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EFFECTS OF FINANCIAL TECHNOLOGY ON ECONOMIC GROWTH: EVIDENCE FROM SELECTED SUB SAHARAN AFRICAN COUNTRIES

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STATEMENT OF DECLARATION

I, Tsige Taddesse G/Tsadik, hereby declare that the thesis I have submitted for consideration for the degree of Master of Financial Economics from Addis Ababa University in Addis Ababa, Ethiopia, entitled "The Effect of Financial Technology on Economic Growth in selective Sub-Sahara Countries," is entirely original work of mine and has never been previously published in a university. The proper attribution of all sources and materials utilized in this thesis has been made.

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With my permission, this master's thesis has been submitted for review.

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This is to certify that the thesis entitled, —The Effect of Financial economic growth evidence from SSA country was carried out by Tsige Taddese Gebretsadik under the supervision of Jonse.B (PhD), submitted in partial fulfillment of the requirements for the degree of Master of Science in Financial economics complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

The use of financial technology, or fintech, in sub-Saharan Africa (SSA) during the past few years has significantly altered the region's access to and provision of financial services. This study used two-step systems GMM to examine the relationship between SSA's economic growth between 2010 and 2021 and the use of fintech. In order to examine the causal relationships between fintech and economic growth, the study also applied the Granger non-causality Test. According to the findings, financial accessibility mediates the benefits of fintech on economic growth in SSA nations, where it is favorably and significantly associated with fintech usage. The effects are unidirectional running from fintech to economic growth. Therefore, an increase in fintech will promote economic growth in sub-Saharan Africa, necessitating the adoption and application of policies and initiatives that promote fintech in SSA. Fintech should benefit everyone equally; hence it is important to continue prioritizing initiatives to increase financial inclusion.

List of Acronyms

FinTech	Financial Technology
ATM	Automate Teller Machine
GDP	Gross Domestic Product
ICT	Information and Communications Technology
UNDP	United Nations Development Program
GMSA	Group Managed Service Accounts
FRED	Federal Reserve Economic Data
IMF	International Monetary Fund
WGI	Worldwide Governance Indicators
FT	Financial Technology
SSA	Sub Saharan African
PCA	Principal Component Analyze

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CHAPTER ONE

1. INTRODUCTION

1. 1 Background of the study

FinTech, often known as "digital finance," has been developed and grown in popularity as a means of providing people with cutting-edge financial services and products through their cards, personal computers, mobile devices, and the internet (Manyika et al., 2016). Modern technology has made it possible for lenders and borrowers to contact and communicate with one another.

Technology is used to boost financial processes in a new financial sector known as fin-tech. Furthermore, according to Leong and Sung (2018), fin-tech is defined as "any new concepts that improve financial service operations by proposing technology solutions according to different business scenarios. The delivery of financial services to the millions of unbanked people in the sub- Sahara countries (SSA) area has been recognized as a potential opportunity and a crucial enabler of financial inclusion for the financial services (Sahay et al., 2020). Fin-tech refers to new technology that aims to provide enhanced and innovative uses of financial services (Popescu, 2019).

Fin-tech firms are described by Gomber et al.,(2017) as businesses with innovative business models based on internet-related technologies (such as cloud computing and mobile internet) that offer financial services (such as transaction banking and money lending) with a higher level of flexibility, security, efficiency, and opportunity than traditional financial services. Additionally, the innovator can be an established financial service provider, a start-up (such as Branch, a mobile app), or an established ICT company (such as Vodaphone and Safaricom with M-pesa). The five main sectors of fin-tech, according to Arner et al., (2020), are finance and investment, operations and risk management, payments and infrastructure, data security, monetization, and consumer interfaces.

Mobile technology's rapid development and adoption are turning mobile phones into pocket banks in SSA, offering nations low prices and a practical approach to include sizable portions of the people that aren't now eligible for traditional financial services (Asongu, 2015). As a result, internet connection and mobile phones are utilized as a stand-in for the availability of digital financial services (Sahay et al., 2020).

Mobile money, also known as mobile financial services, is the extension of the delivery of essential financial services to users who would not be profitable to reach through conventional branch-based financial services (GSMA, 2015). Mobile money can be used in place of or as an alternative to traditional banking services thanks to the high adoption of mobile phones and the dispersion of transactional agents (Mas and Morawczynski, 2009; GSMA, 2015). The mobile phone, also known as "a bank branch in the pocket," is equipped to handle a large portion of financial services. In poor nations, most mobile transactions allow users to accomplish three major things: store value in an account, smuggle cash into and out of the bank account, and transfer stored value between accounts. This is something that Jonathan and Camilo (2008) emphasize. Mobile money accounts are rapidly expanding in SSA. Mobile money agents provide necessary financial services, such as making deposits and withdrawals, in place of a physical bank branch.

According to Sahay et al. (2020), fin-tech payment services are more prevalent in areas with less traditional access to bank services (bank branches and ATMs). It means that fin-tech-driven financial inclusion tends to be stronger where there is a gap or insufficient existing supply of traditional financial services, which may represent banks' migration to digital services (such as mobile and online banking).

The ATM is a cutting-edge method of service delivery that provides a variety of financial services, including checkbook requests, cash withdrawals, funds transfers, cash deposits, utility and credit bill payments, and checkbook withdrawals. According to researchers, consumers' contentment is a crucial factor in determining whether technology-based delivery channels are successful. (Wu and Wang, 2007)

According to Bruhn and Love (2014), increasing low-income people's access to financing has a significant positive impact on the economy. The effects of financial technology and how they relate to sub Sahara's economic growth, as well as the potential advantages of increased financial technology, has been examined in this study. In particular from the perspective of emerging economies, it tries to ascertain whether financial technology is viable and sustain economic growth.

1.2 Statement of the problem

Around 1.7 billion individuals' worldwide lack access to basic financial services without the help of a bank or a mobile money provider, and almost all of these are unbanked adults reside in developing countries (Demirgüç-Kunt et al., 2018). Giving low-income people access to savings, credit, insurance, and payments enables them to manage their financial commitments and create better futures, which contributes to overall economic growth, development, and poverty alleviation (Arner, et al., 2018).

According to the empirical literature, financial technology has a big effect on economic growth in emerging and developing economies (Myovella et al., (2020). Research findings indicate that the financial systems in SSA countries are immature, risk averse, largely centered in urban areas, and prejudiced towards women and the impoverished (Kuada, 2019). Regional inequality(standard of living and employment possibilities) is a problem as well; as nations industrialize, integrate, and develop, the distribution of economic activity becomes increasingly unequal (Enflo and Rosés, 2015).

It has been determined that the development of the financial sector and economic growth have a positive relationship with SSA (Mlachila et al., 2016; Murinde, 2012). Likewise, numerous studies examining the connection between finance and growth in SSA discovered that the connection was positive and causal in one or both directions (Akinlo and Egbetunde, 2010; Fowowe, 2011; Odhiambo, 2008). Furthermore, Nan's (2019) conducted a study on SSA nations and found that widespread use of mobile money boosts a nation's economic development. In contrast, several studies contend that, in part because of their extreme underdevelopment, the financial sectors in SSA nations do not play a crucial role in economic growth (Demetriades and James 2011; Gries,et al., 2009).

The mobile-finance nexus has been addressed by Demombynes and Thegeya (2012). (Demetriades and James 2011; Gries, Kraft, and Meierrieks, 2009), they have placed a focus on basic mobile savings, which is simply using a standard mobile money system like M-PESA to store money. In contrast to the economies of the OECD, the study by Myovella, et al., (2020) looks at the benefits and drawbacks of digitization in developing countries in Sub-Saharan Africa (SSA). The study discovers that digitization has a beneficial impact on economic growth in both groups of nations. Kouladoum et al., (2022), investigates the relationship between digital

technology and financial inclusion in 43 Sub-Saharan African nations and the result shows that financial inclusion is positively and significantly impacted by digital technology.

Earlier studies have attempted to explore the direct effect of fin-tech proxy on economic growth, while the majority of studies focused on the effect on the financial development. However, there have been few studies examining the relationship and causation between fintech and the economic growth of SSA. Instead of focusing on a single indicator, in order to investigate the effect of fintech on economic growth in 22 SSA, this study created a composite fintech index measurement. We could acquire a more comprehensive understanding of the role that fintechs play in economic growth by merging data from various sources. The main goal of this study is to prove a connection either causal or correlative between fintech and economic growth. In order to determine how fintech affects economic growth, the findings would be very beneficial to both researchers and policymakers.

1.3 Objective of the study

The general objective of the study is to investigate the effect of financial technology on economic growth in selected Sub-Saharan African nations. Specifically, this study aims at;

- Examining the effect of fintech on economic growth.
- Analyzing the causal relationship between fintech and economic growth (reverse causality).
- To analyze the performance of fintech development in sub-Saharan African countries.

1.4 Research Hypotheses

As stated early, the primary goal of this research is to investigate the effect of fintech on economic growth of SSA. According to the format outlined in the previous section, the following category of hypotheses has been looked in this study.

H1: Fintech have a positive and significant effect on economic growth.

1.5 Scope of the study

This study intends to determine how Fintech influence particular countries' economic growth. In addition, as the results of earlier studies have shown, there are a number of fintech-specific factors that have their own effects on economic growth. However, because to data availability

and practical considerations, this study mainly took into account and assessed a limited number of fintech-specific characteristics over the period 2010 to 2021.

Geographically in the sub-Saharan region, there are 48 countries; however, the research selects 22 countries based on the data availability of the variable of interest. The nations include;- Benin, Botswana, Cameroon, Chad, Congo Rep, Gabon, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Liberia, Namibia, Nigeria, Rwanda, South Africa, Tanzania, Uganda, Zambia, And Zimbabwe.

1.6 Significance of the study

The study advances the field of study in a variety of ways. The study is notable in the first place for its contribution to the scientific analysis of the key financial factors driving the economic expansion of sub-Saharan countries. In actuality, the concept is mature for both developed and poor countries. By providing evidence of the influence of fintech on a specific economic growth, research on and examination of the most significant fintech impact on economic growth is highly valuable to the literature already in existence.

Along with contributing to the body of knowledge, the article has substantial practical implications for financial institutions in sub-Saharan Africa. Finally, this study serves as a starting point for other academics who want to conduct research on a relevant or analogous topic.

1.7 Organization of the study

This study is set up as follows. The researcher provides a succinct introduction to the research issue in the opening chapter. For greater comprehension, Chapter 2 summarizes earlier studies. In the third chapter, the variables are defined, along with the study strategy and data collection technique. The descriptive results and statistical outputs of the dynamic panel regression analysis were reported in the fourth chapter along with their findings and interpretation. On the basis of the presented findings, the article has been summarized with recommendations for future policy in chapter five.

CHAPTER TWO

2. LITERATURE REVIEW

This chapter summarizes previous research on the effects of fintech on economic growth, including the factors, methodology, findings, and recommendations.

2.1 Definition of FinTech

What is FinTech?

The term "fintech" refers to the use of computer and related digital technology in financial services, and it is fundamentally altering how financial institutions operate. Such technology is gradually altering our lives, and it has helped to popularize names like AdTech, InsurTech, RegTech, and FinTech. FinTech, as defined by Zavolokina et al. (2017), is the union of "financial" with "information technology."Gai et al., (2018) claim that the term "FinTech" has gained popularity to designate cutting-edge technologies embraced by financial sector firms. Evidently, the interest multiplied more than four times (from 20 to >90) between mid-2015 and mid-2019.

According to Ferdiana et al., (2019), Fintech is derived from the phrase financial technology. Technology is defined as "innovative in financial service" or "innovation in financial services" by The National Digital Research Center (NDRC), which is located in Dublin, Ireland. The term "fintech," a portmanteau for financial technology, is the latest link to describe the use of technology to provide financial services, also known as alternative finance. The UK Alternative Finance Industry Report (2014) states that alternative finance refers to a variety of new financing models that are emerging outside the conventional financial system and that make use of online platforms or websites to put founders and investors in direct contact with fundraisers; in other words, they use digital technology to provide financial services. These business concepts include invoice trading, peer-to-peer business lending, peer-to-peer consumer lending, crowd funding, and digital payment systems. The consumer and small company lending markets have been significantly impacted by alternative financing, which is also quickly transforming the financial inclusion landscape.

