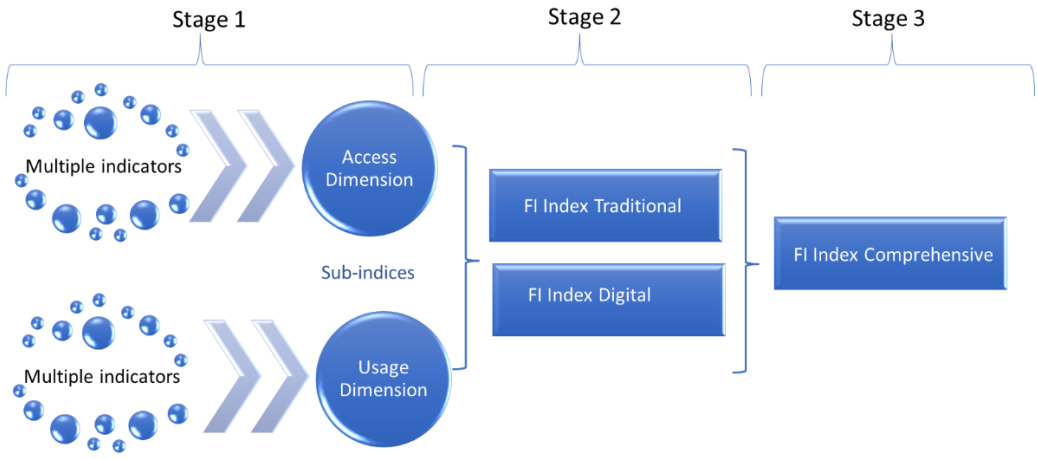
It should be noted that previous studies in the literature on this topic have predominantly utilised the traditional financial inclusion index with incumbent enablers such as branches and ATMs as explanatory variables; therefore, one should perhaps not be surprised by the low financial inclusion statistics in SSA, where financial inclusion is driven by digital finance through mobile banking. The results might not be a true reflection of the financial inclusion progression trend in SSA. Recent cross-country panel research conducted by the IMF on a data sample of 52

developing economies for 2014 to 2017 revealed that in eight cases – including the two largest economies in the region, South Africa and Nigeria – the progress of financial inclusion is entirely driven by mobile banking (also referred to as digital financial inclusion), while traditional financial inclusion shows negative growth(Khera, Ng, Ogawa & Sahay, 2021; Ofori-Abebrese et al., 2020). The drive for digital financial inclusion is particularly strong in Asia, Africa and the Pacific; thus, ths study presumes that including digital indicators in the overall measure of inclusion will produce a more realistic estimate for the region.

The IMF study followed a three-stage PCA approach with weighting methodology for objectivity, by deriving the applicable weight for usage of each dimension (demand side) and access (supply side), limited to payments, where stage one defines variables for the access and usage sub-indices; stage two combines the sub-indices to establish two separate indices (digital and traditional financial inclusion); and stage three creates a comprehensive financial inclusion index comprising weighted dimensions for both indices (traditional and digital) to compute an overall financial inclusion index (Khera, Ng, Ogawa & Sahay, n.d.). The selected digital variables for access include the number of registered mobile money agents, mobile subscriptions per 100 people, and percentage of the population who have access to the internet; while digital usage is defined by the percentage of adults who have a mobile account, the percentage of adults who use the internet to pay, the percentage of adults who use a mobile phone to receive salary or wages and the percentage of adults who use a mobile phone to make utility payments. The access variables targeted for the traditional financial inclusion index are the number of ATMs per 100 000 adults, and the number of branches per 100 000 adults; the traditional usage variables are the percentage of adults with a financial institution account, the percentage of adults who save at a financial institution, the percentage of adults with a debit card, the percentage of adults who receive wages through a financial institution account, and the percentage of adults who use a financial institution account for utilities. These indices (traditional, digital and comprehensive) are derived using separate regression models and also normalised separately, to provide a sense of where a country stands in terms of financial inclusion regardless of the data sample at hand; therefore, the inclusion levels can be compared over time, but the indices cannot be directly compared to each other (Khera et al., n.d.).

Diagram 2 below summarises the composition process for the three-stage PCA financial inclusion indices.

Diagram 2: Financial Inclusion index computation



***Sources**: IMF The Promise of Fintech (2020); author's diagram*

Bakar & Sulong (2018) recommended developing inclusion by increasing access through the expansion of bank branches and other enablers in the banking sector, to remedy negative and weak financial inclusion in already compromised financial systems. However, that approach did not yield the expected results, as demonstrated in studies on South Africa (Shipalana, 2019), while the results from the IMF study (where the two financial inclusion indices, digital and traditional, were modelled) revealed a variation in financial inclusion estimations for developing markets (Sahay et al., 2020). Therefore, with the previous approach, the traditional financial inclusion index did not necessarily present a complete reflection of financial inclusion in developing countries, particularly in Africa.

However, it should be noted that according to Honohan (2007), though endogeneity is not too problematic in a study aiming at explaining inequality and poverty, it should be a concern when explaining income levels and growth. To deal with the endogenous issue of control variables, researchers flagged values that are utilised for all control variables accordingly (Demir et al., 2020). The potential existence of multicollinearity and overparameterisation between the variables is exposed by the correlation matrix; the low correlation (less than 0.8 approximately) between variables indicates that multicollinearity is not problematic in the models (Asongu & Odhiambo, 2019; Chima, Babajide, Adegboye, Kehinde & Fasheyitan, 2021; Musau, Muathe & Mwangi, 2018). Alternatively, the Durbin-Watson statistic can validate the absence of multicollinearity when it is close to standard 2.0 (Makina et al., 2015). Multicollinearity and heteroscedasticity issues can be tackled and minimised with the panel data approach, while

endogeneity in variables is minimised with the implementation of the GMM technique (Matekenya et al., 2021). To test for robustness in GMM estimation, the two tests to be conducted are the Arellano-Bond test (to establish if there is autocorrelation in the model), and the Sargan-Hansen test for over-identification restrictions (Kelikume, 2021).

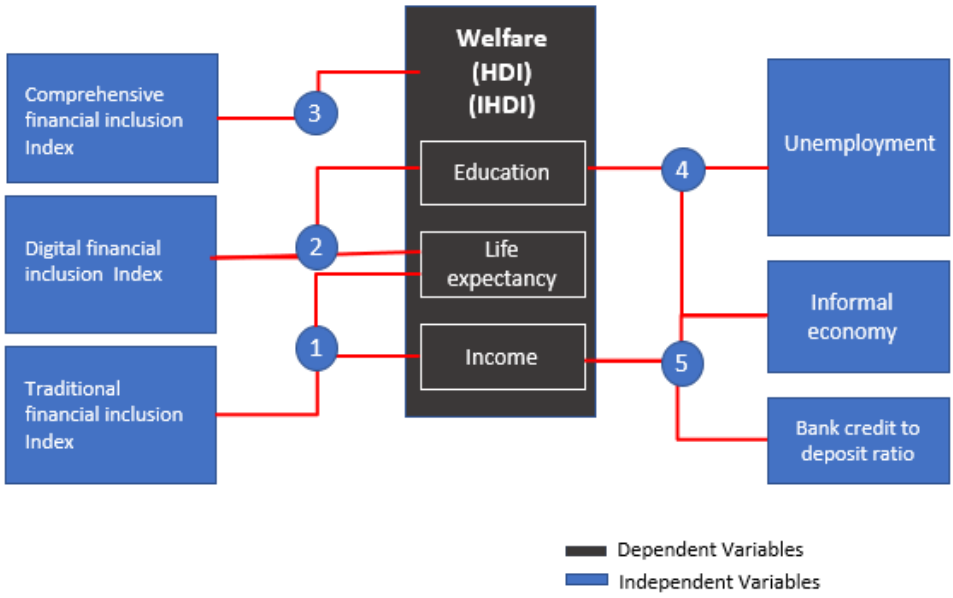
Inequality is a game-changer in SSA studies, since it invalidates the expected results of regressions on financial inclusion with traditional banking variables. This was demonstrated by Tita and Aziakpono (2017)**,** where account use for business, electronic payment and savings variables all have a positive relationship with income inequality. This factor should therefore be considered in empirical investigations of financial inclusion and its impact on socio-economic challenges in SSA, because high levels of inequality in the region cannot be ignored (Honohan, 2007). Other studies showed digital finance, specifically savings, to be negatively related to inequality: as digital financial inclusion increases, inequality decreases (Demir et al., 2020). Income should be regressed with inequality when conducting research in SSA because the two variables are positively related and they negatively impact financial inclusion and its influence on welfare and unemployment, depending on the inequality levels of a country (Tita & Aziakpono, 2017). Though income plays a key role in poverty reduction as a human development index indicator, its positive correlation with inequality in SSA has resulted in regressions where it negatively impacts financial inclusion, while education is highlighted as the dominant and most important factor to significantly drive financial inclusion and improve welfare in SSA, with inequality included.

Traditional banking variables (ATM and branch for access, deposits and loans for usability) are frequently used in research to calculate financial inclusion; from an SSA perspective this approach is flawed without digital inclusion, as it limits the significance of which financial inclusion index impacts multiple factors representing challenges in the region in regression models (Ofori-Abebrese et al., 2020; Sarma & Pais, 2008). Tita & Aziakpono (2017) showed that health insurance and loans for school fees had an insignificant negative relationship with income inequality. This is theoretically the reason for slow progress in poverty reduction, because the approach adopted for measuring and facilitating financial inclusion through traditional financial services is not necessarily appropriate for SSA.

The nature of financial usability and activity among the poor and marginalised has evolved towards mobile banking, or digital financial services; thus, studies that adopt a digital inclusion approach to deriving the financial inclusion index and conducting regression investigations are

more likely to reveal the significance or impact of financial inclusion on challenges such as unemployment, inequality, lack of education and poverty, all predominantly affecting the poor (Abor et al., 2018).

Diagram 3: Conceptual Framework Financial inclusion and Welfare



Source: Author's diagram

2.4 Summary of the chapter

Though financial development is related to better and more sustainable economic growth for all sections of the population, it has not resulted in an equal rate of financial inclusion in SSA, even when economies experienced significant growth and increased national income. Ths occurs in instances of wealth concentration and growing monopolies within financial services. Developing countries in SSA have experienced low rates of financial inclusion even after witnessing a higher rate of financial development, primarily supported by the extraction of natural materials. Thus there is a drive to promote financial inclusion among the marginalised, as well as encouraging the development of digital finance services.

The level of financial inclusion through traditional banking variables is arguably not an appropriate measure of inclusion in SSA, where the marginalised use mobile banking to access financial services. It is from this narrative that this study postulates that financial inclusion of

the poor can be enabled by digital finance through mobile banking. Therefore, theoretically, the measurement and analysis of financial inclusion in SSA should be determined by mobile banking variables. It is through this approach that the impact of financial inclusion on poverty, welfare challenges and other social barriers such as unemployment can be assessed.

Around the world, financial inclusion is being stimulated by the growth of mobile phone usage. Digital finance has made traditional financial services available to remote and vulnerable populations, thus promoting equitable access to financial services. In theory, for countries to benefit from affordable, swift and reliable digital finance, government intervention through policies is imperative to facilitate the development and integration of fintech organisations within financial services, which are currently dominated by the traditional bank monopolies who try to discourage new players.

Countries showing expansion in ICT should demonstrate growth in digital financial inclusion over time, but only if the level of education is also increasing or remaining at par. Hypothetically then, if ICT is gradually improving but the level of primary or secondary education is stagnant, it is to be expected that digital financial inclusion will decelerate or not progress at the expected pace because of the direct impact of the use of mobile phones. Advancement in mobile banking should theoretically be coherent with improvements in human capital and education, which implies that depth in digital finance within the SSA region should progress from stage 1 (payment services) with the improvement of education levels over time. Countries such as Kenya are expected to have progressive education levels stimulating and supporting deep digital financial services.

In theory digital financial inclusion is critical, as it is a feasible way to decrease inequality organically; however, that will depend on the expansion and depth of digital financial usage. Countries with high levels of inequality are expected to have lower levels of inclusion compared to countries with less inequality. However, unlike traditional inclusion, digital financial inclusion and education should increase inclusion regardless of inequality levels, because the main participants and beneficiaries of digital services are the marginalised. Over time, unemployment in the informal sector should be impacted by entrepreneurship and job opportunities, which ultimately lead to development of the informal sector and improved welfare.

Based on the above and the empirical literature, inequality must be considered when regressing financial inclusion and its impact on the welfare of SSA countries. With the growth of income, African economies have experienced increased inequality, and the two variables – national income and inequality – have proven to be positively related in the SSA context because the beneficiaries of inequality are the rich and educated, who are predominantly represented by the traditional financial services. Therefore, by implication, the traditional financial inclusion index and welfare regressions will result in low levels of financial inclusion and welfare in the region. However, this research views the outcome of - inequality, welfare and financial inclusion regressions to be different when welfare is regressed with the digital financial inclusion index, which adequately represents the marginalised, proving that financial inclusion improves welfare.

Other studies have found that growth in national income without inclusion promotes inequality (Dutt, 2016; Tita, 2017). Another study observed a robust inverted-U relationship between informal economy size and economic growth (Elgin & Birinci, 2016). The missing component in these studies is the influence of digital finance (which drives inclusion) on the informal economy, national income and inequality. The current research foresees the development of informal economies for those countries where digital finance is embraced and the marginalised participate in financial services to invest in education, which creates opportunities for the unemployed to partake in a country's national income.

Previous studies have confirmed unemployment to be insignificant to welfare when regressed with the traditional financial inclusion index (Ofori-Abebrese et al., 2020; Sarma & Pais, 2008). Ideally, unemployment and welfare should demonstrate traces of correlation when regressed with financial inclusion. Therefore, this research includes unemployment as a variable when regressing welfare with the digital financial inclusion index, to validate the ideology of the digital financial inclusion index being the pertinent index fostering a correlation between unemployment and welfare.

Consequently, traditional banking institutions impact the level of financial inclusion by controlling the allocation and level of credit available in the economy. Theoretically, countries with efficient government institutions can influence liquidity in financial institutions and the allocation of credit in economies using appropriate policies to drive financial inclusion and human development. The influence of credit on digital financial inclusion and its expansion is

highly dependent on the intentional policies of government institutions. Hence it is expected for countries with depth in digital financial services to have government institutions also driving this agenda.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This section of the study describes the methodologies and tools used to investigate research problems and explains the strategy selection and approach leading to appropriate, reliable, and detailed research findings. The research methodology was highly impacted by the resource availability, particularly the data and the scope intended for the study. This study has taken cognisance of the literature reviewed and built on it; therefore the analysis, research approach, design, strategy and data collection were implemented to explore the research questions, which primarily entailed the investigation of financial inclusion impact through digital finance on welfare in SSA, substantiated by the significance of comprehensive (digital and traditional) financial inclusion and inequality on welfare.

3.2 Research approach

The purpose of this research was primarily to investigate the influence of financial inclusion on welfare, where financial inclusion was expanded into traditional financial inclusion, digital financial inclusion, and comprehensive financial inclusion; it was also imperative for the study to examine the impact of inequality on financial inclusion and welfare. Hence the primary question of the study was:

“What is the interaction between financial inclusion, inequality, and welfare in sub-Saharan Africa?”

To deepen the research and establish the appropriate research approach, the following sub-questions were probed:

“What is the impact of digital finance on the education and income of citizens in SSA, considering different human development models?”

“What is the impact of the informal economy on the growth of mobile banking and digital financial inclusion in SSA countries?”

To fulfil the requirements of this investigation in alignment with the literature, the quantitative deductive research approach was adopted to construct numerical input data into statistical models which could be validated and utilised to test hypotheses, with the aim of expanding knowledge on existing financial inclusion and welfare theories.

The quantitative descriptive research strategy was applied to establish the correlation of variables explaining financial inclusion, welfare and inequality, with financial inclusion separated into three indices: digital financial inclusion, traditional financial inclusion, and comprehensive financial inclusion (combined traditional and digital financial inclusion), from an SSA perspective; other factors, such as unemployment, informality and financial efficiency were utilised to deepen the analysis on digital financial inclusion and welfare.

3.3 Research Strategy

The research design appropriate to testing the specified hypotheses and answering the research questions of this study involves observing changes in the dependent variable (welfare) as a consequence of changes or movement of the independent variables: digital financial inclusion, traditional financial inclusion, comprehensive financial inclusion, income, life expectancy, education, unemployment, and bank credit to deposit ratio (liquidity).

For contextual purposes, the variables income, life expectancy and education are highlighted to explain welfare, and are proxied by HDI; they are also adjusted by inequality and proxied as IHDI to explain the impact of inequality on welfare or human development.

This research adopts the three-stage PCA approach to compute the financial inclusion indices, because it calculates the third index – called the comprehensive financial inclusion index – which is a combination of digital and traditional financial inclusion indices in order to derive the overall impact of financial inclusion, and follows the same methodology as the IMF research (Khera, Ng, Ogawa, & Sahay, 2021).

The SSA countries to be used as the data sample are intentionally categorised by country informality with the purpose of exploring the hypothesis of a sub-question, which is to establish if informality stimulates the use of mobile banking. The digital financial inclusion PCA sub-indices, access and usage dimension results, and country formality grouping are utilised to answer this question.

Due to data requirements such as the categorial grouping of countries and country-level results to enable analysis of the output and answer the research questions across limited time series observations of three years, the panel data approach and pooled OLS are adopted in this investigation.

