UNIVERSITY OF CAPE COAST

PREDICTIVE MODEL ON DIGITAL FINANCIAL INCLUSION AND SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

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BY

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DECLARATION

I hereby declare that this dissertation is the result of my original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's signature……. Date……

Name: Benedict Amoako Mensah

Supervisors' Declaration

I hereby declare that the preparation and presentation of the dissertation was supervised in accordance with the guidelines on supervision of dissertation laid down by the University of Cape Coast.

Supervisor's Signature…….……. Date……

Name: Dr. William Godfred Cantah

ABSTRACT

This study examined the nexus between digital financial inclusion (DFI) and sustainable development in Sub-Saharan Africa (SSA). The research aimed at analysing trends in DFI and exploring its impact on economic, social, environmental, and overall sustainability across 28 SSA economies with complete data from 2009 to 2023. Using three key indicators the study assessed DFI's role in promoting sustainable development. The two-step System Generalized Methods of Moment (GMM) approach is employed to address endogeneity and improve the accuracy of panel data estimations. Key findings reveal significant disparities in DFI across the region, with notable progress in some countries but ongoing challenges in ensuring equitable access, especially in rural and underserved areas. Moreover, the study provides strong evidence that higher levels of DFI positively influence all the dimensions of sustainable development. These findings emphasize the role of digital financial services in promoting sustainable development by enhancing economic participation, reducing poverty, and fostering social inclusion and environmental sustainability. The study recommends that governments in SSA integrate DFI into economic growth strategies, promote public-private partnerships to expand digital infrastructure, and enhance financial literacy and inclusivity, especially among marginalized populations. Future research could expand this analysis to other emerging economies and examine country-specific dynamics to inform more tailored policy interventions.

KEYWORDS

Digital Financial Inclusion

Sustainable Development

System Generalised Method of Moment

Sub-Saharan Africa

Adjusted Net Savings

Mobile Money

Predictive Model

Public-Private Partnerships

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DEDICATION

To my Grandfather, Mr. Albert Kwesi Addison

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LIST OF ABBREVIATIONS

GMM	Generalised Method of Moment
DFI	Digital Financial Inclusion
MSP	Account ownership with mobile money service provider
PPI	Percentage Population with access to Internet
AMS	Mobile Subscription per 100 people
SD	Sustainable Development
ANS	Adjusted Net Savings
SSA	Sub-Saharan Africa
MDGs	Millennium Development Goals
SDGs	Sustainable Development Goals
PPPs	Public-Private Partnerships

CHAPTER ONE

INTRODUCTION

There is a growing call on policymakers on African continent to formulate and implement initiatives aimed at achieving a substantial portion of the Sustainable Development Goals (SDGs). This call is prompted by the continent's limited progress in reaching the SDG targets (Banik, 2022). At the forefront of these concerns is the inclusivity of the financial sector, which plays a pivotal role in advancing sustainable development (Guru & Yadav, 2019). Recent discourse has intensified around the intricate relationship between digital financial inclusion and sustainable development, emphasizing the overriding significance of the financial sector in facilitating the provision and allocation of financial resources for development in Sub-Saharan Africa (SSA) (Abekah-Nkrumah, Assuming, & Mohammed, 2020). Practically, this study will be essential for policymakers as they coordinate efforts towards the attainment of sustainable development in SSA.

Background of the Study

It is worth considering that digital financial inclusion may be a way to make financial facilities available for the poor at all levels of income to achieve sustainable development (Yang & Zhang, 2020). Digital financial inclusion (DFI) is not different from the notion of financial inclusion (FI). It is the extension phase of Financial Inclusion where technology is being entertained to increase access (Ozturk & Ullah, 2022). Digital financial inclusion means delivering or providing basic financial services to marginalized and excluded members of society, usually enabled through digital devices or tools. These marginalized groups of people include women, the poor, the informal sector,

and other disadvantaged members of society that constitute over 1.4 billion people who remain unbanked globally. Technology has fundamentally altered the traditional practices of the financial sector, making it easier for people to access a wide range of financial services (Ozili, 2018). In this regard, digital financial inclusion is seen as a changing agent that can bring revolutionary development to the financial sector and the economy at large (Ozili, 2018). Moreover, the Covid-19 pandemic has put forward the implementation of digital financial services to accelerate financial inclusion and enhance financial services that can be enjoyed through electronic devices in a cashless manner without much pain by which both the service providers and receivers can benefit (Klapper, 2017).

Reckoning the undeniable impact and importance of digital financial inclusion, most SSA countries are also on their way to a fully-fledged implementation of digital financial services such as Fintech, E-wallet, and other cashless transactions (Jameaba, 2020). The impacts and prospects of digital financial inclusion are no longer abstract notions; rather, time demands their proper execution. Manyika et al. (2016) posit that digital finance has the potential to provide access to financial services for 1.6 billion people in emerging economies. Widespread adoption and use of digital finance could increase the GDP of all emerging economies by 6%, or USD 3.7 trillion, by 2025. Moreover, 95 million new jobs would be created in all sectors across the world through this additional GDP. The implementation of digital finance in the banking sector will contribute to enhancing GDP, which will help to alleviate poverty and ultimately lead to inclusive economic growth to achieve the SDGs (Chien, & Sadiq, 2022).

Financial analysts foresee the prospects of digital financial inclusion to meet the huge investment gap for attaining sustainability, through a wider lens as it is the recent phase of financial inclusion, which played a great role during the 2007–2009 global financial crisis (Banna, Hassan, & Alam, 2020). The crisis caused a USD15 trillion loss in the global financial sector but financial inclusion played a major role in retaining banking stability (Ahamed & Mallick 2019). Although financial inclusion has brought a myriad of positive changes and benefits for underprivileged and less developed people, its proper implementation and utilisation has become a burden for those who are unable to afford it (Koomson & Danquah, 2021). Both the negative and positive effects of financial inclusion raise the question of whether the implementation of digital financial inclusion, the latest innovation of financial inclusion, can be a solution for attaining sustainable development or not. Against this background, this study seeks to build a predictive model on digital financial inclusion and sustainable development in SSA economies.

Statement of the Problem

Defined in the United Nations' 2030 Agenda, sustainable development integrates three critical dimensions: economic growth, social inclusion, and environmental sustainability, collectively advancing the 17 Sustainable Development Goals (SDGs). In sub-Saharan Africa (SSA), the need to address these dimensions is particularly pressing. While economic development is essential to reducing poverty and enhancing livelihoods, it must also support social progress and protect the region's natural resources to ensure long-term stability (Chinoda, & Kapingura, 2022; Tay, 2022).

Despite recent growth, SSA faces complex challenges in achieving balanced development across these dimensions. Economically, many SSA economies are constrained by low productivity, limited financial access, and high levels of poverty. Socially, persistent inequalities, limited access to healthcare and education, and high rates of unemployment hinder inclusive growth, limiting the ability of vulnerable groups to fully participate in economic activities. Environmentally, the over-reliance on resource-based industries and the impact of climate change are putting immense pressure on SSA's ecosystems, threatening biodiversity, water resources, and agricultural productivity key components of the region's development (Mensah, 2019; Chinoda, & Kapingura, 2022).

As barriers in traditional financial systems decline, digital financial inclusion (DFI) has become more widespread, emerging as a powerful enabler for achieving the 2030 Sustainable Development Agenda (Allen et al., 2016; Kooli et al., 2022; Wysokińska, 2021). However, global financial inclusion gaps persist, emphasising the significance of digital financial inclusion (Demirgüç-Kunt et al., 2018; Pazarbasioglu et al., 2020). According to the World Bank Global Financial Index report, only 33% of the adult population owned a bank account at a formal banking institution in SSA in 2020 which is less than any other sub-region globally (Global Financial Index Report, 2020). On the other hand, 65% of the adult population in the poorest developing countries still lack access to a formal bank account, and only 20% use a formal financial institution to save (Pazarbasioglu et al., 2020). Considering the prospects and importance of digital financial inclusion, banks in SSA countries have started implementing digital financial services in a full-fledged manner (Babayan et al., 2022),

because broader digital financial inclusion helps banks achieve financial advancement (Demirgüç-Kunt et al., 2018), stability (Ahamed and Mallick 2019), and a flourishing banking sector.

From 2014 to 2020, there has been a notable upsurge in digital financial inclusion variables across SSA, such as internet usage to access financial services (% of population), mobile subscriptions per 100 people, registered mobile money agents per 100,000 adults, and active mobile money accounts per 1000 adults. Internet usage for financial services increased from 12.5% to 37.2% of the population representing a 197.6% growth rate. Mobile subscriptions rose from 71 to 98 per 100 people. The added 27 new subscriptions per 100 people shows a 38% growth in overall penetration. Registered mobile money agents on the other hand increased from 125 to 502 per 100,000 adults indicating 301.6% expansion in the agent network. Finally, active mobile money accounts grew from 277 to 920 per 1,000 adults representing 232.1% increase.

By 2019, SSA had amassed a remarkable 469 million active mobile money accounts, with over 181 million registered accounts. This represented more than 15% of active users within more than 40% of the region's total population (Munoz et al., 2022). Furthermore, the advent of COVID-19 epidemic propelled these activities, leading to significant advancements in mobile money-driven activities and the digital economy, particularly in African nations such as Zimbabwe (Ecocash), Kenya (M-Pesa), South Africa (E-wallet), Ghana (MoMo), among others (Wysoki´nska, 2021; Babayan et al., 2022). These substantial improvements in DFI metrics across SSA demonstrate the region's rapid digital transformation in financial services. However,

opportunities for further growth remain, as penetration rates still lag global averages in certain areas. Formulating policies to promote continued DFI progress is crucial for enhancing the attainment of sustainable development goals in SSA economies.

Purpose of the Study

The purpose of the study is to build a predictive model on digital financial inclusion, and sustainable development in SSA economies.

Research Objective

Specifically, the study sought to achieve the following objectives;

1. Analyse the trend of digital financial inclusion in SSA economies.
2. Examine the effect of digital financial inclusion on various dimensions of sustainable development in SSA economies.

Research Hypotheses

In line with the research objectives, the study seeks to test the following hypotheses:

For Objective One:

H_1: There is a significant development trend of digital financial inclusion in SSA economies

For Objective Two;

H_1: Digital financial inclusion significantly influences the various dimensions of sustainable development in SSA economies.

Significance of the Study

This study holds significant value for both the regulatory bodies of SSA economies and the research community. Furthermore, the findings of the study will be valuable to businesses and the broader economy. By identifying the

potential risks and opportunities associated with DFI and sustainable development, such as changes in consumer preferences, regulatory requirements, and resource availability, companies will make informed decisions about investments, innovation, and risk management.

Finally, this study fills the gaps identified in literature, by way of adding to existing knowledge regarding the nexus between digital financial inclusion, and sustainable development in SSA.

Delimitation of the Study

The study was conducted on 28 out of the 48 SSA economies which had complete data on digital financial inclusion, and sustainable development over the research period. The main variables included in this study were digital financial inclusion which is measured by percentage population with access to internet, mobile subscription per 100 people and account ownership with mobile money service provider, and sustainable development measured in three dimension namely economic, social and environmental sustainability. The study was conducted for a period of 15 years from 2009 to 2023, a period within which the financial sector in SSA has seen an expansion in digitalisation, policy, and regulatory reforms. Data for the analysis of the objectives were sourced from the Global Financial Development (GFD), and World Development Indicators (WDI) of the World Bank.

Limitation of the Study

The study measured digital financial inclusion by using three indicators and not all the 48 SSA economies had complete data on the variable. Additionally, the study is limited to the use of two-step System Generalized Methods of Moment in its estimation although other panel estimation

techniques such as the fixed effect model and the pooled ordinary least squares estimation techniques exist. The two-step System Generalized Methods of Moment is more efficient in analysing panel data and also addresses endogeneity problems associated with panel data estimations. Again, the study is limited to the period under review due to data availability. Hence the result of this study was obtained based on only 28 SSA economies that had complete data from 2009 to 2023. However, generalisation can be drawn from the findings to other periods with similar characteristics.

Organisation of the Study

This chapter of the study covers sections including the background of the study, statement of the problem, objectives of the study, research questions and hypotheses, significance of the study, delimitation of the study, and the study's limitations. The second chapter considers the review of existing theoretical and empirical literature in the area of digital financial inclusion, and sustainable development. The third chapter discusses the research design with much particular attention on the sample design and the estimation technique employed for the study. The fourth chapter shows the presentation of results and discussions. The last chapter of the study is organized into summary of findings with conclusion and recommendations and is followed by references and appendices.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter provided a review of the conceptual, theoretical, and empirical framework for digital financial inclusion, and sustainable development. The review also shows how these constructs (digital financial inclusion and sustainable development) relate to the SSA region. This chapter is based on the study's research problem, objectives, and hypotheses. The purpose of the study is to examine digital financial inclusion as a gateway to sustainable development among selected SSA countries. The write-up of the chapter will begin with addressing concepts and definitions underpinning the study, before review of theories and empirical issues of digital financial inclusion, and sustainable development.

Concepts and Definitions

This section seeks to provide an extensive discussion and enhanced knowledge with respect to the constructs used in this study. How the various concepts are operationalized in literature is also addressed.

Concept of Digital Financial Inclusion

Digital financial inclusion, as a concept is relatively new and multifaceted, it refers to the use of digital technologies to provide financial services for individuals who have limited access to traditional banking services (Ozili, 2022). It is a process of ensuring that all individuals, regardless of their income level, geographic location, or social status, have access to affordable and reliable financial services that meet their needs. The concept of digital financial inclusion seeks to leverage the proliferation of digital technologies

such as mobile phones, the internet, and other forms of electronic communication to increase access to financial services. The aim is to create a more inclusive financial system that reaches those who are currently excluded from the traditional banking system (Aziz, & Naima, 2021).

One of the key components of DFI is mobile banking, which allows individuals to access financial services through their mobile devices. Mobile banking enables individuals to make and receive payments, transfer money, and access credit and savings products, among other financial services (Goh, Mah, & Chay, 2022). Another important aspect of DFI is the use of digital identification systems to help individuals without formal identification documents open bank accounts and access other financial services. Digital identification can also help to reduce the cost of due diligence for financial service providers, thereby increasing the accessibility and affordability of financial services (Gelb, & Metz, 2018).