2.1.1 Evolution of FinTech

The most well-liked subfield of economics is theoretical research of the elements that influenced economic expansion. According to economists' measurements sixty years ago, the technology revolution is a significant driver of economic growth and labor productivity (Kendrick, 1956; Solow, 1957; Abramovitz, 1986).

As early as 1838, when Samuel Morse unveiled the electric telegraph system, we may begin to trace the origins of fintech. The first transatlantic cable was later created as a result, and it provided the framework for the globalization of finance in 1866. Since then, FinTech has seen advancements in the form of credit cards in the 1950s, ATMs in the 1960s, electronic stock trading in the 1970s, mainframe computers in banks in the 1990s, and internet and e-commerce business models in the 1990s. Traditional banks were not in danger of going out of business as a result of these advances; on the contrary, they helped them run their businesses.

Pioneers in the field of fintech, like PayPal, first appeared in the 1990s to provide a platform for online payments. Today, PayPal has expanded its business model to include a wider range of services, including instant credit approval and mobile apps that help customers find nearby businesses that accept PayPal. One of the biggest Fintech companies, Stripe, is based in the US and was formed in 2011 to provide a better online payment system. It has raised more than $300 million from venture capital firms like Founders Fund, Khosla Ventures, and Sequoia Capital.

2.1.2 Innovation of FinTech and Influence on Financial Service

The year 2015 was the turning point for FinTech interest as it started to gain popularity rapidly. Chuen and Teo (2015) assert that FinTech will influence the future financial industry. Technology (FinTech), commonly referred to as "digital finance," has evolved and become increasingly well-liked for delivering cutting-edge financial services and products to individuals via mobile phones, personal computers, the internet, and cards (Manyika et al., 2016). Through the use of modern technologies, borrowers and lenders can now connect and communicate with one another.

According to Gomber et al., (2018), the FinTech revolution will significantly alter the financial services industry's operations by boosting efficiency, customer centricity, and transparency. The Fintech ecosystem, according to Gozman et al. (2018), consists of innovations in core business

services, infrastructure, and its parts, and it generates value through cooperative competition by redesigning, reorganizing, and rerouting the flow of financial services among significant market participants.

Since 2008, the digital delivery of financial products and services has become more important than the actual financial products and services themselves. It is a technological advancement driven by FinTech start-ups, which are challenging or even displacing traditional banks in the provision of financial services. The delivery of financial services today includes the use of Web 2.0 technologies like crowd funding, mobile wallets, payment apps, cryptography, rob advisors (which use algorithms and surveys to help investors build portfolios), and cryptography. Digital financial services, particularly in the context of financial inclusion, are revolutionizing the payment, savings, and lending ecosystems (Ozili, 2018). As more customers are tested, information is shared, and risk assessment is made simpler, the rise of the fintech industry may successfully lower transaction costs and ease information asymmetry within the financial system. Therefore, it encourages international trade (Fernandes et al., 2019), fosters entrepreneurship boosts household income (Zhang et al., 2020), and enhances financial development (Appiahotoo and Song, 2022; Peia and Roszbach, 2015).

According to Magnuson (2018), FinTech has brought about "fundamental changes" in many areas, including the way that banking operates the method that capital is created, even to the very shape of money itself." According to Loo (2018), if given the chance to compete freely, FinTech could improve consumer welfare and reduce the likelihood of a financial disaster. The unbanked are being drawn in as bankable customers as fintech is revolutionizing the delivery of digital financial services and opening up new markets. Digital financial services have a "significant potential to provide a range of affordable, convenient, and secure banking services to poor people in developing countries," according to the Consultative Group to Assist the Poor.

Modern technologies bring into life new business models, such as FinTech companies at financial market (fintech start-ups, fintech centres, fintech hubs, fintech clusters, and financial ecosystems). In fact, most of these definitions are synonyms, but all together they build up fintech industry, which affects traditional financial institutes. In business community some experts forecast disappearance of these institutes in the near future; others predict inevitable mutual interference of traditional and new financial business models.

2.1.3 The Practices and Experiences of Fintech in Bank

This theme groups the articles that examined how FinTech affected the operation of the banking or financial sectors. According to Jagtiani and Lemieux (2018), fintech is playing a more and bigger role in the banking and other financial industries. The question of whether the two have a symmetrically advantageous relationship is the subject of academic dispute. According to Navaretti et al. (2018), natural FinTech innovation could raise promoter banks' operational efficiency, but new FinTech players put incumbent banks under more competition. Gozman and Willcocks (2019) noted that traditional bank players were being disrupted by FinTech companies leveraging cloud technologies. However, Jakic and Marinc (2019) contend that relationship banking still has a competitive edge over FinTech companies that focus on transactions, thus they should continue to prioritize relationship banking while using new technologies to stay competitive. Despite the advantage of relationship banking, the traditional banking and finance sector is faced with a conundrum. In the US market, FinTech lenders' market share climbed four-fold between 2010 and 2016 (Fuster et al., 2019) as they processed loan applications more quickly, kept default rates stable, and refinance loans more frequently. The authors also noted that FinTech companies quickly modify their supply in response to variations in demand. The adoption of FinTech products was examined by Gulamhuseinwala et al. (2015), who discovered that many of the "most economically valuable consumers" of the traditional banking and insurance sectors have already done so. According to Jagtiani and Lemieux (2018), FinTech firms' lending covered areas that banks could not adequately cover, boosting the amount of credit available in areas facing challenges. Small- and medium-sized organizations (SMEs), which were underserved by traditional banking, were helped by FinTech companies, according to Lu (2018) and Gomber et al. (2017). According to Guild (2017), by serving the untapped market, FinTech can increase financial inclusion and stimulate the economy. According to Zetzsche and Dewi (2018), FinTech companies can lower loan rates by fostering more competition. For instance, according to Jagtiani and Lemieux (2018), FinTech could help consumers get more affordable loans. According to Gomber et al. (2017), digital initiatives have slashed the amount of time it takes to process information throughout the entire banking sector. Overall, the advent of FinTech products and services has enhanced efficiency and competition, decreased service costs, and provided avenues to fill the vacuum felt by different sectors. There are drawbacks to FinTech, though. The interconnectedness of FinTech goods and services has raised the sector's

systemic risk. According to Lai and Order (2017), who concentrate on China, the traditional banking system may be threatened if FinTech companies begin to do financial intermediation.

2.2 Economic Growth Concept

Fundamentally speaking, consumerism does not propel economic advancement. According to Nobel laureate Amartya Sen, economic progress is necessary to increase peoples' substantive freedoms. These freedoms have a direct impact on how many people have more opportunities to live longer, be healthier, and eat better. The Wealth of Nations outlines Adam Smith's theory of economic growth, which is based on the possibility of rising returns in manufacturing due to greater specialization and the division of labor as well as the accumulation of real capital, which is necessary to support the greater division of labor.

Growth is essentially about investing in capital and labor and increasing the productivity of these factors of production through the processes of innovation and technical absorption, according to the Wealth of Nations. How to increase the low levels of investment and productivity development that are typical of underperforming nations is perhaps the most essential challenge for low-income regions, such as sub-Saharan Africa.

2.2.1 Theory of Economic Growth

Neoclassical Growth Theory

Technological change was incorporated into the model as an exogenous variable in accordance with Solow's (1957) neoclassical growth theory. The idea split output into two categories: growth in factor inputs, such as land, labor, and capital, and increase in output as a result of growth in factor inputs. Consequently, investment and savings are the sources of economic growth as indicated by the annual growth rate of GDP per person (Gordon, 2009). The production function is presented as follows in Solow's model;

$$y = Af(K, L)$$

A sustained rise in production is required for output (Y), which is dependent on inputs such as labor (L), capital (K), and an autonomous growth factor (A).

Two categories of technical change can be distinguished in Solow's model. The notion that, as technology advances, it will improve workers' productivity and alter the industrial process from

one based on per-person output to one based on per-person capital. Labor-augmenting technology change is the first type of Solow's model. The relationship between education level and technological advancements makes labor more efficient in carrying out tasks that are deemed to be effective labor inputs, which should be a concern rather than placing a higher priority on the number of workers. Neutral technical change is the second category of technological change.

Endogenous Growth Theory

Neoclassical growth theory emphasized that although there are no fundamental assumptions about where such change arises from, technological change leads to sustainable growth of reaction to the exogenous technological change assumption of Solow's model, Romer (1990) developed the endogenous growth theory. Instead of trusting that technical progress happened exogenously without understanding its underlying reasons, Romer contended that technological change genuinely stemmed from market action because of incentives to benefit the economy. Three premises form the basis of the new growth theory presented. The first is that economic growth brought about by technological change represents an improvement in the direction because all raw materials are combined. The second premise claims that society or an individual's desire to maximize profit is what drives technical advancement. Due to the prospect of incurring fixed expenses from producing new technology, the third assumption is that technology acted as instructions for mixing raw materials that were different from economic goods.

Schumpeterian growth theory

The foundation of this idea is Schumpeter's well-known claim that "creative destruction," or innovation-driven industrial restructuring, serves as a catalyst for economic progress. Recent publications by economists Phillippe Aghion, Ufuk Akcigit, and Peter Howitt provide the most thorough explanation and analysis of the Schumpeterian growth theory to date. They start off by stating that this model is Schumpeterian in that it is about growth produced by innovations, innovations result from entrepreneurial investments that are themselves motivated by the prospects of monopoly rents, and new innovations replace old technologies and also growth involves creative destruction.

2.2.2 The Link between Financial Technology and Economic Growth

Financial technology, an abbreviation for technology and finance, offers a solid theoretical foundation for promoting economic progress. The financial system is crucial in directing money from those with a surplus of resources to those who are in need, ensuring that economic activity runs smoothly and productively (Matthews et al., 2013).

In contrast to other breakthroughs, financial innovations have the ability to have a direct impact on the efficiency of the financial sector, which serves as a bridge between savings and investment in an economy and, in turn, influences growth. The digital economy has given rise to innovations that have fundamentally altered how we live, despite the fact that productivity growth has been sluggish in wealthy countries for decades Myovella et al., (2020).

In the more accessible financial markets, fintech has thus far advanced swiftly. One such example is the e-payment system M-Pesa, which has been utilized in Kenya, Tanzania, and other nations since its launch just ten years ago and is one of the biggest Fintech success stories. By successfully transforming mobile phones into payment accounts, M-Pesa has increased financial access for those who were previously without a bank account. It is the perfect example of how Fintech has upended the financial sector and increased productivity across the economy Burns (2015).

Fintech is most common in nations with less stringent financial regulations, higher incomes, and less competitive banking institutions, according to research by the Bank for International Settlements. If fintech can encourage financial inclusion worldwide as it has in Kenya, it would more efficiently move savings into investments in industry, infrastructure, and human capital—the kind of capital needed for economic growth. The broad acceptance and use of digital finance could increase the GDPs of all emerging nations by 6%, or a total of $3.7 trillion, by 2025, according to a McKinsey Global Institute analysis published in 2022. This might enable an additional $2.1 trillion in loans to individuals and small enterprises, increase government tax revenue, and provide access to the market for 1.6 billion people who are now unbanked.

Institutionally, fintech can encourage growth in the information technology, corporate services, pension funds, and insurance sectors. Another noteworthy finding is that the development of fintech has resulted in the loss of 215,433 jobs while increasing labor income, expressed as pay

and salaries, to $4.56 trillion. By providing loans, particularly to the MSME sector, fintech financing has also shown that it can stimulate the economy (Adhinegara et al., 2018).