In summary, this study has a fourfold goal to satisfy the research objectives comprehensively. The first goal is to determine the impact of financial inclusion on welfare in SSA countries, where welfare is proxied by human development index. The second goal is to establish the effect of inequality on the welfare and financial inclusion correlation, where welfare is proxied by the inequality-adjusted human development index. Thirdly, the researcher focuses on digital inclusion, to reveal its influence on human development in relation to education and income. Fourthly, to explore the informality of economies in relation to the adoption of mobile money, the economy informality structure is strategically applied to the selection of countries in the data sample, as it is the intent of the research to investigate the overall influence of this factor. This investigation serves an insightful guide to where investment should be allocated to drive optimal financial inclusion in the region. The other variables, unemployment, and liquidity are included to provide clarity or explain output where required.

3.4 Model and Variable Specification

The financial inclusion and human development indices are macro in nature, to enable comparative analysis between SSA countries with different levels of inclusion, informality, inequality, welfare and ICT development; however, this limits the ability to interrogate country-specific information (Nanda & Kaur, 2016). The multi-regression approach is adopted in this investigation because the variables demonstrate significant traces of collinearity, which can be reduced by regressing the indices separately. However, the selected variables are not binary, and also have a linear relationship between them.

Before regressing the data, indices are calculated for both financial inclusion (traditional financial inclusion index, digital financial inclusion index and comprehensive financial inclusion) and human development (HDI and IHDI). The financial inclusion indices are regressed separately to provide clarity on the impact and robustness of indices, from an SSA perspective. At a higher level, the sub-indices or dimensions for financial inclusion comprise access and usage, while human development includes education, life expectancy and GNI per capita (income). The digital financial inclusion variables necessitate logarithmic transformation to achieve a normal distribution and enable reliable predictions of linear regression models, with dependent variables digital financial inclusion index and comprehensive financial inclusion index. The logarithmic transformation is not required to derive the traditional financial inclusion index.

3.4.1 The estimation models

a) Inequality and Welfare

From a welfare perspective, this investigation should empirically prove that digital financial inclusion substantiates traditional banking in enhancing welfare immensely in SSA. The model adopted for the investigation follows the approach of Amendola (2016) and Ofori-Abebrese (2020). However, this research advances the previous studies by acknowledging the impact of inequality on welfare to be significant, as this is undoubtedly shown in the theoretical and empirical literature (Conformática, 2013; Dutt, 2016; Galor & Zeira, 1993; Regional et al., 2019; United Nations, 2020). To establish a true representation of welfare in SSA, inequality is adjusted in the dimension indexes (life expectancy, years of schooling, gross national income) of HDI, by discounting the dimensions by level of inequality to produce IHDI. In summary, IHDI is HDI discounted with inequality (Conceição, 2020). Separate models (2) and (4) are created to verify the inequality impact on welfare. These models are then expanded by incorporating the traditional financial inclusion index, digital financial inclusion index and comprehensive financial inclusion index to examine the influence of these indices on welfare. Lastly, the bank credit to deposit ratio is added, to analyse the impact of credit efficiency in the models.

$$W_{i,t} = f(\, INC_i, EDU_i, LEX_i\, UNEM_i) \tag{1}$$

Where: W_i is welfare
INC_i is Income
EDU_i is Education
LEX_i is Life expectancy
$UNEM_i$ is Unemployment
i is the ith country

The level form of equation (1) is specified thus:

$$W_i = \alpha + \gamma INC_i + \delta EDU_i + \beta LEX_i + \theta UNEM_i + \varepsilon_i \tag{2}$$

The symbols are explained as follows; γ is the effect of Income, δ the effect of education, β is the effect of life expectancy, θ the effect of Unemployment, and ε represents the constant and error terms.

Welfare is measured using the human development index (HDI), which aggregates country-level measures of the three dimensions income per capital, schooling, and life expectancy, represented by these explanatory variables in equation (2): $INC_{i,t}$, $EDU_{i,t}$, and $LEX_{i,t}$. The $UNEM_{i,t}$ variable is included because unemployment is one of the biggest challenges in SSA, and it is expected to impact welfare as it does in the literature (Sarma & Pais, 2008).

Equation (3) and (4) below are the HDI dimensions adjusted with inequality to create IHDI. The IHDI can be defined as a geometric mean of normalised indices for the three inequality-discounted dimensions: life expectancy, schooling, and income. The IHDI index ranges from 0 to 1, where a score closer to 1 indicates good welfare and those closer to 0 imply poor welfare.

Inequality-adjusted welfare

$$IAW_{i,t} = f(\ IAINC_i, IAEDU_i, IALEX_i\ UNEM_i) \tag{3}$$

Where: IAW_i is Inequality-adjusted Welfare
$IAINC_i$ is Inequality-adjusted Income
$IAEDU_i$ is Inequality-adjusted Education
$IALEX_i$ is Inequality-adjusted Life expectancy
$UNEM_i$ is Unemployment
i is the ith country

The level form of equation (3) is specified thus:

$$W_i = \alpha + \gamma IAINC_i + \delta IAEDU_i + \beta IALEX_i + \theta UNEM_i + \varepsilon_i \tag{4}$$

b) Financial Inclusion and Welfare

The traditional financial inclusion index and the digital financial inclusion index are computed and used as independent variables for estimations of financial inclusion, to determine its impact on welfare. This study adopts the approach of Sharma & Goel (2017), where the calculation of the Financial Inclusion Index is dependent on various dimensions which can be divided into further different indicators; a multidimensional approach is followed, for comprehensiveness. However, the focus of this study is on two-dimension indexes, Access and Usage, as per IMF (2021) on the new digital financial inclusion index. Access is defined as availability of facilities to enable individuals to utilise a financial service when required. This sub-index is mainly influenced by the quality and availability of infrastructure such as ATM, branches, and connectivity for telecommunication. Usage entails the willingness of individuals to use the services provided to make simple transactions such as payments, borrowings, saving money and sending money such as remittances. Usage is a good indicator for establishing if the products provided meet the needs of the population, particularly the marginalised.

Stage 1

To calculate each dimension D_iI for financial Access and Usage, formula (5) below is used (Gupte, Venkataramani & Gupta, 2012)**:**

$$D_iI = (d_{i1} + d_{i2} + d_{i3} \ldots . d_n)/n) \quad (5)$$

This formula is used to calculate the dimension index of various dimensions.

$$D_d = W_d * \frac{A_d - m_d}{M_d - m_d} \quad (6)$$

Where, W_d is Weight attached to the dimension d, $1 \geq W_d \geq 0$

A_d is Actual value of dimension d

m_d is minimum value of dimension d

M_d is Maximum value of d

D_d are Dimensions of financial inclusion d

Stage 2:

The overall digital financial inclusion index or traditional financial inclusion index:

$$FI_i = 1 - \frac{\sqrt{(1-D_{ai})^2}+\sqrt{(1-D_{ui})^2}}{\sqrt{n}} \quad (7)$$

Stage 3:

For the advancement of the investigation, a comprehensive financial inclusion model is utilised, which combines traditional financial inclusion and digital financial inclusion to assess the impact of overall financial inclusion on welfare. The results should indicate the level of financial inclusion driven by both fintech and conventional institutions to welfare. The ω in model (8) represents the weight assigned to subcomponents $(DIFI_i)$ and $(TRFI_i)$

$$COMFI_i = \omega_1(TRFI_i) + \omega_2(DIFI_i)_{it} + \omega_{it} \quad (8)$$

Where:

$COMFI_i$ = Comprehensive financial inclusion index

$TRFI_i$ = Traditional financial inclusion index

$DIFI_i$ = Digital financial inclusion index

i is the ith country

The Digital financial inclusion index

Following the IMF approach, this study has two dimensions defined to calculate the digital financial index, Access and Usage, with the digital explanatory variables below. The Access and Usage dimensions are calculated from these variables.

Digital access using equation (4):

$$D_aI = (d_{a1} + d_{a2})/2) \quad (9)$$

Digital usage using equation (4):

$$D_uI = (d_{u1} + d_{u2} + d_{u3} + d_{u4} + d_{u5})/5) \quad (10)$$

Where:

d_{a1} = Mobile subscriptions per 100 people (Access)

d_{a2} = Population with access to internet (Access)

d_{u1} = Adults with mobile accounts (Usage)

d_{u2} = Adults with internet to pay (Usage)

d_{u3} = Adults using mobile phones to receive salary or wages (Usage)

d_{u4} = Adults using mobile phone for utility payments (Usage)

d_{u5} = Received or sent domestic remittances using a mobile phone (Usage)

n = number of dimensions (variables used in the index)

Calculating the dimension Index for digital access using equation (5):

$$D_a = W_d * \frac{D_a I - m_d}{M_d - m_d} \quad (11)$$

Digital Financial Inclusion Index equation:

$$DIFI_i = 1 - \frac{\sqrt{(1-D_a)^2} + \sqrt{(1-D_u)^2}}{\sqrt{n}} \quad (12)$$

The Traditional Financial Inclusion Index

The traditional financial inclusion index is denoted by $TRFI_i$ and the same approach utilised as to calculate digital financial inclusion index.

The Access and Usage dimensions are calculated from the variables below.

Traditional access using equation (4):

$$DT_a I = (dt_{a1} + dt_{a2})/2) \quad (13)$$

Traditional usage using equation (4):

$$DT_u I = (dt_{u1} + dt_{u2} + dt_{u3} + dt_{u4})/4) \quad (14)$$

Where:

dt_{a1} = Number of ATMs per 100 000 adults (Access)

dt_{a2}= Number of Branches per 100 000 adults (Access)

dt_{u1} = Adults with a financial institution account (Usage)

dt_{u2}= Adults who save at a financial institution (Usage)

dt_{u3} = Adults with debit card (Usage)

dt_{u4}= Adults who have borrowed from a financial institution (Usage)

n = number of dimensions (variables used in the index)

Calculating dimension Index for traditional access using equation (5):

$$DT_a = W_d * \frac{DT_aI - m_d}{M_d - m_d} \quad (15)$$

Traditional Financial Inclusion Index:

$$TRFI_i = 1 - \frac{\sqrt{(1-DT_a)^2} + \sqrt{(1-DT_u)^2}}{\sqrt{n}} \quad (16)$$

The computed financial inclusion indices are regressed into the welfare model to establish their impact on welfare. Regression models are used in this research to enable analysis of the relationships between the variables. Where $FI_i, INC_i, EDU_i, LEX_i, UNEM_{i,} BNK_{i,}$ are regressor variables, α is the intercept, symbols $\varphi\ \gamma\ \delta\ \beta\ \theta$ are the estimated parameters and ε_i denotes the error term. The dependent variable W_i is the outcome of the regression, which represents welfare in this instance. As mentioned earlier in the chapter, the multiple regression analysis is adopted to deal with multicollinearity between the financial inclusion and human development variables, and also with data limitations on mobile variables. Using this approach the strength and importance of the relationship between the dependent variable and the predictor variables can be established efficiently, without interrupting other predictors.

The multi-regression models below investigate the integration between financial inclusion, unemployment, bank credit to deposit ratio and welfare. These models are differentiated by financial inclusion indices and inequality. The traditional financial inclusion is modelled for the periods 2011, 2014 and 2017, hence the *i* cross-sectional dimension and *t* representing the particular period as mentioned earlier in this section. The digital and comprehensive financial

inclusion indices are conducted for 2017, due to limited data availability. Income and education are regressed separately due to correlation between the variables, and the same applies to traditional financial inclusion index, digital financial inclusion index and comprehensive inclusion index.

The following independent variables are studied in an attempt to explain welfare: LEX (life expectancy index), EDU (education index), INC (gross national income), UNEM (unemployment), BNK (bank credit to deposit ratio) DIFI (digital financial inclusion index), TRFI (traditional financial inclusion) and COMPFI (comprehensive financial inclusion). The investigation in expanded by determining the influence of inequality on welfare (IHDI), for which inflation-adjusted welfare explanatory variables are utilised: IAEDU (inequality-adjusted education), IAINC (inequality-adjusted gross national income) and IALEX (inequality-adjusted life expectancy). The multi-regression approach is adopted and presented below.

The fixed-effect method is a method of preference based on the panel data for this study, and the models are estimated with year-specific effects or specific points in time; therefore there is no linear time trend. Though fixed-effect is the preferred method, the results of both methods (fixed-effect and random-effect) are presented in chapter 4 for comparison where required. This method does not apply to the 2017 cross-sectional data for digital financial inclusion; the pooled OLS methodology is adopted.

As per the sub-question, models 3 to 6 below aim to observe the influence of digital inclusion on human development, with a focus on income and education. This is repeated with inequality-adjusted human development models 7 to 10 below.

Model 1 – traditional inclusion on welfare – EDU

$$W_{i,t} = \alpha + \varphi TRFI_{i,t} + \delta EDU_{i,t} + \beta LEX_{i,t} + \theta UNEM_{i,t} + \omega BNK_{i,t} + \varepsilon_{i,t} \quad (17)$$

Model 2 – traditional inclusion on welfare INC

$$W_{i,t} = \alpha + \varphi TRFI_{i,t} + \gamma INC_{i,t} + \beta LEX_{i,t} + \theta UNEM_{i,t} + \omega BNK_{i,t} + \varepsilon_{i,t} \quad (18)$$

Model 3 – digital inclusion on welfare – EDU

$$W_i = \alpha + \varphi DIFI_i + \delta logEDU_i + \beta logLEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (19)$$

Model 4 – digital inclusion on welfare – INC

$$W_i = \alpha + \varphi DIFI_i + \delta logEDU_i + \beta logLEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (20)$$

Model 5 – comprehensive inclusion on welfare – EDU

$$W_i = \alpha + \varphi COMFI_i + \delta logEDU_i + \beta logLEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (21)$$

Model 6 – comprehensive inclusion on welfare – INC

$$W_i = \alpha + \varphi COMFI_i + \delta logEDU_i + \beta logLEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (22)$$

Models 1 to 6 above are repeated, to analyse the impact of inequality on welfare. Hence the inequality-adjusted variables $IAEDU_i, IALEX_i, IAINC_{i,}$ are adopted to produce models 7 to 10 below, intended to establish the significance of inequality on welfare in the SSA countries on welfare.

Model 7 – digital inclusion on welfare – EDU Inequality

$$W_i = \alpha + \varphi DIFI_i + \delta logIAEDU_i + \beta IAlogLEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (23)$$

Model 8 – digital inclusion on welfare – INC Inequality

$$W_i = \alpha + \varphi DIFI_i + \gamma logIAINC_{i,} + \beta logIALEX_i + \theta logUNEM_i + \omega logBNK_r + \varepsilon_i \quad (24)$$

Model 9 – traditional inclusion on welfare – EDU Inequality

$$W_{i,t} = \alpha + \varphi TRFI_{i,t} + \delta IAEDU_{i,t} + \beta IALEX_{i,t} + \theta UNEM_{i,t} + \omega BNK_{i,t} + \varepsilon_{i,t} \quad (25)$$

Model 10 – traditional inclusion on welfare – INC Inequality

$$W_{i,t} = \alpha + \varphi TRFI_{i,t} + \gamma IAINC_{i,t} + \beta IALEX_{i,t} + \theta UNEM_{i,t} + \omega BNK_{i,t} + \varepsilon_{i,t} \quad (26)$$

The conceptual framework presented in chapter 2 diagram 3 summarises the hypotheses of this study, while the models are used to predict and test the hypotheses defined. Referring to the framework, this research hypothesises the traditional financial inclusion index and income to impact welfare positively when inequality is low. Therefore, in SSA, where inequality is high, welfare cannot be optimised through traditional financial inclusion. Traditional financial inclusion is only likely to impact welfare effectively in developed countries with good financial systems and low levels of inequality.

Theoretically, as income increases, traditional financial inclusion should increase and unemployment decrease, leading to improved life expectancy and education, and ultimately better overall welfare, when levels of inequality are low. This is achievable in a scenario where growth in income does not increase inequality – which is not the case in SSA; instead, as income increases, inequality rises with unemployment.

Digital inclusion impacts welfare through improvement of education, irrespective of inequality levels, because advancement in digital financial inclusion should decrease inequality. However, in SSA, where education levels are not satisfactory, it is unlikely that optimal levels of welfare can be achieved, though there might be slow progress in inclusion through digital finance.

Theoretically, however, over time, digital inclusion increasing should lead to improved education, lower levels of unemployment and improved life expectancy; and inequality should organically align to reduced levels. Therefore, digital financial inclusion impacts inequality and increases welfare through education. This hypothesis is an ideal approach from the SSA perspective, considering the challenges faced by the region: low education levels, unemployment and inequality. In theory therefore, digital financial inclusion can reverse the existing positive correlation between income and inequality, and ultimately impact welfare, with or without inequality.

However, digital financial inclusion and education affect unemployment within the informal economy; over time, as digital inclusion improves education and welfare, the informal economy should reduce in size.

Comprehensive financial inclusion is hypothesised to be in alignment with digital financial inclusion, because digital inclusion appears to be the driver of financial inclusion in SSA.

Bank credit to deposit ratio measures credit liquidity in financial services, and credit is theoretically facilitated by traditional financial institutions. Traditional financial inclusion should increase financial inclusion by allocating credit to the marginalised in economies with good, efficient government institutions. Financial inclusion through credit is dependent on government institutions and policies to influence the allocation of credit and liquidity of financial institutions. Therefore, this research hypothesises the impact of credit on financial inclusion in SSA to be low, as the region is known to have poor government institutions, and the traditional financial institutions limit credit to the marginalised.

