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The Causal Relationship between FinTech, Financial Inclusion, and Income Inequality in African Economies

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Abstract: Income inequality is one of the biggest problems affecting developing economies. Market imperfections and information asymmetry lead to lack of access to the financial system, which will exacerbate income inequality. The growing adoption of FinTech (financial technology) has altered the structure of how financial services are delivered and makes these services accessible to underserved groups. This study explores the causal relationship between FinTech development, financial inclusion, and income inequality in a panel study of 29 African countries. We apply pooled OLS regression and structural equation models to samples from the years 2011, 2014, and 2017. The findings indicate that FinTech has a positive and statistically significant effect on financial inclusion and income inequality in African countries. The study results also demonstrate that financial inclusion plays a pivotal mediation role in the negative effect of FinTech on income inequality in African economies. Further, financial inclusion (the ability to create a bank account and borrow money) negatively and significantly affects income inequality in African countries, whereas saving shows a positive and significant impact on income inequality. Overall, our study results suggest that to reduce income inequality and increase the effectiveness of FinTech investments, policymakers in African countries should design proper policies to enhance financial inclusion and offer more accessible and equitable financial services.

Keywords: fintech; financial inclusion; income inequalities; pooled OLS regression; SEM; Africa

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1. Introduction

One of the main challenges that developing economies face is growing income inequality. Research studies relate inequality with various socio-economic issues such as the decline of innovation and capital investments, slowing economic growth, as well as rising violence, a decline in social mobility, and healthcare issues (Polacko 2021). Despite the attempts made to promote inclusive growth and reduce income inequality and poverty, most developing countries—particularly African nations—continue to struggle to meet the fundamental needs of their citizens and to close income disparity gaps. Thus, income inequality has become one of the main issues for each country and for international organizations in general. For instance, minimizing income disparities within and among countries is one of the United Nations' 2030 Sustainable Development Goals (SDGs).

The development of financial services contributes to sustainable economic growth through increasing productivity and enhancing access to capital for investment activities (Beck and Levine 2004; Hunjra et al. 2022). However, market frictions and inefficient allocation of resources may undermine the effect of the financial sector and lead to the exclusion of some businesses and individuals from the formal financial system (Demir et al. 2020). Spreading access to financial services is one of the tools for reducing poverty and income inequality by opening previously restricted advancement prospects for disadvantaged sectors of the population (Omar and Inaba 2020). However, most people in developing

nations—notably those in sub-Saharan Africa—are involuntarily prevented from accessing formal financial services for long periods of time. The lack of initial investment, distance to the nearest financial institution, or lack of documentation are some of the reasons for the exclusion of billions of people in developing countries from formal financial system services (World Bank 2022). This exclusion of millions of people from formal financial services potentially results in the loss of the advantage of savings, investable money, and capital asset-building opportunities. Thus, underserving the financial needs of millions of entities and individuals is associated with an unfair and unequal distribution of economic growth (Demir et al. 2020). The prior literature shows that enhancing financial inclusion is one of the keys enablers for achieving sustainable economic development and reducing income inequalities in most developing countries (Atadouanla Segning et al. 2023; Menyelim et al. 2021; Omar and Inaba 2020; Polloni-Silva et al. 2021; Soro and Senou 2023). Similarly, Pazarbasioglu and Mora (2020) argued that countries with deeper and more technologically advanced financial systems achieve better economic growth, lower levels of poverty, and decreased low-income disparities.

Close to one-third of adults—1.7 billion—were still unbanked in 2017, of which the majority live in developing countries, especially in Africa (World Bank 2021). However, evidence shows that the recent expansion and adoption of technological advancements in financial services enhances financial inclusion and brings an opportunity for the unbanked communities to access basic financial services easily through mobile banking technology. For instance, the recently developed mobile banking technology has increased global financial inclusion by 8% between 2017 and 2021 (World Bank 2022). Also, existing studies document that the recent adoption of financial technology plays a pivotal role in reducing financial exclusion and income inequalities (Demir et al. 2020; Chinoda and Mashamba 2021; X. Zhang et al. 2020). Thus, financial inclusion provides the opportunity for enhanced economic growth and equitable income distribution among different population groups.