Additional empirical studies have revealed that financial inclusion, including both traditional and digital financial inclusion, has a favorable effect on economic growth (Dahiya and Kumar, 2020; Emara and Said, 2021). According to Myovella et al. (2020), the OECD and SSA economies both experience economic growth as a result of economic digitization. Ahmad et al. (2021) claim that the inclusion of digital financial services has a significant impact on China's economic growth. Economic growth was facilitated by financial inclusion in Islamic Development Bank member countries. The increasing growth of digital financial services over traditional financial services has enabled more people to access financial services (Espinosa-Vega et al., 2020). The economic value added by mobile technology and services in Sub-Saharan Africa was close to $140 billion, or around 8% of the region's GDP, according to a GSMA estimate from 2021. The mobile ecosystem directly and indirectly supported more than 3.2 million workers, and the industry's $16 billion in tax income considerably contributed to funding the public sector. By 2025, mobile's contribution will expand by $65 billion (to about $155 billion), as the region's nations benefit more and more from the growth.

2.2.3 Determinants of Economic Growth

1) Financial technology

Financial technology indicated by the below listed;-

a) ATM

Cash, debit, and credit cards are all now accepted forms of payment. Automated teller machines (ATMs) were regarded as intermediary devices that provided the ability to transfer funds from cash to a payment card and vice versa while also providing multiple denominational values in cash (Agarwal and Brem, 2017; Bernini and Brighi, 2018). Earlier approaches for improving client request processing algorithms had been published, which encouraged more people to use ATMs and improved the security of non-cash payments.

B) Mobile Banking /Payment

Millions of people who had no official financial accounts before are now becoming account holders thanks to mobile money, which is made possible by mobile technology. It is frequently the initial step into the mainstream financial system for many people. Africans are more likely to have a mobile money account than just a traditional bank account, according to the World Bank. M-Pesa, which is Swahili for "mobile money," is the name given to the mobile money that first appeared in Africa in Kenya in 2007. Vodacom and Safaricom, two independent mobile phone providers, introduced it. Anyone with a basic phone may use M-Pesa, making it a straightforward technological solution. No data capacity is necessary because it uses SMS Burnset al. (2015).

An account with a bank is not required for use. Cash can be withdrawn through a network of agents, and the mobile money account is simple to top up. Because it uses a private PIN to work, money is kept secure even if the phone is lost. M-Pesa thus satisfies both PEOU and PU's requirements. M-Pesa reached one million active accounts in 2008, one year after its debut. The same year, Vodacom introduced a second M-Pesa service in Tanzania while another mobile operator, Orange Cote d'Ivoire, debuted mobile money in West Africa under the name Orange Money. Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea-Bissau, Rwanda, and Uganda were the seven SSA markets where MTN Mobile Money was operational by 2010.

C). Credit card

This plastic card is used to make purchases of the provided goods or items. The lack of POS (swipe card facilities) at the merchant end is a disadvantage of this system.

D) E-transfers:

"E-transfer" refers to electronic transfers that can be performed online utilizing computers, laptops, and other devices. Bank customers who have registered for internet banking are able to carry out basic financial activities online. 40% of Sub-Saharan Africa's adult population now uses mobile internet services, according to GMSA (2021). The utilization gap indicates that another 44% of residents of areas with mobile broadband networks do not currently use mobile internet services. Stakeholders should give priority to overcoming the main barriers to mobile

internet adoption for these people, including affordability and digital skills, in order to achieve the promise of mobile connection to foster economic growth and development in a post-pandemic future.

2) Gross Capital formation

Most researchers acknowledge that capital development is one of the most significant forces influencing economic growth. Most of them concur that capital formation boosts investment, productivity, and competitiveness. Additionally, research has shown that capital production can raise living standards and contribute to the reduction of inequality and poverty. A number of variables, including the standard of the institutions, the level of competition, and the accessibility of finance, moreover, the effect of investment on development. Gross capital formation, formerly known as gross domestic investment, is made up of expenditures for new fixed assets for the economy as well as net changes in inventory levels.

There are three separate, if not related, activities involved in capital formation. One of these activities is saving, which involves putting claims to resources, which could be used to support present consumption, aside so that they are then made available for subsequent uses, Emmanuel (2014).

3) Labor Productivity

Numerous academics conclude that worker productivity and economic growth are positively correlated. The economy is more efficient overall and grows more quickly when workers are able to create more output per hour of work. While some academics contend that expenditures in infrastructure, technology, and education can increase labor productivity, others stress the significance of institutional elements like property rights, market competition, and the rule of law. Overall, there is continuing research and discussion in the field of economics about the complicated and diverse relationship between labor productivity and economic growth.

4) Political stability

Political stability (PS), which is the absence of volatility a country's government, regimes, and communities, is likely to have a positive impact on economic growth (Fous, 1992). Political

stability is characterized by possible policies with accompanying development plans. The most significant examples of this include absence of violence, good property rights, and other types of laws that encourage economic agents and political stability affects economic growth through investment, savings, and disruption of the labor market, levels of productivity/output of private agents, and the monetary and fiscal policies of the government (Cervantes and Villasenor, 2015).

According to Prasad (2002), political instability is a phenomena brought on by state-sponsored coups and some other related factors with the sole intention of stalling reform and thereby impairing the performance of the economy. The author makes an effort to establish a link between growth, political unpredictability, and structural improvements.

5) Gini Coefficient (income inequality)

Increases in income inequality have a detrimental long-term impact on GDP per capita levels. Ciegis and Dilius (2019), on the other hand, show that the effect of inequality on economic growth through fiscal policy differs depending on countries' income and levels of income inequality. Due to the rise in the wealth of the richest people, inequality in countries with relatively high incomes and fiscal policies has a beneficial impact on growth. Due to higher social protection costs, inequality has a detrimental impact on economic growth.

2.3 Importance of Financial Technology

FinTech is a powerful tool for enhancing financial inclusion since it may lower information asymmetries and transaction costs. Politicians and profit-driven private entrepreneurs have both noticed the opportunities presented by technology. Mobile money and crowd funding are two FinTech technologies that are having or promise to have a significant impact on financial inclusion in Africa, the continent with the lowest level of banking Nan (2019).

First, it is likely to be beneficial for economic growth and development when fintech helps to increase financial inclusion, such as when providing basic payments services in EMDEs. See Levine (2005) and Sahay et al., (2020). For an overview (2015) the economic factors pushing SMEs to adopt fintech globally. However, this could become more problematic if it leads to excessive lending or excessively large debt loads for specific (groups of) borrowers. Second, as time goes on, fintech activity may heighten international competitiveness in the financial services industry. There have been several instances of cross-border expansion and the

replication of successful fintech business models in other markets, despite the fact that many fintech firms first concentrate on one economy. Such international financial integration could promote better economic diversification and risk sharing additionally, it might aid in partially reversing the fall in cross-border financial activity that has been observed since the global financial crisis. It is essential that this cross-border expansion be accompanied by proper collaboration amongst global regulators due to disparities in regulation across different markets and the potential for regulatory arbitrage. Third, while certain market failures can occasionally be resolved by fintech advances (e.g. by reducing information asymmetries, transaction costs, etc.)

The 2017 Global FinTech Report from PwC offers some information on the expanding impact of fintech on the financial services industry. The report notes that as more people expect to use non-traditional financial services providers, FinTech is posing a significant threat to established financial institutions. Additionally, it notes that traditional financial institutions are embracing the disruptive nature of FinTech by dramatically stepping up their internal innovation efforts in response to this threat.

The International Finance Corporation (IFC, 2020), claims that FinTech firms have at least three substantial impacts on the financial sector. Through the digitalization of service delivery, they are first encouraging efficiency in the supply of financial services. Second, when traditional banks lack the flexibility needed to offer affordable and accessible goods and services, FinTechs do so. Third, they provide services resembling those of banks but are not subject to the same regulations as conventional banks. In its development report from 2020, UNDP makes an effort to clarify how technology, particularly ICT, is facilitating development outcomes. The report discussed the relationship between technology and human development from the viewpoint that technological innovation improves human capabilities, including participation in social, economic, and political life as well as healthy lifestyle, knowledge, and creativity. It also has an impact on economic growth through productivity gains. At the same time, human capabilities play a significant role in the advancement of technology.

2.4 Challenges of Financial Technology

New fraud vectors evolved at the same time as disruptive technologies, rendering outdated detection techniques (Ryman-Tubb et al., 2018). Although there has been progressed in the fight against cybercrime, it is expensive (Achim et al., 2021; Gogolin, 2010) and may cause a net loss

to the economy. The same well-known dangers that are typically inherent in the banking industry will continue to apply to fintech activity. For instance, even when provided by non-banks, deposit-like activities are nonetheless susceptible to liquidity mismatch and the risk of bank runs. Speculative bubbles can still affect new financial assets, as was the case with Bitcoin in 2017.

There is a chance that certain fintech or major tech companies could grow to be systemically significant ("too big to fail"), leading to moral hazard and excessive risk-taking. Lastly, new forms of connectivity, such as operational dependencies (such as reliance on outside services like cloud computing), have the potential to spread market shocks across institutions and markets. Public sector authorities will continue to be responsible for managing these risks. Fintech involves technical dangers (Gu and Shi, 2020). Massive amounts of data are continuously growing at the power level as a result of Fintech's creation of a new financial ecosystem, all-day service methods, and participant diversification. A significant amount of information data has also been generated. The improper processing and storage of this data will result in data leaks, make risk identification more challenging, and raise the possibility of technology getting out of hand. The processing of the unprecedentedly large amount of data generated by Fintech has hit a bottleneck since there are not enough people with good computer technology skills and deep financial knowledge. During the period of acclimating to the new technology, there will also be hazards associated with the storing, reading, and processing of data during the running in period with the original technology. The inappropriate processing of incomplete and distorted data will also pose substantial hazards and have a negative influence on the information management system of commercial banks.

2.5 Empirical Review

In general, the invention of electronic money and other forms of payments has encouraged the growth of the non-cash digital economy and E-banking (Yousafzai et al., 2003; Kumbhar, 2011). Other researchers have identified factors that are necessary for effective online banking and have gathered data from an interpretive study of banking clients' experiences (Shah and Siddiqui, 2006). Banking firms must surely take into account the expanding risks of switching to financial technologies that influence living standards and sustainable development from the onset of the shift to technological breakthroughs (Rymarczyk, 2020; Sieja and Wach, 2019). Another study examined how a large portion of the population is exposed to financial vulnerability due to the

dominance of market-based medical operations, the absence of risk pooling and prepayment systems, and the lack of risk management policies, which results in catastrophic payments to cover costs (Selvaraj and Subramanian, 2012; Alao and Sorinola, 2015).

In Wang and Xu's (2021) investigation of the effect of technological advancement on China's economic growth from 1990 to 2019, theoretical mechanism analysis and empirical model research are used. The outcomes of the theoretical study demonstrate that an economy will continually improve as a result of technological advancement. They discover through developing the OLS and WLS models that economic development will be much improved when the government invests more money in science and technology innovation.

The effect of financial technology (FinTech) on Palestinian economic growth was studied by Badwan et al., in 2022. (2008 to 2021). To take into account both long- and short-term causality, the researcher employed a vector error correction model using a co-integration distributed autoregressive technique. However, the data demonstrates that FinTech products (number of Internet users, broadband subscriptions, mobile cellular subscriptions, automated transfer machines, and branch locations) contribute to the growth in financial inclusion. The data also demonstrates that FinTech products have a causal relationship with both economic growth and financial development over the long and short terms.

According to Sahay et al., (2020), how often people use ATMs depends on how much money they have on hand. In this regard, he made note of the fact that banks purposefully load ATMs in multiples of 5, 10, and 20 US dollars, which encourages the use of non-cash payments since most users are unlikely to carry large notes or carry a lot of small change. This will have an impact on the rate and level of GDP growth. Numerous studies that examine internet payments, online payments, and mobile payments from various angles have been published in academic literature. Clearly, this required the use of electronic money. The growth of electronic trade and commerce is a direct result of the development of the non-cash payment industry. While banks replicate top-performing initiatives after the leaders, scientists study and create new software systems on the interaction between customers and a business - Kaspi.kz (Soldatenko and Essimzhanova, 2021)

In a study published in 2022, Emmanuel et al., explore the impact of fintech in Nigeria over a quarterly period from 1999 to 2020. The Granger non-causality test, a Toda-Yamamoto

technique, and the Johansen cointegration test were used. Results complement the goals of the UN-2030-ASD by demonstrating how FinTech influences economic growth and financial inclusion by lowering income inequality and the poverty rate.