3.4.2 Dependent Variable

Welfare

This study examines welfare as the core dependent variable. Welfare as a socio-economic status of a country is represented by the Human Development Index (HDI), which is an assessment of a country's average accomplishments in three dimensions of human development, namely access to knowledge, a long and healthy life and a decent standard of living (income/consumption). The three dimensions are normalised, and their geometric mean is the HDI; it is adjusted with inequality to derive the IHDI (Asongu & Roux, 2017; Ofori-Abebrese et al., 2020). As previously mentioned, this approach of utilising HDI to measure welfare was implemented in these studies: Asongu & Roux (2017); Ofori-Abebrese (2020); and Sakyi, Bonuedi, & Opoku (2018). The index ranges are expected to range from 0 to 1, where values close to 0 indicate poor welfare and those close to 1 indicate good welfare. To elaborate on the three dimensions: knowledge is measured by mean years of schooling received in a lifetime by people aged 25 or older; per capita Gross National Income (converted using purchasing power parity, or PPP) measures standard of living; and life expectancy is the measure of a long and healthy life (Conceição, 2020). To deepen the study, and taking considerations of the impact of inequality on welfare from the literature, IHDI (which is calculated as HDI discounted for inequality) is modelled accordingly (Conceição, 2020). Inequality has been described as "stealing" human development, and the difference between HDI and IHDI reveals a loss in human development as a consequence of inequality. A key point to consider regarding the education dimension is primary schooling, which is assumed in the literature to be an indicator of the basic knowledge required to use a mobile phone.

3.4.3 Independent Variables

The financial inclusion index is a multi-dimensional index, utilises various dimensions of financial inclusion, and produces a single-decimal-place number which ranges from 0 to 1, with 0 representing financial exclusion and 1 representing inclusion (Goel & Sharma, 2017; Ofori-Abebrese et al., 2020; Sakyi et al., 2018). Financial inclusion is measured in terms of three dimensions: access, usage and quality of products offered (Goel & Sharma, 2017). However, this study aligns with the IMF Khera, Ng, Ogawa, & Sahay (2021) methodology and uses two dimensions: access and usage.

The access dimension variables for digital financial inclusion are ICT (information and communications technology) indicators including mobile subscriptions per 100 people, percentage of population with access to the internet, and number of registered mobile money agents per 100 000 adults; while the usage dimension includes these variables: percentage of adults with mobile accounts, percentage of adults with internet banking for payments, percentage of adults using mobile phones to receive salary or wages, and percentage of adults using mobile phone for utility payments (Khera et al., 2021). These variables are kept unchanged, in alignment with the IMF (2021) paper; however, this study expands on usage variables to broaden analysis on depth of financial inclusion in relation to channels such as savings, remittances and credit, to establish the correlation significance of financial inclusion to welfare through these channels.

To establish the significance of digital financial services on financial inclusion, as opposed to the traditional financial services, the traditional financial inclusion index is also computed, as it was in prior studies Matekenya (2021), Nanda & Kaur (2016), Ofori-Abebrese (2020) and Sarma & Pais (2008), where the access dimension was measured by number of ATMs per 100 000 adults and number of branches per 100 000 adults. For the traditional usage dimension, the variables are percentage of adults with financial institution accounts, percentage of adults saving at a financial institution, percentage of adults with debit cards, percentage of adults who receive wages through a financial institution account, and lastly, percentage of adults who use a financial institution account for utilities. The comprehensive financial inclusion index is derived from both the traditional and the digital financial inclusion indices, and the variables are the same.

The bank credit to bank deposit ratio (also referred to as “liquidity”) is included as a variable, to establish the effect of finance accessibility within the financial services environment controlled by the banking institutions. Banking liquidity is speculated to affect the correlation between income inequality and accessibility of credit; this was a result of a study by Tita & Aziakpono (2017), in which an out-of-the-ordinary positive relationship was shown to exist between income inequality and account usage for business, payments and savings. The researchers attributed this correlation to high liquidity in the financial institutions as a possible explanation (Tita & Aziakpono, 2017). In this study therefore, the variable bank credit on bank deposits (%) is sourced from the financial development and structure database, to assess the impact of liquidity on welfare, which theoretically is expected to impact welfare indirectly via

financial inclusion. In a study conducted by Allen, Carletti, Valenzuela and others (2014) on financial inclusion gaps, access to loans was shown to be vital for growth (measured by per capita GDP), and it remains a challenge to financial inclusion for countries in Africa.

Table 1: Variables Summary

Variable	Description	Variable type	Hypothesised relationship (Expectation)	Literature	Source and Frequency
W_i	welfare	Dependent			
LEX_i	Life Expectancy – a measure of a long and healthy life.	Explanatory	Improvement in ICT through mobile usage has enabled payments to hospitals, schools, agriculture, industry, and in remote rural areas. Mobile phones have therefore impacted the health sector, with health practitioners in Africa utilising mobile health projects for development. Farmers have adopted mobile phones and mobile money options to extend agricultural services, contributing positively towards food security in Africa. This study hypothesises ICT to be positively correlated to life expectancy and welfare in SSA.	(Aker & Mbiti, 2010)	United Nations Development Programme database Data available yearly
INC_i	Income – Gross national income (per capita GNI, PPP$) accumulated by a country's residents inclusive of aid and remittances, excluding income repatriated abroad.	Explanatory	Income is a key determinant of household welfare, and also drives usage of financial services. Financial inclusion has a strong positive effect on household income. However, at country level, high-income countries benefit the most from financial inclusion, which is not necessarily the same for low- or middle-income countries. Hypothesis: income, and welfare have a positive	(Mallick & Zhang, 2019) (Matsebula & Yu, 2020) (Nanda & Kaur, 2016)	IMF World economic outlook Data available yearly

			correlation, which is expected to be enhanced by digital financial inclusion.		
EDU_i	Education – mean years of schooling for adults aged 25 years or more. Inclusive of expected schooling years for children at schooling age. Can be viewed as the average population education of a country.	Explanatory	Improving the quality of education at primary level with universal access schemes for mobile phones simultaneously will curb poverty and inequality in Africa. Education is positively related to financial inclusion, and drives usage of financial services. Therefore, the education dimension is hypothesised to improve welfare, and is therefore positively related.	(Asongu et al., 2019) (Matsebula & Yu, 2020)	United Nations Development Programme database Data available yearly
$UNEM_i$	Unemployment – labour force eligible and seeking employment, but have no work.	Explanatory	High level of unemployed population reduces income opportunities and participation in the financial system, which decreases inclusion and ultimately welfare. Some studies find unemployment to be insignificant to welfare in SSA, though mobile money is confirmed to stimulate or create employment in Africa as a whole. The insignificance of the correlation might be attributed to incumbent variables utilised to represent financial services inclusion. This research hypothesises a decrease in unemployment with digital financial inclusion, and a negative correlation between unemployment and welfare.	(Matekenya et al., 2021) (Ofori-Abebrese et al., 2020) (Sarma & Pais, n.d.) (Aker & Mbiti, 2010)	The World Bank, International Labour Organisation database (ILOSTAT) Data available yearly
$IAINC_i$	Inequality-adjusted Income	Explanatory	Income inequality is expected when a small population is exposed to financial services.	(Dutt, 2016) (Tita & Aziakpono, 2017)	United Nations Development

			Consistent high levels of inequality and poverty have been shown to correlate to underdevelopment, low societal income, and welfare. Therefore, high inequality should reduce income and decrease welfare.		Programme database Data available yearly
$IAEDU_i$	Inequality-adjusted Education	Explanatory	Wealth and income distribution influence the aggregate investment amount in human capital. The basic approach to combating inequality is through human capital investment and education, where skill results in technological progress and innovation. Therefore, education index is expected to be negatively related to inequality.	(Galor & Zeira, 1993) (Zhao, 2020)	United Nations Development Programme database Data available yearly
$IALEX_i$	Inequality-adjusted Life expectancy	Explanatory	Poverty levels are impacted significantly by changes in inequality, meaning that countries with high levels of inequality may not be able to achieve a reduction in poverty irrespective of the growth rate; therefore, with high inequality, economic growth will be ineffective in reducing poverty. Poverty impacts life expectancy negatively, therefore there is a negative correlation between life expectancy and inequality.	(United Nations, 2020) (Conformática, 2013)	United Nations Development Programme database Data available yearly
$DIFI_d$	Digital Financial Inclusion	Explanatory	Human development and financial inclusion of a country are closely aligned. There is significant positive correlation between the digital financial inclusion index and welfare.	(Sahay et al., 2020) (Khera et al., 2021)	World Bank Global Findex database (WB Findex) Data available every three years

$TRFI_t$	Traditional Financial Inclusion Index	Explanatory	Significant positive unidirectional correlation between financial inclusion index and welfare.	(Ofori-Abebrese et al., 2020) (Sarma & Pais, n.d.) (Nanda & Kaur, 2016) (Khera et al., 2021)	World Bank Global Findex database (WB Findex) Data available every three years
$COMFI_{dt}$	Comprehensive Financial Inclusion Index	Explanatory	Positive correlation between financial inclusion index and welfare, driven particularly by mobile banking.	(Sahay et al., 2020)	World Bank Global Findex database (WB Findex) Data available every three years
d_{a1}	Mobile subscriptions per 100 people (Access)	Explanatory	Mobile ownership reduces the probability of a household falling into poverty; therefore positively related to welfare.	(Abor, Amidu & Issahaku, 2018)	International Telecommunication Union (ITU), World Bank Data Data available yearly
d_{a2}	% of Population with access to internet (Access)	Explanatory	ICT enhances inclusive human development in regions with high penetration; therefore, there exists a positive correlation between ICT and welfare.	(Mishra & Singh Bisht, 2013) (S. Asongu et al., 2017)	International Telecommunication Union (ITU), World Bank Data Data available ysearly
d_{u1}	Adults with mobile accounts (Usage)	Explanatory	Households with mobile money accounts are more likely to be banked and transact more, receive or send remittances more frequently, and accumulate more savings, which increases welfare. Therefore, mobile accounts and welfare are positively related.	(Ouma, Odongo & Were, 2017)	World Bank Global Findex database (WB Findex) Data available every three years
d_{u2}	Adults using internet to pay (Usage)	Explanatory	A positive correlation between ICT usage and welfare.	(Andersson & Naghavi, 2021) (Nanziri, 2017)	World Bank Global Findex database (WB Findex)

					Data available Every three years
d_{u3}	Adults using mobile phones to receive salary or wages (Usage)	Explanatory	Financial inclusion through payments enables the marginalised to be included in the financial system, which reduces inequality, ultimately improving welfare. Positive correlation between internet usage and welfare.	(Khera et al., 2021)	World Bank Global Findex database (WB Findex) Data available every three years
d_{u4}	Adults using mobile phone for utility payments (Usage)	Explanatory	The biggest impacts to reduce poverty and increase welfare come from savings accounts and digital payments. Payments and savings are positively correlated with welfare.	(Andersson & Naghavi, 2021) (Nanziri, 2017) (Demirgüç-Kunt & Klapper, 2012)	World Bank Global Findex database (WB Findex) Data available every three years
d_{u5}	Adults receive or send domestic remittances using a mobile phone (Usage)	Explanatory	Remittances are proven to alleviate poverty, enabling access to clean energy, water, food and medicine, empowering women and promoting entrepreneurship, therefore contributing to the progress of many SGDs. Positive correlation between remittances and welfare.	(Bisong, Ahairwe, & Njoroge, 2020)	World Bank Global Findex database (WB Findex) Data available every three years
dt_{a1}	Number of ATMs per 100 000 adults (Access)	Explanatory	Increase in financial services access leads to an increase in financial inclusion, which improves welfare. Financial access and welfare are positively correlated.	(Matekenya et al., 2021) (Nanda & Kaur, 2016) (Matekenya et al., 2021)	IMF Financial Access Survey (IMF FAS), World Bank Data
dt_{a2}	Number of branches per 100 000 adults (Access)	Explanatory	Increase in financial services access leads to an increase in financial inclusion, which improves welfare. Financial access and welfare are positively correlated.	(Matekenya et al., 2021) (Nanda & Kaur, 2016)	IMF Financial Access Survey (IMF FAS), World Bank Data

dt_{u1}	Adults with a financial Institution account (Usage)	Explanatory	Positive relationship to welfare.		World Bank Global Findex database (WB Findex) Data available every three years
dt_{u2}	Adults who save at a financial institution (Usage)	Explanatory	The biggest impacts to reduce poverty and increase welfare come from savings accounts and digital payments. Payments and savings are positively correlated with welfare.	(Demirgüç-Kunt & Klapper, 2012)	World Bank Global Findex database (WB Findex) Data available every three years
dt_{u3}	Adults with debit card (Usage)	Explanatory	Positive relationship between use of financial services through debit cards and welfare.		World Bank Global Findex database (WB Findex) Data available every three years
dt_{u4}	Adults borrowing from financial institution (Usage)	Explanatory	Positive relationship between use of financial institutions and welfare.		World Bank Global Findex database (WB Findex) Data available every three years
BNK_r	Bank credit to deposit ratio	Explanatory	High bank liquidity is negatively related to economic growth and financial inclusion through credit, therefore negatively related to welfare.	(Chima et al., 2021)	Global financial development database (FDSD) Yearly

3.5 Data Collection, Frequency, and Choice of Data

3.5.1 Data Choice

This study uses secondary data on developing SSA countries for the three years 2011, 2014 and 2017. To compute the financial inclusion indices, the World Bank Global Findex database (WB Findex) is adopted, as it is the largest database in which survey data on individuals (not households) is homogenously collected, providing insight on the demand side of financial inclusion, including fintech and use of mobile phones. This database was initially published in

2011 and again in 2014 and 2017. The approach of using Findex as a data source is in alignment with other studies on financial inclusion (Cámara & Tuesta, 2014; Demir, Pesqué-Cela et al., 2020; Demirgüç-Kunt, 2017; Sahay et al., 2020; Tita & Aziakpono, 2017). Other data sources used for purposes of this research align with the data frequency of the financial inclusion index calculation; these include United Nations Development Programme database, the World Bank database (World Development Indicators), World Bank Global Findex database (WB Findex), International Telecommunication Union (ITU), International Monetary Fund database (IMF FAS), GSMA Mobile Money Dataset and the Financial Development and Structure Database (FDSD).

Table 2 below includes 41 SSA developing countries selected for this study, with their informality classification and income. Defining and listing the SSA countries with informality level in Table 2 is linked to the sub-question in which the researcher is investigating whether the informality of economies impacts the use of mobile money and influences digital financial inclusion. The income level of the countries is included to observe any pattern regarding income status of a country which might impact this analysis. The literature also alludes to informality of economies aligning with level of country income; though this might not necessarily be the case for oil exporters and fragile countries, as they embrace informality regardless of income level.

The country sample selection and informality classification of the economies is based on a study by the IMF (2017) in which estimations were conducted to determine the size of the informal economy in SSA countries; it was shown to be the largest in the world (Medina et al., 2017). The author of the current study thus saw the need to include this factor in an analysis of the research through data classification or sampling, to reduce complexity and deviation of this research from its intent in terms of inclusion and welfare. The time period in which the IMF study took place aligns with the period of data used in this study. For information purposes, the IMF study used the Multiple Indicator-Multiple Cause (MIMIC) model, PMM and national accounts of the SSA countries to determine the size of the informal economies in the region (Medina et al., 2017) .

Table 2: Analysis of countries in the study

Country	Informality of the Economy	Level of Income
	0-20% Of GDP	
Botswana	Low size	Upper middle income
Mauritius	Low size	Upper middle income
Lesotho	Low size	Lower middle income
Eswatini (Kingdom of)	Low size	Lower middle income
South Africa	Low size	Upper middle income
	20-40% of GDP	
Cabo Verde	Middle size	Lower middle income
Cameroon	Middle size	Lower middle income
Eritrea	Middle size	Low income
Gabon	Middle size	Upper middle income
Kenya	Middle size	Lower middle income
Malawi	Middle size	Low income
Namibia	Middle size	Upper middle income
Sierra Leone	Middle size	Low income
The Gambia	Middle size	Low income
Uganda	Middle size	Low income
Zimbabwe	Middle size	Lower middle income
	>40% of GDP	
Angola	High Size	Lower middle income
Burkina Faso	High Size	Low income
Burundi	High Size	Low income
Central African Republic	High Size	Low income
Chad	High Size	Low income
Comoros	High Size	Lower middle income
Congo	High Size	Low income
Congo (Democratic Republic of)	High Size	Lower middle income
Côte d'Ivoire	High Size	Lowe middle income
Equatorial Guinea	High Size	Upper middle income
Ethiopia	High Size	Low income
Ghana	High Size	Lower middle income
Guinea	High Size	Low income
Guinea-Bissau	High Size	Low income
Liberia	High Size	Low income
Madagascar	High Size	Low income
Mali	High Size	Low income
Mauritania	High Size	Lower middle income
Mozambique	High Size	Low income
Niger	High Size	Low income
Nigeria	High Size	Lower middle income
Senegal	High Size	Lower middle income
Togo	High Size	Low income
Tanzania (United Republic of)	High Size	Lower middle income
Zambia	High Size	Lower middle income

The information in Table 2 and the results of the PCA stage 2 calculating digital financial inclusion are used to provide clarity in this investigation. The PCA methodology follows three stages of computing the sub-indices. Within the first stage of PCA the weights are derived for each of the variables to estimate usage and access, which are sub-indices and have weights calculated only in 2017; this was due to limited availability of data for mobile banking. Deriving weightings is a process in which principal components are derived and normalised as a sum of squares that equates to 1. For this study, one component across all variables for usage and access explains between 86% and 91% of the variation in the variables; thus, only the first principal component (PC1) is used to compute the weightings.