Digital financial inclusion has the potential to create significant social and economic benefits, including poverty reduction, increased economic growth, and improved financial resilience. However, there are also potential risks associated with digital financial inclusion, such as the potential for fraud, cyber-attacks, and data breaches. It also has the potential to transform the way financial services are delivered and accessed, particularly in developing countries where traditional banking services may be inaccessible or prohibitively expensive (Sun, 2018). By leveraging digital technologies, digital financial inclusion can overcome many of the barriers that prevent people from accessing financial services, including geographical barriers, lack of formal identification, and high transaction costs. Digital financial inclusion enables

people to conduct financial transactions at lower costs than traditional banking services. This is because digital financial services can be delivered remotely and do not require the same physical infrastructure as traditional banking services. This can help to reduce the cost of financial services and make them more affordable for people on low incomes.

Another advantage of digital financial inclusion is that it can help to promote financial inclusion by reaching people who are excluded from the traditional banking system. This includes people who live in rural areas, women, and low-income earners. By providing financial services to these groups, digital financial inclusion can help to reduce poverty and promote economic growth. digital financial inclusion can also help to promote financial literacy by providing people with access to financial education and training. This can help to build financial capability and empower people to make informed financial decisions. digital financial inclusion promotes financial inclusion for marginalized groups such as women, refugees, and people with disabilities (Ariyanto, Soejono, & Dewi, 2020). These groups may face additional barriers to accessing financial services, including cultural and social barriers, lack of access to formal identification documents, and discriminatory practices. By leveraging digital technologies, digital financial inclusion can overcome some of these barriers and provide financial services to these groups. Digital financial services can be designed to meet the specific needs of underserved populations, such as microfinance products that are tailored to the needs of small business owners and farmers. This can help to promote development by providing people with the financial tools they need to grow their businesses and invest in their futures (Khera, Ogawa, & Sahay, 2022).

Digital financial inclusion help promotes financial stability by reducing the reliance on cash-based transactions. Cash-based transactions are expensive, inefficient, and can be vulnerable to fraud and theft. By promoting digital transactions, digital financial inclusion can help to reduce the use of cash and promote financial transparency and accountability (Mader, 2016). Digital financial inclusion enhances financial resilience by providing people with access to financial services that can help them to cope with unexpected shocks, such as natural disasters, economic downturns, or health crises. By providing people with access to savings and insurance products, digital financial inclusion can help to build financial resilience and reduce the impact of these shocks. The concept of digital financial inclusion is the fourth stage of the financial revolution after developing microcredit, microfinance, and financial inclusion (Wang & He, 2020). Compared to financial inclusion, digital financial inclusion places more importance on technology to broaden the accessibility to formal financial services. Initially, the term "microcredit" refers to a small loan offered by financial institutions to businesses and individuals. In the 1990s, the word "microcredit" had been replaced by "microfinance," which covers more immense scopes of financial services such as savings, mutual funds, insurance, and loans.

Another significant revolution is shifting from "microfinance" to "financial inclusion". Financial inclusion is a concept that seeks to guarantee that formal financial services are accessible to all people. However, microcredit, microfinance, and financial inclusion initiatives are manual and field-based operations (Hassan, Le, Hoque, 2021). Thus, it limits the effectiveness of helping the poor. Lately, ICT has led financial inclusion to

advance to the fourth stage: digital financial inclusion. This radical innovation has the potential to transform the lives of those at the bottom of the economic ladder. Digital financial inclusion aims to eradicate obstruction to encourage individuals' participation in the financial services offered by financial institutions and benefiting from it. Due to fast technological advances, cell phones, and social media have a very high penetration rate in today's internationally linked economy.

Many nations across the globe have a tremendous potential to enhance their countries' economic development and financial stability by embracing financial inclusion via mobile payment systems (Almarashdah, et al., 2021: Dawei, Anzi, & Gen, 2018: Vo, Nguyen, & Van, 2021). Overall, digital financial inclusion is an important development in the financial sector, which has the potential to create a more inclusive and equitable financial system for all.

Concept and Dimensions of Sustainable Development

The concept of sustainable development denotes a way of meeting the needs of the present without compromising the ability of future generations to meet their own needs (Daly, 1990). In other words, it involves creating a balance between economic growth, social well-being, and environmental protection to ensure that society can thrive without depleting the planet's resources. Sustainable development recognizes the finite nature of natural resources and emphasizes the responsible and equitable use of these resources. It underscores the importance of long-term thinking and planning to ensure that economic growth and social progress can be maintained over time (Beckerman, 2017; Zikic, 2018).

Sustainable development is founded on the recognition of the interdependence of economic, social, and environmental factors. A healthy environment is essential for human health and well-being, while a robust economy is needed to invest in environmental protection and support social initiatives. Social well-being is intrinsically connected to economic and environmental conditions, as individuals and communities depend on both for prosperity. The concept emphasizes equity and fairness, advocating for equal opportunities for all individuals to participate in and benefit from economic, social, and environmental progress (Adams, 2017; Schlüter, 2018; Rosca, Reedy, & Bendul, 2018). Addressing social and economic inequalities is critical to ensuring that marginalized groups can access the same opportunities and benefits as others (Rusca, 2019).

The three main dimensions of sustainable development economic, social, and environmental form the pillars of this holistic approach (Tomislav, 2018; Purvis, Mao, & Robinson, 2019):

Economic dimension focuses on fostering a strong and stable economy that supports the well-being of individuals and communities over the long term. It involves sustainable economic growth that does not compromise future generations' ability to meet their needs. Sustainable economic practices include promoting responsible production and consumption, investing in clean technologies, and supporting renewable energy development. The social dimension on the other hand aims to ensure access to essential services like healthcare, education, and housing. It promotes social equity by reducing inequalities and providing opportunities for participation in economic, social, and political decision-making. Key areas include gender equality, protection of

the rights of marginalized groups, and safeguarding basic human rights (Alola, 2019; Kurniawan & Managi, 2018; Ratnawati, 2020; Lubchenco, 2019).

The environmental dimension emphasizes protecting natural resources and minimizing human activities' environmental impact. Key actions include promoting conservation, sustainable resource use, reducing greenhouse gas emissions, supporting renewable energy, reducing waste and pollution, protecting biodiversity, and practicing sustainable agriculture and land use (Holden, Linnerud, & Banister, 2017; Kasztelan, 2017; Van-Huis & Oonincx, 2017).

Sustainable development is a global agenda that addresses interconnected challenges such as climate change, poverty, and inequality through collective action. The United Nations' Sustainable Development Goals (SDGs) provide a framework for this endeavor, encompassing 17 goals and 169 targets aimed at achieving sustainable development by 2030. Tracking progress involves monitoring and reporting on social, economic, and environmental indicators to identify areas for improvement (Arora & Mishra, 2019). Sustainable development is dynamic, requiring continuous adaptation, learning, and the willingness to adopt new ideas and approaches to meet evolving challenges (Bexell & Jönsson, 2017; Husted et al., 2021).

Overall, the concept of sustainable development is a holistic approach that takes into account a range of economic, social, and environmental factors. By promoting access to financial services, and addressing issues such as affordability, infrastructure, and financial education, we can help to build a more sustainable and equitable system.

The Role of Digital Financial Inclusion in Meeting the Sustainable Development

Ozili (2023) illustrates that the key aim of digital financial inclusion is to provide formal financial services to the poor, rural, and underprivileged or unbanked people, which has a long-run impact on banking stability and sustainable development. The inclusion of people in formal financial services helps banks to be financially stable and consequently benefits the government by generating higher tax revenue (Manyika et al., 2016). Such types of financial services are delivered via smart mobile phones, personal computers, or laptops, which need an internet connection (Manyika et al., 2016). According to Gomber, Koch, and Siering (2017), digital financial service includes innovative financial products, finance-related software, and a great way of interacting and communicating with customers provided by FinTech and other finance-related service providers (BigTech firms). They can transform people from cash-based to cashless transactions where they need a mobile phone, one of which is owned by almost 50% of people in developing countries (World Bank Group 2018).

A recent study by Klapper, Miller, and Hess (2020) shows that through digital financial inclusion, informal business institutions can be registered as formal business institutions and help the government to collect taxes more easily by enforcing laws since in the database all the records are available and there is no way to escape payment. More tax collection contributes to the national revenue sector and eventually makes the country's economic growth stable. Digital financial inclusion, when provided responsibly and sustainably in a well-regulated environment, not only drives growth but also enables faster progress toward many of the other sustainable development goals. In their

study, Siddik and Kabiraj (2020) show the impact of digital finance and proper implementation of digital financial inclusion can spur sustainable growth by eradicating poverty. Poverty is more visible among rural and underprivileged people, who are usually neglected in most developed societies, which hinders the ultimate financial growth of any country. These types of deprived people can be included in formal financial services by implementing digital financial inclusion properly.

But, globally only 33% of all adults have financial knowledge that is, they understand at least three out of four main financial literacy issues, such as knowledge of inflation, interest rates, risk diversification, and compounding interest, which are essential for decision-making in financial affairs (Klapper and Lusardi 2020). Moreover, through the proper application of digital financial inclusion, the gender gap in financial inclusion can be minimized. In most of the developing economies, women are still lagging in terms of having a formal bank account. In this regard, the study of Sioson and Kim (2019) shows that digital financial inclusion plays a significant role in reducing the gender gap in financial services, moreover, inclusive finance brings banking stability and sustainability.

Definitions of Terms

Digital financial inclusion in the context of this study means delivering or providing basic financial services to marginalized and excluded members of society, usually enabled through digital devices or tools.

Sustainable development on the other hand refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Theoretical Review

The theoretical frameworks that will help provide logical structure of meaning which guide the development of this study are Endogenuos Growth Theory, Information Asymmetry Theory and Triple Bottom Line Theory. These frameworks were chosen to help bring meaning and generalization to the study. It also helps create the vision on which the research problem is focused.

Endogenous Growth Theory

The endogenous growth theory, introduced by Romer (1987), provides a foundation for understanding how digital financial inclusion and sustainability are interconnected and contribute to economic development, particularly in Sub-Saharan Africa (SSA). This theory posits that economic growth, both in the short and long term, is propelled by factors inherent to the economic system itself, such as innovation, human capital development, and institutional efficiency (Romer, 1987). Long-term growth hinges on the resilience of economic structures and the robustness of institutions that effectively allocate capital and resources (Grossman & Helpman, 1991).

Technological progress, driven by investments in innovative ideas, processes, and new market explorations, is essential for sustainable economic advancement (Aghion & Howitt, 1992). The availability of consistent capital facilitated by a stable and reliable financial system—is critical for firms to engage in such productive ventures. A stable banking sector not only ensures this continuous flow of capital but also enhances the broader productive capacity of the economy. This stability supports research and development (R&D) efforts, which play a crucial role in fostering technological advancements and sustained economic growth (Dwomfour, 2017).

Digital financial inclusion, underpinned by a stable financial sector, ensures that digital financial services are accessible, reliable, and inclusive. By integrating more people into the financial ecosystem, digital financial inclusion reduces income disparities and provides marginalized communities with greater access to resources such as education, healthcare, and other critical services, fostering social inclusion. This aligns with the broader goals of sustainable development, which seeks to balance economic growth, social equity, and environmental stewardship.

In SSA, the integration of digital financial inclusion as a growth driver requires addressing infrastructural deficits, enhancing financial system resilience, and promoting institutional inclusivity. A stable banking sector supports the growth of small and medium-sized enterprises (SMEs) by providing necessary capital for expansion and innovation, thereby contributing to job creation and productivity. Additionally, sustainable development is bolstered when financial systems fund environmentally friendly projects and technologies, ensuring long-term environmental sustainability.

Information Asymmetry Theory

The information asymmetry theory, introduced by George Akerlof, Michael Spence, and Joseph Stiglitz, explores the impact of unequal access to information between parties in a transaction, leading to market inefficiencies and failures. In financial transactions, this asymmetry can manifest when one party, such as a lender or investor, possesses less information than the borrower or service provider. This leads to adverse selection, where lenders struggle to discern the true risk associated with borrowers, potentially resulting in higher interest rates to cover uncertainties. This scenario deters low-risk borrowers,

inviting higher-risk ones, which can degrade the market quality (Akerlof, 1970).

Additionally, moral hazard occurs when individuals take greater risks because they do not bear the full consequences of their actions, often seen when borrowers protected by financial safety nets engage in riskier behavior (Stiglitz & Weiss, 1981). To mitigate these issues, mechanisms like signaling and screening are employed. Signaling, used by informed parties, helps demonstrate quality or risk levels (e.g., companies issuing dividends). Screening, conducted by less informed parties like lenders, involves obtaining more data through means such as collateral requirements or credit checks (Spence, 1973).

Digital financial inclusion (DFI) presents an effective solution to reduce information asymmetry, especially in Sub-Saharan Africa (SSA). By leveraging technology to provide financial services to previously underserved communities, DFI enhances transparency, facilitates access to data, and promotes efficient credit assessments. This improved access can reduce adverse selection and enable more equitable loan terms, encouraging broader financial participation.

In SSA, digital platforms are vital for closing information gaps. They enable lenders to monitor borrower behavior, improve creditworthiness evaluations, and foster real-time data analysis, thus curbing moral hazard and contributing to market stability. Furthermore, DFI's capability to lower transaction costs and simplify processes bolsters financial system efficiency, empowering economic growth and encouraging investments in sectors like education and healthcare. Such advancements support the pillars of sustainable development: economic resilience, social inclusion, and environmental sustainability.

For policymakers, fostering DFI requires developing regulatory frameworks that ensure transparency, data security, and consumer protection. Investment in digital infrastructure, particularly internet connectivity, is crucial for expanding financial access and addressing information asymmetries. Moreover, DFI can align with sustainability goals by facilitating funding for eco-friendly initiatives and promoting sustainable practices, such as renewable energy projects and climate-resilient agriculture.

Triple Bottom Line Theory

Triple Bottom Line Theory was first propounded by John Elkington in 1997. Elkington argued that traditional financial reporting was inadequate in capturing the full impact of a company's activities on society and the environment, and thus, businesses should adopt a broader approach to measure their performance. The Triple Bottom Line theory posits that a company's success should not be measured solely based on its financial profits. Instead, it should be evaluated on three interrelated dimensions, social, economic and environmental (Żak, 2015). The social dimension focuses on a company's impact on society and the well-being of its stakeholders, including employees, customers, suppliers, communities, and other relevant parties. Companies are encouraged to prioritize fair labor practices, diversity and inclusion, community engagement, and other social initiatives that contribute positively to society. The environmental dimension considers a company's environmental impact, including its carbon footprint, resource consumption, waste generation, and efforts to protect and preserve natural ecosystems. Sustainable practices, such as reducing emissions, conserving water, and promoting renewable energy, are essential components of the environmental bottom line. The economic bottom

line is the traditional financial aspect of a company's performance, focusing on its profitability, revenue, and financial stability.