Although African economies have achieved impressive economic growth over the past twenty years, they still experience a significant level of income inequality (Ofori et al. 2022). On the other hand, even though the financial system of African countries falls below the standards of other developing nations, the inclusion of financial services has become one of Africa's most remarkable success stories over the past decade. In addition to this, the adoption and use of FinTech application systems in Africa have shown notable growth in the last decade (Yermack 2018). Given Africa's historical progress in these economic indicators over the past decade, it has become important to examine the causal relationship between income inequality, financial inclusion, and FinTech adoption.

Despite growing academic and practitioner interest in the relationship between FinTech, financial inclusion, and income inequality, previous studies provide mixed and inconclusive evidence. The literature has established that advancements in FinTech increase financial inclusion in global financial systems; however, how FinTech impacts inequality is unclear. In addition, the impact of FinTech on inequality and financial inclusion has been relatively underexplored in the context of African countries. We discuss the literature in more detail in the next section. This study aims to examine the causal relationship between FinTech, financial inclusion, and income inequalities in the selected African economies using pooled ordinary least squares (OLS) regression techniques and structural equation models.

We use balanced macro panel data from twenty-nine African countries for the years 2011, 2014, and 2017, based on the availability of FinTech measures. First, we estimate the effect of FinTech on income inequality and the impact of FinTech on financial inclusion using an OLS estimation model. We find that FinTech and income inequality are positively associated in African economies. We also find that financial inclusion, such as the ability to open an account and to borrow higher amounts, leads to lower inequality in Africa. We employ a structural equation model to analyze the channels through which the effect of FinTech on financial inequality flows. We focus on financial inclusion variables. We show that financial technology significantly and positively drives financial inclusion in Africa.

This indicates that FinTech enables financial inclusion in African countries. The indirect relationship regression analysis shows that FinTech helps to reduce income inequality by boosting financial inclusion. Our findings imply that policymakers and regulators should design policies that enhance financial inclusion, such as easier and broader access to FinTech applications, and invest in financial infrastructure to ensure that the growing use of FinTech tools helps to reduce income inequality. The rest of the paper is organized as follows: Section 2 provides the relevant literature on the FinTech, financial inclusion, and income inequality causal relationship. Section 3 describes the research materials and methods used in the study. Section 4 presents the discussion of the study analysis results. Finally, Section 5 provides conclusions.

2. Literature Review

In this section, we review the relevant literature on the relationship between FinTech, financial inclusion, and income inequality. We specifically review the relationships between FinTech and income inequality; FinTech and financial inclusion; and financial inclusion and income inequality.

2.1. FinTech and Income Inequality

The traditional financial system fails to provide equitable credit services to the economy's clients, resulting in unequal income distributions and a detrimental impact on economic growth. Therefore, reforming the financial sector's services should be crucial for reducing income disparities and boosting economic development (Stiglitz 2016). The emergence of "FinTech" has revolutionized the industry in recent years, presenting the promise of reducing the credit gap in economic opportunities (Bazarbash and Beaton 2020). If FinTech enhances the equitable distribution of financial product services in the economy, it has the potential to reduce income disparities by enabling disadvantaged people and small businesses to engage in economic production activities through facilitating credit access.

The relationship between FinTech and income inequality is scarcely researched. A few studies on the relationship between FinTech and income inequalities argue that FinTech is linked with the reduction of income inequalities. For instance, Asongu and Nwachukwu (2018) and Asongu and Odhiambo (2019) establish a direct relationship between FinTech and income inequality. They show that the development of FinTech services, such as the use of mobile banking to pay bills, significantly reduces income inequality in developing countries and plays a significant role in responding to other challenges of inclusive development. Similarly, X. Zhang et al. (2020) conclude that the expansion of Chinese financial technology improves access to financial services for poor people in rural areas, while at the same time helping to reduce income gaps between urban and rural residents. Appiah-Otoo and Song (2021) examined the effects of financial technology and credit on poverty using data from 31 Chinese provinces between 2011 and 2017. Their findings support the notion that FinTech helps to reduce poverty by fostering financial development and economic growth. Moreover, Hodula (2023) investigates the impact of FinTech and big tech credit on income inequalities in a panel data set of 78 countries from 2013–2019 and concludes that FinTech and other big tech developments are linked with a reduction in income inequality. In contrast, Saraswati et al. (2020) show that FinTech development increases income inequality in Indonesia using the partial adjustment model from 1990–2017. This may be due to the fact that FinTech by itself requires prerequisite initial investments for its utilization, such as knowledge, smart phones, ICT infrastructure, electricity, and capital. In fact, fulfilling such a prerequisite initial investment is difficult in developing countries, especially in Africa, where most of the people are rural residents and their income level is very low. As a result, those poor people may be unwillingly excluded from using FinTech services; but still, FinTech will benefit the rich class of people, which will aggravate income inequality. Rather, FinTech has the potential to achieve better economic growth, lower levels of poverty, and decreased income disparities in countries with deeper and more technologically advanced financial systems (Pazarbasioglu and Mora 2020). On the other