Stage 1 output is then used to calculate the stage 2 sub-indices. The access and usage dimensions are combined using PCA methodology to create access and usage sub-indices separately. The access and usage sub-indices indicate the usage of mobile money in the SSA countries, which is the demand side, in relation to access to digital banking, the supply side.

3.5.2 Data Sampling

Financial services has many dimensions affected by digital finance; these include remittances, savings, insurance, investment management, domestic payments and credit. However, the sample data in this study focuses predominantly on payment transactions conducted on mobile phones, as the majority of SSA countries (excluding Kenya) are still in the early stages of digital financial services, where "payments" is the entry service to financial inclusion.

According to the literature, mobile money payment services have provided a much-needed banking services platform for low-income and lower-middle-income countries in SSA, and the most effective channel so far to impact welfare through financial inclusion for the marginalised (Andersson & Naghavi, 2021; Demirgüç-Kunt et al., 2017; Nanziri, 2017; Ouma, Odongo, & Were, 2017; Sahay et al., 2020).

The selected data size is of sufficient significance to enable analysis and observations on the selected countries in order for the study to produce a conclusion. Other channels of financial inclusion, specifically borrowings and savings, are included in the traditional banking calculations to provide detail on how these products influence financial inclusion. The dataset utilised in this study is secondary data, therefore a unique sampling technique is not relevant.

3.5.3 Data Analysis Methods

Analysis and estimation of the relationship between traditional financial inclusion, inequality and welfare was performed using the fixed-effect methodology on a panel sample of SSA data to test the correlation using multi-regression models across the three years 2011, 2014 and 2017 (Demir et al., 2020). Due to mobile data limitations on the demand side, the study adopts the pooled OLS methodology to enable multi-regression of the digital financial inclusion and the comprehensive financial inclusion, together with inequality and welfare in 2017. The variables unemployment and bank credit ratio are included in the models to help rationalise the results in alignment with the literature.

This analysis approach is in accordance with methodologies prescribed for panel data studies. The three main modelling analyses for panel data are pooled OLS, fixed effects and random effects; though a study by Mallick & Zhang (2019) showed that the OLS approach does not cater for endogeneity in financial inclusion, resulting to biased and inconsistent estimations. However, pooled OLS is used on the mobile money analysis in this study, because the data is non-binary and a linear relationship exists between the variables.

To ensure that the fixed-effects model is the correct model for this analysis, the F-test for fixed effects and the Breusch-Pagan Lagrange Multiplier (LM) for random effects were conducted. To choose between the random-effects model and the fixed-effects model the Hausman test was modelled, with a null hypothesis of the random-effects model being the preferred method; the alternative implication is that the fixed-effects model is appropriate. Based on the results of this test, the study opted for the fixed-effect approach.

The Stata software was used to analyse the data. The financial inclusion index calculation followed the three-stage PCA approach (Cámara & Tuesta, 2014; Sahay et al., 2020)

3.5.4 Research Reliability and Validity

Diagnostic tests are performed to validate consistency and reliability of the results where estimations do not contain econometric problems, and regression assumptions in the models are met and tested as the null hypothesis against alternative hypothesis with problematic models. The regression assumptions include homoscedasticity, no multicollinearity and absence of autocorrelation.

Before regression analysis this study adopted the Pearson correlation matrix to establish multicollinearity between variables, which was confirmed. This is important because multicollinearity leads to biased results, with large, unreliable standard deviations of regression coefficients. The correlation coefficient measures the strength and relationships of the coefficients for the variables, and low correlation is defined to be less than 0.8 between variables, which shows non-problematic multicollinearity in the models (Chima et al., 2021; Leke & Asongu, 2019; Musau et al., 2018). The correlations are influenced by outliers and non-normality (Vogt, 2015). To deal with the multicollinearity issue, winsorisation was adopted in this study to resolve outliers in the range 5% to 95%. The main reason for winsorising is to trim outliers for stability of the data (Jadhav & Kashid, 2014). This approach reduced the intercorrelation between the variables significantly.

When testing for normality, the Shapiro-Wilk test was not in alignment with the absolute skewness and the kurtosis methods; however, it is normal in some instances for this scenario to occur. But it should be noted that for regression estimations the data might not always be normal, and alternative analysis methods may be used for investigations. This study adopts the panel data analysis method; with this approach, the data is normalised or transformed only in instances where the relationship between the variables is non-linear, and this can be detected using scatterplot. It is important to analyse linear relationships between variables, as it can provide insight on the significance of the association they have with each other, and logical explanations when analysing regression models.

The research ran the Breusch-Pagan test to test for heteroscedasticity and the existence of errors in the regression analysis. Its null hypothesis assumes the error variables to be equal. The null hypothesis is confirmed to be valid if the chi-square and p-value are small. The data used in this investigation displayed no trace of heteroscedasticity. The White test is an alternative method for testing heteroscedasticity but is unsuitable for this study because it is used for large samples.

To verify the validity and robustness of the estimates, this research implemented the parametric PCA approach to minimise biased results; this is a process in which endogenously computed weights are assigned to the sub-indices when calculating the financial inclusion index, to curb possible high correlation between the financial access variables and the explanatory variables (Cámara & Tuesta, 2014; Thathsarani et al., 2021). Data normalisation of the financial inclusion

indicators occurred before derivation of the two sub-indices, using the formula below. Normalisation is considered critical in instances in which the indicators used have different scales.

$$Xnormalised = \frac{X_i - min_x}{Max_x - min_x}$$

It is critical to note that missing data is an issue with SSA data sourced from the Global Findex, which mainly provides in-depth demand-side perspectives of individuals at a country level. As expected, missing data was a challenge experienced in this investigation. There are three main mechanisms for dealing with missing data: MCAR (missing completely at random), MAR (missing at random) and NMAR (not missing at random), where MAR is said to be the missing-data mechanism for which data missing from the model can be ignored in the estimation process (Soley-Bori, Horn, Morgan & Min Lee, 2013). There are three methods for handling missing data: deletion (case deletion), single imputation methods and multiple imputation (Soley-Bori et al., 2013). The case deletion method is adopted as a default for Stata, which involves complete exclusion of a case from analysis if there is missing data for any variable. Imputation methods entail guessing a reasonable value and conducting the analysis as normal without missing values; however, this can lead to unreliable, overestimated test statistics. This research will adopt the case deletion approach, which is the easiest method in Stata and works well if random data is missing. This means that all countries with missing values would be excluded from the regression analysis and the sample would be reduced; however, should this result in larger standard errors, then the alternative single-imputation method would be implemented.

The digital finance regression results are based on a small data sample due to missing data, as explained above. The minimum sample size of 20 is used in the regression models where digital and comprehensive inclusion are included as predictors. As stated in the literature, small samples may lead to type I or type II errors, where significance or outcome are assumed to be true when they are false .or vice versa. (Faber & Fonseca, 2014). To control and resolve the small-sample challenge, this study followed a Monte Carlo approach, from research by Gavilanes (2020) in which they investigated a regression technique to be utilised to achieve statistical significance and lower bias when dealing with small sample sizes of 6,10, 20 and 500. The study found Jackknife and OLS regressions to be more suitable for lower sample sizes; however, when the sample size is 20 with degrees of freedom at 14, OLS predicts better co-efficient results, while OLS and Jackknife perform equally well deriving the best expected

value for standard deviation(Riveros Gavilantes, 2020). Interestingly, their study discovered that simulations of the Monte Carlo method showed no change to significant relationships in small samples when the sample size increased. Therefore, Jackknife and OLS regressions were adopted in this study, in alignment with recommendations by Gavilantes (2020) to reduce bias and increase the significance of variables, faults that appear to persist in instances where the sample size increases.

3.6 Limitations of the study

The study presented the following limitations:

The availability of research data regarding mobile banking is limited. The main data source (the World Bank Global Findex database) was created in 2011, and the survey data is released every three years. For some SSA countries, the 2011 and 2014 data for the explanatory variables selected to calculate the digital financial inclusion index is unavailable; however, that improved significantly in 2017, so the digital finance analysis is limited to 2017 in this research, and the time series approach could not be adopted for trend analysis. The demand side of the data is also available from only a smaller sample of SSA countries, reducing analysis data significantly, with a minimum sample size of 20.

The COVID-19 pandemic period is likely to present new challenges in the financial inclusion and development space, particularly for the periods of government lockdowns; and that might require recalibration of theories, models and certain indicators in the future. Due to the limitations of data availability, the unprecedented economic impact of COVID-19 was not incorporated in this empirical testing.

This study is limited to payments as a type of of digital banking because most SSA countries are in the early stages of mobile banking. More financial depth resulting from the use of other financial products such as loans, insurance and investment would broaden analysis on digital financial inclusion and inform scholars regarding the advancement of mobile banking technology to improve welfare in the region.

It would have been ideal to expand on the literature by assessing the impact of COVID-19 government debt on financial inclusion and welfare in the pandemic period, as research by

Gebrehiwot & Makina (2015) revealed financial inclusion to be negatively related to government debt. However, research has also shown that digital government payments or development funds tend to increase digital financial inclusion, which is positively correlated to welfare (Cámara & Tuesta, 2014). During the COVID-19 pandemic, SSA governments borrowed (and significantly increased their debt) to fund solutions to welfare catastrophes rather than growth investments, which is not a typical scenario. It would therefore be informative for the literature to assess the relationship between government debt, digital financial inclusion and welfare in such circumstances.

This research could be improved with a deeper analysis of market structures in SSA by considering the impact of digital banking competition on the traditional banking sector, and establishing what integration strategy is best suited and could be facilitated via government policies to stimulate financial development, inclusion and welfare through digital banking. This type of analysis requires mobile banking data that distinguishes between digital services on mobile phones by fintech and traditional banking institutions. To date, as far as this researcher knows, that level of granularity is not available, and this limitation precludes comprehensive analysis.

CHAPTER 4

RESEARCH FINDINGS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the findings and analysis of the investigation, to provide clarity and answers to the questions posed by the research. The results were achieved by following the methodology detailed in chapter 3. This section of the study is split into four sections, dealing with descriptive statistics, correlation coefficients and the regression results. and finally drawing a conclusion.

4.2 Descriptive Statistics

This section provides descriptive statistics relating the impact of financial inclusion to welfare. Both digital financial inclusion and traditional financial inclusion indexes are considered, to gauge where resources should be employed to improve inclusion and welfare in SSA. Of the two, digital financial services are hypothesised to significantly impact welfare in SSA.

Normality tests are performed to determine if the selected data set fits into a normal distribution when modelled; this informs the approach to be implemented when regressing the data.
The skewness and kurtosis test is used to determine the normality of all the variables used in this study. As demonstrated in Table 3 below, normally distributed variables have absolute skewness values of between -2 and +2, and kurtosis values between -7 and +7. In Table 3, all the variables have skewness and kurtosis values within the prescribed ranges for normality.
Further normality tests were also conducted. Table 4 below demonstrates the Shapiro-Wilk test results for normality. In this test, the null hypothesis states all values greater than 0.05 to be normally distributed; while those less than 0.05 deviate from the null hypothesis, therefore rejecting it and showing that the data is not normally distributed. The probability column on the far right of Table 4 is the most important one, and it reveals only LEX, TRFI, BNK, COMPFI and DIFI to be above 0.05, demonstrating normality, while all the other variables are less than 0.05, meaning they are not normally distributed. The approach to dealing with the reliability of the different normality results is detailed in chapter 3.

Table 3: Normality test

Variable	N	skewness	kurtosis
IHDI	112	1.565	6.718
HDI	132	0.793	3.439
EDU	132	0.212	2.800
LEX	135	0.183	3.099
IALEX	134	0.924	3.896
IAINC	115	1.179	5.081
IAEDU	118	0.698	3.171
TRFI	96	-0.229	3.354
INC	118	1.884	5.644
BNK	108	-0.149	3.179
UNEM	120	1.313	3.713
DIFI	26	0.013	2.736
COMPFI	22	0.056	2.325

Notes*: TRFI = Traditional Financial Inclusion Index; EDU= Education; INC= Income; LEX= Life Expectancy; UNEM= Unemployment; IAEDU= Inequality-adjusted Education; IAINC= Inequality-adjusted Income; IALEX = Inequality-adjusted Life Expectancy; BNK= Bank credit to deposit ratio; DIFI= Digital Financial Inclusion Index; COMFI= Comprehensive Financial*

Table 4: Shapiro-Wilk test

Shapiro - Wilk W test - normal distribution test			
Variable	**Obs**	**z**	**Prob>z**
IHDI	112	3.449	0.00028
HDI	132	3.061	0.0011
EDU	132	1.728	0.04199
LEX	135	-0.18	0.57139
IALEX	134	3.469	0.00026
IAINC	115	3.569	0.00018
IAEDU	118	3.037	0.0012
TRFI	96	0.543	0.29361
logINC	118	4.109	0.00002
BNK	108	0.48	0.31565
logUNEM	120	2.507	0.00609
DIFI	26	-0.631	0.73606
COMPFI	22	-1.479	0.93048

Notes*: TRFI = Traditional Financial Inclusion Index; EDU= Education; INC= Income; LEX= Life Expectancy; UNEM= Unemployment; IAEDU= Inequality-adjusted Education; IAINC= Inequality-adjusted Income; IALEX = Inequality-adjusted Life Expectancy; BNK= Bank credit to deposit ratio; DIFI= Digital Financial Inclusion Index; COMFI= Comprehensive Financial*

4.2.1 Correlation Analysis

The correction matrix in Table 5 below displays high correlation between EDU and IAEDU, IALEX and LEX, IAINC and INC, IALEX and EDU; this is expected, because the variables are the same, with adjustment for inequality. The inequality-adjusted variables are regressed separately from EDU, LEX, and INC, because they introduce traces of multicollinearity when used in the same regression analysis. The INC is an interesting variable; it is strongly correlated to EDU and moderately correlated to LEX, which ultimately applies to IAEDU and IALEX; this correlation is monitored in the study because the three variables INC, LEX and EDU constitute welfare. The same variables (INC, EDU, IALEX, IAINC and IAEDU) were highlighted in the Shapiro-Wilk test above.

The very strong correlation between COMPFI and DIFI is expected because COMPFI is a combination of TRFI and DIFI, and the three variables will be regressed separately to provide clarity and answer the questions of the study. At first glance, comprehensive financial inclusion seems to be driven by digital finance; however, this can also be overstated due to the fact that DIFI data is available only from 2017. Overall, correlation does not imply causation, which is why regression analysis is conducted in this research to investigate the cause and effect relationship between the independent variables and the dependent variable. An unexpected observation is that there is a negative correlation between education and the financial inclusion variables TRFI, DIFI and COMPFI. This negative relationship is contrary to the literature.

Table 5: Correlation matrix

	EDU	INC	LEX	UNEM	IAEDU	IAINC	IALEX	BNK	DIFI	TRFI	COMPFI
EDU	1.000										
INC	0.711	1.000									
LEX	0.368	0.582	1.000								
UNEM	0.464	0.381	-0.139	1.000							
IAEDU	0.966	0.752	0.394	0.501	1.000						
IAINC	0.339	0.723	0.523	-0.104	0.332	1.000					
IALEX	0.557	0.726	0.953	0.067	0.595	0.556	1.000				
BNK	-0.255	0.096	0.208	-0.085	-0.177	-0.149	0.105	1.000			
DIFI	-0.025	0.285	0.217	-0.337	0.050	0.279	0.150	0.346	1.000		
TRFI	-0.234	-0.119	0.157	-0.542	-0.235	0.312	0.046	0.013	0.274	1.000	
COMPFI	-0.225	0.069	0.078	-0.487	-0.153	0.161	-0.026	0.329	0.967	0.365	1.000

Notes: *TRFI = Traditional Financial Inclusion Index; EDU= Education; INC= Income; LEX= Life Expectancy; UNEM= Unemployment; IAEDU= Inequality-adjusted Education; IAINC= Inequality-adjusted Income; IALEX = Inequality-adjusted Life Expectancy; BNK= Bank credit to deposit ratio; DIFI= Digital Financial Inclusion Index; COMFI= Comprehensive Financial Inclusion Index*

4.3 Regression Results

4.3.1 Diagnostic Results

The diagnostic test results for the models are presented in this section; they demonstrate alignment with the assumption made that the estimations do not have any of the econometric problems regarding reliability and validity, therefore there is no rejection of the null hypothesis.

Analysis of the regression models shows they mostly demonstrated a high r-squared of between 85% and 96%, which is useful information in general to indicate that the models are a good fit, considering the observations of the test. However, residual plots are also conducted to expose whether the models are biased in any way, to substantiate the reliability of the high r-squared and verify that it is not over-inflated by the variables. The results are in the Appendix section, and they show that the variables are randomly scattered around zero for all models, confirming that the residuals do not contradict the linear assumptions.
The Durbin-Wu-Hausman test is conducted on models 1 and 2 (refer to Table 7 below) to confirm the choice of the fixed-effect model as the appropriate method for the traditional inclusion regression; the p-value is less than 0.05 for the models, therefore the null hypothesis is rejected. This supports the choice of the fixed-effect methodology as the preferred regression approach for models 1 and 2; the details regarding fixed-effect and random-effect methodologies can be perused in chapter 2 and chapter 3 above.