However, the Triple Bottom Line theory opines that, financial success is viewed as just one part of a company's overall performance, not the sole determinant of success. Companies that adopt the TBL theory often produce sustainability reports that disclose their social, environmental, and economic performance. These reports provide stakeholders with a comprehensive understanding of the company's impact and sustainability efforts. TBL urges companies to adopt responsible business practices that consider the impact on employees, customers, and the broader community. This involves implementing fair labor practices, promoting diversity and inclusion, and supporting local communities. The TBL theory encourages companies to integrate sustainability and social responsibility into their business strategies. This can lead to more sustainable supply chain management, energy-efficient operations, and reduced waste generation. Governments and policymakers may use the Triple Bottom Line theory to shape regulations and incentives that promote sustainable practices and responsible corporate behavior.

The triple bottom line (TBL) is a theory for measuring the performance of an organization in terms of its economic, social, and environmental impacts. It is based on the idea that these three dimensions are interconnected and that a sustainable organization must be successful in all three areas. In the context of bank stability and sustainable development, the TBL can be used to assess the long-term risks and opportunities facing banks. For example, a bank that focuses solely on profits may be more likely to take on risky loans or engage in environmentally harmful practices. This could lead to financial instability in the

short term and environmental damage in the long term. On the other hand, a bank that adopts a TBL theory is more likely to be resilient to shocks and stresses. This is because it will be more mindful of its social and environmental impacts, which can help to mitigate risks and build trust with stakeholders.

In addition, a TBL theory can help banks to identify new opportunities for sustainable development. For example, a bank could invest in renewable energy projects or provide loans to businesses that are working to reduce their environmental impact. This could help to create jobs, boost economic growth, and improve the environment. Overall, the TBL is a valuable theory for banks that are looking to build long-term stability and contribute to sustainable development. By taking a holistic view of their impacts, banks can reduce risks, build trust, and identify new opportunities.

Empirical Review

The empirical review was developed in line with the overall purpose of the study and the relationship that exists between the constructs of the study.

Chinoda and Kapingura (2023) used a new measure of digital financial inclusion along with z-score, Herfindahl–Hirschman Index (HHI), and non-performing loans as data variables to investigate the impact of digital financial inclusion and bank competition on bank stability in Sub-Saharan Africa from 2014 to 2020. The findings indicated that digital financial inclusion had a significant positive relationship with bank stability (z-score) and a negative relationship with non-performing loans. Additionally, bank competition (HHI) had a significant negative effect on bank stability, aligning with the competition-fragility view. The study suggests that policymakers should focus on enhancing digital financial literacy, which contributes to bank stability, and

explore ways to improve bank competition to reduce non-performing loans and enhance overall bank stability. The study also underscores the importance of digital financial inclusion in enhancing bank stability, suggesting that policymakers should focus on promoting digital financial literacy.

Using panel data for 30 Chinese provinces from 2011 to 2020, Khan et al. (2023) examined the impact of digital financial inclusion on sustainable development measures such as GDP per capita and real output growth. Their findings demonstrated a significant and robust positive impact of digital financial inclusion on sustainable development indicators, with this effect being influenced by the breadth of coverage and the degree of digitization. Notably, this impact was more pronounced in central and western regions, northern areas with high winter heating demand, and urban areas. The study highlighted that digital financial inclusion contributed to economic growth and improved GDP per capita primarily through changes in household energy consumption patterns, thereby providing valuable insights for policymakers focused on promoting sustainable economic development in Chinese provinces. These findings underscore the role of digital financial inclusion in fostering not only environmental benefits but also broader sustainable development goals through enhanced economic growth.

Yusheng, Ntarmah, Cobbinah, and Menyah (2021) explored the impacts of banking system stability on economic sustainability for the period 2000-2016 covering pre and post-global financial crisis periods. They employed econometric frameworks of dynamic fixed effects, system GMM and most recently estimator panel quantile regression with fixed effects and parameter heterogeneity approaches. The findings of their study unveiled

that, when considering other factors influencing sustainable development, the stability of the banking system exerts a significant influence on sustainable development. Additionally, the research provided empirical evidence of varying parameter responses for sustainable development in countries that are situated on both low and high sustainable development trajectories, both in the short term and the long term. The study by Ozili and Terhemba Iorember (2023) examines the relationship between financial stability and sustainable development. They analyse 26 countries from 2011 to 2018 using the system GMM method. The findings of the sustainable development index analysis show that financial stability has a significant effect on the level of sustainable development and the effect is negative in Asian countries.

Ahamed and Mallick (2019) explored the relationship between traditional financial inclusion and economic growth measures such as GDP per capita and real output growth, focusing on its influence on bank stability across various international samples. Their study concluded that financial inclusion positively impacts economic stability, which is crucial for sustained real output growth. However, it did not address the role of digital financial inclusion, leaving a research gap regarding the extent to which digital platforms may drive sustainable development through economic metrics like GDP per capita and real output growth.

The study by Ozili and Iorember (2023) examined the impact of financial stability on sustainable development across 26 countries from 2011 to 2018. They utilised a unique financial stability index, sustainable development index, and four Sustainable Development Goals (SDG) indicators, employing the system GMM method for analysis. The findings revealed that financial

stability had a significant but context-dependent effect on sustainable development, with a negative impact observed in Asian countries. Additionally, the study highlighted variations in the impact of financial stability on specific SDGs, suggesting that the relationship between financial stability and sustainable development is influenced by the measurement approach and the economic context of the countries studied. This study highlights the context-dependent nature of the relationship between financial stability and sustainable development, suggesting the need for tailored strategies that consider regional economic conditions.

Gap in Empirical Literature

The existing literature on sustainable development and its measurement often relies heavily on traditional economic indicators such as GDP per capita and real output growth. However, this narrow approach does not fully capture the multifaceted nature of sustainable development, which includes economic, social, and environmental dimensions. According to Tomislav (2018), sustainable development should be measured using three broad proxies: economic, social, and environmental. These proxies offer a more holistic view of a country's progress toward sustainability and can highlight potential trade-offs between economic growth and social or environmental well-being. By employing these broader measures, researchers can gain a more comprehensive understanding of the complex interactions and dependencies involved in sustainable development. Despite the recognition of the importance of these broader proxies, much of the existing literature still focuses predominantly on economic indicators. This gap suggests a need for studies that integrate social and environmental factors into their analysis of sustainable development.

In addition, this study utilised comprehensive proxies for digital financial inclusion, such as the mobile subscription per 100 people, account ownership with mobile money service provider, and percentage population with access to internet. These indicators provide a more detailed assessment of the banking sector's health and stability, which is crucial for understanding its role in sustainable development.

Conceptual Framework

Figure 1 shows how digital financial inclusion influences sustainable development in SSA economies. Additionally, Figure 1 shows the direct link between the control variables (inflation rate, quality education, reduced inequalities, real interest rate, research and development) and the dependent variables (sustainable development).

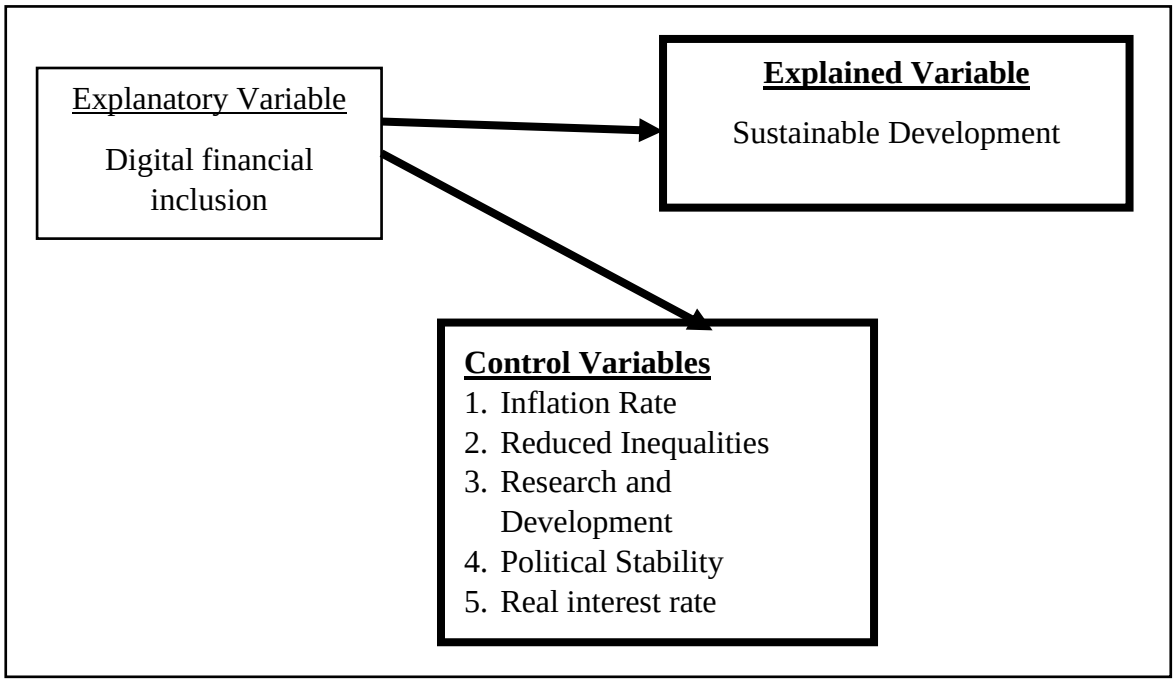

Figure 1: Conceptual framework

Source: Author's Construct (2024)

Chapter Summary

This chapter reviewed literature based on the objectives and research questions. The first section explored concepts such as digital financial inclusion, sustainable development and its dimensions, and the relationship between the concepts. The second section also examined the theoretical models underpinning the study. These theories include; technology acceptance model and triple bottom theory. Finally, the last section focused on empirical literature and conceptual framework of the relationship between the constructs of the study.

CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter outlines the systematic procedures employed to explain the role of digital financial inclusion in enhancing the achievement of sustainable development. The chapter articulates how the researcher went about this study and the logic behind each method used. Specifically, this chapter presents the research paradigm, research design, research approach, sources and measurement of variables, model specification and justification, and the estimation techniques.

Research Paradigm

This study adopted the post-positivist research paradigm due to its appropriateness for systematically testing hypotheses and analyzing relationships among variables, which is essential for examining the effect of digital financial inclusion on sustainable development (Saunders, Lewis, & Thornhill, 2016). The selection of this paradigm was informed by its balanced approach, which acknowledges the existence of an objective reality while also considering the role of subjectivity and value judgments in research outcomes (Creswell & Creswell, 2018). This dual recognition allows for comprehensive empirical analysis that is both rigorous and open to interpretative insight (Sekaran & Bougie, 2016).

Employing the post-positivist paradigm facilitated the development of hypotheses grounded in established theories related to financial inclusion and sustainable development (Saunders et al., 2016). These hypotheses were then rigorously tested through empirical data collection and analysis, ensuring that

the findings could either validate or challenge the theoretical assumptions underpinning the study (Young & Javalgi, 2007). The post-positivist approach enabled a methodologically robust investigation, combining the precision of quantitative analysis with contextual qualitative interpretation (Zikmund et al., 2012). This paradigm was therefore deemed suitable for addressing the complex and multifaceted nature of digital financial inclusion and its implications for sustainable development in Sub-Saharan African economies (Potwarka et al., 2019).

Research Design

This study adopted an explanatory research design due to its suitability for investigating cause-and-effect relationships among key variables, namely digital financial inclusion and banking sector stability (independent variables) and sustainable development (dependent variable). The rationale for selecting this design lies in its ability to clarify the nature and direction of relationships between these constructs, providing a structured approach for understanding how digital financial inclusion contributes to sustainable development. As noted by Zikmund et al. (2013), explanatory research design is instrumental in detailing these relationships, which aligns with the study's objectives of elucidating underlying dynamics and offering predictive insights.

Furthermore, Potwarka et al. (2019) highlight that explanatory research is rooted in a systematic approach that is often associated with the positivist paradigm, emphasizing empirical evidence and causative analysis. This design was employed to enable a thorough exploration of the logical connections and interactions among the identified variables. The choice of explanatory research design was also informed by its potential to facilitate a comprehensive analysis

that goes beyond mere description, allowing for the formulation of conclusions about causality (Malhotra, 2015; Potgieter et al., 2019). By adopting this approach, the study aims to contribute to a deeper understanding of the implications of digital financial inclusion for sustainable development in Sub-Saharan African economies.

Research Approach

This study employed a quantitative research approach due to its appropriateness for analyzing the relationships between digital financial inclusion and sustainable development through numerical data analysis. The decision to adopt this approach was informed by the study's objectives, the hypotheses formulated, and the nature of the secondary data to be analyzed (Creswell & Creswell, 2018). The quantitative approach facilitated a structured analysis of data, enabling the identification and examination of relationships among key variables, which aligns with the study's purpose of investigating how digital financial inclusion influences sustainable development. This method was particularly suitable for testing hypotheses and generating empirical evidence that supports or refutes theoretical assumptions (Creswell, 2014).

The use of quantitative research allowed for the collection and analysis of data in a manner that emphasized objectivity, ensuring the validity and reliability of the findings (Saunders et al., 2016). This objectivity was critical in minimizing researcher bias during data analysis, thereby enhancing the credibility of the results. Furthermore, employing a quantitative approach facilitated the generalization of findings to the broader context of the Sub-Saharan African countries from which the data was sourced (Creswell & Creswell, 2018). By leveraging statistical tools and methods, this approach

enabled the study to derive insights regarding the patterns and relationships among the variables of interest, providing a comprehensive understanding of how digital financial inclusion impacts sustainable development (Saunders et al., 2016).

Quantitative research approach was instrumental in achieving the study's objectives, offering a solid foundation for drawing conclusions that are both rigorous and applicable to the wider regional context. This method underscored the study's commitment to empirical precision and reproducibility, essential for contributing to the academic discourse on digital financial inclusion and sustainable development in Sub-Saharan Africa.

Data Sources

The data sources for this study included the Global Financial Development Indicators (GFDI) and the World Development Indicators (WDI) provided by the World Bank. These sources were selected due to their reliability and comprehensive coverage of economic and financial data across various countries. The GFDI was used to obtain key metrics relevant to financial development, while the WDI provided data for the control variables and broader socioeconomic indicators essential for assessing sustainable development.

The study utilized annual panel data spanning the period from 2009 to 2023 to capture temporal variations and trends in digital financial inclusion and sustainable development. Digital financial inclusion was assessed using indicators such as the percentage of the population with internet access, mobile subscription per 100 people, and account ownership with mobile money service providers. This choice of metrics reflects the multidimensional nature of digital financial inclusion and its impact on the financial ecosystem.