hand, other studies argue that there are mechanisms with which FinTech minimizes income inequality indirectly through financial inclusion (Demir et al. 2020; Chinoda and Mashamba 2021). Given that the empirical literature on the relationship between FinTech and income inequality is limited, and the existing evidence provides mixed results, we believe that there is a need for further investigation to strengthen the existing literature. Thus, taking into consideration the existing literature, we develop the following hypotheses to contribute additional information on the FinTech–income inequality relationship:

H1a: *FinTech significantly decreases income inequality in African countries.*

H1b: *FinTech significantly increases income inequality in African countries.*

H2: *FinTech significantly reduces income inequality in African countries via financial inclusion.*

2.2. FinTech and Financial Inclusion

Financial innovations (FinTech)—such as automated teller machines (ATMs), mobile payment systems, mobile wallets, internet banking, and blockchain technology—have been a recent development in the financial sector, leading to the digitalization of financial services. The recent adoption and development of FinTech tools provides consumers with easy access to financial services, fast and easy confirmation of financial transactions, and reduced operational costs. For instance, Prasad (2021) argues that FinTech developments enhance domestic and international payment systems by increasing the speed of financial transactions and reducing transaction costs. Moreover, the revolution and transformation of digital-based financial service development helps to promote the inclusion of financial services in society. Recent empirical studies show that the expansion of FinTech development in developing countries plays a crucial role in reducing financial exclusion, income gaps, and poverty, as well as increasing economic growth. The FinTech revolution expands financial inclusion by providing the government with new avenues to include the "legible", and global finance with new methods of "profiling" impoverished families into producers of financial assets (Gabor and Brooks 2017).

In addition, the recent literature shares a common argument that "FinTech boosts financial inclusion". In the last ten years, 1.2 billion previously unbanked individuals have gained access to financial services, and the unbanked population has decreased by 35%, mostly due to the increase in mobile money accounts (Appaya 2021). The recent adoption of mobile money-boosted financial inclusion in developing countries increased by 8% between 2017 and 2021 (World Bank 2021). Developing nations, such as African countries, show remarkable progress in the adoption and use of FinTech application systems in recent decades. On the other hand, financial sector development—especially the inclusion of financial services—has become one of Africa's most remarkable success stories over the past decade. Given this historical progress on the continent and the limited empirical literature on the relationship between FinTech and financial inclusion in the context of African countries, in this study we attempt to look the relationship between FinTech and income inequality in African countries. Based on the historical literature on the relationship between FinTech and financial inclusion, we develop the following hypothesis:

H3: *FinTech significantly increases financial inclusion in African countries.*

2.3. Financial Inclusion and Income Inequality

According to economic theory, financial exclusion can result in inequality in the long run. In the absence of asymmetric information, transaction costs, and other market imperfections, financial institutions and markets play a critical role in the efficient allocation of capital resources (Demir et al. 2020). Financial inclusion can help to reduce income inequality by expanding educational options, encouraging entrepreneurship among the poor, and making credit more accessible.

Several empirical studies show that financial inclusion—which is defined as the level of access to, and the use of, financial services by consumers—has a negative and significant effect on income inequality (Lan and Hung 2018; Omar and Inaba 2020; Menyelim et al. 2021). On the other hand, Madukala and Silva (2022) documented that financial inclusion has a positive effect on income inequality in Sri Lanka. Similarly, Tita and Aziakpono (2017) examine the relationships between various aspects of financial inclusion and income inequality in sub-Saharan Africa using the World Bank Global Findex 2011 data, and the results of these studies demonstrate that financial inclusion—defined by the use of bank accounts, electronic payments, and formal savings—has a significant positive relationship with income inequality under the colonial financial system. Given the inconclusive arguments regarding the relationship between financial inclusion and income inequality, we develop the following hypotheses for further investigation:

H4a: *Financial inclusion significantly decreases income inequalities in African economies.*

H4b: *Financial inclusion significantly increases income inequalities in African economies.*

The ICT infrastructure, such as mobile phone penetration and internet connectivity, are essential components of utilizing digital financial services. Therefore, to understand the possible impacts of financing via digitalization on income disparities, we believe that ICT infrastructure components should be controlled, in order to avoid the possible endogeneity problems that have not been addressed in existing research. Information and communication technology includes both the penetration of mobile phone subscribers and Internet users. Better connectivity of ICT infrastructure helps to stimulate financial and economic development in the long and the short run (Aker and Mbiti 2010; Rudra et al. 2015; Shamim 2007; Sassi and Goaied 2013). Additionally, there is evidence that supports the idea that the fair spread and quality of broadband Internet adoption improves the income of consumers and contributes to income equality (Canh et al. 2020). On the other hand, ICT occasionally becomes a sole source of income disparity, due to the unfair expansion of infrastructural development across users (Bauer 2018; S. Zhang et al. 2020; Asongu 2015; Lucas and Sylla 2003). Other remaining control variables that are essential to consider in the causal relationship between FinTech and income inequality are described in the methodology section.

Following the abovementioned studies, we can conclude that the effects of the empirical mechanisms of FinTech on income inequality are still unclear. First, the relationship between FinTech and income inequality might vary depending on how the use of financial technology is measured. Most existing studies regard the use of a mobile phone to pay bills as a proxy for FinTech, whereas we believe that the effect of other FinTech measures, such as the use of mobile phones to send and receive money from others, should also be examined. In addition, the effect of FinTech on income inequality may vary depending on what measure of financial inclusion is used as a mediation variable. Second, the existing studies fail to address the possible endogeneity problems in which the impact of FinTech on inequality may be explained by unobservable variables, such as ICT infrastructure and education. This implies the need to carefully control those variables and include them in the model to avoid the possible endogeneity problem arising due to omitted variables in the model. Third, most of these studies do not focus on African economies that have historically suffered from income inequality but are also experiencing a significant growth in FinTech activity. Finally, the impact of FinTech on income inequality may vary depending on different measures of income inequality, such as the GINI and Palma ratios. For robustness purposes, this study uses both measures of income inequality.

We also require control for the variables that have been found to affect inequality in the prior literature. For example, Hsing (2005) and Lee and Son (2016) show the negative relationship between economic growth and income inequality. On the other hand, Rubin and Segal (2015) conclude that growth and income inequalities are positively associated in the

United States. Several studies show a significant relationship between trade and inequality, which depends on the region and the type of trade (Silva and Leichenko 2004; Silva 2007). Also, trading with high-income countries increases income inequality in developing countries (Meschi and Vivarelli 2009). The system of government also affects the relationship between trade and income inequalities. For instance, trade reduces income inequality in autocracies and increases it in democratic government systems (Lin and Fu 2016). Furthermore, Raychaudhuri and De (2016) show that trade openness increases income inequality in 14 Asia–Pacific countries. Another variable that affects income inequality is inflation. The effect of inflation on income inequality is dependent on the relative importance of capital and skill heterogeneity (Jin 2009). Studies by Law and Soon (2020) conclude that in long-run developed economies, inflation is associated with high income inequality. On the other hand, Zheng (2020) argues that, given the same wage rate for all households, inflation that has a monotonically decreasing effect on economic growth helps to reduce income inequality by weakening the contribution of asset income compared to wage income. The government spending policy also plays a significant role in the distribution of income across nations (Doerrenberg and Peichl 2014; Hatch and Rigby 2015). Spending on education, educational attainment, and a fairer distribution of education are key enablers for achieving fairer income distribution (Keller 2010; Lee and De Gregorio 2002; Abdullah et al. 2015; Rodrguez-Pose and Tselios 2009; Sylwester 2000). However, the level of educational status broadens the income gap between nations (Glomm and Ravikumar 2003). Finally, demographic structures are likely to affect income disparity. Differences in population growth and structure between nations at diverse levels of development have proven to worsen global economic inequality (Rougoor and Marrewijk 2015).