Pooled OLS regression is adopted on models 3, 4, 5 and 6 for 2017, due to digital inclusion data limitations. The Breusch-Pagan test is conducted to test for heteroscedasticity on these models – 3, 4, 5 and 6 – and the p-value results (refer to Table 8 below) were 0.49, 0.24, 0.68 and 0.45 respectively, proving that the data is homoscedastic, as all values are greater than 0.05. As there is no evidence of heteroscedasticity, the null hypothesis is accepted. The Lagrange-Multiplier (LM) test statistic produced chi-square figures of 0.87, 0.21, 0.78 and 0.28 respectively to confirm there is no heteroscedasticity, and confirming the use of pooled OLS to be reliable.

Models 7, 8, 9 and 10 examine the effect of inequality on welfare, considering both traditional and digital inclusion. Pooled OLS regression is adopted for these models. This is because the digital data in models 7 and 8 is limited to 2017, while traditional inclusion when regressed

with inequality-adjusted data is mostly significant with the pooled OLS approach. Models 9 and 10 have signs of heteroscedasticity. Though OLS remains unbiased and consistent under heteroscedasticity, it loses efficiency, which is rectified using the "Robust" function in Stata. The regression output of comprehensive financial inclusion and the inequality-adjusted variables had insignificant co-efficients, and is therefore excluded from the analysis. A detailed analysis of the regression output for all models follows.

4.3.2 Traditional financial inclusion: effect on human development

Table 7 below displays results showing the effect of traditional financial inclusion on welfare for the years 2011, 2014 and 2017, where 2011 is the base year. Only the fixed-effect results will be discussed in this section because that is the most appropriate approach, given the results of the Durbin-Wu-Hausman test; however, the random-effect results are included for information purposes. EDU and INC are regressed separately due to possible multicollinearity issues highlighted in the correlation matrix. Model 1 regresses EDU, LEX, TRFI, UNEM and BNK, mainly to establish the influence of traditional financial inclusion and education on welfare. This regression has a high between r-squared of 0.86, demonstrating that the model explains the differences between variables well in the output. The within variation r-squared is 0.93, which means the model can predict the output within the same group of variables well over time. For an estimation of overall data, the r-squared is 0.85, which is a good fit for predicting the dependent variable, HDI. The F statistic test proves model 1 to be significant because it has a p-value of less than 0.05% at 0%, which means that there is no time-invariant heterogeneity, and there are significant differences between the variables.

The correlation coefficient (u_i, Xb) between u_i (represents unobserved heterogeneity) and x-variables for model 1 is slightly high at 0.72, meaning the fixed-effect model is the best approach because the assumption that u_i is not correlated to explanatory variables fails, suggesting possible endogeneity. The fixed-effect model remains consistent, even in instances where the assumption fails. The variance of u_i, rho, is the percentage of the variation explained by the individual specific effect, which is 0.99.; and that is a good result, because of its idiosyncratic effect.

Model 2 regresses INC, LEX, TRFI, UNEM and BNK, to assess the impact of traditional financial inclusion with income on welfare. Analysing the output, model 2 has a moderate

between r-squared of 0.64, with a high within-variation r-squared of 0.91; while the overall data estimation seems average, with the 58% of the variation observed in the dependent variables explained by the regression model. The F statistic for model 2 is significant at 0%, and the correlation coefficient (u_i, Xb) between u_i (represents unobserved heterogeneity) and x-variables is 0.58, meaning the fixed-effect model is the best approach, due to possible endogeneity. The intraclass correlation, rho, is 0.99, which implies a high proportion of variation in the dependent variable to be explained by changes in u_i. Models 1 and 2 confirm the relevance of the fixed-effect modelling methodology adopted to avoid endogenous bias. With the fixed-effect model, the effect of time-invariant characteristics is removed, to enable assessment of the predictors on the dependent variable.

The coefficients of model 1 and 2 display small standard errors of the regression coefficients, which shows sample representation accuracy. The three variants EDU, LEX and INC are expected to be significant and positively related to HDI. TRFI is significant at 0.039 with education (model 1), and 0.046 with income (model 2); both are positively correlated to HDI. In both regressions, model 1 and model 2, UNEM has a negative relationship to welfare that is not significant; this is in line with research by Ofori-Abebrese et al. (2020) on welfare. Predictably, BNK is not significant in either model but positively related to HDI, because allocation of credit as hypothesised is low, and not driving any financial inclusion through TRFI or DIFI because it is controlled by the financial institutions. Credit allocation and liquidity are highly dependent on policies in SSA.

In line with the hypothesis, traditional financial inclusion (TRFI) is on the borderline, with a p-value of 0.046 when regressed with income because inequality is high in SSA, impacting inclusion and welfare suboptimally, though it is good that they are positively related. However, the significance of TRFI at 0.039 when regressed with EDU validates the predictions that education should impact welfare, irrespective of inequality levels; both variables are significant and positive to welfare. Unemployment (UNEM) is not significant, and is therefore in alignment with the literature and with the hypothesis of this study, TRFI does not impact unemployment to improve the welfare of the poor.

Table 6: Effect of traditional financial inclusion on welfare in SSA

Dependent variable	HDI							
	Model 1				*Model 2*			
	Fixed Effect		Random Effect		Fixed Effect		Random Effect	
VARIABLES	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
EDU	0.332***	0,000	0.558***	0.000				
LEX	0.271***	0,000	0.350***	0.000	0.257***	0.000	0.393***	0.000
UNEM	-0.001	0,535	0.001*	0.095	0,000	0.810	0.002***	0.007
BNK	0.000	0,843	0.000	0.429	0,000	0.399	0.000	0.333
TRFI	0.020**	0,039	0.014	0.168	0.021**	0.046	0.012	0.331
INC					0.000**	0.044	0.000***	
Constant	0.194***	-0,001	0.031	-0.352	0.345***	0.000	0.232***	0.000
R^2 Overall	0.849		0.916		0.583		0.832	
R^2 within	0.929		0.912		0.911		0.876	
R^2 Between	0.861		0.914		0.645		0.837	
R^2_a	0.88		.		0.849		.	
Number of id	30		30		30		30	
corr(u_i, Xb)	0.7241		0		0.5784		0	
rho	0.991		0.967		0.994		0.975	
Hausman	20.89		.		83.58		.	
Prob > chi2	0.004***		0		0.000***		0	
F-Statistic	76.75		.		100.64		.	
Prob (F-statistic)	0.000***		.		0.000***		.	
Observations	88		88		88		88	

Notes: *** p<0.01, ** p<0.05, * p<0.1

DIFI= Digital financial Inclusion Index; logEDU= Education; logINC= Income; logLEX= Life Expectancy; logUNEM= Unemployment; logIAEDU= Inequality adjusted Education; logIAINC= Inequality adjusted Income; logIALEX = Inequality adjusted Life Expectancy; logBNK= Bank credit to deposit ratio; COMFI= Comprehensive Financial Inclusion Index

4.3.3 Effect of digital financial inclusion on human development

Table 8 below presents the pooled OLS and Jackknife regression of digital inclusion and comprehensive inclusion. As explained in chapter 3, analysis of digital inclusion and comprehensive inclusion is limited to 2017. Pooled OLS is preferred over Jackknife regression because it produced the best results, considering the small sample size caused by the missing data in deriving digital financial inclusion and comprehensive financial inclusion predictors. This sub-section unpacks the pooled OLS regression results; the Jackknife output is included in Table 8 for information purposes. Variables DIFI (models 3 and 4) and COMPFI (models 5 and 6) are regressed separately due to the existing correlation confirmed earlier in this chapter.

The independent variables are logged when regressed with DIFI and COMPFI to increase the normality and significance of the observations. In summary, the SSR (sum of squares regression) is large relative to the SSE (sum of squares of errors) for all four models (3, 4, 5 and 6), meaning that their coefficient of determination (also known as r-square) is high, implying significant good models. However, the significance of these models is nevertheless tested with residual plots, to expose whether they are biased in any way in order to substantiate the reliability of the high r-squared.

Table 8 below refers. Models 3 and 4 use digital financial inclusion (DIFI) as an independent variable for financial inclusion. Analysing the results of model 3, there's a high r-squared of 0.963 and adjusted r-squared of 0.952, confirming that the variation in the dependent variable HDI is explained by differences in the independent variables logEDU, logLEX, logUNEM and DIFI, making the model a good fit. The standard error of the regression for model 3 is low, at 0.0005, implying that the model is a good fit, as it shows on average the "distance", or how much the observation misses the prediction (regression line) of welfare (HDI). The F-statistic is 87.57, with a probability value of less than 0.05 at 0.00, making model 3 significant. The DIFI independent variable is confirmed significant in model 3 with a p-value of 0.029, and positively related to HDI when regressed with logEDU and logLEX as welfare factors; logINC is regressed separately from EDU in Model 4, due to correlation challenges. The other predictors – logEDU, logUNEM and logLEX – have p-values of 0.00, making them significant too, while BNK is insignificant at 0.295. The co-efficients of logEDU, logLEX, logUNEM and DIFI are positively related to HDI and statistically significant, with t-values of above 2 (refer to Appendix Table 17 for t-values). The order of significance for this model is key for analysis in the study, which is confirmed using the t-statistic of the coefficients: logEDU at 10.00, logLEX 5.88, logUNEM 4.40 and DIFI 2.39 (refer to Appendix Table 17 for t-values). The standard error of all the independent variables for model 3 is low, with DIFI at 0.038, logLex 0.05, logEDU 0.024, logBNK 0.02 and logUNEM 0.006, which confirms the accuracy of the sample representation (refer to Appendix Table 17 for standard error values).

Model 4 has an r-squared of 0.936 and an adjusted r-squared of 0.917, with the standard error of the regression low at 0.0009; while the F-statistic is 49.57 with a probability value of less than 0.05 at 0.00. An interesting point is that the independent variables DIFI, logUNEM, logLEX and logBNK are not significant in model 4, with p-values of 0.439, 0.209, 0.071 and 0.074 respectively when regressed with welfare factors INC and LEX, without EDU which is

regressed separately in model 3. The only significant predictor in model 4 is logINC with a p-value of 0.00 and a positive coefficient of 0.123, indicating that a unit change in INC should increase HDI by 12%.

The hypothesised digital inclusion (DIFI) is significant and positively impacting inclusion with education (EDU) to improve welfare. The lack of significance of the variables DIFI, logUNEM, logLEX and logINC is as predicted, because income without education will not facilitate inclusion or improve welfare, because of its positive relationship with inequality in SSA. logUNEM is significant when regressed with logLEX, logEDU and DIFI; this validates the hypothesis that as digital inclusion increases, education should increase and impact unemployment to improve the lives of the marginalised, therefore improving welfare, which explains the positive relationship with HDI.

Models 5 and 6 differ from models 3 and 4 in that comprehensive financial inclusion is used as a predictor for financial inclusion. However, the regression results of models 5 and 6 are included in Appendix Table 16, because COMFI is not significant in either model and therefore the results do not provide the clarity required in investigating the relationship of income, education and comprehensive financial inclusion with welfare. Though this study expected low levels of overall financial inclusion, the results are not in line with the hypothesis that comprehensive inclusion should impact welfare, with digital inclusion as the driver; this was not the case.

Table 7: Effect of digital financial inclusion on welfare in SSA

Dependent variable	HDI							
	Model 3				*Model 4*			
	Pooled OLS		Jackknife		Pooled OLS		Jackknife	
VARIABLES	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
logLEX	0.296***	0.000	0.296***	0.000	0.154*	0.071	0.154*	0.076
logEDU	0.244***	0.000	0.244***	0.000				
DIFI	0.091**	0.029	0.091	0.100	-0,044	0.439	-0,044	0.454
logBNK	0.021	0.295	0.021	0.301	-0.046*	0.074	-0.046*	0.073
logUNEM	0.031***	0.000	0.031***	0.000	-0,019	0.209	-0,019	0.210
logINC					0.123***	0.000	0.123***	0.000
Constant	0.688***	0.000	0.688***	0.000	-0,137	0.449	-0,137	0.469
Observations	23		23		23		23	
R^2	0.9627		0.962		0.936		0.936	
R^2_a	0.952		0.952		0.917		0.917	
F-Statistic	87.74		62.41		49.57		71.58	
Prob (F-statistic)	0.00***		0.00***		0.00***		0.00***	
Breusch-Pagan (F-Stat)	0.93		.		1.52		.	
Breusch-Pagan (P-value)	0.4865		.		0.2369		.	
chi2(1)	0.03		.		1.58		.	
Prob > chi2	0.8707		.		0.2092		.	
Mean VIF	1.52		.		2.78		.	
SSR	0.242		.		0.234		.	
SSE	0.009		.		0.016		.	

Notes: **** p<0.01, ** p<0.05, * p<0.1*

DIFI= Digital Financial Inclusion Index; logEDU= Education; logINC= Income; logLEX= Life Expectancy; logUNEM= Unemployment; logIAEDU= Inequality-adjusted Education; logIAINC= Inequality-adjusted Income; logIALEX = Inequality-adjusted Life Expectancy; logBNK= Bank credit to deposit ratio; COMFI= Comprehensive Financial Inclusion Index

Lastly, the researcher investigated the effect of inequality on welfare by regressing the inequality-adjusted explanatory variables (IALEX, IAEDU and IAINC) as proxies for inequality-adjusted human development index (IHDI) with explanatory variables DIFI, TRFI, UNEM and BNK. Table 9 below presents the results for models 7 to 10; models 7 and 8 were regressed with digital financial inclusion (DIFI), while models 9 and 10 were regressed with traditional financial inclusion (TRFI). The two financial inclusion predictors, DIFI and TRFI, were regressed separately to investigate the most effective factor regarding financial inclusion in SSA, and due to the correlation relationship detected between IAEDU and IAINC, these two

variables were also regressed separately, which explains why there are four models. The predictors are logged when regressed with DIFI and TRFI, to increase stability and significance.

The overall significance of model 7 has a low F-stat of 23.59; however, the p-value is significant at 0.00, implying that at least one of the predictors must impact IHDI. The standard error of the regression is also significant, at 0.002. The r-square of the model is high at 0.88 and with an adjusted r-square of 0.84, implying that the model is a good fit, which means that changes in IHDI can be explained well by the explanatory variables DIFI, logIAEDU, logIALEX, logUNEM and logBNK. The Breusch-Pagan F-stat is 0.054, therefore heteroscedasticity is not present in model 7. The significance of the predictors is validated by the p-values of DIFI, logIAEDU and logIALEX at 0.045, 0.00 and 0.00, while logUNEM and logBNK are not significant, with p-values of 0.09 and 0.61 respectively. As expected, all three variables are positively related to IHDI with co-efficients for DIFI of 0.138, logIALEX 0.386 and logIAEDU 0.201.

Model 8 has an adjusted r-squared of 0.657 and an r-squared of 0.739, with the standard error of 0.003 making the model a good fit for analysis. The 9.03 F-statistic is very low; however, the probability value of 0.00 makes it worth investigating the predictors and their influence on IHDI. An interesting aspect to the regression output for model 8 is that the independent variables DIFI, logIAINC and logBNK are insignificant, with p-values of 0.218, 0.141 and 0.337 respectively, while logIALEX and logUNEM are significant at 0.001 and 0.026 respectively. The heteroscedasticity test was conducted to assess the reliability of the co-efficient outcome; the chi-square is 0.06 and the F-stat from the Breusch-Pagan test is 0.493, confirming homoscedasticity. Both significant predictors have a positive relationship to IHDI, with logIALEX being the dominant variable to explain movement in IHDI, by 50%, and logUNEM very minimally, at 4%. Model 8 is able to estimate the coefficients of logIALEX and logUNEM; however, it is unable to provide clarity on the relationship between digital financial inclusion and income and their effect on welfare considering inequality, which the study is also seeking to understand.

Model 9 regressed TRFI, logIALEX, logIAEDU, logUNEM and logBNK to establish their significance for explaining movement in IHDI. The model has an F-statistic of 64.36 with probability of 0.00, while the r-squared and adjusted r-squared are high at 0.811 and 0.798 respectively, confirming that the model is a good fit. Model 9 is confirmed to have

heteroscedasticity present, with a chi-square of 0.000 and F-stat of 0.000; this was rectified by the "Robust" function in Stata. The independent variables TRFI, logIALEX, logIAEDU and logUNEM displayed a highly significant relationship with IHDI, with p-values of 0.034, 0.000, 0.00 and 0.003 respectively, while logBNK was insignificant, with 0.396. The order of significance was noted for analysis in the study, and is demonstrated by the t-statistic of the coefficients of logIAEDU (9.32), logIALEX (6.42), logUNEM (2.69) and TRFI (2.63) (refer to Appendix Table 18 for t-statistics). The coefficient values reflect a positive relationship to inequality-adjusted welfare IHDI, with 0.28 logIALEX, 0.224 logIAEDU, 0.017 logUNEM and 0.133 TRFI.