The dataset focused on 28 selected countries within the Sub-Saharan African region, including Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Congo DR, Cote d'Ivoire, Eswatini, Ethiopia, Kenya, Lesotho, Ghana, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Uganda, Zambia, and Zimbabwe. The selection of these countries was informed by data availability and their representation of the region's diverse economic and social landscapes.

By employing panel data from these countries over a 15-year period, the study aimed to capture both cross-sectional and longitudinal variations, allowing for an in-depth analysis of how digital financial inclusion influences sustainable development. This comprehensive approach provided a robust foundation for understanding the dynamics of financial inclusion within the Sub-Saharan African context, supported by reliable and globally recognized data sources.

Measurement of Variables

The variables examined in this study include sustainable development (SD) as the dependent variable, and digital financial inclusion as independent variables. Sustainable development was operationalized using adjusted net savings (ANS), which captures the environmental, economic, and social dimensions of SD. Specifically, carbon dioxide emissions (CO2), Gross National Income (GNI), and Government Expenditure on Education (GEE) were used as proxies for the three dimensions, respectively. Digital financial inclusion, on the other hand, was assessed by the percentage of population with access to internet, mobile subscription per 100 people and account ownership

with mobile money service provider. This indicator serves as a proxy for the level of digital financial inclusion within the studied countries.

Additionally, the study incorporated control variables to account for other factors that could influence sustainable development. These control variables were selected based on their relevance in existing literature on sustainable development, their suitability for national and global analysis, and the availability of data within the specified sample period. By including control variables, the study aimed to isolate the specific effects of digital financial inclusion on sustainable development, while accounting for potential confounding factors. These variables include inflation rate, reduced inequalities, real interest rate, research and development policy and political stability. The selection of measurement indicators and control variables was guided by the need to capture and analyze key dimensions of sustainable development and their relationships with digital financial inclusion. The chosen indicators and variables have been widely used and accepted in previous studies, ensuring consistency and comparability with existing research (Sen, 2013; Strezov et al., 2017; Romero & Linares, 2018; Cassely et al., 2020; Koirala and Pradhan 2020). This is further explained in the table below:

Table 1: Description of Variables and Source of Data

Variables	Type	Measurement / Proxy	Data Source
Explained/Dependent Variables:		**4 Proxies**	
Sustainable development		Adjusted Net Savings (Ans)	Global Financial Development Indicators (GFDI)
Economic Sustainability	Continuous	Gross National Income per capita US$ (GNI)	
Social Sustainability		Government Expenditure on Education (GEE)	
Environmental Sustainability		CO2 Emissions (kg per US$ of GDP) (Co2)	
Independent Variable		**3 Proxies**	
Digital Financial Inclusion	Continuous	Percentage population with access to internet (PPI) Mobile Subscription per 100 people (MSP) Account ownership with mobile money service provider (AMS)	World Development Indicators (WDI)
Control Variables:		**5 proxies**	
Inflation Rate Research and Development Political Stability Reduced Inequalities Real Interest Rate	Continuous	Inflation, GDP Deflator (annual %) Research and Development Ex penditure (rnd) Political Stability and Absence of Violence/Terrorism: Percent ile Rank (PS) Gini index	World Development Indicators (WDI)

Source: Author's Construct, Amoako-Mensah (2024)

Estimation Technique and Model Specification

The two-step System Generalised Method of Moments by Roodman (2009) was employed to investigate the relationship among the variables. The two-step System GMM extends the approach used by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The approach by Arellano and Bond (1991) makes use of the lagged levels of the

explanatory variables and the first difference of the variables to deal with issues of unobservable simultaneity bias and country-specific effects. Arellano and Bover (1995) later observed that Arellano and Bond's (1991) technique would result in erroneous conclusions when the series have time-persistent problems. Additionally, Blundell and Bond (1998) contend that if the instruments utilized in the traditional first-difference GMM are not strong enough, then there is the possibility of the results of the within groups being biased. The System GM, therefore, originated as a remedy to the problems posed by the approaches of the earlier scholars.

The System GMM combines both the level of the residuals and the difference of the disturbance term as well as additional instruments in the levels equations (Odhiambo, 2020). It consists of one-step and two-step System GMM. The latter has been confirmed to be more efficient and robust to heteroscedasticity and autocorrelation (Obuobi et al., 2021). The choice of the two-step System GMM is motivated by the following justifications which have received massive support from earlier works (Fosu & Abass, 2019; Agyei, Marfo-Yiadom, Ansong, & Idun, 2020; Abeka, Andoh, Gatsi, & Kawor, 2021, Acher & Idun, 2023). The estimator is suitable to use when the cross-sectional data (the number of countries) is significantly more than the time series data (the number of periods). The countries of interest for this current paper are 28 while the period is 15 years. Moreover, the technique deals with the proliferation of instrumental variables as well as controlling for the persistence of the dependent variables. The argument for persistence in the dependent variables is that the previous year's sustainable development tends to influence that of the current year. Adding to this, Agyei et al. (2020) contend that if the

correlation between the regressand and its lag exceeds 0.80, then the former is persistent. In this study, the correlation between sustainable development (SD) and its lag (L.SD) is 0.821.

Additionally, the technique tends to account for the possible endogeneity problem or bias resulting from the potential reverse causality between the explained and explanatory variables and time-invariant omitted variables and account for it using instrumental variables (Tchamyou, 2020; Agyei et al., 2021). Lastly, it controls for the problem of unobserved heterogeneity and reduces the overidentification of instruments and cross-sectional dependence (Agyei et al., 2020). The general system GMM equation is specified as follows;

$$SD_{it} = \beta_o + \beta_1 SD_{it-1} + \sum_{h=i}^{n} \beta_h Z_{it-1} + \mu i + \delta_t + \varepsilon_{it} \ldots\ldots\ldots(1)$$

$$SD_{it} - SD_{it-1} = \beta_1 (SD_{it-1} SD_{it-2}) + \sum_{h=i}^{n} \beta_h (Z_{it-1} - Z_{it-2}) + \delta_{it} - \delta_{it-1}) + \varepsilon_{it} - \varepsilon_{it-1} \ldots\ldots\ldots\ldots\ldots(2)$$

Where:

SD_{it} represents the explained variable

SD_{it-1} is the lagged value of the explained for each country i at time t.

$SD_{it} - SD_{it-1}$ represents the change in SD over time.

$SD_{it-1} SD_{it-2}$ represents the change in lagged SD over time.

Z_{it-1} denotes a set of explanatory variables for each country i at time t.

$Z_{it-1} - Z_{it-2}$ denotes change in explanatory variables over time.

β_o, β_1 and β_h are coefficients to be estimated.

μi represents the individual specific fixed effects.

δ_t represents time-specific effects.

ε_{it} is the error term.

Aside GMM, the researcher could have equally employed other panel estimation techniques such as pooled ordinary least square (POLS), pooled mean group (PMG), two-stage least square (2SLS), and fixed and random effect. However, GMM has been disclosed to have some advantages over these estimators. The POLS is not the best method because it does not account for heterogeneity among panels (Hill, Griffiths & Lim, 2012) and violates one of the assumptions of no the traditional linear regression model. The PMG as a cointegration model estimates the long-run relationship among variables. Though it uses lags of the variables because of its autoregressive nature (Pesaran, Shin & Smith, 1999), it requires panel models with more time series observations than cross-sectional which may not be appropriate for this study. Concerning fixed and random effects, the assumption of the current value of the dependent variable being completely independent of its past values is unrealistic which leads to leads to endogeneity arising from unobservable heterogeneity (Gujarati & Porter, 2009; Bell & Jones, 2015). The GMM technique is superior over 2SLS in the sense that the instrumental variable estimates are retrieved from lagged values which eliminate the need for an external instrument as required in 2SLS (Roodman, 2006).

Model Specification

Baseline model

$$Y_{it} = a_i + Y_{it-1} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

$$e_{it} = a_i + \varepsilon_{it}$$

Where;

i refers to the country (i = 1, 2, 3,..., 15);

t refers to time period from (2009 to 2023) (t = 1, 2, 3, ..., 15)

Y_{it} is the dependent variable

Y_{it-1} is the lag of the dependent variable

a_i is the intercept

X_{it} is the vector of independent variables (regressors, control variables and intervening variables)

ε_{it} is the error term assumed to be serially uncorrelated.

The equation for the error term eit specifies that the error term is a function of the time-invariant individual effect ai and the idiosyncratic error term ε_{it}.

Thus,

$$SD_{it} = \beta_{o+}\beta_1 SD_{it-1} + \beta_2 MSP_{it} + \beta_3 AMS_{it} + \beta_4 PPI_{it} + \sum_{h=i}^{n} \beta_h Z_{it+}\mu_{it} + \varepsilon_{it}$$

$$SD_{it} = \beta_{o+}\beta_1 SD_{it-1} + \beta_2 IFS_{it} + \sum_{h=i}^{n} \beta_h Z_{it+}\mu_{it} + \varepsilon_{it} \quad (2)$$

Where;

SD_{it} is Sustainable development (explained variable) measured by Adjusted Net

Savings for each country i at time t.

SD_{it-1} denotes the lag of the explained variable.

$MSP\ denotes$ mobile subscription per 100 people for each country i at time t.

AMS_{it} represents account ownership with mobile money service provider for each country i at time t.

PPI_{it} represents percentage population with access to internet for each country i at time t.

$\sum_{h=i}^{n} \beta_h Z_{it}$ represents the summation of the control variables (inflation, research and development, reduced inequalities, political stability and real interest rate).

$\beta_{o,}\beta_1, \beta_2, \beta_3, \beta_{4,}\beta_h$ are the regression coefficient

μ denotes the unobserved country-specific effect

ε_{it} also denotes the error term

Model 1

$$SD_{it} = \beta_{o+} \beta_1 SD_{it-1} + \beta_2 l_n IFS_{it} + \beta_3 l_n MSP_{it} + \beta_4 l_n AMS_{it} \sum_{h=i}^{n} \beta_h l_n Z_{it+} \varepsilon_{it} \quad (3)$$

Where;

- SD_{it} represents Sustainable development (explained variable) measured by Adjusted Net Savings for each country i in sub-Saharan Africa at time t.
- SD_{it-1} represents the lag of the explained variable.
- $l_n PPI_{it}$ represents percentage population with access to internet for each country i at time t.
- $l_n MSP_{it}$ represents the natural log of mobile subscription per 100 people for each country i at time t.
- $l_n AMS_{it}$ represents the natural log Account ownership with mobile money service provider for each country i at time t.
- $\sum_{h=i}^{n} \beta_{hl_n} Z_{it}$ $r$epresents the summation of natural log of control variables (inflation, research and development, reduced inequalities, political stability and real interest rate).
- $\beta_{o,}\beta_1, \beta_2, \beta_3, \beta_{4,}\beta_h$ are the regression coefficient
- ε_{it} also denotes the error term.

To eliminate country-specific effects, we take the first differences of eqn. (1)

$$SD_{it} - SD_{it-1} = \beta_o + \beta_1 (SD_{it-1} - SD_{it-2}) + \beta_2 l_n(PPI_{it} - PPI_{it-1}) + \beta_3 l_n(MSP_{it} - MSP_{it-1}) + \beta_4 l_n (AMS_{s\,it} - AMS_{it-1}) + (\sum_{h=i}^{n} \beta_h Z_{it} - \sum_{h=i}^{n} \beta_h Z_{it-1} + \varepsilon_{it} - \varepsilon_{it_{-1}} \quad (4)$$

Where;

$SD_{it} - SD_{it-1} = \Delta SD_{it}$ and this definition applies to all explanatory variables as well. Similarly, $\varepsilon_{it} - \varepsilon_{it-1} = \Delta\varepsilon_{it}$.

Model Diagnostic Tests

To assess the potential over-identification problem, the Sargan test of over identifying restrictions is employed in the technique. The null hypothesis for this test is that "overidentifying restrictions are valid." The purpose of this test is to determine whether all instruments used in the analysis are valid. It is expected that the null hypothesis should not be rejected, indicating that the instruments are indeed valid for the model. In addition to the Sargan test, the system GMM approach requires conducting the Arellano-Bond test for serial correlation. The null hypothesis for this test is "no serial correlation." Specifically, the AR (1) test examines first-order serial correlation in first differences, while the AR (2) test examines higher-order serial correlation in first differences. It is anticipated that the null hypothesis of no first-order serial correlation (AR (1)) will be rejected, suggesting the presence of serial correlation. However, the null hypothesis of no higher-order serial correlation (AR (2)) is expected to be non-rejected.

Furthermore, the Difference in Hansen Test (DHT) is employed to assess the exclusion restriction of the exogenous variable in the model. The purpose of this test is to determine whether the exogenous variable is truly

exogenous and does not suffer from endogeneity issues. By examining the statistical significance of the test, it helps to evaluate the validity of the exclusion restriction. The utilization of these model diagnostic tests is crucial for ensuring the validity and reliability of the empirical analysis. These tests provide insights into the robustness of the model, the validity of instruments, the presence of serial correlation, and the appropriateness of the exclusion restriction. By conducting these tests, the quality of their model can be assessed and make informed decisions regarding the validity of the results.

Chapter Summary

This chapter explained in detail the methodology followed in carrying out the research. The research paradigm of the study, research approach, research design, data sources and analysis procedure, empirical model specification and estimation, were thoroughly discussed. The positivist research paradigm was used as the theoretical foundation of the study. The quantitative research approach was employed for the study. Explanatory research design was adopted to ensure objectivity in the research process.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The results obtained from the empirical analysis are presented and discussed in this chapter. First, descriptive statistics on all the variables are discussed to give an overview of digital financial inclusion, and sustainable de velopment in SSA economies using data visualisation. The chapter then presen ts a correlation matrix which help to avoid the issues of multicollinearity in the empirical specification. Subsequently, the chapter presents a formal discussion of the various models estimated in the study. The latter is systematically achieved by following the objectives of the study.

Descriptive Statistics

Before any empirical analysis and discussion can be conducted, Idrees (2018) advocated that the descriptive information of the various indicators employed in the study should be displayed to help the researcher know the distribution of the data. Specifically, for this study, the mean, standard deviation, and minimum and maximum values were presented in Table 3. The results from the table show that overall sustainability which is measured as Ans depicted an average of 3.294 percent of Gross National Income (GNI) within minimum and maximum values of -45.265% and 35.955% respectively. The rate of volatility is 11.616 which is an indication that the level of development in the Sub-Saharan African continent is widely dispersed with some of the countries being more developed than others as some nations recorded negative Ans. This negative value implies that the current generations are not fully

meeting their needs and as such are not preserving any resource for the future generation.