3. Data and Methodology

3.1. Research Data

We use balanced macro panel data collected from twenty-nine African countries, which has sufficient data to elucidate the relationship between FinTech, financial inclusion, and income inequalities for the years 2011, 2014, and 2017. We choose these study periods based on the availability of FinTech data. The global financial development index was released for the third generation of FinTech development survey data (the usage of mobile phones to pay bills or to receive and send money) from 2011 to 2021 within three-year intervals for each country across the world. However, most African countries do not have the full data for the 2021 FinTech survey, and also lack the income inequality data. As a result, based on the study variable data availability, we decided to fix our study period to the years between 2011 and 2017. We obtained data for the income inequality measure from the Standardized World Income Inequality Database (SWIID); for the FinTech and financial inclusion variables, from the Global Financial Inclusion Database (Findex); and for the variables controlled in our study, from the World Development Indicators Database. Summary statistics for our variables are provided in Table 1.

Table 1. Description of the study variables.

Name of Variable	Source of Data	Definition and Measurement
A. Dependent variables		
Gini coefficient—Disposable	The Standardized World Income Inequality Database (SWIID)	Net Inequality
Palma ratio	The Standardized World Income Inequality Database (SWIID)	Net Inequality
B. Interest variables		
FinTech	Global Findex	Send and receive digital payment (% age 15+)
C. Mediating variables		
Financial inclusion	Global Findex	(Account, saving, borrowing)

Table 1. *Cont.*

	Name of Variable	Source of Data	Definition and Measurement
D.	Other control variables		
	ICT infrastructure	Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database	Internet broadband penetration and cell phone subscriber per 100 persons
	Consumer price index	World development indicator (World Bank Data)	Inflation rate
	Trade	World development indicator (World Bank Data)	Trade % Of GDP
	Education	World development indicator (World Bank Data)	Secondary school enrolment rate
	Population	World development indicator (World Bank Data)	Population growth annual rate
	Economic growth	World development indicator (World Bank Data)	Real GDP per capita growth

Note: Table 1 shows the variables used in the paper, their source of data, and their definition/measurement. Source: developed by the authors, based on a previous literature review, 2023.

3.2. Research Model Specification

We employ the following two econometric models to test our hypothesis of the study.

First, to determine the impact of FinTech and financial inclusion on income inequality, we use the following econometric model:

$$Income\ inequality_{i,t} = \alpha 0 + \alpha 1 FinTech_{i,t} + \alpha 2 FI_{i,t} + \alpha 3 \sum_{\infty=1}^{\infty} \rho X_{i,t} + \mu_{i,t.} \quad (1)$$

Second, to estimate the relationship between financial inclusion and FinTech, we have the following model:

$$FI_{i,t} = \alpha 0 + \alpha 1 Fintech_{i,t} + \mu_{i,t.} \quad (2)$$

where income inequality is measured using the Gini coefficient of disposable income—which ranges from 0 (perfect equality) to 100 (total inequality)—and the Palma ratio, which measures both within- and between-household income inequalities across the richest and poorest segments in a country. FinTech refers to the measure of financial technology that is proxied by sending and receiving a digital payment (percent of the population aged 15+) in the past year. FI refers to financial inclusion measured by three variables: account, saving, and borrowing. X stands for a set of control variables that are commonly used in the recent literature on finance, financial inclusion and income inequality relationship, including both the special control variables—such as ICT infrastructure, proxied by Internet broadband penetration and cell phone subscriber per 100 persons—and other macroeconomic and demographic variables that are likely to affect inequality, such as economic growth (measured as the annual percentage change in GDP per capita); trade (measured as the sum of exports and imports as a percentage of GDP); inflation (measured as the consumer price indexes); redistributive policies (measured as public spending on GDP); education level (measured as enrollment in secondary school); and population growth (measured as the annual percentage change in population). μ stands for the error term, i represents countries included in the study, and t stands for years of observation.

3.3. Research Method of Data Analysis

Our study objective is to empirically examine the causal relationship between FinTech, financial inclusion, and income inequalities in the economies of African countries. We employ linear regression techniques to test the linear associations of our study variables. We find that the pooled ordinary least squares (OLS) regression technique is the best fit for our data set, based on the Hausman (1978) and the Breusch and Pagan (1980) Lagrange multiplier (LM) model selection tests of linear regression techniques. In fact, the pooled ordinary least squares (OLS) regression technique has weaknesses in addressing endogeneity problems. However, we control variables that have potentially minimized the endogeneity problems in our study model. In addition, we aim to explore the indirect effect of FinTech on income inequalities in African economies. We estimate the indirect effects

using structural equation models, because the structural equation model is better than other methods in measuring both the indirect and direct causal effects amongst structure variables (Chinoda and Mashamba 2021).