Model 10 regressed TRFI, logIALEX, logIAINC, logUNEM and logBNK, aiming to establish the influence of traditional financial inclusion and income on IHDI without education in order to investigate the possibility of increasing welfare for countries with high inequality and without education. The standard error of the regression is significant at 0.002, while the F-statistic is low at 33.97. However, the probability is 0.00, making model 10 significant for analysis. Both r-squared and adjusted r-squared are average, at 0.694 and 0.673 respectively. Traces of confirmed heteroscedasticity by chi-square of 0.000 and F-stat of 0.000 were remedied by running the "Robust" function in Stata. The predictors logIALEX, logIAINC and logUNEM are highly significant, with a p-value of 0.00. Unexpectedly, TRFI is insignificant in model 10, with a p-value of 0.871; meaning that for this regression, traditional inclusion does not influence outcome for welfare where inequality is considered. The same is true for logBNK.

Table 8: Effect of digital and traditional financial inclusion on inequality-adjusted welfare in SSA

Dependent variable	IHDI							
	Model 7		***Model 8***		***Model 9***		***Model 10***	
	Pooled OLS		Pooled OLS		Pooled OLS		Pooled OLS	
VARIABLES	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
logIALEX	0.386***	0.000	0.500***	0.001	0.275***	0.000	0.386***	0.000
logIAEDU	0.201***	0.000			0.223***	0.000		
DIFI	0.138**	0.045	0.126	0.218				
logBNK	-0.017	0.611	-0.047	0.337	0.009	0.589	-0.004	0.837
logUNEM	0.021*	0.09	0.041**	0.026	0.017**	0.009	0.031***	0.000
logIAINC			0.121	0.141			0.147	0.000
TRFI					0.133**	0.010	-0.008	0.900
Constant	0.693***	0.000	0.814***	0.002	0.546**	0.000	0.675***	0.000
Observations	22		22		81		81	
R-squared	0.881		0.738		0.811		0.694	
r2_a	0.843		0.657		0.798		0.673	
F-Statistic	23.59		9.03		64.36		33.97	
Prob (F-statistic)	0.000***		0.000***		0.000***		0.000***	
Breusch-Pagan (F-Stat)	2.79		0.92		7.34		12.37	
Breusch-Pagan (P-value)	0.054		0.493		0.00		0.000	
chi2(1)	7.42		3.54		40.76		38.68	
Prob > chi2	0.01		0.06		0.000		0.000	
Mean VIF	1.47		1.43		1.39		1.22	
SSR	0.181		0.152		0.556		0.476	
SSE	0.025		0.054		0.13		0.210	

Notes: **** p<0.01, ** p<0.05, * p<0.1*

DIFI= Digital Financial Inclusion Index; logEDU= Education; logINC= Income; logLEX= Life Expectancy; logUNEM= Unemployment; logIAEDU= Inequality-adjusted Education; logIAINC= Inequality-adjusted Income; logIALEX = Inequality-adjusted Life Expectancy; logBNK= Bank credit to deposit ratio; COMFI= Comprehensive Financial Inclusion Index

4.4 Digital inclusion and informality

This research also sought to analyse whether informality of economies encourages digital financial inclusion through expansion of mobile banking usage in SSA countries. The approach adopted by this study to provide clarity was through data selection and grouping, as detailed in chapter 3. SSA countries were selected and grouped by level of economy informality, and the output of stage 2 PCA sub-indices in the digital inclusion calculation were used to inform the calculation of mobile banking usage at country level. The PCA methodology applied in the study is also detailed in chapter 3 above. The results for usage and access sub-indices on digital inclusion are summarised in Table 10 below. The intent is to see whether the countries with the most informal economies demonstrate higher usage than countries with low informal economies.

Table 10 below demonstrates that mobile money usability is not necessarily impacted by economy informality alone, but seemingly by both the income level of the country and the informality of its economy. Countries on top of the list regarding use of digital banking are Kenya, Namibia, Gabon, Zimbabwe and Ghana, They are classified as having middle-sized (20-40% of GDP) and high-sized (>40% of GDP) informal economies, with an income level of between upper-middle and lower-middle income. Upper-middle-income countries with low-sized (0-20% of GDP) informal economies are lower down the list for usability, such as Mauritius, Botswana and South Africa. In alignment with the literature, it is clear from the grouping results that access to digital banking does not necessarily translate to usability, because upper-middle income countries with low-sized informal economies dominate ICT (Information and Communication Technology) access but have usage figures that are lower than expected. Predominantly low-income countries with large informal economies have low mobile banking usage – in the negative range. Based on this fact, it is apparent that the informality of an economy should be considered a contributing factor to the usability of mobile banking.

Table 9: Usage and Access Ranking

Country	Usage	Access Ranking	Economy Informality	Income Level
Kenya	6.946	15	Middle-sized	Lower-middle income
Namibia	3.296	7	Middle-sized	Upper-middle income
Gabon	3.116	4	Middle-sized	Upper-middle income
Zimbabwe	2.342	10	Middle-sized	Lower-middle income
Ghana	1.708	5	High-sized	Lower-middle income
Tanzania	1.397	20	High-sized	Lower-middle income
Senegal	0.657	9	High-sized	Lower-middle income
South Africa	0.548	1	Low-sized	Upper-middle income
Lesotho	0.487	6	Low-sized	Lower-middle income
Rwanda	0.483	17	Middle-sized	Low income
Liberia	-0.335	21	High-sized	Low income
Mozambique	-0.354	25	High-sized	Low income
Cameroon	-0.411	13	Middle-sized	Lower-middle income
Botswana	-0.435	3	Low-sized	Upper-middle income
Mali	-0.465	8	High-sized	Low income
Togo	-0.467	19	High-sized	Low income
Benin	-0.928	18	High-sized	Lower-middle income
Nigeria	-1.185	14	High-sized	Lower-middle income
Malawi	-1.213	22	Middle-sized	Low income
Guinea	-1.396	12	High-sized	Low income
Mauritania	-1.580	11	High-sized	Lower-middle income
Sierra Leone	-1.826	16	Middle-sized	Low income
Chad	-1.996	26	High-sized	Low income
Niger	-2.450	24	High-sized	Low income
Ethiopia	-3.380	23	High-sized	Low income
Mauritius	-3.766	2	Low-sized	Upper-middle income

The study therefore concludes from the research findings that traditional financial inclusion and its impact on welfare are in line with the literature, having shown that traditional financial inclusion has a positive relationship with welfare, and the variables income and education are contributing to welfare improvement, while unemployment is not significant (Ofori-Abebrese et al., 2020; Sarma & Pais, 2008). An additional variable was incorporated into this study: the bank credit-to-deposit ratio, for determining the significance of credit allocation and liquidity on welfare. This turned out to be not significant in any model, with prospects of a positive correlation. Following a study by the IMF (2021), a digital financial inclusion index and comprehensive financial inclusion index were derived to determine the impact of digital finance on welfare, with variables income, education, unemployment and bank credit to deposit ratio. From these, the investigation confirmed a significant and positive correlation between digital financial inclusion and welfare, and the variables education and life expectancy contribute positively to welfare (Abor et al., 2018; Aker & Mbiti, 2010). Unlike traditional financial inclusion regressions regarding welfare, digital financial inclusion and education impact unemployment. Interestingly, income has a positive correlation to welfare, while digital financial inclusion, unemployment and life expectancy are insignificant. This makes income a variable impacting welfare such that the vulnerable are excluded; and in such instances, inequality increases (Tita & Aziakpono, 2017). Comprehensive financial inclusion has no significant effect on welfare, in all models, when regressed with income, education, life expectancy and unemployment, indicating that a strategy for optimising the benefits of financial inclusion on welfare should not split focus or effort between digital financial inclusion and traditional financial inclusion.

When accounting for inequality in the welfare variables, the regression of income and digital financial inclusion produces results in alignment with the literature, in that digital financial inclusion and income have no significant effect on welfare (Obeng-Odoom, 2015; Tita & Aziakpono, 2017). This results in trends such as the “Africa on the rise” scenario, where income increases with inequality and does not impact welfare. However, the result is different when inequality-adjusted welfare variables are regressed with digital financial inclusion, education and life expectancy; the study observed a positive correlation with welfare. Unexpectedly, unemployment was not significant. Traditional financial inclusion reflects a positive correlation to inequality-adjusted welfare with the variables education, life expectancy and unemployment. Traditional financial inclusion has no significance for inequality-adjusted welfare when regressed with income, unemployment and life expectancy, though these variables are positively related to welfare, with inequality. This indicates that education is the key component of financial inclusion when inequality is considered.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter concludes the paper; therefore, a summary of the research is presented below, with conclusions reached from the empirical investigation. Recommendations made contribute particularly to policy creation in SSA on welfare and financial inclusion. Also, suggestions are provided for future studies which can further the literature and provide clarity on this topic.

5.2 The hypothesis and results discussion

An analysis of the results and their relation to the hypotheses of the study is presented in this section, though the emphasis is on digital financial inclusion and welfare and the effects of income, education, unemployment, and inequality.

The study hypothesised that growth in national income (GNI) will not reduce poverty and improve welfare to the levels required without investment in education, which stimulates financial inclusion. This hypothesis was supported by Amendola & Bocca (2016), who confirmed that countries with educated citizens have a high rate of financial inclusion, and research by Zhao (2020), who added to this that education is the major factor encouraging people to adopt digital financial services. To validate the hypothesis, the impact of digital financial inclusion and education on welfare was regressed, and so was the effect of digital financial inclusion and income on welfare. Based on the regression results it is evident that movement in digital financial inclusion and education impacts welfare positively, meaning that as the population becomes better educated, the use of mobile banking will increase as well. This occurs because education encourages the marginalised to participate in financial services and strengthens financial inclusion, which ultimately improves welfare. However, this is not the case with digital inclusion and income, as digital inclusion is not significant and is detrimental to welfare. This implies that digital financial inclusion is ineffective in driving inclusion with income alone, possibly because those who dominate a country's income are not among the marginalised or excluded from financial services; therefore, mobile banking is not significantly contributing to their welfare, and neither is it reaching those in need. Ultimately it does not add the required value to financial inclusion. Hypothetically, this negative relationship to welfare is motivated by inequality, as detailed in the discussion below.

On average the results show a decline in the traditional financial inclusion index over the three years of analysis. An explanation for the lower traditional financial index numbers in comparison to digital inclusion is simply that inclusion through traditional methods excludes the majority of the marginalised – those without education or money – which amounts to a significant number in SSA (Demirgüç-Kunt & Klapper, 2012). The top three countries dominating digital financial inclusion (Kenya, Ethiopia and Mauritius) are characterised by the same results in 2017; higher digital financial inclusion and lower traditional financial inclusion index results. The latter is also true for countries with robust financial systems, such as South Africa, Namibia, and Botswana. However, the regression of traditional financial inclusion and income is significant and positively related to welfare, and so is that for traditional financial inclusion and education. The same outcome resulted in studies by Ofori-Abebrese (2020) and Matekenya (2021) which were also based on traditional banking variables. However, from an SSA perspective, those represented in the traditional financial services are the main beneficiaries of inequality; these results are thus obscured by inequality, because traditional financial inclusion derived from the traditional financial institution ' variables strongly denote a population with money or education and who are financially included and serviced by the traditional financial institutions, such as banks. This is intriguing, because although traditional financial inclusion is significant and positively related to welfare in both models, the situation is not as clear in a region with high poverty; thus the effect of inequality on welfare is a key factor to be regressed.

This research also placed more emphasis on the possibilities of the impact of higher financial inclusion on welfare than previous studies have done, because the empirical literature has focused on traditional financial inclusion and not digital inclusion, which dominates financial inclusion among the poor in the region (Amendola et al., 2016; Mallick & Zhang, 2019; Ofori-Abebrese et al., 2020). Theoretically therefore, the expectation of this research was for comprehensive financial inclusion to have a significant impact on welfare, as it incorporates both traditional and digital financial inclusion. However, that was not the case; according to the results, comprehensive inclusion is insignificant regarding welfare – though there is a positive correlation when education is included, with income the relation is still not significant but is negative. This outcome confirms that overall, the SSA countries have very low levels of financial inclusion to improve welfare, meaning that digital inclusion is not at a level where the majority of the marginalised are included so as to significantly reduce poverty and increase welfare, or even that the depth of financial services on digital platforms is not where it should

be to drive welfare impact. The regression results also reveal that the comprehensive inclusion index mirrors the movement of digital financial inclusion, reflecting the dominance of digital inclusion in the overall financial inclusion index in the region. This aligns with a study by the IMF which revealed that financial inclusion progress in South Africa, Nigeria and another eight countries in SSA is driven entirely by digital financial inclusion, while traditional financial inclusion is negative (Ofori-Abebrese et al., 2020;Khera et al., 2021). The emphasis should be on digital inclusion to drive future financial inclusion in the region.

Digital financial inclusion and education are significant in impacting unemployment and improving the welfare of the poor, but this is not true for digital inclusion and income. The correlation of the two regressions to welfare is positive; this implies that though unemployment is increasing in the region, the unemployed individuals might be getting or creating job opportunities in the informal sector, which is stimulated by digital inclusion and ultimately improves welfare. As more people are categorised as unemployed in the formal sector, they move to the informal sector, seeking opportunities to make a living. Through digital inclusion they can acquire skills and become educated in order to create jobs through entrepreneurship within the informal sector, and thereby improve welfare. Though the comprehensive financial inclusion index is not significant, unemployment is significant for driving positive movement in welfare when regressed with education, reflecting the dominance of digital inclusion (as mentioned earlier), and that unemployment can be positive in the informal sector because jobs and opportunities are created to improve the welfare of the unemployed. In alignment with research by Ofori-Abebrese (2020), unemployment is not significant when regressed with traditional financial inclusion; the same is true with income and traditional inclusion, because traditional institutions serve the privileged or educated, and thus unemployment – which predominantly affects the poor and uneducated – is not significant in those models. Therefore, traditional inclusion does not influence unemployment to impact welfare, because financial institutions focus predominantly on the formal sector and restrict welfare incentive services to the unemployed. Therefore, increasing digital inclusion and education will stimulate an already increasing number of the unemployed to create opportunities within the informal sector and improve welfare within this group, since most economies in SSA are largely informal. This also confirms observations by Kelikume (2021) and Amponsh (2021) who showed that mobile banking stimulates a positive relationship between financial inclusion and the informal economy, thereby reducing poverty.

This study hypothesised that countries with high levels of inequality are theoretically expected to have lower levels of inclusion compared to countries with less inequality. Inequality plays a crucial role in the analysis of traditional financial inclusion because it distorts the regression results of income and traditional financial inclusion to be positive and significant regarding welfare, which is questionable. After all, the poverty levels in the region do not reflect that scenario. Hence, when income is regressed with inequality-adjusted traditional financial inclusion, we get different results – the negative and insignificant relationship of inequality-adjusted traditional inclusion to welfare, while income is significant and positive. This explains the robust growth that occurred in the region between 2005 and 2015, which led to dire poverty levels and unemployment due to inequality (Obeng-Odoom, 2015; World Bank Group, 2020). Growth increased income, which improved the welfare of those already in the financial system, while the marginalised did not partake in the income growth because of the lack of significance of financial inclusion in an environment of high inequality. Research by the World Bank also confirmed that greater income inequality in the region can be associated with higher poverty figures (World Bank Group, 2020). The regression outcome ofinequality-adjusted traditional inclusion aligns with that of inequality-adjusted digital inclusion, where income increases without education, and financial inclusion does not impact welfare. The results are different with education, because both indices (inequality-adjusted traditional inclusion and inequality-adjusted digital inclusion) are significant and positive for welfare. This implies that with education, inequality can be overcome, through financial inclusion, to yield improved welfare and reduce poverty. This also aligns with the results of an investigation by Tita and Aziakpono (2017).

Economies in SSA with large informal economies and low income levels can reduce poverty and improve welfare through digital inclusion; this study confirms that opportunities for the unemployed and marginalised can be created in the informal sector through education and have an impact on the welfare of the poor. However, these countries must also invest in ICT, because currently, most are at the bottom of the list regarding access to mobile banking. From the analysis in thi study, countries such as Liberia, Burundi, Niger, Chad, Mozambique, Madagascar, Central African Republic and Ethiopia fit this profile. Welfare can be magnified over time, because as digital inclusion increases, the poor can invest in education and entrepreneurship, which will curb poverty (Tita & Aziakpono, 2017). Therefore, the low income level of a country does not necessarily paint a bleak picture regarding future financial inclusion and poverty levels. These countries should emphasise digital inclusion over

traditional inclusion, so that the majority of the marginalised are empowered to participate in financial services through mobile banking in the informal sector and can create opportunities for the unemployed. This investigation confirms that this is an optimal approach to increasing financial inclusion and welfare in these economies. Though access is low in Niger and Chad, these countries have substantial use of mobile banking; thus their digital inclusion index is in the top five, based on the sample data used in this study. Therefore, a low level of access does not necessarily mean low usage and low financial inclusion; inclusion can be escalated and improved significantly by expanding ICT access in an economy where there is already usage.