On the various dimensions of sustainable development, it is seen from Table 2 that the environmental dimension which is measured with Co2 emissions (kg per US$ of GDP) had a mean value of 0.311kg with 0.236 standard deviation and a minimum and maximum values of 0.062kg and 1.495kg respectively. It is further observed that economic sustainability (GNI per capita (US$)) recorded an average value of $1753.078 lying within a range of $261.948 and $11208.346 with 1981.667 standard deviations. This indicates that the per capita income is low and highly dispersed because most countries are low-income nations with higher population growth rates. The social dimension which is government investment in education (human capital) averaged 17.563% of total expenditure within a boundary of 5.131–37.521%. This implies that the expenditure governments incur on education is very low since the average value is less than half of the maximum value. Thus, as some countries within SSA region are developing initiatives to advocate the need for formal education others are still lagging behind and probably prioritising other sectors.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ANS	545	3.294	11.606	-45.265	35.955
Co2	500	.311	.236	.062	1.495
GNI	402	1753.078	1981.667	261.948	11208.346
GEE	515	17.563	4.744	5.131	37.521
MSP	513	67.884	5.559	28.731	38.683
AMS	514	75.961	22.881	23.317	136.271
PPI	527	58.699	15.734	.072	73.5
INF	510	10.608	31.563	6.762	245.946
PS	530	32.449	21.876	.529	90.566
RnD	535	.308	.093	.005	.898
Gini	535	43.435	3.181	29.8	64.8

Source: Amoako Mensah (2024)
***, **, * represent 1%, 5% and 10% significant levels respectively

SD denotes sustainable development, co2 represents environmental dimension, GNI represents economic dimension, GEE denotes social dimension, PPI, MSP and AMS are measures of digital financial inclusion, INF is inflation, RnD denotes research and development, Gini is Gini index used to measure reduced income inequalities, PS is political stability.

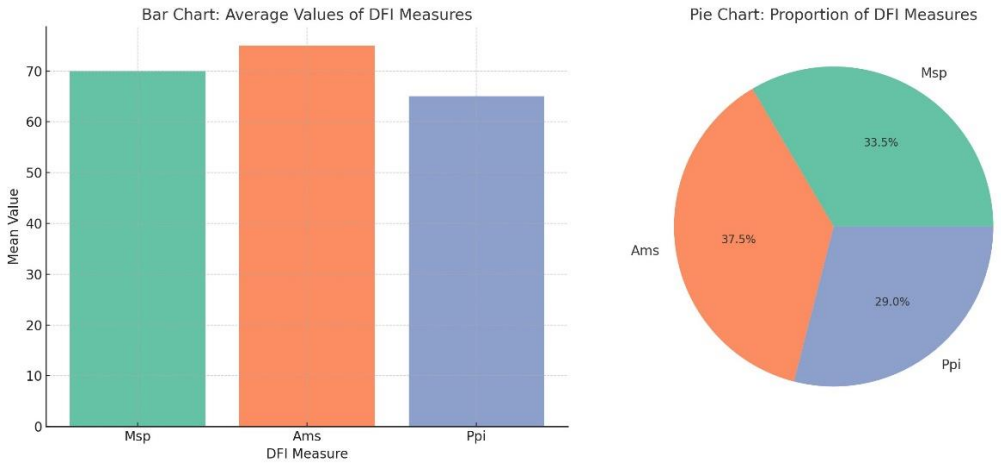

Figure 2: **Charts of DFI measures**

Source: Amoako Mensah (2024)

The average value of 67.884 for MSP indicates that, on average, there are approximately 68 mobile subscriptions per 100 people in the region. This suggests a moderate level of mobile penetration, which is a key component of digital financial inclusion, as mobile subscriptions are often the primary means through which individuals access mobile financial services. The relatively low minimum value of 28.731 and the highest value of 38.683 reflect variability in mobile subscription rates across different areas or countries. A higher MSP generally correlates with greater potential for digital financial inclusion, as more individuals have access to mobile technology that can facilitate financial transactions.

The mean AMS value of 75.961% indicates that on average, a significant portion of the population in the region has an account with a mobile money service provider. This is a strong indicator of digital financial inclusion, as mobile money accounts enable individuals to participate in financial activities such as saving, transferring money, and making payments. The minimum value of 23.317% suggests that in some areas, access to mobile money services is quite low, which could indicate barriers to financial inclusion. Conversely, the highest value of 136.271% implies that in certain regions, mobile money services are extremely widespread, with some individuals possibly holding multiple accounts. This highlights a high level of financial inclusion through mobile services, but also raises questions about the quality and distribution of access.

The average value of 58.699% for PPI indicates that just over half of the population in Sub-Saharan Africa has access to the internet, which is a critical enabler of digital financial services. Internet access allows individuals to use online banking, mobile apps, and other digital financial platforms. The range of 0.072% to 73.5% shows significant variability in internet access, reflecting disparities in infrastructure, affordability, and digital literacy across different countries in the region. The standard deviation of 15.734% highlights these disparities, indicating that while some areas may have relatively high internet penetration, others have very limited access, contributing to unequal levels of digital financial inclusion.

Regarding the independent variables, the first indicator for digital financial inclusion (DFI) which is mobile Subscription per 100 people (MSP) had an average value of 67.884 with 28.731 and 38.683 as the lowest and highest

values respectively. A mean value of 67.884% for mobile subscriptions per 100 people suggests that mobile penetration in the region is moderate, with considerable variation across countries. The fact that the lowest value is 28.731% and the highest is 38.683% indicates significant disparities in mobile access within the sample of countries. This gap highlights unequal access to mobile technology, which can limit the potential of digital financial inclusion (DFI) in fostering broad-based financial access and inclusion.

This disparity also suggests that while some countries may have nearly universal access to mobile services, others are lagging behind, potentially due to infrastructure gaps, affordability issues, or socio-economic challenges. The variation in mobile subscription rates could also reflect different levels of readiness for adopting digital financial services, which might influence the relationship between financial inclusion and broader economic outcomes, such as banking sector stability and sustainable development.

The moderate mobile penetration rate implies that while mobile networks are somewhat widespread, a substantial portion of the population remains without access to mobile subscriptions. This could hinder efforts to leverage mobile technology for enhancing financial inclusion, particularly in underserved and rural areas where traditional banking services are limited. Moreover, if mobile subscriptions are primarily concentrated in urban areas or among wealthier populations, the intended benefits of DFI in promoting equitable financial access and enhancing sustainable development might not be fully realized.

The second indicator, account ownership with a mobile money service provider (AMS), recorded a mean value of 75.961%, with a minimum value of 23.317% and a maximum value of 136.271%. This indicates that mobile money account ownership is relatively high across the countries in the sample, suggesting that mobile money services play a significant role in financial inclusion efforts. The mean value of 75.961% indicates that, on average, a large portion of the population is engaged with mobile money services, which are critical for providing financial services in areas where traditional banking infrastructure is lacking. However, the wide range from a low of 23.317% to a high of 136.271% suggests notable variation in the adoption and usage of mobile money services across countries. The high value exceeding 100% likely reflects multiple account ownership by individuals or high usage rates, which further emphasizes the importance of mobile money in facilitating financial transactions.

Countries with low AMS values may still face barriers such as limited access to mobile technology, poor infrastructure, regulatory hurdles, or low levels of financial literacy. In contrast, countries with high AMS values demonstrate the successful integration of mobile money into daily financial activities, which could contribute to improved banking services by widening access to financial services and reducing the reliance on informal financial systems. This variation implies that while mobile money is a powerful tool for financial inclusion, though there is still work to be done to ensure more equitable access and usage across different regions.

The average of 38.699% for the percentage of the population with access to the internet across Sub-Saharan Africa suggests that internet penetration is relatively low, with less than half of the population being connected. This highlights significant limitations in digital financial inclusion (DFI), as internet access is a crucial enabler for many digital financial services, such as mobile banking and online payment platforms. The wide range, from as low as 0.072% to as high as 73.5%, reveals substantial variability in internet access across the region. Some countries are almost fully connected, while others have virtually no access, which points to large disparities in digital infrastructure development, affordability, and potentially in government policy focus on digital inclusion.

This variability suggests that in countries with low internet penetration, the population may face barriers to accessing digital financial services, further limiting financial inclusion and hindering the potential benefits of such services on economic growth, banking stability, and sustainable development. Conversely, countries with higher internet access are better positioned to capitalize on digital financial platforms, which can enhance economic opportunities, improve financial inclusion, and support development goals.

These disparities in internet access could result in uneven outcomes in terms of DFI's influence on sustainable development across the region. Countries with higher internet penetration are more likely to see positive impacts, while those with low internet access may struggle to experience the full benefits of digital financial services.

Relative to the control variables, the results revealed that the rate of inflation averaged 10.608%. This means that, on average, prices are increasing by 10.608% over a specific period indicating that prices are rising at a relatively

moderate pace. This signifies that the inflation rate in some of the countries has relatively been on the decrease since some recorded a negative value. However, the range of -16.762-604.946% shows that there is a great deal of variation in inflation rates across countries, with some countries experiencing deflation (falling prices) and others experiencing extremely high inflation. The standard deviation of 31.563% indicates that there is a lot of variation in inflation rates within countries, with some individuals experiencing much higher inflation rates than others. Gini index which measures reduced income inequalities had an average figure of 43.435% of GDP between a range of 29.8% and 64.8% of GDP.

A high Gini index indicates that the distribution of income is very unequal, with a small number of people earning a very high percentage of income and a large number of people earning a very low percentage of income. A low Gini index indicates that the distribution of income is more equal, with a smaller difference between the incomes of the rich and the poor. An average Gini index of 43.435% of GDP indicates that income inequality is relatively high in Sub-Saharan African continent. The range of 29.8% to 64.8% of GDP shows that there is a significant variation in income inequality across countries. Expenditure on research and development recorded an average value of 0.308% of government expenditure between a range of 0.005-0.898% with 0.093% standard deviations.

It means that, on average, governments spend 0.308% of their total expenditure on research and development. However, there is a wide range of variation in this spending, from 0.005% to 0.898%. This variation is likely due to a number of factors, including the level of economic development of the

country, the government's priorities, and the availability of resources. The standard deviation of 0.093 indicates that there is a relatively small amount of variation in the spending on research and development within countries. This suggests that, once a country has decided to invest in research and development, it tends to invest a relatively consistent amount. The high average spending on research and development is a positive sign, as it suggests that governments are investing in the future. However, the wide range of variation suggests that there is still room for improvement. Governments should strive to increase their spending on research and development, as this can lead to economic growth, innovation, and improved lives for citizens.

Political stability had an average of 32.449% with a wide range of 0.529–90.566% and standard deviation of 21.876%. The average political stability of 32.449% indicates that most countries are in a state of moderate political stability. However, there is a wide range of political stability, with some countries being very stable (90.566%) and others being very unstable (0.529%). The standard deviation of 21.876% indicates that there is a significant amount of variation in political stability from country to country. Finally, real interest rate averaged 7.698% with a minimum and maximum values of -81.132% and 52.437% respectively. This means that, on average, investors in Sub-Saharan Africa were rewarded for lending money over the period of time of the study. However, the standard deviation is 11.084%, meaning that there are lot of variation in the real interest rate in Sub-Saharan Africa.

The descriptive statistics reveal that, there is a wide variation in the levels of sustainable development, banking sector stability and digital financial inclusion across countries in Sub-Saharan Africa. This suggests that there is no

single "best" model for sustainable development in the region, and that different countries need to tailor their approaches to their specific circumstances.

Panel Unit Root Test

Table 3 Fisher-type unit-root test for panel dataset

Variables	Inverse chi-square statistics	P-value (Inv. chi-sq stats)	Inverse normal statistics	P-value (Inv. norm. stats)
LnANS	85.8644	0.0038	-2.2109	0.0135
lnco2	414.5838	0.0000	-16.9341	0.0000
LnGNI	118.8554	0.0000	-2.2070	0.0137
LnGEE	245.3549	0.0000	-8.5387	0.0000
LnMSP	99.1953	0.0003	-4.0120	0.0000
LnAMS	487.1694	0.0000	-18.0026	0.0000
LnPPI	88.4567	0.0037	-0.3477	0.0040
LnINF	320.4100	0.0000	-12.0434	0.0000
LnRnD	189.0428	0.0000	-10.0601	0.0000
LnGini	608.5671	0.0000	-21.2664	0.0000
LnPS	147.4936	0.0000	-4.7069	0.0000

Source: Amoako Mensah (2024)

***, **, * represent 1%, 5% and 10% significant levels respectively

SD denotes sustainable development, co2 represents environmental dimension, GNI represents economic dimension, GEE denotes social dimension, PPI, MSP and AMS are measures of digital financial inclusion, INF is inflation, RnD denotes research and development, Gini is Gini index used to measure reduced income inequalities, PS is political stability.

Table 3, shows the results of Fisher-type unit root test for a panel of 28 countries. The null hypothesis is that all panels contain unit roots, which means that they are non-stationary. The alternative hypothesis is that at least one panel is stationary. For each variable listed, there are two test statistics (inverse chi-square and inverse normal) along with their corresponding p-values. In all cases,

the p-values associated with both types of test statistics are very close to zero (typically less than 0.05 or even 0.01). This indicates strong evidence against the null hypothesis of unit roots, suggesting that the variables are stationary at 0.05.

Correlation Analysis

The correlation matrix for the variables used in this study is presented in Table 5. A thorough examination of the table reveals that there is a strong positive connection (0.870) between the dependent variable (lnans) and its lag which is even more than the threshold of 0.80, making it suitable to employ the System GMM (Tchamyou, 2020). This high correlation coefficient suggests that the level of persistency in the dependent variable is very high. The individual sustainability dimensions exhibited weak correlation with the composite sustainability measure. Albeit the weak correlation, they had positive connection except the social dimension that had inverse association. Additionally, a cursory observation of the correlation matrix unveils that there is generally weak correlation among all the variables used in the study with the exception of digital financial inclusion which exhibited moderate association with both the environmental dimension and the first indicator for stability (lnbzs), thus, 0.268 and 0.181 respectively. These associations among the variables do not pose any problem of multicollinearity since they are all lesser than 0.90 as suggested by Adam (2016).