4. Results and Discussion

4.1. Summary Statistics

Table 2, below, shows the descriptive statistics for the sample used in this study. The countries with the lowest and highest levels of income disparity (GINI) were found to be Egypt and Gabon, respectively. Algeria, Egypt, Mali, and Nigeria have the lowest Palma ratios. Mauritius and Kenya have the fastest growth rates when it comes to using a mobile phone to send and receive money, while Guinea and Togo have the slowest.

Table 2. Summary statistics.

Variable	Observation	Mean	Std. Dev.	Min	Max
GINI	87	51.15	9.65	32.00	68.00
Palma	87	4.52	3.13	1.00	18.00
Fintech	87	0.38	0.22	0.04	0.90
Account	87	0.45	0.22	0.07	0.94
Saving	87	0.51	0.13	0.17	0.76
Borrowing	87	0.50	0.13	0.26	0.86
Mobile	87	1.99	0.11	1.74	2.21
Internet	87	1.42	0.34	0.73	1.92
RGDPG	87	1.49	2.93	−8.12	7.51
Trade	87	1.78	0.16	1.35	2.12
Inflation	87	8.40	19.91	−1.09	154.76
Govt exp	87	14.50	5.14	2.36	27.73
Education	87	1.93	0.06	1.74	2.00
Population	87	2.39	1.64	−2.42	11.79

Source: authors' computation using STATA, 2023.

4.2. Pooled OLS Regression Analysis

In Table 3, we show the linear relationship between FinTech, financial inclusion, and the income inequality nexus in African economies using the pooled ordinary least squares (OLS) regression technique. Our study results demonstrate that the FinTech variable, which is proxied by the usage of mobile phones to pay and receive money (age +15) in the past year, has a positive and significant impact on income inequalities in both the GINI coefficient and the Palma ratio proxies at the 1% and 10% significance levels. Thus, the findings of our study are robust in both proxies of income inequalities and support those of Saraswati et al. (2020), who find that FinTech provides more benefit to the rich in Indonesia than the poor and broadens the income inequalities gap. The results are not consistent with the findings of Asongu and Nwachukwu (2018), Asongu and Odhiambo (2019), X. Zhang et al. (2020), and Hodula (2023), who find that FinTech helps to reduce income disparities. The significant positive relationship between FinTech and income inequality in African countries can be clarified by the fact that, for the use of FinTech services, there are conditions that the user should fulfill such as knowledge, financial capacity to afford the technology, and other public infrastructures such as the internet, electricity, etc. However, African countries are characterized by the reality that most of the populations are under poverty; the majority of the economy is under the control of a small number of people; and the majority of the populace are living in rural and dispersal areas, which are far from basic public infrastructural services such as education, electricity, transportation, and internet services; this makes it difficult for most African nations to utilize FinTech services. Therefore, due to the abovementioned problems, most Africans will be naturally excluded from the use of FinTech services. The probable users of FinTech in Africa will be those who have better economic status and the facilities to utilize FinTech, and as such, the economic benefits from FinTech services will be concentrated in urban areas. Under these

circumstances it is a coincidence that FinTech increases income gaps in African economies. Moreover, FinTech requires deeper and more technologically advanced financial systems to reduce income inequality (Pazarbasioglu and Mora 2020). However, developing countries—such as countries in Africa, where the deepening and technological advancement of their financial systems are weak—will still be unable to provide equal access to the services of FinTech.

Table 3. Pooled ordinary least squares (OLS) regression analysis.