Awad and Albaity (2022) identifies the routes of transmission through which information and communication technology (ICT) promotes economic progress and the role of ICT use to the economic growth in SSA (Albiman and Sulong, 2016); The study employs panel methodology, the data was gathered from 45 SSA nations between 1990 and 2014, and the three primary ICT proxies are fixed telephone lines, mobile phone users, internet users per 100 people and discover that mobile phones and the internet were proven to have directly sparked economic growth. Mass use of ICT proxies, however, appears to sluggish economic growth according to nonlinear effect analyses.

In contrast to the economies of the OECD, the study by Myovella, et al., (2020) looks at the benefits and drawbacks of digitization in developing countries in Sub-Saharan Africa (SSA). The study employs GMM estimators and panel data collection for 74 countries and discovers that digitization has a beneficial impact on economic growth in both groups of nations. Kouladoum, et al., (2022); Investigates the relationship between digital technology and financial inclusion in 43 Sub-Saharan African nations between 2004 and 2019. The techniques use the Generalized Method of Moment (GMM) to account for double causation and geographic heterogeneity. Financial inclusion is positively and significantly impacted by digital technology as evaluated by ICT indicators of the subscription rate of fixed and mobile telephone users, fixed broadband, internet users, and a composite indicator of digitization. Discover how the development of digital technology has increased the rate of financial inclusion in Sub-Saharan Africa countries.

Kireyeva, et al., (2021) Impact of financial technology on economic development: Theories, methodologies, and analysis. Data is gathered for the years 2004 through 2019 when the countries under examination were actively building and expanding their financial and technological capacities. The majority of the analysis' findings point to an increase in the number of bank branches in several of the nations examined. Additionally, they take into account the relationships between gender indicators, financial technologies (such as the number of ATMs, internet users, and mobile communications users), and economic growth (as measured by metrics like GDP). Conclusions indicate a link between financial innovations and economic expansion.

A review of the literature reveals that, despite the fact that several studies have featured theoretical arguments on this topic and that some studies have partially investigated different aspects of fintech, no empirical data on how fintech affects economic growth using fintech index can be found in the literature. This kind of gap in the literature led to the choice to carry out an extensive empirical study of the total impact of fintech on economic growth.

2.6 Conceptual Framework

The effects of drivers of fintech can be transmitted into changes in GDP through various channels and mechanisms. Fintech, which encompasses a wide range of financial technologies and innovations, has the potential to impact economic growth and GDP in both direct and indirect ways. Here's how:

1. Increased Financial Inclusion: Fintech can facilitate access to financial services for underserved populations, such as those without access to traditional banking. This can lead to increased savings, investments, and economic activity among previously excluded individuals and small businesses.

2. Efficiency Gains: Fintech solutions often streamline financial processes and reduce operational costs for both financial institutions and consumers. These efficiency gains can translate into higher productivity, cost savings, and ultimately contribute to GDP growth as resources are reallocated to more productive uses.

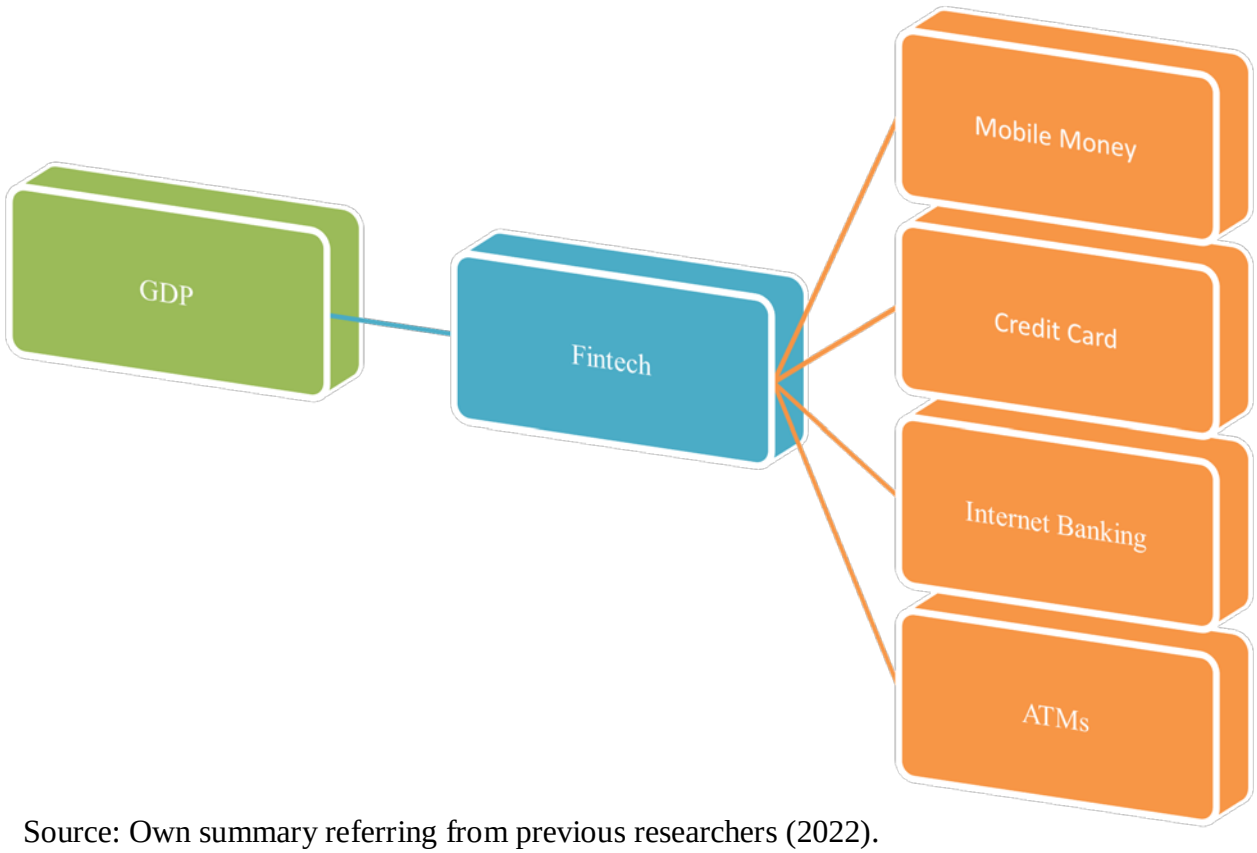
3. E-commerce Growth: The growth of fintech has been closely tied to the rise of e-commerce. Payment processing solutions, online lending platforms, and digital wallets have enabled the expansion of online businesses. The increased volume of online transactions can directly contribute to GDP growth, especially in sectors related to e-commerce.

5. Data-Driven Decision-Making: Fintech relies heavily on data analytics and artificial intelligence to make financial decisions more precise. This can lead to better risk management, investment decisions, and resource allocation, which in turn can positively impact economic growth.

7. Cross-Border Transactions: Fintech can facilitate cross-border trade and transactions by providing efficient and cost-effective methods for international payments and currency exchange. This can boost international trade and contribute to GDP growth.

10. Consumer and Business Confidence: As fintech solutions become more integrated into daily life and business operations, they can enhance confidence in financial systems. This increased confidence can lead to higher consumer spending and business investment, both of which contribute to GDP growth.

Figure1. Conceptual framework of fin-tech determinate associated with economic growth



Source: Own summary referring from previous researchers (2022).

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Description of the Study Area

Geographically speaking, the regions of Africa south of the Sahara are referred to as sub-Saharan Africa. They include West Africa, Southern Africa, East Africa, and Central Africa. Depending on the organization defining the region (e.g. UN, WHO, World Bank, etc.), this is seen as a non-standardized geographic area with somewhere between 46 and 48 countries included. There were over 1.18 billion people living in Sub-Saharan Africa as of 2021. The population of sub-Saharan African countries is now growing at a pace of 2.3%, and more than 40% of the population is under the age of 15. The recovery in Sub-Saharan Africa has been abruptly stopped. Activity eventually recovered in 2018, increasing 2021 GDP growth to 4.7 percent. The sub-Saharan region of Africa has the lowest literacy rates worldwide, according to the CIA. However, literacy rates in sub-Saharan Africa vary greatly between nations. Zimbabwe has the highest recorded literacy rate in the area (90.7%; 2003 est.), while South Sudan has the lowest (27%).

3.2 Research Design and Approach

3.2.1 Research Design

According to Creswell (2014), "Research design is the specific process involved in the research process, including data collecting, data analysis, and report writing. There may be several other factors that influence economic growth in addition to the variables identified in the study, given that the overall goal of the study is to investigate the effect of fintech on economic growth, evidence on specific sub-Saharan countries, and the study is interested in identifying the most significant factors associated with the problem.

This study employed the explanatory research technique to assess the hypothesis, which allows judgments regarding the relationship and causality between variables. Explanatory studies, as opposed to descriptive studies, aim to explain the reasons of the phenomena rather than simply perceiving and reporting the condition.

3.2.2 Research Approach

This study is carried out using a quantitative research methodology. Since the research problem is translated into specific variables and hypotheses based on a framework developed deductively through a review of previous studies, quantitative research employs a review of the literature to develop theories and hypotheses to be tested. Prefigured information has been gathered in advance of the study from various literatures.

3.3 Data type and Source

This study, as stated; aims to investigate the relationships between financial technology and economic growth in a sample of chosen Sub-Saharan African nations. The data were compiled from the World Development Indicators (WDl), International monetary fund (IMF), Global Findex database, Worldwide Governance Indicators (WGI), and the quarterly FRED economic statistics for twenty two Sub-Saharan countries from 2010 through 2021.

3.4 Econometric Model

3.4.1 Development of a FT index

Fintech cannot yet be measured using particular statistics. For the purposes of this study, we employ a composite index that measures access to and use of financial services made available through fintech channels from 2010 to 2021, including ATMs, internet banking, credit cards, and mobile banking. One benefit of creating composite indices is that they may be able to assist in resolving issues with precision, reliability, accuracy, and validity that are connected to using individual indicators. For example, a variable that is not directly observable through an individual indicator may require integration of multiple indicators, each of which corresponds to a different aspect of the variable.

According to the literature review, there are two widely used methods for evaluating fintech through the creation of a composite FT index: the nonparametric way (represented by Sarma, 2016's method) and the parametric method (represented by the principal component analysis method of Camera and Tuesta, 2018). The nonparametric approach, however, uses exogenous weights that are selected based on the researchers' intuition to determine the significance of the indicators. Indicators are susceptible to arbitrary weighting because even little changes in the weights can have a significant impact on the outcome. In order to measure the impact of fintech

in SSA, this study creates the FT index based on the benefits of the PCA technique and used the same methodology as Camara and Tuesta (2018).

Steps to construct the composite fintech index:

1. Determine the variables: Selecting the variables that make up the composite index is the first step.

2. Determine the weights: Assign a weight to each variable based on its relative importance. The weights should take into account each variable's relative significance to achieving the study objective.

3. Normalize the data: By normalizing the data, we can ensure that each variable's data is on the same scale. To do this, either multiply each observation by its highest value, or convert the data into z-scores.

4. To get the weighted normalized score, multiply the weights by the normalized values. The weights and normalized values for each variable must be multiplied in order to obtain the weights and normalized values.

5. Add the weighted normalized scores for each observation to total the findings.

FT is linearly determined as follows;

$$FT_i = w_1 ATM_i + w_2 CD_i + w_3 MOB_i + w_4 IB_i + e_i \qquad (1)$$

Where,

- The composite FT index of the nation; $w_1, w_2, w_3 and\ w_4$ are the relative weights of each dimension;
- ATMs are measured per 100,000 adults,
- CD is the number of credit cards per 1,000, adults registered
- MOB is the number of Active mobile money account and
- IB is Internet banking transaction (during reference year) per 1000 adults and
- e_i is the error term, and i is country

To investigate the effect of fintech on economic growth; the neoclassical aggregate production function serve as a basis for this study's model specification (APF).This theory, which Song and Appiah (2022) used in their study, looks at the relationship between inputs and outputs in production.