Table 4: Pairwise correlations

Variables	lnANS	lnGNI	lnGEE	lnco2	lnMSP	lnAMS	LnPPI	LnINF	lnRnD	lnGini	lnPS
LnANS	1.000										
L. lnANS	0.870*	1.000									
	(0.000)										
LnGNI	0.144*	-0.187*	1.000								
	(0.001)	(0.000)									
LnGEE	-0.059	-0.119*	-0.093*	1.000							
	(0.161)	(0.016)	(0.027)								
lnco2	0.139*	-0.130*	0.552*	-0.019	1.000						
	(0.001)	(0.009)	(0.000)	(0.656)							
LnMSP	0.012	0.090	-0.181*	0.114*	-0.088*	1.000					
	(0.773)	(0.070)	(0.000)	(0.007)	(0.038)						
LnAMS	-0.032	-0.032	0.032	0.067	0.017	0.458*	1.000				
	(0.456)	(0.525)	(0.447)	(0.114)	(0.689)	(0.000)					
LnPPI	0.116*	0.015	0.041*	-0.218*	0.312*	-0.024	-0.017	1.000			
	(0.000)	(0.361)	(0.000)	(0.000)	(0.000)	(0.565)	(0.384)				
LnINF	-0.089*	-0.132*	0.054	0.079	-0.030	-0.044	-0.144*	-0.126*	1.000		
	(0.042)	(0.011)	(0.222)	(0.072)	(0.494)	(0.318)	(0.001)	(0.004)			
LnRnD	0.018	0.026	0.075	-0.065	0.197*	0.023	0.126*	0.164*	-0.106*	1.000	
	(0.666)	(0.596)	(0.075)	(0.126)	(0.000)	(0.583)	(0.003)	(0.000)	(0.016)		
LnGini	-0.044	-0.137*	0.124*	0.022	0.169*	-0.152*	-0.098*	0.045	0.043	0.030	1.000
	(0.298)	(0.005)	(0.003)	(0.609)	(0.000)	(0.000)	(0.020)	(0.283)	(0.329)	(0.474)	
LnPS	0.072	-0.223*	0.131*	0.058	0.203*	-0.086*	0.118*	0.039	-0.051	0.035	0.147*	1.000
	(0.088)	(0.000)	(0.002)	(0.170)	(0.000)	(0.042)	(0.005)	(0.351)	(0.244)	(0.403)	(0.000)	

Source: Amoako Mensah (2024)

***, **, * represent 1%, 5% and 10% significant levels respectively

SD denotes sustainable development, co2 represents environmental dimension, GNI represents economic dimension, gee denotes social dimension, PPI, MSP and AMS are measures of digital financial inclusion, INF is inflation, RnD denotes research and development, Gini is Gini index used to measure reduced income inequalities, PS is political stability.

Endogeneity Test

The study analysed the endogeneity of the explanatory variables in Table 5. The endogeneity analyses were conducted on percentage population with access to internet, mobile Subscription per 100 people and account ownership with mobile money service provider. The STATA command "estat endog" was employed to examine endogeneity, with the null hypothesis being that the variables are exogenous and unrelated to the model's error term. The endogeneity of the variables was then assessed using the Durbin Wu-Hausman (DWH) test. The p-value was evaluated at the significant threshold of 0.05. The rejection of the null hypothesis denotes the existence of endogeneity. The DWH tests' findings suggested that the null hypothesis should be disproved, proving that all explanatory variables in the model are endogenous.

Table 5: Durbin Wu- Hausman (DWH) Test Results

Variables	DWH test Coefficient	DWH Test P-value	Test Results
Percentage population with access to internet	51.4224	0.0000	Rejected at 5% significance level
Mobile Subscription per 100 people	18.5182	0.0306	Rejected at 5% significance level
Account ownership with mobile money service provider	43.2934	0.0010	Rejected at 5% significance level

Source: Author's Construct, Amoako Mensah (2024)
Null hypothesis (H0): Variables are exogenous

Trend of Digital Financial Inclusion in Sub-Saharan Africa

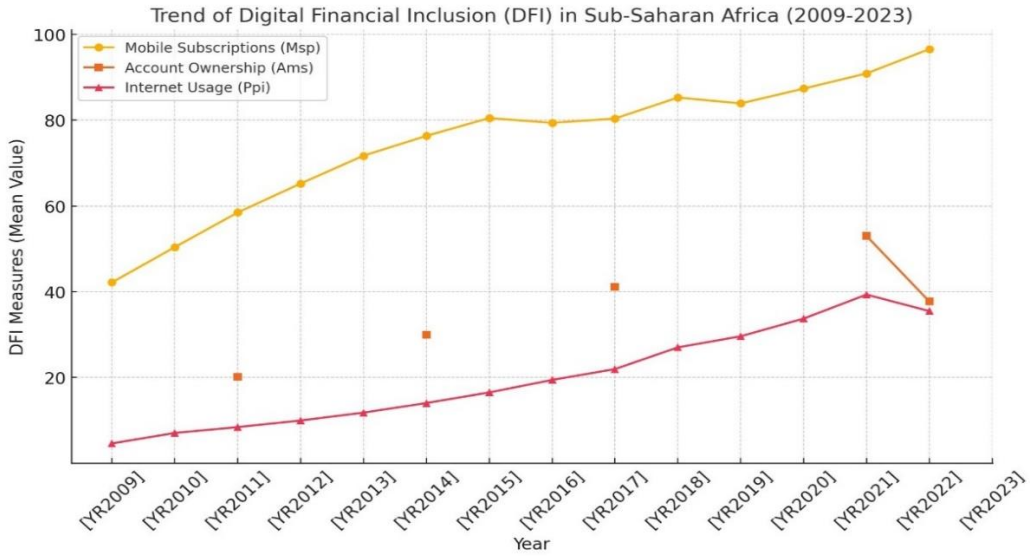

Figure 3: Trend of DFI in SSA
Source: Amoako Mensah (2024)

From figure 3 above, the yellow line in the graph, which represents mobile subscriptions, shows a steady increase over the years. The trend line is consistently rising, indicating that mobile phone penetration has improved significantly over time. The slope of the line is relatively steep between 2009 and 2014, reflecting rapid growth in mobile subscriptions. From 2014 onwards, the rate of increase is slower, suggesting that mobile penetration is reaching a saturation point in certain regions. The jump towards the later years, particularly from 2021 to 2023, indicates that mobile access is broadening again after a period of slower growth. While mobile penetration is growing, the data shows disparities across countries. Some regions may still lack the necessary infrastructure for mobile connectivity, or there could be socio-economic challenges affecting mobile access. Policymakers need to focus on expanding mobile networks to underserved and rural areas where

mobile phone penetration is low. Governments could incentivize private sector investments in mobile infrastructure and remove barriers such as high costs of mobile services, taxes on mobile devices, and regulatory hurdles. Additionally, creating programs that provide affordable mobile access to low-income households would be crucial for closing the mobile access gap.

The orange line with squares represents mobile money account ownership. The line demonstrates a gradual rise starting from 2014, reaching a peak in 2021, followed by a slight drop in the following years. This suggests that mobile money services have expanded significantly, but there are fluctuations, indicating that account ownership is not uniformly increasing. The peak around 2021 suggests that mobile money adoption surged in response to factors such as improvements in mobile infrastructure, the growth of mobile financial services, and possibly the increased demand for digital transactions during the COVID-19 pandemic. The dip post-2021 could indicate a variety of factors, such as policy changes, market saturation, or even economic challenges affecting the ability of individuals to maintain mobile money accounts. Policymakers should aim to sustain the momentum gained in mobile money adoption by promoting financial literacy, addressing regulatory barriers, and encouraging competition. A competitive mobile money market will reduce costs and increase service quality, helping more people access and use these services.

The red line with triangles represents internet usage. This line shows the slowest rate of increase compared to mobile subscriptions and mobile money account ownership. The graph indicates that internet penetration remains limited,

although there has been noticeable growth since 2009. The curve rises more steadily after 2015, reflecting the gradual expansion of internet access in the region. Even with growth, internet access is significantly lower compared to mobile phone access, which suggests that infrastructure for internet connectivity is still inadequate in many regions. The slight drop in the later years could signal the digital divide becoming more pronounced in some countries, or it may indicate economic factors making internet access unaffordable for many. Policymakers need to invest in internet infrastructure, improve affordability, and leverage digital platforms. As internet penetration improves, governments should support digital financial platforms by ensuring that all segments of the population, including marginalized communities, have access to the necessary devices and digital literacy programs.

System GMM Results on the Separate Effect of Digital Financial Inclusion and Sustainable Development in SSA.

This subsection presents and discusses the empirical results related to the objective two of the study. The results from Table 6 reveal that the lag of the dependent variables significantly influences their current values across all models. This suggests that an economy's level of sustainable development is heavily influenced by its previous levels. In other words, sustainable development achieved by an economy is not solely a result of current efforts but is deeply rooted in its historical trajectory. Past investments, policies, and societal values play a crucial role in shaping the conditions necessary for sustainable development, making it a cumulative process that builds upon itself over time. This finding is consistent with

Liu, Zhang, Hafeez, and Ullah (2022), who argue that past economic and environmental performance significantly impacts current outcomes.

Table 6: Separate Effect of Digital Financial Inclusion on Sustainable Development of SSA Economies

	(Model 1)	(Model 2)	(Model 3)	(Model 4)
	Lnans	lnCo2	Lngni	Lngee
L.lnans	0.319***			
	(0.0778)			
L.lnCO2		-0.0930***		
		(0.0291)		
L.lngni			0.832***	
			(0.0484)	
L.lngee				0.563***
				(0.195)
Lnmsp	0.725**	-0.079***	0.219***	0.575*
	(0.317)	(0.0527)	(0.0692)	(0.299)
Lnams	0.354**	-0.162***	0.210***	0.091*
	(0.164)	(0.0532)	(0.0448)	(1.142)
Lnppi	0.0859**	-0.0323**	0.0415***	0.295***
	(0.0426)	(0.0164)	(0.0109)	(0.0655)
Control				
Lninf	0.564***	-0.0507***	-0.0565***	0.553**
	(0.105)	(0.00821)	(0.0155)	(0.203)
Lnrnd	0.313***	-0.0595	-0.0759	0.291***
	(0.0897)	(0.0450)	(0.0513)	(0.0767)
Lngini	0.891	0.428**	-1.547***	-1.071**
	(0.841)	(0.198)	(0.324)	(0.496)
Lnps	0.177	-0.119**	0.168***	-0.0648
	(0.125)	(0.0453)	(0.0400)	(0.192)
Constant	5.645	-1.662**	5.804***	6.848***
	(3.443)	(0.751)	(1.223)	(2.248)
Diagnostics				
Observations	234	410	417	427
No. of instruments	40	41	44	22
AR1 (p-value)	0.000945	0.000497	0.0615	0.0101
AR2 (p-value)	0.539	0.807	0.654	0.653
Hansen-J (p-value)	0.928	0.823	0.975	0.499

Source: Amoako Mensah (2024)

***, **, * represent 1%, 5% and 10% significant levels respectively

SD denotes sustainable development, co2 represents environmental dimension, GNI represents economic dimension, GEE denotes social dimension, PPI, MSP and AMS are measures of digital financial inclusion, INF is inflation, RnD denotes research and development, Gini is Gini index used to measure reduced income inequalities, PS is political stability.

The results from column 1 of Table 6 indicate a positive relationship between the three variables used to measure DFI and the various dimensions of sustainable development. In column 1 of model 1, it is observed that a 1% increase in mobile subscriptions per 100 people would result in a 0.725% increase in overall sustainable development in the sampled SSA economies. The positive relationship between mobile subscriptions per 100 people and overall sustainable development indicates that mobile subscriptions serve as a key gateway for many people in SSA to access financial services, especially in regions where traditional financial infrastructure is limited. The availability of mobile banking and digital payment systems, such as mobile money, enables individuals to engage in economic activities more efficiently. For instance, people can save, transfer money, make payments, and access credit through their mobile devices. Consequently, this improved access fosters entrepreneurship, reduces transaction costs, and promotes greater financial inclusion, which in turn contributes to economic growth, a crucial aspect of sustainable development.

This is in line with Chinoda and Kapingura (2023) who argued that as mobile subscriptions rise, individuals and businesses, particularly in rural and underserved areas, are able to tap into broader markets. Mobile phones facilitate

better communication, provide access to information, and allow integration into supply chains, which ultimately improves productivity and income generation. This, in turn, enhances livelihoods and reduces poverty levels, both of which are essential to sustainable development as they contribute to the economic and social dimensions of sustainability by improving living standards and reducing inequalities. Moreover, the widespread use of mobile phones allows marginalized groups, such as women, rural communities, and the unbanked, to participate more actively in the economy. By accessing digital financial services via mobile phones, these groups are empowered to engage in economic activities, thereby reducing gender and economic disparities. Since social inclusion is a key pillar of sustainable development, ensuring equitable access to opportunities and resources becomes vital.

Again, mobile technology fosters innovation by providing a platform for startups and small businesses to flourish, particularly in areas like e-commerce, fintech, and agritech. Entrepreneurs can leverage mobile technology to develop new products and services that address local challenges. For example, mobile-based platforms are being used to provide agricultural information, weather updates, and market prices to farmers, thus improving their productivity and sustainability. Mobile subscriptions enable governments to deliver public services more effectively. Mobile platforms can be used to improve healthcare delivery, such as through telemedicine, as well as education via mobile learning, and social protection programs like mobile cash transfers. This enhances the overall quality of life and contributes to the social and institutional dimensions of sustainable

development (Banna, & Alam, 2021).

While the direct impact of mobile subscriptions on environmental sustainability may be less obvious, mobile technology can still play a role. For instance, mobile platforms enable the dissemination of information about sustainable practices, climate change adaptation, and environmental conservation. Also, mobile services can reduce the need for physical infrastructure, such as branches of financial institutions, thereby reducing the environmental footprint associated with traditional banking services.

Column 1 of model 1 on the other hand, reveals that account ownership with mobile money service providers, as measured by DFI, has a positive relationship with overall sustainable development at the 5% significance level. The coefficient of account ownership with mobile money service providers is 0.354, indicating that a 1% increase in this measure is associated with a 0.354% increase in overall sustainable development in the sampled SSA economies. This positive relationship arises because account ownership with mobile money service providers significantly increases access to financial services, especially for individuals who are unbanked or underserved by traditional financial institutions. In SSA, many people lack access to formal banking services due to geographical barriers, high transaction costs, and limited infrastructure. However, mobile money accounts provide a more accessible and convenient alternative, allowing users to store money, send and receive payments, and manage transactions via their mobile phones. As a result, this inclusion of previously excluded populations in the financial system facilitates economic participation and poverty reduction, which

are core components of sustainable development.