In alignment with the literature, this study found that liquidity is not significant to welfare in any regression, with digital inclusion, traditional inclusion, and comprehensive inclusion. Though the relationship is positive for traditional financial inclusion, it has a negative relation to welfare when regressed with digital financial inclusion. This was anticipated, because the marginalised are systematically excluded from accessing credit by financial institutions, and the flow of credit is still dominated by these institutions. This agrees with the results of Subika (2015) and Tita (2017), who stated that access to traditional financial services does not necessarily translate to credit availability for the marginalised, due to information asymmetry and moral hazard. Mobile money is also still in its infancy for most countries in SSA, therefore financial depth with credit facilities is not yet available to them; they are still in development stage 1 of digital finance (predominantly payments) – excluding Kenya, which is in an advanced stage (Pazarbasioglu et al., 2020). Hypothetically, based on Kenya's results, access to credit and financial depth on mobile banking accelerates financial inclusion, which should ultimately impact welfare. In an analysis of the indices, Kenya leads the digital financial inclusion space, irrespective of average ICT access and usage compared to other African countries such as Gabon or South Africa. This implies that the advancement of digital financial inclusion in the country services the needs of the marginalised and increases the level of inclusion, penetrating effectively to improve welfare through financial inclusion. The traditional inclusion index for Kenya is average; however, its overall comprehensive inclusion index is leading other SSA countries, though it is low compared to the digital inclusion numbers. This aligns with the analysis discussed earlier, that comprehensive financial inclusion mirrors digital financial inclusion due to mobile banking dominating and driving financial inclusion in the region. Therefore, financial depth (for example, access to credit for the marginalised on a mobile platform, has a possibility of improving financial inclusion and welfare.

Though bank liquidity is not significant, it is interesting to look at the results of the inequality-adjusted welfare models; because the results are different, in that bank liquidity is negatively related to welfare when regressed with income and traditional inclusion, and has a positive relationship when traditional inclusion is regressed with education, meaning that the traditional financial system will increase the welfare of the educated. This aligns with Matsebula and Yu (2020), who concluded that households headed by educated, older individuals had a higher financial inclusion index, while those in rural areas with low real per capita income and no education were more prone to being completely financially excluded or discriminated against by banks. This study takes this further, highlighting that education and not per capita income can steer the allocation of credit in the right direction to increase financial inclusion and welfare within the existing traditional financial system. The inequality-adjusted regressions do not change for digital financial inclusion with income and education; they have a negative relationship to welfare, because mobile banking is dominated by the marginalised and not favoured by inequality; and the penetration of credit facilities on digital platforms in SSA is almost non-existent.

5.3 Summary

The intent of this study was to investigate the influence of mobile money on financial inclusion, as the traditional financial institutions were previously accepted as the main stimulus of financial inclusion. In conducting this analysis, the researcher computed the indices for traditional, digital, and comprehensive financial inclusion, to establish their impact on welfare. This was achieved by regressing the panel data for SSA countries using panel estimation methods: pooled Ordinary Least Squares (OLS), and fixed effects. The investigation went further, grouping countries into categories of income level together with the informality status of the economy, to establish whether mobile money is more influential in more informal economies than in less informal economies. The PCA methodology was used for estimating this; access and usage sub-indices were computed and analysed accordingly. The financial inclusion results revealed indications that mobile money has become the dominant driver of financial inclusion in SSA through payments. The levels of traditional financial inclusion and comprehensive financial inclusion are low in SSA, relative to mobile banking.

As mentioned earlier in the analysis, the regressions of the traditional financial inclusion index calculated using the traditional financial inclusion variables without accounting for inequality,

in a region with high levels of inequality, have questionable reliability, because inequality distorts the actual regression results. To understand and resolve financial inclusion challenges in SSA, scholars must cater for challenging factors specific to the region. It was therefore recommended that this study consider inequality when investigating welfare, poverty, financial inclusion and financial development in the region. Of course, inequality adjustment regarding welfare would be irrelevant, or at least have little impact, in the analysis of developed countries with relatively low inequality.

The high inequality level seen in this study may cloud the observer's realistic view of financial inclusion, when the traditional inclusion index is calculated. In fact, when inequality is considered and adjusted for, financial inclusion turns out to be insignificant regarding welfare; thus, countries with high inequality experience high poverty levels and low welfare. Observing upper-middle countries such as Namibia, Botswana, South Africa and Gabon, it is intriguing that they have good financial systems and institutions and good ICT access, and yet also experience persistent unemployment and increasing levels of poverty, while in the literature, traditional financial inclusion suggests low positive and significant financial inclusion. This study contradicts that view, in that high inequality makes traditional financial inclusion and digital financial inclusion insignificant to welfare, meaning there is persistent unemployment and poverty. However, it is not all doom and gloom for these countries, because this can be reversed with education. Education can drive traditional and digital inclusion to impact welfare positively, and be significant in scenarios where inequality is considered and adjusted. With high levels of unemployment in these countries, opportunities can be created in the informal sector through digital inclusion to impact welfare, as traditional inclusion is not significant regarding impact on unemployment. Though mobile banking access and technology infrastructure is good in Namibia, Botswana, South Africa and Gabon compared to other SSA countries, usage is not at par hence the traditional financial inclusion and digital financial inclusion indices produced similar results. To curb unemployment, the use of mobile banking by the marginalised should increase with education, to create opportunities in the informal sector for those who are not absorbed in formal industries; through digital financial inclusion, unemployment can be tackled to impact welfare and reduce poverty.

The approach to calculating the financial inclusion index going forward must include digital financial inclusion or mobile banking, especially in SSA. Basing financial inclusion calculations on ATM and branch variables no longer reflects the true picture of financial

services in the region, which impacts the outcome of the regression conducted. A comprehensive view of financial inclusion in the region should include both mobile banking and traditional banking; the approach to or methodology for doing the calculation may be different, depending on the intent of the study, but there must be a digital inclusion representation. From the regressions conducted in this research, it is clear that unlike in developed countries, in SSA, digital financial inclusion predominantly drives financial inclusion as a whole; therefore, it must be taken into account when studying inclusion for developing countries, particularly in the SSA region.

The informal economy of countries in SSA should be factored into welfare or poverty regressions; as can be seen from this study, unemployment is a significant co-efficient when regressed with digital financial inclusion and education – unlike examples in the existing literature, where it was not significant when traditional inclusion represented financial inclusion. To fully understand the criticality of informal sectors and their influence on financial inclusion, where the unemployed are creating opportunities and contributing to better welfare, the true market structure of these countries should be taken into account in order to make relevant recommendations. One cannot have a blanket statement regarding formalising economies based on assumptions made for developed countries, which might not necessarily be a solution for developing countries in the region with less satisfactory levels of education. In this study education is highlighted as a stimulus to digital inclusion and welfare, while the significance of national income is questionable in a scenario where financial inclusion is dominated by digital inclusion. The empirical results confirm that education (and not income, as seen in the existing financial development literature) stimulates inclusion in the region, which impacts welfare positively. Therefore, from a regression perspective it is clear that depth of financial services on mobile banking (besides payments) and education are key components that must be monitored in order to analyse the progress of financial inclusion in the region; this is a different approach to that used in developed countries. In summary, the approach and solutions to financial inclusion in SSA are unique and different from those used in developed economies.

5.4 Conclusions

Empirically, the digital financial inclusion index is the appropriate measure of financial inclusion in SSA. Digital financial inclusion is the most effective approach to tackling socio-

economic challenges in the region. The inequality-adjusted human development index is the preferable index for revealing the true state of welfare in SSA, where the impact of inequality is too great to ignore.

5.5 Policy recommendations

This research recommends that predominantly informal economies adopt a financial inclusion strategy that serves their economic structure and circumstances, meaning that in these economies, mobile money is embraced by the marginalised and impacts unemployment by creating job opportunities through entrepreneurship within the informal sector. Therefore, governments should strengthen its efforts to channel investment into supporting the informal sector and assisting fintech service providers to flourish in expanding financial inclusion in their industry to improve welfare. Therefore, policymakers and regulatory personnel should focus on ensuring that there is growth, innovation and security in mobile money, and that the limitations of infrastructure do not restrain the growth of financial inclusion growth, as is the case with traditional financial inclusion.

What is critical, and apparent from this study, is that comprehensive financial inclusion does not drive inclusion optimally yet, due to the low levels of financial inclusion in the region. That suggests that a strategy of driving both digital inclusion and traditional inclusion simultaneously is not the most effective approach to financial inclusion, because of its lack of significance to welfare; while digital inclusion and traditional inclusion indices are both significant but separate, with digital inclusion predominantly impacting welfare. This implies that governments should perhaps prioritise digital financial services over traditional financial services, and not split the focus by developing both simultaneously, as this strategy will delay financial inclusion progress. Therefore, policies should be implemented to support fintech start-ups in an environment or economy where financial institutions act as monopolies and dominate the markets. Governments should provide funding or facilitate funding for these fintech companies so that they can sustain their businesses and advance their digital platforms to encourage financial depth for the marginalised by offering a variety of financial services products besides payments, such as credit, insurance and investment. As has been observed in Kenya, financial depth within the digital finance space accelerates financial inclusion.

This study showcases the importance of the link between digital financial inclusion and education on welfare. National income dominated discussions during the financial development

era, but that has changed; digital financial inclusion should focus on education to reduce poverty. Governments should improve their education systems, and provide programmes to encourage entrepreneurship and create jobs in the informal sector, because the formal industries no longer provide sufficient opportunities for the unemployed. Increasing income without investing in education will not tackle the challenges of poverty or improve financial inclusion, because education is the primary factor in stimulating digital financial inclusion, which is the optimal approach to financial inclusion in SSA. This investigation also led to a policy recommendation to prioritise digital financial inclusion for countries or governments with high inequality, because it is through mobile banking and education that financial inclusion can organically impact welfare; this is not the case with traditional financial inclusion.

5.6 Avenues for Future Research

Future studies should perhaps investigate other channels of digital banking beyond just payments by incorporating digital access and use of products such as savings, investments, insurance and loans, to strengthen knowledge on strategies to be adopted towards financial depth in the mobile money space, and its contribution to increasing financial inclusion and improving welfare. This analysis will be possible only after progress is made in mobile banking; as already mentioned, most of the SSA countries except Kenya are still in the early stages, most only with payment functionality. That research approach will close the gap in the literature – currently, analysis is mainly conducted on payment transactions. Digital financial depth necessitates expansion, so that the marginalised can be fully exposed to financial services for different needs to enhance their welfare.

Demand-side data limitation of digital banking on the World Bank Global Findex database for SSA countries should be improved with the addition of COVID-19 pandemic survey data, as a lot happened in those years to drive the trends and research outcomes of digital financial inclusion in a different direction; this data must be made available for future research. Studies conducted on reliable survey data from the user perspective (demand side) can inform and guide governments, regulations and policy creators in the region, because SSA countries have unique challenges; research recommendations should not always be based on research conducted on developed economies, or developing markets in Asia. It was shown in this study that SSA countries have unique economies with unique challenges; the blanket approach does not seem to work effectively, especially on the multidimensional financial inclusion indices.

This study observed that the informality of economies in SSA seems to influence mobile usage. Countries with medium to large informal economies seem to experience greater usage of mobile banking compared to those with smaller informal economies. In the literature, the size of the informal economy is linked with income, and national growth income in countries with inequality does not reduce poverty, improve welfare or create adequate employment. Thus the informal sector and its growth, size and development are of importance, especially since this study has shown that digital inclusion has a positive and significant impact on the welfare of the unemployed for countries with medium to large informal economies such as Kenya, Ethiopia, Niger, Chad, Malawi and Sierra Leone. However, a deeper analysis of the informal market structure in SSA with digital financial inclusion, unemployment, and inequality is required to understand the relationship between the variables and provide recommendations to governments with small informal sectors, high inequality and high unemployment. It can already be observed that usage of mobile money in medium to large informal economies has reached encouraging levels and the level of digital financial inclusion is higher than in most countries with small informal economies.

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APPENDIX

Table 10: Access and Usage Results - Digital Financial Inclusion Sub-indices

Country	Digital financial inclusion variables (DIFI)		
	Access	Informal Economy	Income Level
	2017		
South Africa	2.740	Low size	Upper middle income
Mauritius	2.454	Low size	Upper middle income
Botswana	2.115	Low size	Upper middle income
Gabon	1.869	Middle size	Upper middle income
Ghana	1.457	High Size	Lower middle income
Lesotho	1.152	Low size	Lower middle income
Namibia	1.031	Middle size	Upper middle income
Mali	0.658	High Size	Low income
Senegal	0.582	High Size	Lower middle income
Zimbabwe	0.353	Middle size	Lower middle income
Mauritania	0.151	High Size	Lower middle income
Guinea	-0.054	High Size	Low income
Cameroon	-0.141	Middle size	Lower middle income
Nigeria	-0.175	High Size	Lower middle income
Kenya	-0.197	Middle size	Lower middle income
Sierra Leone	-0.235	Middle size	Low income
Rwanda	-0.406	Middle size	Low income
Benin	-0.503	High Size	Lower middle income
Togo	-0.519	High Size	Low income
Tanzania	-0.577	High Size	Lower middle income
Liberia	-1.017	High Size	Low income
Malawi	-1.426	Middle size	Low income
Ethiopia	-1.478	High Size	Low income
Niger	-1.613	High Size	Low income
Mozambique	-1.657	High Size	Low income
Chad	-1.666	High Size	Low income

Country	Usage	Economy Informality	Income Level
Kenya	6.946	Middle size	Lower middle income
Namibia	3.296	Middle size	Upper middle income
Gabon	3.116	Middle size	Upper middle income
Zimbabwe	2.342	Middle size	Lower middle income
Ghana	1.708	High Size	Lower middle income
Tanzania	1.397	High Size	Lower middle income
Senegal	0.657	High Size	Lower middle income
South Africa	0.548	Low size	Upper middle income
Lesotho	0.487	Low size	Lower middle income
Rwanda	0.483	Middle size	Low income
Liberia	-0.335	High Size	Low income
Mozambique	-0.354	High Size	Low income
Cameroon	-0.411	Middle size	Lower middle income
Botswana	-0.435	Low size	Upper middle income
Mali	-0.465	High Size	Low income
Togo	-0.467	High Size	Low income
Benin	-0.928	High Size	Lower middle income
Nigeria	-1.185	High Size	Lower middle income
Malawi	-1.213	Middle size	Low income
Guinea	-1.396	High Size	Low income
Mauritania	-1.580	High Size	Lower middle income
Sierra Leone	-1.826	Middle size	Low income
Chad	-1.996	High Size	Low income
Niger	-2.450	High Size	Low income
Ethiopia	-3.380	High Size	Low income
Mauritius	-3.766	Low size	Upper middle income

Table 11: Financial inclusion Index - Digital

Country	Digital financial inclusion (DIFI)	
	2017	Ranking
Kenya	0.723	1
Ethiopia	0.659	2
Mauritius	0.655	3
Niger	0.609	4
Chad	0.584	5
Malawi	0.521	6
Sierra Leone	0.503	7
Mozambique	0.493	8
Mauritania	0.465	9
Guinea	0.455	10
Nigeria	0.440	11
Benin	0.436	12
Liberia	0.433	13
Namibia	0.419	14
Gabon	0.418	15
Togo	0.397	16
Botswana	0.359	17
Cameroon	0.359	18
South Africa	0.356	19
Tanzania	0.332	20

Mali	0.315	21
Rwanda	0.314	22
Zimbabwe	0.312	23
Ghana	0.203	24
Senegal	0.141	25
Lesotho	0.139	26

Table 12: Financial Inclusion Index – Comprehensive

Country	2017	
	Comprehensive financial inclusion (COMPFI)	Ranking
Kenya	0.398	1
Niger	0.372	2
Chad	0.364	3
Mauritius	0.328	4
Malawi	0.319	5
Mozambique	0.290	6
Guinea	0.289	7
Liberia	0.275	8
Benin	0.271	9
Mauritan	0.265	10
Nigeria	0.256	11
Togo	0.244	12
Cameroon	0.239	13
Namibia	0.210	14
Mali	0.206	15
Zimbabwe	0.200	16
Rwanda	0.199	17
Botswana	0.193	18
South Africa	0.179	19
Ghana	0.131	20
Senegal	0.116	21
Lesotho	0.112	22

Table 13: Financial Inclusion Index - Traditional

Country	2011	Rank	2014	Rank	2017	Rank
	Traditional financial inclusion (TRFI)					
Angola	0.314	27	0.248	31	0.324	28
Benin	0.488	12	0.462	12	0.353	25
Botswana	0.103	32	0.326	27	0.346	26
Burundi	0.533	5	0.537	5	0.501	7
Cameroon	0.463	13	0.499	8	0.571	3
Central	0.530	6	0.242	32	0.186	31
Chad	0.489	11	0.537	4	0.421	15
Comoros	0.392	20	0.389	19	0.356	23
Ethiopia	0.401	19	0.383	20	0.481	9
Gabon	0.385	22	0.264	30	0.414	18
Ghana	0.312	28	0.324	28	0.327	27
Guinea	0.547	4	0.537	6	0.478	10
Kenya	0.418	16	0.431	15	0.544	4
Lesotho	0.383	23	0.365	23	0.426	14
Liberia	0.404	18	0.389	18	0.492	8
Madagascar	0.548	3	0.545	3	0.476	11
Malawi	0.419	15	0.446	13	0.664	1
Mali	0.500	9	0.493	9	0.371	21
Mauritania	0.411	17	0.382	21	0.612	2
Mauritius	0.700	1	0.621	1	0.532	6
Namibia	0.274	30	0.406	17	0.129	32
Niger	0.570	2	0.562	2	0.415	17
Nigeria	0.254	31	0.330	25	0.449	12
Rwanda	0.311	29	0.322	29	0.533	5
Senegal	0.511	8	0.480	10	0.431	13
Sierra Leone	0.427	14	0.422	16	0.419	16
South Africa	0.513	7	0.522	7	0.197	30
Tanzania	0.391	21	0.434	14	0.264	29
Togo	0.497	10	0.471	11	0.401	19
Uganda	0.365	24	0.359	24	0.395	20
Zambia	0.336	26	0.328	26	0.356	24
Zimbabwe	0.346	25	0.382	22	0.358	22