The model as stated in equation (1)

Starting with the Cobb-Douglas production function:

$$Y = A * K^{\alpha} * L^{\beta} \qquad (1)$$

Where: Y: Output

A: Total factor productivity (TFP)

K: Capital L: Labor α, β: Output elasticity of capital and labor, respectively

$$Y_{it} = A_{it} \times F(K_{it}, L_{it}) \qquad (2)$$

We substitute fintech into *Ait* (see Equation (3))

$$A_{it} = f(iF_{it}) \qquad (3)$$

Substitute the modified capital input equation (step 3) into the Cobb-Douglas production function (step 1):

$$Y_{it} = f(iF_{it}) * f(K^{\alpha} * L^{\beta}) \qquad (4)$$

Then substitute equation (3) in to equation (4) to get equation (5)

$$Y_{it} = f(iF_{it} K^{\alpha} * L^{\beta} PI_{it} GI_{it}) \qquad (5)$$

Expressing the above equation in logarithmic form gives

$$lnY_{it} = lnk_{it} + lnl_{it} + lnPI_{it} + lnGI_{it} + lnif_{it} + E_{it} \qquad (6)$$

Expressing equation (6) in econometrics and give us equation (7)

$$Y_{it} = b_o + b1lnk_{it} + b2lnl_{it} + b3lnPI_{it} + b5lnGI_{it} + b6lnif_{it} + E_{it} \qquad (7)$$

From equation (7) estimate the growth equation (8)

$$lngdp_{it} = b_o + b1lnk_{it} + b2lnl_{it} + b3lnPI_{it} + b5lnGI_{it} + b6lnif_{it} + E_{it} \quad (8)$$

Where (ln gdpit) denotes the natural ln of economic growth, (ln kit) signifies natural ln of capital gross formation, (ln lit) signifies natural ln of labor productivity, (lnPIit) signifies natural ln of political stability, (lnGIit) signifies natural ln of gini coefficient while (ln i fit) denotes the natural of fintech. The fintech constructed as an index composed of five indicators, which are number of ATM machines and number of mobile banking usage, internet banking, credit card and debit card.

Causality Model

Granger causality measures the effectiveness of contentedness (i.e., causal interactions, extract activity of one area of causal influences of one neural element over another) from one region to another by measuring how well the signal in the seed region can predict the signal in the target region (Granger, 1969).

The causality test developed by Juodis, Karavias, and Sarafifidis (2021) was used to investigate the relationship between fintech and economic growth in sub-Saharan Africa. We chose this test because it works best with high N and small-moderate T with heterogeneous coefficients. The test is described as follows: Equation (8)

$$Y_{it} = \emptyset_0, i + \sum_{p=1}^{p} \emptyset_p\,, i\, Y_{i,t-p} + \sum_{p=1}^{p} \beta_p\,, iX_{i,t-p} + E_{it} \quad (9)$$

β_p, i Are the granger causality parameters .The dependent variables are denoted by Yit, while the independent variables are denoted by Xit.

The hypothesis of grander non causality is:

$$H_0: \beta_i = 0, for\ all\ i\ and\ p$$

The alternative hypothesis is;

$$H_1: \beta_i \neq 0, for\ all\ i\ and\ p$$

3.5 Description and Summary of the study variables

Table 3.5 displays the variables, description, expected sign and measurement.

Table 1: Summary of the study variables

Variables	Measures and Description	Expected sign	Measurement
Dependent Variable			
Economic growth	GDP per capita, Annual percentage growth rate of GDP at market prices based on constant local currency.	+	Number
Explanatory Variables			
Fintech	Mobile banking, ATMs, internet , credit and debit card	+	Index
Mobile Banking	Registered number of Active mobile money account	+	Number
ATM	ATMs per 100,000 adults	+	Number
Internet Banking	Internet banking transaction (during reference year) per 1000 adults.	+	Number
Credit Card	Number of credit cards per 1,000 adults	+	Number
Political instability	Percentile Rank (0-100) indicates rank of country among all countries in the world		Number
Labour productivity	Total population of ages 15–64 a measure of the level of labour force participation.		Number
Gross capital formation	Gross capital formation in national accounts is measured by the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables		value
Gini Coefficient	Gini coefficient is income inequality		index

Source: own compilation

3.6 Estimation Method

From dynamic panel data analysis models GMM (Generalized Method of Moment) applied to identify the fintech factors that affect economic growth in sub-Saharan African (SSA) countries. More so, different diagnostic tests are checked to validate the applicability of the model. The generalized method of moments, which can account for simultaneity and endogeneity in the model, is used in the study to increase the precision and consistency of the findings. In this investigation the methodology estimated by Arellano and Bover (1995) and Blundell and Bond (1998) for the dynamic panel model were used. Moreover, the GMM method is suitable for reduced-form models, producing models that are sparse in comparison to those produced by other regression techniques. Yet, other approaches struggle to deal with the variations in macroeconomic, demographic, and governance characteristics between nations. The Helmet transformation, though, is how the GMM approach addresses the problem of country-specific effects (unobserved heterogeneity) (Arellano and Bover, 1995; Love and Zicchino, 2006). The GMM method can deal with autocorrelation omitted variable biases, and heteroskedasticity.

3.6.1 Two-step system GMM

The system GMM was suggested by Arellano and Bover (Citation 1995). To explicitly reduce the uncertainty and biases related to the difference estimators, the system GMM adds the level form moment conditions on top of the difference form moment conditions. Additionally, the variance-covariance structure is more adaptable with system GMM estimators. Additionally, the dynamic GMM model is excellently suited to account for the endogeneity bias that might result from the use of short macro-panel data and affect estimates.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

In this Chapter, the model's results are provided together with discussions that support them. Descriptive statistics, diagnostic tests (unit root test, heteroskedasticity test and co-integration test), and Granger causality tests were performed after the model was examined. It also discusses the findings of the analysis of the empirical data collected and how fintech has impacted the economic growth of SSA.

4.1 Descriptive analysis

4.1.1. The Trend of Gross Domestic Product

Gross Domestic Product (GDP) is the total dollar amount of goods and services generated inside a nation's borders over a given time period, often a year. The GDP of nations in Sub-Saharan Africa can range significantly from one another as a result of things like their natural resources, economic policies, and political stability. While Sub-Saharan African countries' GDPs generally tend to be lower than those of other parts of the world, some of the region's nations have recently seen significant economic growth. A burgeoning middle class, greater investment in infrastructure, and industries like mining, manufacturing, and agriculture have all contributed to this prosperity. But the area still has a lot of problems, such high poverty rates, poor healthcare and education standards, and limited access to essential services.

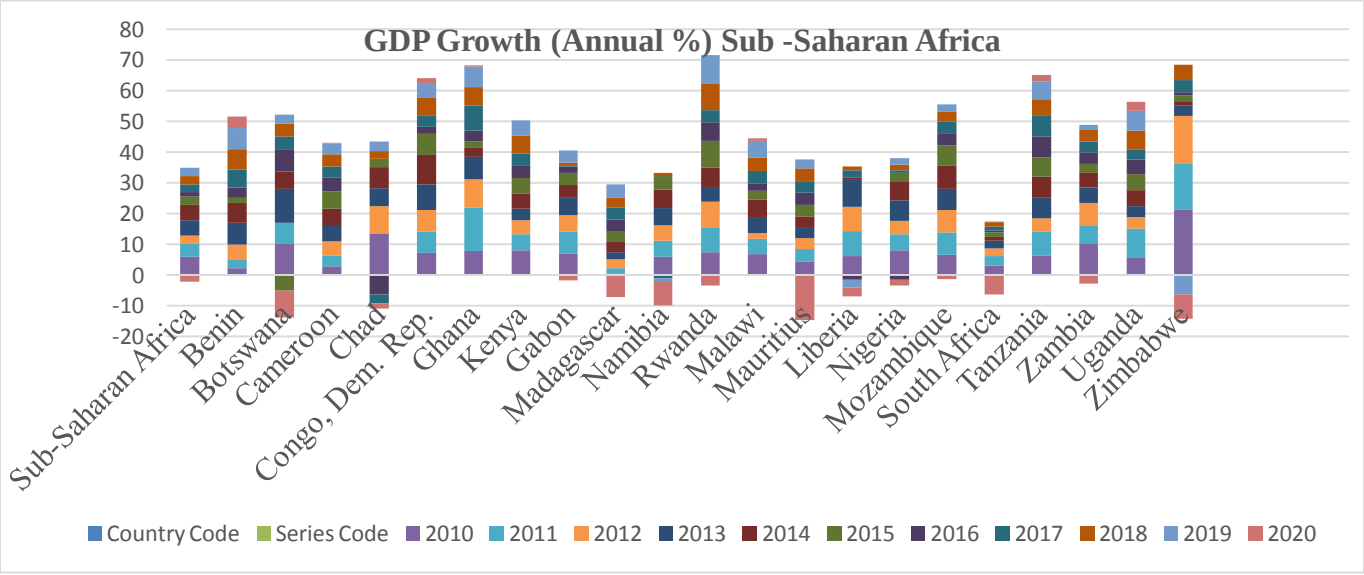


Figure 1 shows the GDP of Sub-Saharan Africa in 2021 was $1,920.90 billion, up 12.18% from the GDP in 2020. The GDP of Sub-Saharan Africa in 2020 was $1,712,28B, a 4.65% decrease from 2019. The GDP of Sub-Saharan Africa reached $1,795.74B in 2019, up 1.25% from the previous year. Botswana has the highest GDP among sub-Saharan African nations in 2021 (11.37002), followed by Rwanda (10.88452), Zimbabwe (8.46807), and Kenya (7.517355).

4.1.2 The Performance of Financial Technology in SSA

Over the past few years, sub-Saharan Africa (SSA) has experienced substantial growth and potential in financial technology, commonly known as fintech. High mobile phone penetration, rising use of digital payment methods, and the necessity to serve the region's sizable unbanked population are some of the main drivers promoting fintech growth in the area. The International Finance Corporation (IFC) said that financial investments in African fintech increased from $198 million in 2014 to $800 million in 2019. This huge expansion underlines the region's economic potential and the great demand for fintech services. Mobile money has been one of the most important areas of fintech growth in SSA.

In a region where there are more than 400 million mobile phone users, mobile money has emerged as a convenient and economical means for consumers to send and receive money, pay bills, and even access credit and savings products. This has helped the area become more financially inclusive, which is a key element in fostering economic progress.

Fintech is thought to be a means to increase accuracy and efficiency in the distribution of social security funds. Through the automation of procedures and the monitoring of data, Fintech has been utilized to increase the accuracy of social security payments. Streamlining benefits administration, it has also been utilized to increase the social security system's effectiveness. In particular, Fintech has been successful in slashing the time needed to process payments. Fintech has been viewed as a technique to increase social security payment accuracy through process automation and data tracking.