This is consistent with Soyemi, Olowofela, and Yunusa, (2020), who posited that mobile money services reduce the costs associated with financial transactions, especially for small and micro businesses in rural and remote areas. With lower transaction costs, businesses can operate more efficiently, boosting productivity and economic growth. Consequently, these efficiencies create a more conducive environment for investment, entrepreneurship, and employment, thereby contributing to sustainable economic development in SSA. Additionally, account ownership with mobile money service providers enables the efficient transfer of remittances, which are a critical source of income for many households in SSA. Mobile money platforms allow families to receive remittances securely and swiftly, helping them meet basic needs such as education, healthcare, and food. In turn, this improves the social welfare of communities and promotes social sustainability. Governments and organizations can use mobile money platforms to distribute social benefits, subsidies, or emergency relief to vulnerable populations, further enhancing social protection systems and resilience.

Thus, mobile money accounts offer users a safe place to store savings, even if they do not have access to traditional banks. This encourages individuals to build financial security, manage cash flow more effectively, and cope with economic shocks. It also helps build a culture of saving and investing, which can have positive macroeconomic implications for the SSA economies. Similarly, mobile money accounts provide a convenient way for small and medium enterprises (SMEs) to conduct business transactions. SMEs, which are a key driver of economic

development in SSA, benefit from the ease and security of mobile payments, allowing them to grow and create jobs. As these businesses expand, they contribute to local economic development, reduce unemployment, and enhance economic sustainability (Aduda & Kalunda, 2012).

Moreover, column 1 of model 1 highlights a positive relationship between percentage of population with access to internet and overall sustainable development. The coefficient of percentage of population with access to internet is 0.0859, indicating that a 1% increase in this measure of DFI is associated with a 0.0859% increase in overall sustainable development in the sampled SSA economies. This positive relationship indicates that increased internet access enables individuals to obtain valuable information and access educational resources. With better access to online learning platforms, job training programs, and academic resources, people in SSA can improve their skills and knowledge, which in turn leads to greater employability and productivity. Consequently, this contributes to economic growth and poverty reduction, both key aspects of sustainable development. Moreover, internet access supports digital literacy and lifelong learning, which are crucial for building human capital in rapidly evolving digital economies.

Internet access allows businesses, particularly small and medium-sized enterprises (SMEs), to engage in e-commerce and connect with broader markets beyond their local areas. This expands their customer base, boosts trade, and encourages innovation in sectors such as agriculture, retail, and services. As businesses adopt digital tools, they can improve efficiency and competitiveness,

which in turn supports economic diversification and sustainable economic development. Additionally, the internet is essential for providing digital financial services, including mobile banking, online payments, and financial management tools. As more people gain internet access, they are able to participate in the formal financial system, improving their ability to save, invest, and access credit. Thus, this expands financial inclusion, particularly in underserved regions, further promoting equitable economic development and reducing income inequality.

This is in line with Hussain, Gul, and Ullah, (2023) who argued that internet access enables marginalized groups, such as women, rural communities, and the youth, to engage in economic, educational, and social activities. For example, women can access online platforms to start businesses or participate in remote work, which empowers them financially and promotes gender equality. In addition, rural communities benefit from access to market information, agricultural technologies, and telemedicine, which helps improve their livelihoods and overall quality of life. As a result, this fosters social inclusion, a vital component of sustainable development. Increased internet access allows governments to deliver services more effectively through e-government platforms. By digitising services, such as tax payments, health services, and social benefits, governments can reduce corruption, improve transparency, and enhance service delivery. This leads to more efficient governance and stronger institutions, which are fundamental to sustainable development.

Internet facilitates the adoption of new technologies and innovation across various sectors, such as agriculture, health, and education. Through access to global knowledge and the ability to collaborate online, SSA economies can leverage new technologies to solve local challenges, improve productivity, and create sustainable solutions. For instance, precision agriculture, supported by internet-based platforms, can help farmers optimize resource use and improve yields, contributing to both economic and environmental sustainability (Jima, & Makoni, 2023). Thus, internet access contributes to environmental sustainability by facilitating the dissemination of information about sustainable practices, climate change adaptation, and environmental conservation.

Regarding the dimensions of sustainable development, the findings from Model 2 shows that DFI, measured by the percentage of the population with access to the internet, mobile subscriptions per 100 people, and account ownership with mobile money service providers, has a significant negative influence on CO2 emissions, a measure of environmental sustainability. Specifically, the results indicate that a 1% increase in each DFI measure corresponds to a decrease in CO2 emissions by 0.079%, 0.162%, and 0.0323%, respectively. This negative influence implies that the reduction in CO2 emissions with increased DFI reflects enhanced environmental efficiency. With more people gaining access to the internet, mobile subscriptions, and mobile money services, economic activities become more efficient and less reliant on carbon-intensive processes. For example, digital transactions and remote interactions reduce the need for physical travel and infrastructure, thereby lowering emissions.

Additionally, the negative relationship indicates that greater internet and mobile access reduces the dependence on physical infrastructure. By enabling more online transactions and services, there is less need for physical banking branches, retail stores, and service centers, which in turn lowers the carbon footprint associated with constructing and operating these facilities. This agree with Khan et al., (2023) who posited that the increase in DFI supports the adoption of remote work and e-commerce, which are associated with lower CO2 emissions. By reducing the necessity for daily commuting and business travel, digital technologies contribute to a decrease in transportation-related emissions. Thus, digital tools can promote sustainable practices in various sectors, such as agriculture and resource management, which helps reduce overall emissions.

In addition, increased access to digital services facilitates the development and adoption of green technologies. Digital platforms are potentially used to support and fund initiatives related to renewable energy, energy efficiency, and environmental conservation, thereby contributing to reduced CO2 emissions and promoting a more sustainable environment.

In contrast, the findings from model 3 reveal that DFI, measured by the percentage of the population with access to the internet, mobile subscriptions per 100 people, and account ownership with mobile money service providers, has a significant positive influence on gross national income, a measure of economic sustainability. The results indicate that a 1% increase in each DFI measure corresponds to an increase in gross national income by 0.219%, 0.210%, and 0.0415%, respectively (environmental, economic and social sustainability). This

positive influence implies that digital financial inclusion expands access to economic opportunities by enabling more efficient financial transactions and access to markets. Increased internet access and mobile subscriptions allow individuals and businesses to participate more actively in the economy, leading to higher economic activity and growth. This boost in economic activity translates into increased gross national income as businesses expand and new opportunities are created.

This is in line with Nucci, Puccioni, and Ricchi, (2023) who argued that digital technologies improve productivity by streamlining processes and reducing transaction costs. For instance, mobile financial services enable faster and more secure transactions, which reduces the time and cost associated with financial operations. Similarly, internet access supports the use of digital tools and platforms that enhance productivity across various sectors, including commerce, agriculture, and services. The increase in productivity contributes positively to economic output and GNI. Thus, internet access and mobile subscriptions facilitate broader market access for businesses and individuals. Online platforms enable businesses to reach new customers, enter new markets, and engage in e-commerce. This expansion of market reach helps businesses increase their revenue and profitability, which in turn contributes to higher GNI. For individuals, access to global markets can provide new income opportunities and enhance economic well-being.

Digital financial services and internet access also foster entrepreneurship by providing platforms for startups and small businesses to grow. Entrepreneurs can leverage digital tools to develop innovative products and services, reach customers,

and access funding. This entrepreneurial activity drives economic growth and contributes to increases in GNI. The ability to access and utilize digital resources promotes a vibrant business environment and supports overall economic development. Account ownership with mobile money service providers improves financial inclusion, allowing more individuals to participate in the formal economy. Access to digital financial services enables people to save, invest, and manage their finances more effectively. This increased financial inclusion supports economic stability and growth, as more people can contribute to economic activities and benefit from financial services (Osabutey, & Jackson, 2024).

Digital financial inclusion potentially leads to increased investment and capital flows by providing access to financial products and services that facilitate investment. For example, mobile money accounts can support micro-investments and savings, while internet access allows investors to explore new opportunities and manage portfolios. The increase in investment and capital flows contributes to economic growth and higher GNI. Thus, digital financial services improve tax collection and government revenue by broadening the tax base and reducing tax evasion. As more economic transactions move to digital platforms, it becomes easier for governments to track and collect taxes. Increased government revenues can be used to invest in infrastructure, public services, and development projects, which further stimulates economic growth and contributes to GNI.

The relationship between DFI and social sustainability is captured in model 4, where the results show that DFI positively influences social sustainability. The results indicate that a 1% increase in each DFI measure corresponds to an increase

in government expenditure on education by 0.575%, 0.091%, and 0.295%, respectively. The positive relationship suggests that as digital financial inclusion measures increase, governments are able to allocate more resources to education. This could be due to increased economic activity and higher revenues generated through broader financial inclusion and digital transactions. With more funds available, governments can invest in educational infrastructure, teacher training, and educational resources, leading to improvements in education quality and access.

This agree with Ozili, (2018) who argued that as digital financial inclusion enhances economic activity and efficiency, it can boost overall government revenues and fiscal capacity. This increased fiscal space allows governments to prioritize and increase spending on social services such as education, healthcare, and social protection. The higher investment in education can improve educational outcomes and contribute to social sustainability by promoting equal access to quality education. Furthermore, increased government expenditure on education, driven by higher levels of DFI, can contribute to greater educational equity. As more resources are allocated to education, governments can focus on addressing disparities and improving access to education for underserved and marginalized communities. This aligns with the social sustainability goal of ensuring equitable access to education and reducing inequalities.

Additionally, higher investment in education supports the development of human capital, which is essential for long-term social and economic sustainability. Improved educational outcomes lead to a more skilled and knowledgeable

workforce, which can drive economic growth, innovation, and social progress. By investing in education, governments contribute to the development of human capital, which benefits individuals and society as a whole. The increase in government expenditure on education linked to higher DFI levels also suggests a focus on digital literacy and skills development. As digital technologies become more prevalent, investing in education that includes digital skills training can prepare students and workers for the demands of the digital economy. This enhances employability and promotes lifelong learning, which are important aspects of social sustainability. Digital financial inclusion can improve access to educational opportunities by providing financial resources for students, such as scholarships and grants. Mobile financial services can facilitate the disbursement of education-related funds and financial aid. As a result, more students can afford to pursue education, leading to higher enrollment rates and educational attainment.

In light of these findings, the study rejects the null hypothesis that digital financial inclusion does not significantly contribute to sustainable development in SSA economies for the period under consideration. The study concludes that digital financial inclusion has a significant and positive effect on sustainable development in SSA economies, driving economic, environmental, and social sustainability.

Control Variables Analysis for Digital Financial Inclusion, and Sustainable Development in SSA Economies

The models in Table 6 controlled for five macroeconomic variables consisting of inflation, real interest rate, political stability, reduced inequality and research and development. The findings from Model 1 of Table 6 reveal that

inflation has positive influence on sustainable development and a mixed relationship with the individual dimensions across the models. In model 1, inflation has a positive coefficient of 0.564, meaning that 1% increase in inflation is associated with 0.564% increase in sustainable development while keeping other variables constant. The positive nexus between inflation and sustainable development implies that as inflation rate increases, sustainable development (measured with adjusted net savings) rises. This means that moderate inflation stimulates economic activity and investment in the selected SSA regions. Investors and businesses may have positive expectations about the future when inflation is on the rise (Rahman, 2022). This optimism can lead to increased investments in sustainable projects and initiatives, further contributing to sustainable development. This is in line with study by Koirala and Pradhan, (2020) who posited that businesses investment may lead to economic growth, job creation, and improved living standards, all of which contribute to sustainable development.

Additionally, model 2 has a negative coefficient of -0.0507 indicating that, in this model, 1% increase in inflation is associated with 0.0507% decrease in environmental sustainability while keeping other variables constant. Thus, the negative coefficient of -0.0507 indicates that higher inflation is associated with lower carbon dioxide emissions (lnCO2). One possible reason for this is that during periods of economic instability or recession, which often coincide with low inflation, industrial production and energy consumption may decrease. This, in turn, leads to lower CO2 emissions. Again, governments may implement policies to reduce inflation, such as controlling money supply and interest rates. These

policies can also include measures to promote cleaner and more energy-efficient technologies, which could lead to reduced CO2 emissions in SSA regions (Setyadharma et al., 2021; Akal, 2023; Khan et al., 2022).

The negative coefficient of -0.0565 in model 3 suggests that higher inflation is associated with lower economic sustainability. Spangenberg, (2005) posits that inflation erodes the purchasing power of consumers and reduces the real value of income. As a result, households, businesses and economies may have less disposable income, which can lead to decreased economic activity and lower national income. Also, high and unpredictable inflation rates can create uncertainty in the economy. This uncertainty can lead to reduced investments and capital flows, ultimately impacting the overall national income negatively. This is consistent with the study by Attacks, (2019), Girdzijauskas et al., (2022) and Croitoru, (2023) who argued that decline in national income negatively impacts economic sustainability by limiting resources available for investment in sustainable development projects and initiatives. Furthermore, the positive coefficient of 0.553 in model 4 indicates that higher inflation is associated with higher social sustainability. This relationship might be due to the fact that moderate inflation can be indicative of a growing economy. This is consistent with the study Chandrakant and Rajesh, (2023) who argued that economic growth often contributes to social sustainability through increased education, employment opportunities, income generation, and poverty reduction. Thus, when more people have access to employment and improved living standards, it positively influences social sustainability.

It was again discovered that research and development has a positive coefficient (0.313) in model 1 of Table 6. The positive coefficient suggests that higher investments in research and development is associated with higher sustainable development in the selected SSA regions. This relationship indicates that research and development activities may contribute to innovations and technologies, and practices that promote sustainability. Economies investing in research and development may develop more efficient and environmentally friendly products which positively impact overall sustainability (Ozili, 2022).

Also, the negative coefficient (-0.0595) in model 2 implies that higher research and development investments are associated with lower carbon dioxide emissions. This suggests that economies or industries focusing on research and development are more likely to adopt cleaner technologies and practices, which can help to reduce carbon dioxide emissions leading to environmental sustainability (Rosen, 2019; Han et al., 2023; Li & Jiang, 2020; Petrović, & Lobanov, 2020).

Similarly, the negative coefficient (-0.0759) in model 3 also indicates that increased research and development investments are associated with lower economic sustainability. This might seem counterintuitive, but it suggests that in the short term, research and development investments may divert resources from other income-generating activities. While there might be a short-term economic trade-off, research and development investments may have long-term economic benefits. This agree with the study of Sarpong et al., (2023); Fang Liu, and Putra, (2022); and Dai et al., (2022) who posited that development of new technologies and products through research and development may lead to increased productivity,

competitiveness, and economic diversification, ultimately contributing to higher economic sustainability.