Table 14: Descriptive Statistics

Variable	N	mean	sd	min	p25	p50	p75	max	skewness	kurtosis
IHDI	112	0.351	0.086	0.208	0.297	0.339	0.382	0.690	1.565	6.718
HDI	132	0.527	0.097	0.338	0.460	0.518	0.576	0.797	0.793	3.439
EDU	132	0.461	0.116	0.189	0.381	0.461	0.532	0.730	0.212	2.800
LEX	135	0.624	0.089	0.403	0.570	0.626	0.676	0.842	0.183	3.099
IALEX	134	0.423	0.117	0.232	0.332	0.412	0.483	0.767	0.924	3.896
IAINC	115	0.352	0.094	0.163	0.295	0.330	0.402	0.675	1.179	5.081
IAEDU	118	0.314	0.115	0.115	0.226	0.310	0.390	0.634	0.698	3.171
TRFI	96	0.419	0.109	0.103	0.354	0.416	0.498	0.700	-0.229	3.354
INC	118	5 117.63	5815.152	680.000	1540.000	2735.000	5460.000	25220.000	1.884	5.644
BNK	108	74.116	22.745	13.966	60.664	75.225	88.257	137.150	-0.149	3.179
UNEM	120	7.829	6.933	0.320	2.755	5.495	10.340	27.040	1.313	3.713
DIFI	26	0.425	0.148	0.139	0.332	0.426	0.503	0.723	0.013	2.736
COMPFI	22	0.248	0.080	0.112	0.199	0.250	0.290	0.398	0.056	2.325

Table 15: Comprehensive Financial Inclusion and Welfare Regression

Dependent variable	HDI							
	Model 5		***Model 5***		***Model 6***		***Model 6***	
	Pooled OLS		Jackknife		Pooled OLS		Jackknife	
VARIABLES	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
logLEX	0.305***	0.000	0.305***	0.001	0.143	0.129	0.143	0.125
logEDU	0.250***	0.000	0.250***	0.000				
logBNK	0.028	0.292	0.028	0.254	-0.049	0.132	-0.049	0.189
logUNEM	0.034***	0.002	0.034***	0.001	-0.023	0.193	-0.023	0.133
logINC					0.124***	0.000	0.124***	0
COMPFI	0.183*	0.069	0.183*	0.164	-0.124	0.352	-0.124	0.428
Constant	0.653***	0.000	0.653***	0.000	-0.122	0.55	-0.122	0.58
Observations	20		20		20		20	
R-squared	0.957		0.957		0.9299		0.9299	
r2_a	0.942		0.942		0.9049		0.9049	
F-Statistic	62.51		36.55		49.57		54.47	
Prob (F-statistic)	0.00		0.00		0.00		0.00	
Breusch-Pagan (F-Stat)	0.63		.		1.00		.	
Breusch-Pagan (P-value)	0.6792		.		0.4509		.	
chi2(1)	0.08		.		1.16		.	
Prob > chi2	0.7814		.		0.282		.	
Mean VIF	1.56		.		1.52		.	
SSR	0.209		.		0.147		.	
SSE	0.009		.		0.023		.	

*** p<0.01, ** p<0.05, * p<0.1

Table 16: Model 4 Pooled OLS Regression

```
. reg HDI logLEX logEDU DIFI logBNK logUNEM i.year
note: 2017.year omitted because of collinearity
```

Source	SS	df	MS	Number of obs	=	23
				F(5, 17)	=	87.74
Model	.241497341	5	.048299468	Prob > F	=	0.0000
Residual	.009358485	17	.000550499	R-squared	=	0.9627
				Adj R-squared	=	0.9517
Total	.250855826	22	.011402538	Root MSE	=	.02346

HDI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logLEX	.2964373	.0504191	5.88	0.000	.1900624	.4028123
logEDU	.2437541	.0243866	10.00	0.000	.192303	.2952053
DIFI	.0908485	.0379787	2.39	0.029	.0107205	.1709766
logBNK	.0209181	.0193776	1.08	0.295	-.0199651	.0618013
logUNEM	.0306002	.0069605	4.40	0.000	.0159148	.0452856
year						
2017	0	(omitted)				
_cons	.6878861	.0913715	7.53	0.000	.4951091	.8806631

Table 17: Model 9 Pooled OLS Regression

```
reg IHDI TRFI logUNEM logBNK logIALEX logIAEDU
```

Source	SS	df	MS	Number of obs	=	81
				F(5, 75)	=	64.36
Model	.556034321	5	.111206864	Prob > F	=	0.0000
Residual	.129590593	75	.001727875	R-squared	=	0.8110
				Adj R-squared	=	0.7984
Total	.685624914	80	.008570311	Root MSE	=	.04157

IHDI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
TRFI	.1329707	.0504724	2.63	0.010	.0324244	.2335169
logUNEM	.0168232	.0062574	2.69	0.009	.0043578	.0292887
logBNK	.0091918	.0169279	0.54	0.589	-.0245304	.0429139
logIALEX	.2752246	.0428953	6.42	0.000	.1897727	.3606764
logIAEDU	.2234875	.0239919	9.32	0.000	.1756931	.2712818
_cons	.5462769	.0857233	6.37	0.000	.3755073	.7170466

Figure 3: Model 3 Residual Plot - Digital Financial Inclusion

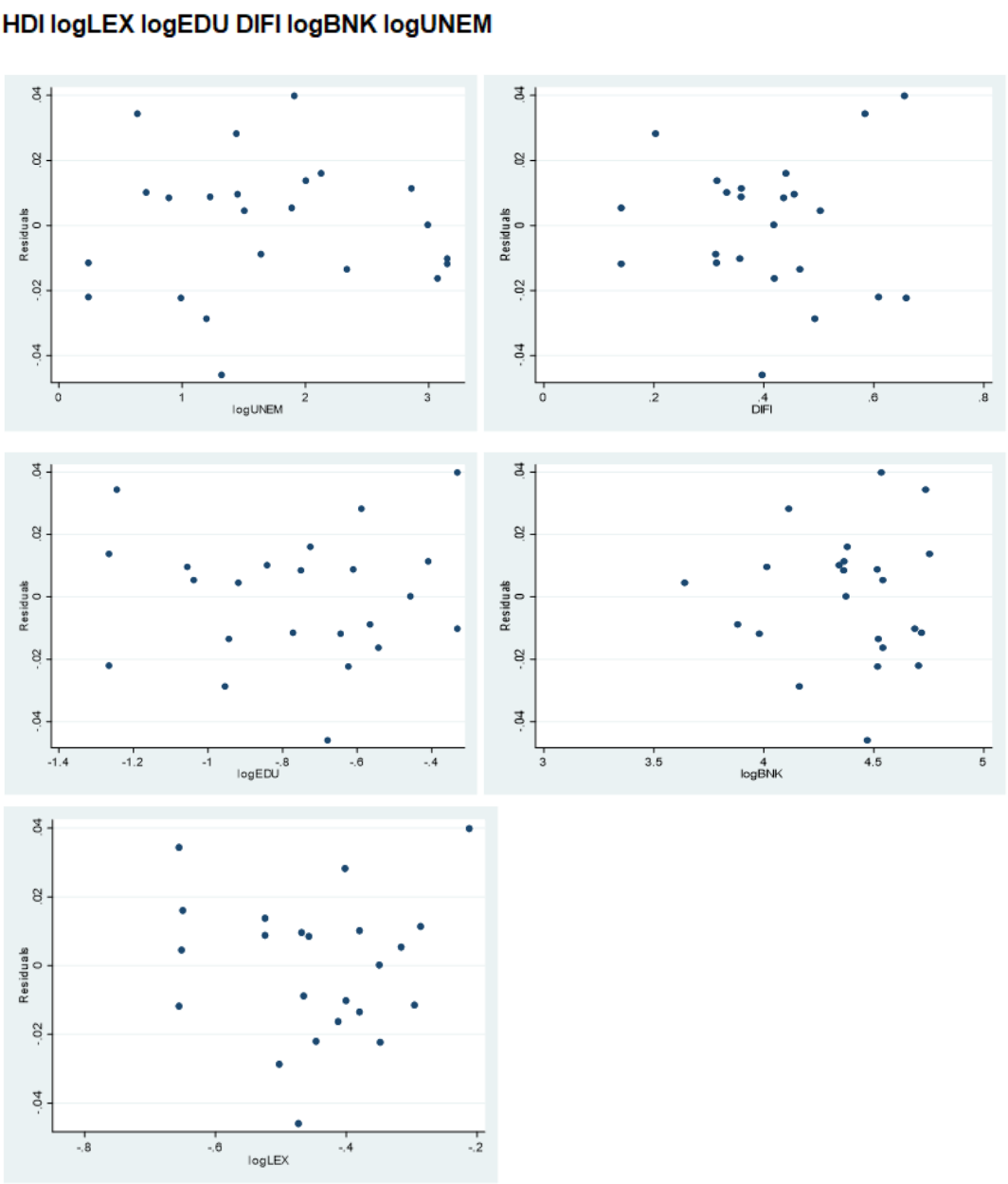

Figure 4: Model 4 Residual Plot - Digital Financial Inclusion

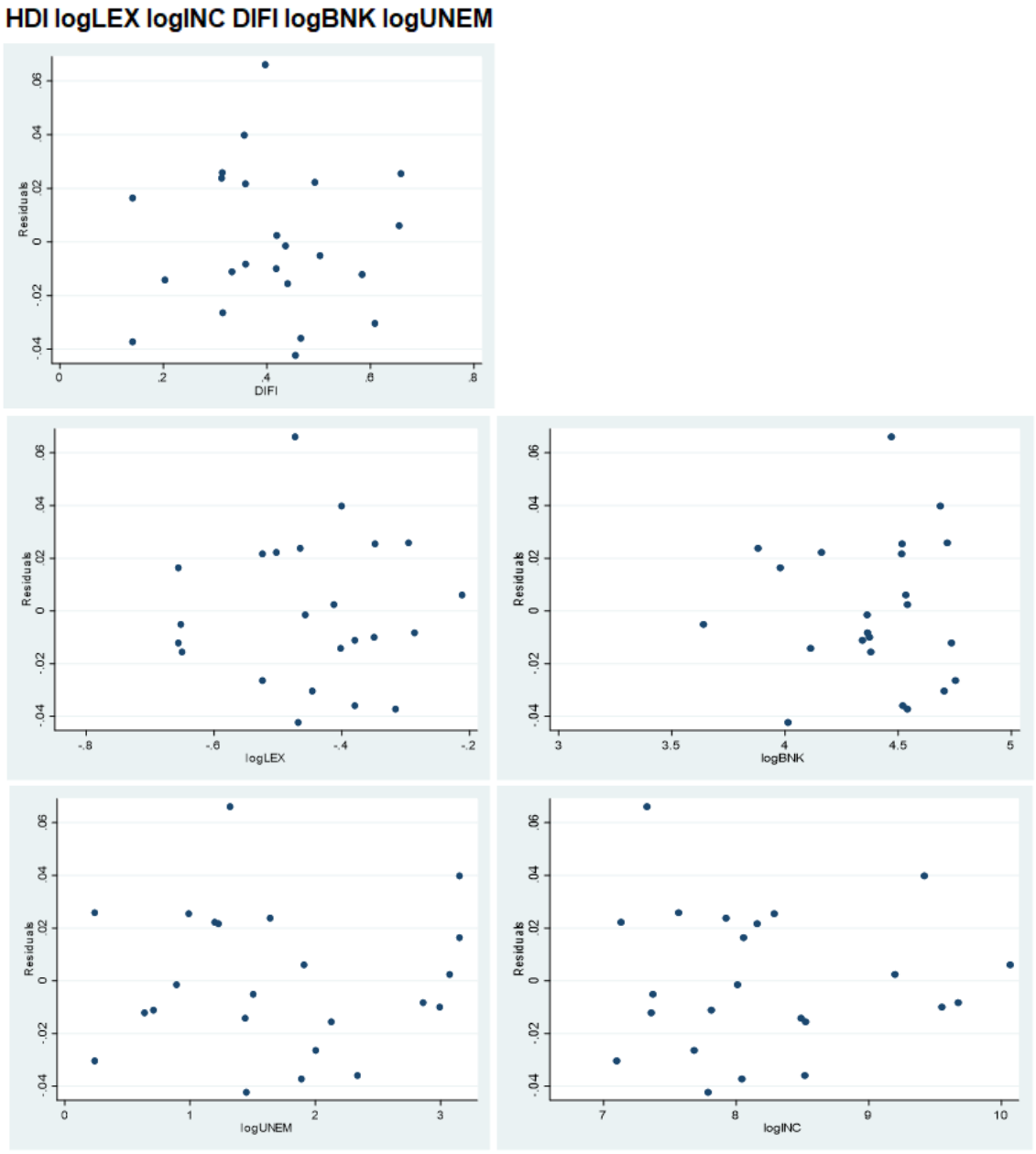

Figure 5: Model 7 Residual Plot - Digital Financial Inclusion

lHDI loglAEDU loglALEX DIFI logUNEM logBNK

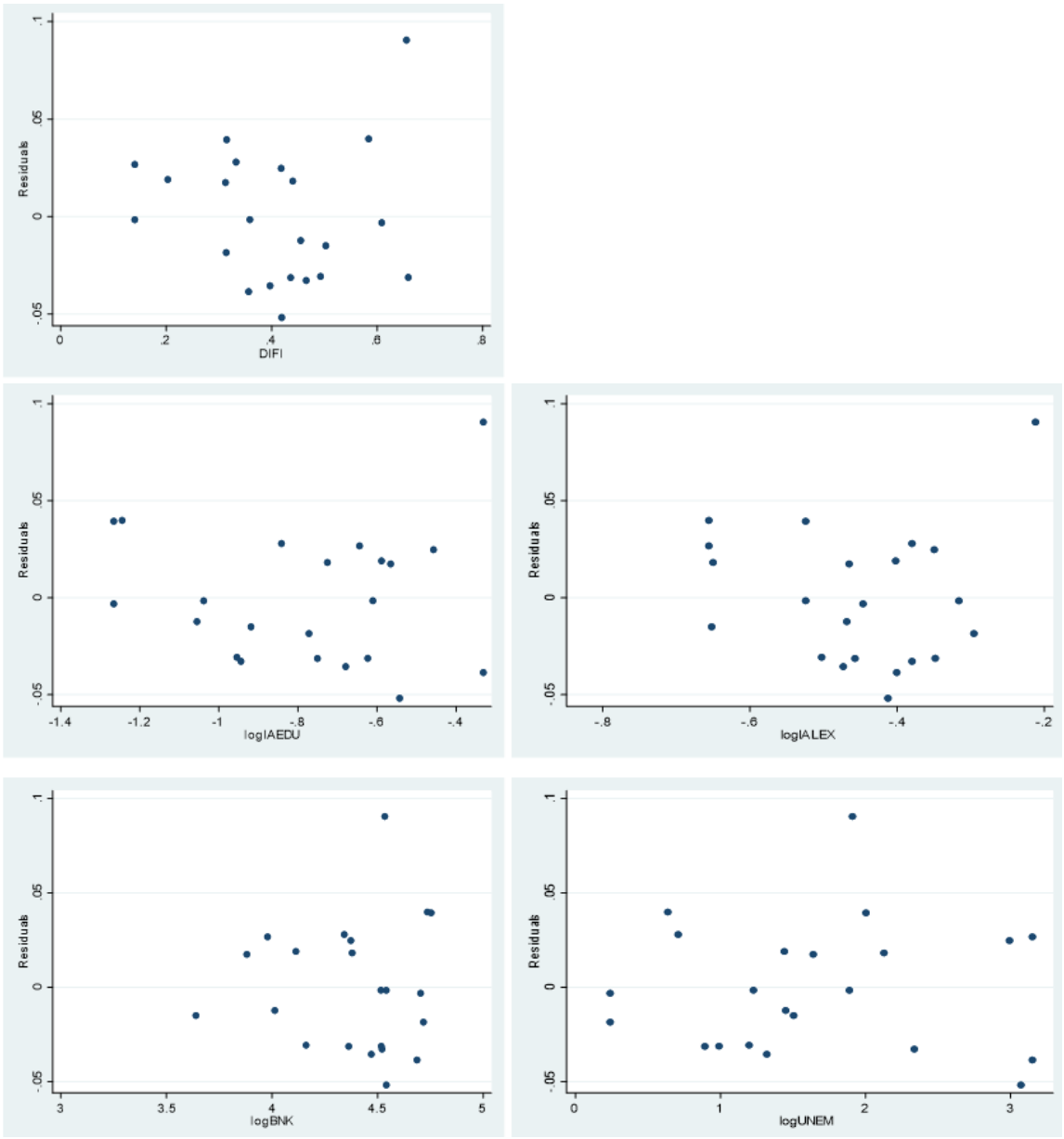

Figure 6: Model 8 Residual Plot - Digital Financial Inclusion