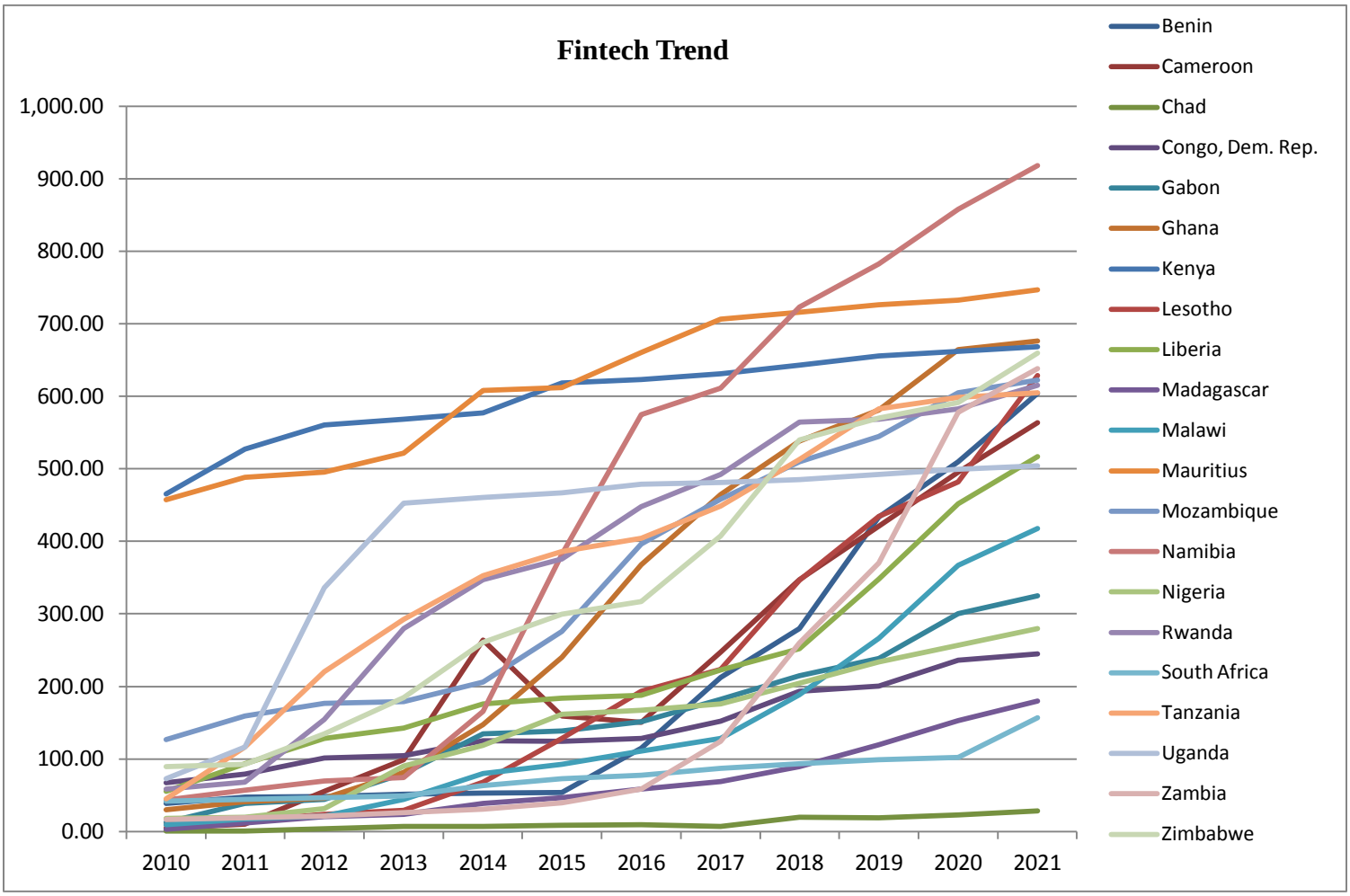


Figure 2 above illustrates that financial technology in sub-Saharan Africa significantly increased after 2012. FinTech is positively influencing the structure of the financial system in sub-Saharan Africa, even if this ratio has been gradually rising over the years. Sub-Saharan Africa is home to new technology startups that have the potential to alter the financial sector's competitive environment.

Table 2 Summary Statistic

Variable	Observation	Mean	Std. Dev.	Min	Max
FinTech Benin	12	203.9294	205.4997	38.81166	604.359
FinTech Botswana	12	4501.197	7213.506	6.642439	23780.35
FinTech Cameron	12	234.7488	188.6483	4.592093	564.0191
FinTech chad	12	11.00611	9.113284	.2491524	28.00144
FinTech Congo Rep.	12	146.3557	59.38673	67.30304	244.8028
FinTech Gabon	12	155.1123	101.7115	12.48813	325.2302
FinTech Ghana	12	323.0891	254.9039	29.85035	675.99
FinTech Kenya	12	600.1186	61.71837	465.3945	668.2542
FinTech Lesotho	12	215.1021	211.4349	9.149749	628.9268
FinTech Liberia	12	229.8234	141.5173	55.2295	517.1265
FinTech Madagascar	12	67.70215	57.25899	2.704004	180.0603
FinTech Malawi	12	145.2439	137.8897	9.140652	417.7455
FinTech Mauritius	12	622.6568	107.6559	457.5058	746.9527
FinTech Mozambique	12	354.8764	187.8506	126.5664	622.433
FinTech Namibia	12	438.3319	344.0027	43.67183	918.4345
FinTech Nigeria	12	146.3349	91.44759	17.85036	279.4404
FinTech Rwanda	12	379.5241	201.2591	58.86183	614.9872
FinTech South Africa	12	77.84356	33.09168	42.02776	156.7547
FinTech Tanzania	12	380.4807	185.3232	45.25274	605.2436
FinTech Uganda	12	403.8994	151.2978	72.44751	504.4818
FinTech Zambia	12	164.6903	230.8788	16.80222	637.9659
FinTech Zimbabwe	12	345.6451	204.8215	89.54734	659.786

Source: Compiled from secondary data

From the above table the variable name is provided in the first column of the Means Procedure table above. The observation is reported in the second column. The sample means (third column), sample standard deviations (fourth column), and maximum and minimum values (fifth and sixth columns) for each variable are listed after this.

The standard deviation demonstrates how far the value deviates from the mean. A data point with a low standard deviation tends to be extremely close to the mean, whereas one with a high standard deviation is spread out over a wide range of values .fintech companies with lower standard deviation may be viewed as more stable and predictable, while those with higher standard deviation maybe considered riskier investments.

As we can see from table 4.1 above, the mean, minimum, and maximum values of Botswana (4501.197, 6.642439 and 23780.35), Ghana (323.0891, 29.85035 and 675.99), Zambia (164.690, 16.80222 and 637.9659), Benin (203.9294, 38.81166,and 604.359) and Zimbabwe (345.6451, 89.54734, and 659.786), with a standard deviation of 7213.506, 254.9039, 230.8788, 205. 4997 and, 204.8215 respectively that indicates presence of high variation in financial technology.

The following countries exhibit low variation in financial technology: Chad (11.00611, 2491524, and 28.00144), South Africa (77.84356, 42.02776 and 156.7547), Madagascar (67.70215, 2.704004 and 180.0603), and DRC (146.3557, 67.30304 and 244.8028), Nigeria (146.3349, 17.85036 and 279.4404) and Gabon (155.1123, 12.48813 and 325.2302) with standard deviations of 9.113284, 33.09168, 57.2589, 59.38675, 61.71837, and 101.7115, respectively. The summary data demonstrate that the majority of them have low standard deviations, this means the performance of fintech in sub-Sahara countries are more stable and predictable.

4.2 Financial Technology Index

We employ a five-step process to create this new measure, and PCA is used to determine the weights given to underlying variables at each stage. PCA is a technique for reducing the dimensional of a data set while maintaining maximum variation.

Table 4.2 Eigenvalues and Eigen vectors of the variable

Principal components (eigenvectors)		
Variable	Comp1	Unexplained
New mobile money	0.6585	.1999
New credit card	0.4294	.6597
New internet banking	0.2459	.8884
New ATMs	0.5671	.4066

Source: Compiled from secondary data using stata

Table 4.2 gives us four components for four variables: mobile banking (0.6585), credit cards (0.4294), internet banking (0.2459) and ATMs (0.5671). We substitute each value of the component result on FT equation to calculate the fintech index.

$$FT_i = (0.6585)Q_1MOB_i + (0.4294)\ Q_2CD_i + (0.2459)Q_3IB_i + (0.5671)Q_4ATMs_i + e_i \ldots (1)$$

4.3 Dynamic panel-data estimation

4.3.1 Fintech and Economic growth

According to Cameron and Trivedi (2009), dynamic data introduce the need of no correlation in the errors term. We employ the Arellano and Bond test to test the model.

Table 3.3, Dynamic panel-data estimation, two-step system GMM

Dynamic panel-data estimation, two-step system GMM					
Group variable: cross id					Number of observation = 65
Time variable : year					Number of groups = 12
Number of instruments = 11					Observation per group:
min = 0					
F(7,11) = 2.41e+07					Average = 5.42
Prob > F = 0.000					max = 10
Lngdp	Coefficient.	Corrected Std Err.	t	P>|t|	[95% Conf. Interval]
L1.	.9540425	.0892656	10.69	0.000	.7575703 1.150515
L2.	.0059451	.0919499	0.06	0.950	-.1964353 .2083255
Fintech	1.82e-06	1.99e-07	9.12	0.000	1.38e-06 2.26e-06
lngcf	-.2841622	.1102243	2.58	0.026	-.5267642 -.0415602
lnlp	.08417	.0120453	6.99	0.000	.0576586 .1106815
Lnpos	.0342575	.0147778	2.32	0.041	.0017319 .0667832
lngni	-1.565169	.2163921	7.23	0.000	1.141048 1.98929
Arellano-Bond test for AR(1) in first differences:				z = -1.99	Pr > z = 0.047
Arellano-Bond test for AR(2) in first differences;				z = -1.81	Pr > z = 0.070
Sargan test of overid. Restrictions				chi2(3) = 5.48	Prob > chi2 = 0.140
Hansen test of overid. Restrictions				chi2(3) = 7.58	Prob > chi2 = 0.056

Notes: (*) Significant at 10%, (**) significant at 5 %(***), significant at 1%, and not significant

Source; Authors' computation using stata

To make sure the model is valid; there should be fewer instruments in a study than there are groups. The fact that there are 11 instruments in this study as opposed to 12 groups' shows the validity of our concept. Therefore, as demonstrated in table 4.3, the lagged dependent variables of GDP, gross capital creation, labor productivity, political stability, and gini coefficient have a sizable impact on GDP. The initial lag of the GDP has a positive coefficient and is significant at

a 1% level of significance for the lagged dependent variables. It implies that stronger prior GDP results will result in higher current GDP.

As a result of the model's output, fintech has a positive relationship with GDP at 1% significance level and 1% increase in fintech increase SSAs economic growth by 0.02%. The findings are in line with those made by Kouladoum et al. (2022) and Myovella et al. (2020), who found that digitalization and fintech has a positive effect on economic growth and as it has developed, financial inclusion has increased in Sub-Saharan African countries. Fintech can aid in lowering the price and duration of financial transactions and also the results of the theoretical study show that an economy will constantly advance due to technological advancement (Kireyeva et al, 2021).

From the coefficient of labor productivity we can conclude that a unit increase in labor productivity leads to a 0.8 increase in GDP and it statistically significant at 1% significance level and also a unit increase in political stability leads to a 0.3 increase in GDP and it is statistically significant at 5%.

From the above coefficient of gross capital formation we can state that a unit increase in gross capital formation leads to a decline in GDP by 0.2 and it is statistically significant at 5% and a unit increase gini coefficient leads to a decline in GDP by 1.5 and it is statistically significant at 1%. As higher gini coefficient is associated with higher income inequality the negative relationship between the variables shows that the dispersion of income inequality among countries should be small.

We should anticipate that at 5%, Ar(2)(pr > z) probability will not be significant. This will formally demonstrate that the errors lack serial auto-correlation. Ar(1) ought to be significant at 5% in a typical situation (AR(1) pr > z >0.05). However, we shall employ AR(2) to reject that null hypothesis. When pr > z is more than 0.05 and the mistakes term is not serially correlated, this rejection holds true. Since the p-value is greater than 0.05 and the model's results indicate that there is no autocorrelation, we can accept the null hypothesis that there is no second-order autocorrelation.

The Sargan and Hansen tests demonstrate the validity of the model's instruments, and since the p-values for both tests are higher than 0.05, we accept the null hypothesis that the over-identifying limitations are true.

4.4 Long run GMM estimates

Table 4.4 Long run GMM estimates

nlcom (_b[fintech])/(1-_b[l1.lngdp])
_nl_1: (_b[fintech])/(1-_b[l1.lngdp])

lngdp	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
_nl_1	6.88e-06	3.27e-06	2.10	0.035	4.68e-07 .0000133

Source; long run estimation

Although having substantial effects on GDP both in the short and long terms, the variable is still significant. Financial technology's predictions for the future indicate that the variable is significant in the long run.