Furthermore, research and development had a positive coefficient (0.291), indicating that higher research and development investments are associated with higher social sustainability. This suggests that research and development activities may lead to societal benefits, such as job creation, improved healthcare, and enhanced education, which are integral to social sustainability. This is in line with the study by Dicuonzo et al., (2022); Mensah, (2019) who posited that innovations stemming from research and development may lead to improved education and healthcare outcomes, positively impacting social sustainability by enhancing the well-being and quality of life for communities.

Reduced income inequality had a positive coefficient (0.891) with overall sustainability. A positive coefficient suggests that higher efforts to reduce income inequality are associated with higher sustainable development. This is consistent with the findings of Seo, Kim, and Lee, (2020) who posits that policies or actions aimed at reducing income inequality may have positive spill-over effects on overall sustainable development. This is because inequality may lead to social unrest and instability, which can hinder sustainable development. Efforts to reduce income inequality often involve policies that promote more inclusive economic growth. When income is distributed more equitably across society, it can lead to increased access to resources, education, and opportunities for marginalised groups contributing to a more stable and sustainable development path (Wilkinson & Pickett, 2010; Li et al., 2023; Roy et al., 2018; Shaheen, 2014).

Similarly, reduced income inequality had a positive coefficient (0.428) with CO2 emission suggesting that higher efforts to reduce income inequality is associated with higher environmental sustainability. This is consistent with the findings of Asongu, and Vo, (2020) that societies with reduced income inequality are more capable of implementing environmentally friendly policies and practices. Thus, SSA economies with reduced income inequality may be more willing to invest in environmentally sustainable technologies and practices including renewable energy adoption, environmental regulations, and conservation efforts (Mushta et al., 2020; Kusumawardani, & Dewi, 2020; Tanchangya, & Ayoungman, 2022).

The negative coefficient (-1.547) between reduced income inequality and economic sustainability implies that higher efforts to reduce income inequality is associated with lower gross national income. In the study by Ullah et al. (2021), they alluded that policies aimed at income redistribution may impact economic performance in the short term in most SSA economies. While there may be short-term economic trade-offs, efforts to reduce income inequality may contribute to long-term economic stability and sustainability. By reducing income disparities, societies can enhance social cohesion, reduce economic disparities, and create a more robust and sustainable economic foundation (Menyelim et al., 2021; Shaheen, 2014; Genevey, Pachauri, & Tubiana, 2013).

Finally, the negative coefficient (-1.071) in model 4 indicates that higher efforts to reduce income inequality is associated with lower social sustainability. This is consistent with the findings of Cuesta, Madrigal, and Pecorari, (2022) who

posited that policies focused solely on income redistribution could have unintended consequences on certain social aspects of development. Income inequality reduction efforts can be complex and multifaceted. In some cases, policies may not address all dimensions of social sustainability effectively. Unintended consequences, such as potential disincentives for economic productivity, could lead to short-term negative impacts on certain social indicators (Hussain et al., 2023; Dabla-Norris et al., 2015).

The coefficient of political stability as a control variable in the four models above provides insights into the relationship between political stability and sustainable development and its dimensions. The positive coefficient (0.177) in model 1 suggests that higher levels of political stability is associated with higher overall sustainable development. This implies that countries or SSA regions with stable political environments tend to have more conducive conditions for sustainable development. Khan and Farooq, (2019); Handoyo and Fitriyah, (2018) alluded that political stability often leads to consistent and predictable policy environments. Governments in politically stable regions can implement long-term sustainable development policies without the interruptions and uncertainties that may arise in politically unstable areas.

Additionally, the negative coefficient (-0.119) in model 2 implies that higher political stability is associated with lower environmental sustainability. This result may seem counterintuitive, but it suggests that regions with high political stability may also have higher industrialisation and carbon emissions. Politically stable regions therefore, may attract more industrial investments and activities,

which may lead to increased carbon dioxide emissions. Stable governance may as well facilitate economic growth, but it may not always prioritise strict environmental regulations (Adebayo et al., 2022; Mughal et al., 2022). Also, the positive coefficient (0.168) in model 3 indicates that higher political stability is associated with higher gross national income, contributing to economic sustainability. Stable political environments can attract investments, promote business growth, and encourage economic development. Political stability is often seen as a key factor in attracting foreign investments. When investors perceive a region as politically stable, they are more likely to invest in businesses and projects, stimulating economic growth and contributing to economic sustainability (Okafor, 2017). Finally, the negative coefficient (-0.0648) in model 4 suggests that higher political stability is associated with lower social sustainability. This result may imply that in politically stable SSA regions, there could be much focus on economic development at the expense of certain social indicators. In some cases, governments in politically stable SSA regions may prioritise economic growth and stability over social welfare programs. While this can lead to economic sustainability, it might not address social sustainability effectively (Khan, & Farooq, 2019; Radu, 2015).

Real interest rates had a positive coefficient (0.151) in model 1 suggesting that higher real interest rates are associated with higher sustainable development. This implies that SSA regions with higher real interest rates are likely to experience more sustainable development. Higher real interest rates may incentivise individuals and businesses to save and invest their money in productive activities.

This increased savings and investment may lead to economic growth, job creation, and poverty reduction, contributing to sustainable development (Mehrotra & Sergeyev, 2021). Again, higher real interest rates can be used as a tool to control inflation. When central banks increase interest rates to combat inflation, it can create a more stable economic environment, which is conducive to sustainable development. In regions with higher real interest rates, financial institutions may offer more attractive savings and investment products, promoting financial inclusion and access to capital for sustainable projects (Advisors, 2012).

On environmental sustainability, the negative coefficient (-0.0384) implies that higher real interest rates are associated with lower environmental sustainability. This result may seem counterintuitive, but it suggests that SSA regions with higher real interest rates may engage in more carbon-intensive economic activities, this may increase the cost of financing sustainable and environmentally friendly projects. This may lead to reduced investment in green technologies and practices, resulting in higher carbon emissions. In regions with higher real interest rates, there may be a greater focus on economic growth, which can lead to increased industrialisation and higher carbon emissions (Schmidt et al., 2019; Basiago, 1998).

Additionally, the positive coefficient (0.0242) in model 3 indicates that higher real interest rates are associated with higher gross national income, contributing to economic sustainability. Thus, higher interest rates can encourage saving and investment, which can stimulate economic growth (Bylund & Jonsson, 2020; Futtwiler, 2017). Also, higher real interest rates can encourage capital

formation and the accumulation of productive assets, which can drive economic sustainability by increasing productivity and income levels. Real interest rates can be used to control inflation, which is crucial for economic stability and sustainability. Controlling inflation can lead to a more predictable economic environment, facilitating economic growth (Beteta Vejarano, & Swinkels, 2023; Hauner & Kumar, 2006).

Finally, the positive coefficient (0.102) in model 4 suggests that higher real interest rates are associated with higher social sustainability. This result may imply that regions with higher real interest rates may have more resources available for social programs and well-being. Higher real interest rates may reflect a region's fiscal capacity to invest in social programs and infrastructure, contributing to social sustainability. In regions with higher real interest rates, financial institutions may be more willing to lend to individuals and businesses, potentially leading to greater access to credit and economic opportunities, which may positively impact social sustainability (Soehaditama, 2023; Bylund & Jonsson, 2020).

Chapter Summary

This chapter aimed at analysing the trend and effect of digital financial inclusion on sustainable development in SSA economies. The study estimated the panel unit root test for each of the variables. The findings of the study reject the null hypothesis that digital financial inclusion does not significantly contribute to sustainable development in SSA economies for the period under consideration and conclude that there is a significant effect of digital financial inclusion on sustainable development in SSA economies.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the key findings obtained from conducting the entire study. The chapter also presents conclusions and policy recommendations as well as the suggestions for further research.

Summary of Key Findings

Several insightful and significant results emerged from the findings of this study. The first objective of the study was to analyze the trend of digital financial inclusion in SSA economies.The second objective examined the effect of digital financial inclusion on the various dimensions of sustainable development in SSA economies. The summary of the findings on these objectivesare summarised below:

From the results on the first objective, the graph highlights significant disparities in mobile subscriptions, mobile money account ownership, and internet access across Sub-Saharan Africa. This indicates that while progress has been made in improving Digital Financial Inclusion (DFI), considerable challenges remain in ensuring equitable access to these essential services across Sub-Saharan Africa.

Also, based on the second objective, the study found strong evidence to support the notion that digital financial inclusion has a significant and positive effect on sustainable development in SSA economies. In summary, higher levels of digital financial inclusion were associated with increased sustainability across multiple dimensions, including economic, environmental, and social aspects. This indicates that digital financial inclusion plays a crucial role in fostering economic growth, environmental sustainability, and social sustainability, ultimately

contributing to the overall sustainable development of SSA economies.

Finally, the analysis of control variables revealed varied impacts on sustainable development in SSA economies. Inflation showed a positive relationship with overall sustainable development but had mixed effects on economic and environmental sustainability, indicating both growth stimulation and potential economic uncertainty. Research and development (R&D) positively influenced overall and social sustainability, promoting long-term benefits but showing a short-term trade-off with economic sustainability. Reduced income inequality supported overall and environmental sustainability but had negative implications for economic and social sustainability, suggesting potential short-term productivity trade-offs.

Political stability positively affected overall and economic sustainability but was negatively associated with environmental and social aspects, indicating an economic focus at the expense of social and environmental priorities. Real interest rates enhanced overall, economic, and social sustainability through savings and investment incentives but were linked to lower environmental sustainability due to possible carbon-intensive activities. These findings highlight the complex interplay of macroeconomic factors on sustainability in SSA.

Conclusions

The study's findings emphasize the critical role of Digital Financial Inclusion (DFI) in driving sustainable development across Sub-Saharan African (SSA) economies. The analysis of the first objective highlights that while there has been significant progress in improving access to mobile phones, mobile money

services, and the internet, there are still substantial disparities across different countries and regions. This uneven access to digital services limits the potential of DFI to reach all segments of the population, particularly in rural and underserved areas. These gaps underscore the need for targeted policies aimed at closing the digital divide and ensuring equitable access to these vital services.

On the second objective, the study provides compelling evidence that digital financial inclusion (DFI) plays a pivotal role in advancing sustainable development across Sub-Saharan Africa. The findings demonstrate that higher levels of DFI are significantly associated with enhanced outcomes in the economic, social, and environmental dimensions of sustainability.

From an economic perspective, DFI fosters growth and stability by broadening access to financial services, thereby promoting financial participation, facilitating investments, and supporting entrepreneurship. This inclusion helps bridge economic disparities, stimulates economic activity, and contributes to overall economic resilience and sustainability.

In terms of social sustainability, DFI serves as an essential tool for promoting inclusivity and improving living standards. By enabling underserved and marginalized populations to access financial services, DFI contributes to poverty reduction, empowers communities, and enhances access to essential services such as education and healthcare. This empowerment supports improved social cohesion and equitable development within the region.

On the environmental front, while the direct impact of DFI may be nuanced, it can facilitate the financing and adoption of sustainable practices. Digital platforms make it easier to channel resources toward green technologies and environmentally friendly initiatives. This aspect of DFI supports the adoption of practices that align with environmental sustainability goals, such as renewable energy and sustainable agriculture.

Recommendations

Drawing from the findings and conclusion of the study, a number of recommendations are presented:

Firstly, in addressing regional disparities Governments should integrate digital financial services into Economic Growth Plans: Governments should consider digital financial inclusion as a key driver for economic development and poverty reduction. Expanding access to mobile and internet-based financial services can increase economic participation, improve livelihoods, and contribute to sustainable development goals (SDGs).

Furthermore, Governments should promote data-driven decision-making. Governments should invest in data collection and analysis tools to monitor the progress of digital financial inclusion across different regions. This will allow policymakers to adjust strategies based on real-time data, ensuring that interventions are effective and well-targeted.

Again, policymakers should enhance inclusivity. Policymakers should pay special attention to marginalized groups, such as women, low-income individuals, and those living in rural areas. Targeted policies such as affordable mobile devices,

lower-cost data plans, and digital literacy campaigns can help close the financial inclusion gap. By focusing on these areas, governments in Sub-Saharan Africa can significantly enhance digital financial inclusion, drive economic growth, and create a more equitable financial system that benefits all citizens.

Finally, policymakers in SSA should adopt an integrative policy framework that ensures balanced growth across economic, social, and environmental dimensions. Given that inflation has demonstrated a dual impact positively influencing overall sustainable development but with potential economic uncertainty monetary and fiscal policies should be carefully calibrated to maintain moderate inflation levels that drive growth without destabilizing the economy. This approach should be complemented by targeted social programs that mitigate any negative social sustainability impacts, such as strengthening social safety nets and investment in infrastructure that supports both economic activity and environmental resilience.

To leverage the positive impact of research and development on overall and social sustainability, SSA economies should implement strategies that promote sustained and strategic investments in R&D. This should include fostering partnerships between governments, private sectors, and international development organizations to fund research that advances green technologies and sustainable innovations. While recognizing that R&D may initially draw resources away from immediate economic activities, long-term policies should focus on balancing short-term trade-offs with the significant long-term gains in productivity, economic diversification, and social advancements. These efforts can ensure that R&D

contributes to a sustainable economic foundation that bolsters environmental and social progress.

Area for Further Research

First, further research can build on this study by looking at how digital financial inclusion influences sustainable development in other emerging economies beyond Sub-Saharan Africa (SSA). Emerging markets, such as those in Asia, Latin America, and Eastern Europe, present unique financial ecosystems and developmental challenges that may yield different insights into the interplay between DFI, and sustainability. By analyzing this nexus in different economic contexts, researchers can identify region-specific patterns, challenges, and opportunities. This broader scope of analysis can lead to the development of more globally relevant frameworks and policies that support sustainable development through enhanced financial inclusion.

Additionally, researchers can look at how different DFI measures affect sustainable development and how they interact with other variables to enhance sustainability.

Finally, with a particular emphasis on studies that are country-specific, future studies can provide more individualised policies that are in line with the distinctive developmental circumstances of each country.

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APPENDICES

A list of the sampled 28 SSA economies selected for the study.

Sub-Saharan Africa	
Angola	Burundi
Benin	*Burkina Faso*
Botswana	*Cote d'ivoire*
Cameroon	*Democratic Republic of Congo,*
Ethiopia	*Ghana*
Kenya	*Lesotho*
Madagascar	*Malawi*
Eswatini	*Mali*
Mozambique	*Mauritania*
Mauritius	*Niger*
Rwanda	*Senegal*
Sierra Leone	*Nigeria*
Uganda	*South Africa*
Zambia	*Zambabwe*