A unit change in financial technology over the long term is correlated with 0.367% increases in GDP, ceteris paribus and it is significant at a 5% significance level. So there is also a positive relationship between GDP and fintech. At a 5% significance level, ceteris paribus, a change in financial technology over the long term is connected with an increase in GDP in 0.365%.

4.5 Unit root test

We applied the Fisher-type test, which Maddala and Wu (1999) developed, to assess the model's stationarity. This test includes the p-values from N-independent unit root tests. Fisher's test pits the null hypothesis that no series in the panel is stationary against the alternative that at least one series in the panel is stationary based on the p-values of individual unit root test.

Table 4.5 Unit root test

Fisher-type unit-root test for lngdp			
Ho: All panels contain unit roots			Number of panels = 22
Ha: At least one panel is stationary			Number of periods = 12
AR parameter: Panel-specific			Asymptotics: T -> Infinity
		Statistic	p-value
Inverse chi-squared(42)	P	81.7719	0.0005
Inverse normal	z	-1.9495	0.0256
Inverse logit	L*	-2.4297	0.0083
Modified inv. chi-squared	Pm	4.0265	0.0000

Source; Authors' calculation

This test's null hypothesis is that all panels have a unit root. We reject the hypothesis in light of our findings. If we examine the tests P, Z, L*, and Pm, we obtain a value for these test statistics (81.7719, -1.9495, -2.4297, and 4.0265), and the p-value is displayed in the next column. They are all less than 0.05, therefore we can rule out the null hypothesis at the 5% level of statistical significance. Therefore, under the specified test parameters (including panel means and temporal trend), there are no unit roots in our panels.

4.6 Heteroskedasticity Test

Table 4.6. Heteroskedasticity Test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho: Constant variance	
F(5 , 78)	1.17
Prob > F	0.3306

Source: Heteroskedasticity test

The Breusch-Pagan-Godfrey test has been developed to make sure that this assumption is still valid. For the test statistic to be considered valid, the chi-square (2) and F-versions' p-values must both be greater than 0.05. From above table 4.3, the p value is great than the significant level (0.05), we accept the null hypothesis and conclude that there is no evidence of heteroskedasticity in the model.

4.7 Co-integration test

In terms of economics, two variables will be co-integrated if they have long-term relationships. Specifically, co-integration suggests that there is a long-term relationship between economic variables.

To ascertain whether there is a long-term link between variables in panel data, we use the Westerlund (2008) panel data co-integration test. Alternative and null hypotheses: Co-integration is assumed to be absent in the null hypothesis (H0), whereas co-integration is assumed to be present in the alternative hypothesis (H1). The p-value associated with the test statistic, which is computed using the Westerlund test, indicates how strong the evidence is against the null hypothesis. A little p-value that is less than the selected level, usually 0.05 as a comparison to the test's value, if the test statistic is higher than the critical value; it provides evidence to reject the null hypothesis.

Table 4.7. Co-integration tests

wasteland test for cointegration		
Ho: No cointegration	Number of panels = 22	
Ha: Some panels are cointegrated	Avg. number of periods = 11.955	
Cointegrating vector: Panel specific		
Panel means: Included		
Time trend: Not included		
AR parameter: Panel specific		
	Statistic	p-value
Variance ratio	-3.4923	0.0002

Source; Co-integration test

Table 4.5, summarizes the results of the Westerlund panel co-integration test and shows that the model is significant at the 5% level. This implies that the model's co-integration null hypothesis cannot be rejected. Therefore, the findings support the hypothesis that fintech and economic growth in sub-Saharan Africa have a long-term co-integration relationship.

4.8 Granger Causality test

Table 4.8 Granger causality test

Juodis, Karavias and Sarafidis (2021) Granger non-causality Test					
Number of units= 22 Obs. per unit (T) = 10					
Number of lags = 2 BIC = 337.2713					
JKS non-causality test					
H0: FinTech does not Granger-cause GDP.					
H1: FinTech does Granger-cause GDP for at least one panelvar.					
HPJ Wald test : 3.2e+12					
p-value : 0.0000					
BIC selection:					
lags = 1, BIC = 487.97419					
lags = 2, BIC = 337.27132*					
Results for the Half-Panel Jackknife estimator					
Cross-sectional heteroskedasticity-robust variance estimation					
FinTech	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]
L1.	.00176	2.49e-07	-7071.98	0.000	-.0017605 -.0017596
L2.	.0032624	1.01e-07	3.2e+04	0.000	.0032622 .0032626

Source: Causality test

The Granger non-causality Test was also utilized in this study to examine the causal relationships between the variables. This test was created by Juodis, Karavias, and Sarafidis (2021). As you can see, the null hypothesis that fintech does not affect GDP is rejected at the 5% level of significance. According to the BIC, two lags are the optimum number. The het option requests that the cross-sectional heteroskedasticity-robust standard error computation be performed. Along with the Wald test statistic, the command also provides regression results for the HPJ bias-corrected pooling estimator. Any two variables' relationship reveals the direction of their causality. The results show a causal link between fintech and economic growth in both directions. Therefore, an expansion in fintech will spur economic growth in sub-Saharan Africa, and vice versa. This conclusion is further supported by studies conducted in 2022 by Badwan et al. and Emmanuel et al., which show that FinTech products have a long-term causal relationship with both economic growth and financial development.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Fintech has a significant impact on the economic growth of sub-Saharan African countries. Fintech has emerged as a powerful tool for enhancing financial inclusion, promoting economic efficiency, and driving innovation in the region's financial sector. Traditional banking services have been limited in their reach, leaving a significant portion of the population unbanked or under banked. Fintech solutions, such as mobile money platforms, have provided accessible and affordable financial services to previously underserved individuals and businesses.

Moreover, Fintech has played a crucial role in enhancing economic efficiency. Digital payment systems, for instance, have facilitated faster and more secure transactions, reducing the cost and time associated with traditional methods. Fintech platforms have streamlined processes such as remittances, bill payments, and peer-to-peer transfers, resulting in increased efficiency and productivity. This has further stimulated economic growth by creating a favorable environment for trade, commerce, and investment. Our findings state that Fintech is a significant contributor to SSA's economic growth. There is a bidirectional causal relationship between fintech and economic growth, with an increase in fintech raising SSA's economic growth by 0.02%.

Sub-Saharan Africa's (SSA) financial industry could undergo a fundamental transformation thanks to fintech, which offers new opportunities to improve accessibility, effectiveness, and inclusiveness. Despite challenges such a lack of infrastructure, regulatory frameworks, and financing, fintech enterprises in SSA are growing swiftly and gaining prominence. The COVID-19 outbreak has accelerated the use of Fintech solutions in SSA at the same time that more people are depending on online financial services.

Fintech has lowered the price of remittances and made cross-border transactions easier. Remittances are a substantial source of income in the SSA, an area with a high rate of migration. The development of digital trade in SSA has been aided by fintech. In SSA, the e-commerce sector is expanding, but using conventional payment methods has proved difficult.

5.2 Recommendation

Financial technology, or fintech, has the potential to have a big impact on economic growth in Sub-Saharan African (SSA) nations. Fintech innovation thrives in the region because to its high mobile penetration and limited access to traditional banking services. However, it is essential to put supportive rules and regulations in place if you want to fully profit from Fintech. This policy suggestion offers important tactics for utilizing fintech to stimulate economic growth in SSA nations.

- Establish flexible and accommodating regulatory environments that stimulate innovation while safeguarding consumers and advancing financial stability are important for governments to do. This includes setting precise rules for electronic signatures, digital identity verification, and customer data security.
- Encourage cooperation between financial institutions, telecom companies, and Fintech companies to develop interoperable platforms that enable seamless and cheap financial services. This would guarantee that people and companies can easily access and conduct business on various Fintech platforms.
- Invest in digital infrastructure: To increase access to Fintech services in remote and underserved areas, governments should give priority to investments in digital infrastructure, such as dependable internet connectivity and mobile network coverage.
- Promote regional integration by facilitating communication and information exchange amongst SSA nations in order to align Fintech laws, norms, and practices. This support regional economic integration and promote cross-border Fintech services.
- Promote international cooperation: Promote coordination between SSA nations and foreign agencies, aid agencies, and Fintech hubs in other areas. This makes it possible to transfer technology, exchange expertise, and have access to international Fintech best practices.
- Promote financial literacy by putting in place financial education initiatives that give people the information and abilities they need to comprehend and use Fintech goods and services. Customers will be better equipped to manage their finances and guard against any hazards as a result.

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Appendix

Constructing financial technology index

```
. pca newmobilemoney newcreditcard newinternetbanking newatms, components(1) covariance

Principal components/covariance                 Number of obs    =        264
                                                Number of comp.  =          1
                                                Trace            =          4
    Rotation: (unrotated = principal)           Rho              =     0.4614
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.8454	.857889	0.4614	0.4614
Comp2	.987513	.152921	0.2469	0.7082
Comp3	.834593	.502101	0.2086	0.9169
Comp4	.332492	.	0.0831	1.0000

Principal components (eigenvectors)

Variable	Comp1	Unexplained
newmobilem~y	0.6585	.1999
newcreditc~d	0.4294	.6597
newinterne~g	0.2459	.8884
newatms	0.5671	.4066

We substitute each value of the component result on FT equation to calculate the fintech index.

$$FT_i = (0.6585)Q_1MOB_i + (0.4294)\ Q_2CD_i + (0.2459)Q_3IB_i + (0.5671)Q_4ATMs_i + e_i$$

Where,

WMM: - weight of mobile money

WNCC: - Weight of credit card

WNBT: - Weight of internet banking

WATM: - Weight of ATMS

FT: - Composite of financial index

WMM	WNCC	WNBT	WATM	FT
35.75	0.888958	0.75	1.427151	38.81
41.47	1.342649	3.23	1.630268	47.67
41.17	1.351203	3.6	2.036076	48.16
42.41	1.427604	4.88	2.545218	51.26
42.81	1.524207	6.26	2.564206	53.17
43.06	1.756727	6.52	2.607518	53.94
103.29	1.877185	7.01	2.748024	114.92
200.89	1.906276	6.7	2.770488	212.27
265.73	1.964178	9.33	2.776135	279.8
416.6	2.421302	11.62	2.779385	433.42
491.5	2.487168	12.58	2.804646	509.37
577.24	2.508248	21.79	2.82733	604.36
1.43	3.747649	0.32	1.148796	6.64
80.72	4.606449	0.51	1.472475	87.31
153.18	9.553853	177.4	1.562649	341.7
250.44	15.22096	296.77	1.647379	564.08
353.49	19.98314	394.59	1.719173	769.78
340.35	24.89392	313.44	1.875952	680.56
409.55	25.57155	1,161.78	1.914302	1,598.82
492.63	26.84143	1,362.43	2.008443	1,883.91
525.34	29.69502	2,089.13	2.524029	2,646.69
605.08	30.94573	9,504.02	2.553302	10,142.60
617.57	32.30735	10,859.39	2.665136	11,511.93
630.36	34.74517	23,112.53	2.716175	23,780.35
2.42	0.703089	0.45	1.019928	4.59
5.39	0.788974	2.66	1.328435	10.17
25.8	0.793271	27.34	1.46427	55.4
76.19	1.028544	19.86	1.791075	98.88
89.25	1.075807	171.45	2.031108	263.81
108.88	1.1348	46.59	2.233319	158.84
70.15	1.160031	76.93	2.431094	150.67
163.27	1.193834	80.44	2.480892	247.38
227.97	1.429554	115.05	2.558316	347.01
297.89	1.623732	118.54	2.61219	420.67
362.61	1.628026	128.44	2.857692	495.54
424.07	1.670366	138.2	0.078902	564.02
0	0.004877	0	0.240789	0.25
0.02	0.043523	0.04	0.268153	0.37
0.03	0.052111	3.23	0.280761	3.59
0.06	0.077875	6.26	0.314085	6.71

0.16	0.08449	6.25	0.320628	6.81
0.22	0.088555	7.78	0.485376	8.57
0.29	0.128628	7.89	0.639641	8.95
0.45	0.152434	6.05	0.638988	7.29
10.14	0.152479	8.53	0.651389	19.47
9.38	0.185769	8.7	0.701892	18.97
12.07	0.237297	9.95	0.825865	23.08
15.27	0.31467	11.59	0.831073	28
5.55	0	61.48	0.276658	67.3
8.51	0.006943	70.26	0.370584	79.15
10.71	0.008454	90.04	0.409129	101.18
13.42	0.011169	90.04	0.628076	104.11
32.15	0.02167	92.39	0.630982	125.18
28.5	0.027256	94.85	0.680142	124.06
30.34	0.03155	97.18	0.766516	128.32
48.97	0.032329	102.4	0.794435	152.2
85.35	0.036881	106.89	0.877036	193.16
90.76	0.04294	108.53	1.258045	200.59
120.44	0.051528	114.41	1.307483	236.21
127.68	0.055822	115.64	1.420902	244.8
1.92	0.044661	8.68	1.844876	12.49
8.64	0.53386	27.05	2.233416	38.46
12.62	1.168622	27.92	2.864502	44.57
13.76	1.38985	61.54	3.033641	79.73
62.21	1.70968	67.65	3.18889	134.77
63.54	1.812722	70	3.233366	138.59
66.76	2.437606	78.6	3.755848	151.56
85.58	2.44663	90.16	4.225606	182.42
115.35	2.480557	92.98	4.284298	215.1
135.82	2.53107	95.26	4.625947	238.23
192.76	2.904645	99.65	4.898394	300.21
212.47	2.960436	104.85	4.955104	325.23
2.85	0.043859	24.76	2.193828	29.85
13	0.129739	25.38	2.266172	40.77
14.31	0.224207	27.92	3.040421	45.5
40.01	0.348543	36.95	4.502297	81.81
99.24	0.394498	43.06	4.526186	147.23
186.25	0.534027	47.87	5.099579	239.76
310.12	0.658313	52.06	5.059702	367.89
404.36	0.726225	54.61	4.700128	464.4
462.86	0.771887	69.59	5.395929	538.62

499.76	0.859998	75.12	5.185014	580.92
577.85	0.872876	80.26	5.359732	664.34
588.57	0.924593	81.2	5.291698	675.99
455.57	1.615218	3.22	4.98825	465.39
515.26	2.139699	4.34	5.09853	526.84
547.16	2.338185	5.58	5.327485	560.41
553.82	2.597865	6.87	5.379648	568.67
560.45	3.298399	8.26	5.464454	577.47
599.65	3.518335	9.77	5.503523	618.45
601.14	3.891915	12.95	5.536175	623.51
608.47	4.075465	13.16	5.540688	631.24
619.74	4.181668	13.82	5.548628	643.29
631.48	4.266019	14.15	5.604058	655.49
638.02	4.397553	14.37	5.608869	662.39
642.11	4.915039	15.62	5.615541	668.25
0.17	0.110448	8.82	0.045557	9.15
1.4	0.524946	12.1	0.490914	14.51
4.26	0.913487	18.68	0.002472	23.85
6.94	1.053116	20.19	0.567309	28.75
42.45	1.342887	23.6	0.633018	68.02
101.29	1.917216	24.25	0.736146	128.19
165.28	2.336706	24.61	0.77822	193.01
193.25	2.772453	26.75	0.783873	223.56
311.38	3.217014	30.93	0.794389	346.33
374.66	3.804754	55.46	0.799863	434.72
400.2	4.2687	76.94	0.806154	482.21
508.78	4.591148	114.74	0.815535	628.93
2.64	2.524829	49.28	0.787516	55.23
3.4	2.892739	86.14	0.788412	93.22
6.27	5.164454	115.65	0.824372	127.91
13.94	5.583922	121.85	0.930962	142.31
26.08	6.012897	142.73	1.016138	175.84
28.39	6.442119	147.67	1.138666	183.64
31.64	6.983592	147.79	1.535724	187.95
59.62	7.602992	154.1	1.545624	222.87
78.64	8.182674	163.52	1.918868	252.27
169.1	8.612074	167.84	2.017632	347.57
268.76	9.188902	171.96	2.068486	451.97
327.09	9.812643	178.09	2.130753	517.13
0.96	0.002462	0.95	0.792783	2.7
4.63	0.002462	5.89	0.886277	11.41

6.96	0.002462	12.22	0.972173	20.16
7.07	0.002462	15.44	1.021002	23.53
19.08	0.053101	18.37	1.161042	38.67
25.35	0.056107	19.75	1.295226	46.45
35.66	0.081871	21.53	1.447403	58.72
45.19	0.093191	21.71	1.585539	68.59
64.48	0.105899	23.08	1.66688	89.34
92.56	0.122746	25.35	1.734871	119.77
99.2	0.131718	51.92	1.776747	153.02
105.55	0.146364	71.97	2.400557	180.06
2.26	0.059571	5.09	1.730317	9.14
3.63	0.06485	11.58	2.228218	17.51
4.37	0.086999	14.22	2.518395	21.19
23.8	0.172835	17.14	2.711794	43.82
58.52	0.258759	18.25	2.863729	79.89
70.53	0.281568	18.59	2.954167	92.35
87.63	0.298787	19.81	2.8065	110.55
100.01	2.86015	22.82	2.817395	128.51
159.06	3.332488	23.51	2.820551	188.72
234.15	3.375431	25.88	2.829188	266.23
330.86	3.796242	29.78	2.829755	367.27
364.59	3.718971	46.6	2.835427	417.75
421.21	4.384264	29.59	2.318368	457.51
432.38	6.06327	47.16	2.343686	487.95
436.46	6.913434	49.62	2.383399	495.38
445.93	21.60741	52.06	2.415732	522.01
485.8	43.54601	76.65	2.462783	608.46
462.05	60.86371	86.49	2.513792	611.92
469.76	99.47536	88.72	2.545162	660.5
505.3	106.3777	92.13	2.554482	706.37
513.18	107.2675	93.03	2.585691	716.06
513.88	111.5258	98.16	2.637173	726.2
517.27	112.0724	100.59	2.642019	732.58
518.52	122.58	103.18	2.674811	746.95
79.66	3.172632	40.48	3.255144	126.57
111.23	3.176687	40.9	3.686115	158.99
123.62	3.379226	45.68	3.992817	176.67
123.29	3.459027	47.61	4.403043	178.76
149.41	3.780157	47.85	4.66176	205.7
181.12	3.951957	86.16	4.688663	275.93
253.54	3.974506	133.88	5.104211	396.5

277.32	4.051322	171.37	5.113332	457.85
322.23	4.09371	178.1	5.229309	509.65
350.26	4.187275	184.6	5.239367	544.28
407.23	4.203868	188.49	5.263082	605.19
415.73	4.510944	196.53	5.665714	622.43
7.1	6.447036	28.44	1.679676	43.67
8	8.194694	38.83	1.773581	56.8
10.58	8.428848	48.15	2.813598	69.97
11.12	8.471447	51.54	3.040039	74.17
89.14	11.72458	61.39	3.215245	165.47
291.2	15.41597	72.3	3.308059	382.22
479.07	19.03344	72.63	3.840128	574.58
413.76	107.025	86.18	3.993886	610.95
491.78	127.603	99.88	4.10834	723.37
497.38	140.4887	140.83	4.103997	782.8
554.65	148.3612	150.39	4.127419	857.53
579.13	171.8508	163.31	4.139334	918.43
13.23	0.172263	3.81	0.636618	17.85
13.72	0.339734	5.02	0.643296	19.72
24.04	0.690294	6.05	0.65177	31.44
47.55	1.111847	40.88	0.698208	90.24
47.02	1.184906	69.31	0.918037	118.44
52.97	1.188765	106.75	0.919347	161.82
53.83	1.214913	111.32	0.926552	167.29
58.63	1.228082	114.95	0.931645	175.74
64.01	1.245211	137.92	0.937431	204.11
88.78	1.270595	142.36	0.970016	233.38
105.96	1.288042	148.33	0.972389	256.55
127.01	1.442027	150.01	0.978513	279.44
36.95	0.023864	21.08	0.811653	58.86
44.85	0.032452	21.56	1.570612	68.02
93.22	0.041831	58.22	2.670739	154.16
175.25	0.056876	101.3	2.969052	279.57
232.47	0.166145	111.65	3.1877	347.48
245.89	0.22156	126.4	3.19058	375.7
315.22	0.226185	129.62	3.200843	448.26
346.54	0.2632	141.92	3.210179	491.94
415.76	0.340374	144.7	3.281672	564.08
407.01	0.379919	157.54	3.309421	568.24
418.16	0.38441	161.06	3.380209	582.99
438.15	0.411829	173.04	3.385654	614.99

0.78	2.383544	37.06	1.81038	42.03
1.13	3.328263	38.23	1.817742	44.5
2.13	3.371594	39.06	1.821434	46.39
4.27	3.374983	39.58	1.830675	49.05
15.92	3.728166	41.62	2.02792	63.3
19.12	3.809756	48.1	2.062057	73.09
19.76	3.852662	51.58	2.067245	77.25
26.62	3.856998	54.41	2.110824	86.99
31.14	5.780664	54.66	2.113917	93.69
33.39	6.339309	56.87	2.200742	98.79
34.37	6.382726	59.32	2.20641	102.28
70.94	8.161859	75.32	2.332487	156.75
27.87	0.216888	14.85	2.308232	45.25
96.32	0.219401	17.31	2.701158	116.56
199.88	0.224806	17.56	2.975784	220.64
271.3	0.26775	17.81	3.236397	292.61
330.77	0.310686	18.03	3.309802	352.42
362.53	0.323572	19.75	3.355057	385.96
377.69	0.326975	22.7	3.412345	404.14
421.94	0.361326	23.2	3.526319	449.03
485.19	0.365664	23.65	3.588706	512.8
554.18	0.404266	24.25	3.978298	582.81
569.23	0.417148	24.33	4.319706	598.3
575.83	0.425297	24.44	4.5454	605.24
67.16	0.657368	2.57	2.057704	72.45
110.93	0.700308	2.75	2.199251	116.58
329.72	0.702777	3.36	2.394313	336.17
444.45	0.715407	5.34	2.471764	452.99
450.65	0.719953	6.39	2.526818	460.28
455.29	0.738249	8.58	2.573137	467.18
463.87	0.84448	11.55	2.574914	478.84
465.09	0.995889	12.32	2.663182	481.06
466.17	1.009798	15.46	2.691082	485.33
470.7	1.036857	17.7	2.696496	492.13
477.21	1.037583	18.27	2.785629	499.3
479.27	1.048068	21.33	2.842395	504.48
1.17	0.088199	13.94	1.598279	16.8
1.72	0.105375	14.9	1.716491	18.44
4.31	0.118257	15.24	1.860342	21.53
7.35	0.126845	16.81	1.906922	26.2
11.47	0.135433	17.34	1.971525	30.91

19.27	0.161197	17.61	2.017349	39.06
38.72	0.165651	17.87	2.067859	58.82
103.82	0.202981	18	2.147473	124.18
237.36	0.315808	20.23	2.186021	260.09
322.1	0.404744	23.49	2.454124	637.97
550.85	0.425152	24.04	2.283928	577.6
608.6	0.465699	26.45	2.454124	637.97
70.09	0.199531	16.75	2.500541	89.55
71.54	0.482526	17.96	2.56137	92.55
110.93	0.485777	20.61	2.750083	134.78
160.09	0.524095	21.03	2.837906	184.48
234.51	0.587273	22.84	2.958611	260.89
268.54	0.855674	26.62	3.274065	299.29
281.59	0.914853	30.88	3.475917	316.86
371.6	0.931211	31.66	3.530369	407.72
486.09	0.942683	49.56	3.628383	540.23
508.67	1.279525	56.54	3.664539	570.16
513.95	1.528514	72.25	3.722952	591.45
570.46	1.970796	83.47	3.891326	659.79