Variables	1 GINI	2 PALMA
FinTech	67.66 (0.002) ***	14.21 (0.096) *
Account	−56.55 (0.006) ***	−13.56 (0.095) *
Saving	34.99 (0.001) ***	9.164 (0.021) **
Borrowing	−17.66 (0.065) *	−3.07 (0.417)
Mobile phone	0.00288 (0.939)	0.00842 (0.576)
Internet	−0.175 (0.001) ***	−0.0408 (0.052) *
RGDPG	0.292 (0.369)	−0.0475 (0.713)
Trade	0.0426 (0.326)	−0.00816 (0.636)
Inflation	0.0463 (0.323)	0.0196 (0.295)
Govt exp	0.550 (0.008) ***	0.255 (0.002) ***
Education	0.263 (0.001) ***	0.0419 (0.017) **
Population	0.622 (0.288)	0.0573 (0.805)
Constant	11.81 (0.254)	−4.363 (0.291)
Observations	87	87
R-squared	0.544	0.311

Where ***, **, * represents the 1%, 5%, 10% level of significance, respectively. Source: authors' computation using STATA, 2023.

We also show the impact of financial inclusion on income inequality in Table 3. Our findings demonstrate that financial inclusion—proxied by the number of accounts and borrowing—significantly decreases income inequality (GINI) at the 1% and 10% significance levels, respectively; however, the effect of saving is positive and significant at the 1% significance level. This implies that the impact of financial inclusion on income inequalities is conditional on the measure of financial inclusion. The account and borrowing aspects of financial inclusion help to reduce income inequalities in African economies, which supports the notion that financial inclusion is a key tool for reducing income inequalities, and this finding is in line with those of Lan and Hung (2018); Omar and Inaba (2020); and Menyelim et al. (2021). However, the saving aspect of financial inclusion shows a significant positive impact on income inequalities in African economies, and this finding is consistent with

those of Madukala and Silva (2022) and Tita and Aziakpono (2017). The positive association between financial inclusion (savings) and income inequalities in Africa may be due to the fact that most African countries' economies are inflationary, and their inflation rates are higher than their interest rates. In this case, the savers will lose the value of their fiat money, and their wealth will be negatively affected, whereas the borrowers will get a better economic advantage than the savers, which will create income gaps. Thus, our study results indicate that the impact of financial inclusion on income inequalities is conditional depending on the measure of financial inclusions.

Other control variables, such as government expenditure and education, affect income inequality (GINI) positively at the 1% significance level, while internet penetration significantly negatively affects the GINI coefficient at the 1% significance level. We find no significant effects of mobile phone subscriptions, trade openness, GDP per capita, or population growth on inequality. In column 2, we report the findings for the Palma ratio, an alternative measure of inequality. The results show that FinTech drives income inequality (Palma ratio) positively at the 10% significance level. Furthermore, the effect of financial inclusion is mixed. Specifically, the Palma ratio is negatively associated with accounts (at a 10% significance level) and positively associated with savings (at a 5% significance level). Like the findings for the GINI ratio, government expenditure and education positively and significantly affect the Palma ratio (at the 1% and 5% significance levels, respectively). Although internet penetration has a negative impact on income inequality at the 1% significance level, the impact of borrowing, mobile subscriptions, GDP, trade, inflation, and population growth are statistically insignificant.

Overall, our findings indicate that FinTech and income inequality are positively associated. While savings increase income inequality, borrowing and owning bank account activities decrease income inequality.

4.3. Structural Equation Model (SEM) Analysis

In this section, we investigate the direct effects of FinTech development on financial inclusion, and the indirect effects of FinTech on income inequality through financial inclusion using a structural equation model. Our study model in the structural equation model analysis passes the global fitness indices (see Table 4), and the model passed the model fitness test. We present the path analysis results visually in Figure 1. Accordingly, first, we test whether FinTech drives financial inclusion or not, in order to see the indirect effect of FinTech on income inequality through financial inclusion. The regression results (Table 4), ashow that FinTech significantly and positively drives financial inclusion in Africa. This finding indicates that FinTech leads to greater financial inclusion in African countries, which is consistent with previous studies (Appaya 2021; Gabor and Brooks 2017; World Bank 2021) showing that FinTech helps to boost financial inclusion. Second, we test the indirect effects of FinTech on income inequality through financial inclusion. Our regression analysis shows that FinTech helps to reduce income inequality in African countries by boosting financial inclusion, which is consistent with the findings of Demir et al. (2020); and Chinoda and Mashamba (2021). Furthermore, the direct relationship between FinTech and income inequality in African countries is tested using structural equation modeling. The results revealed in Table 4 show that FinTech increases income inequality (GINI and Palma ratio) at the 1% and 5% significance levels, respectively. This result is consistent with the pooled ordinary least squares (OLS) regression output of this study.

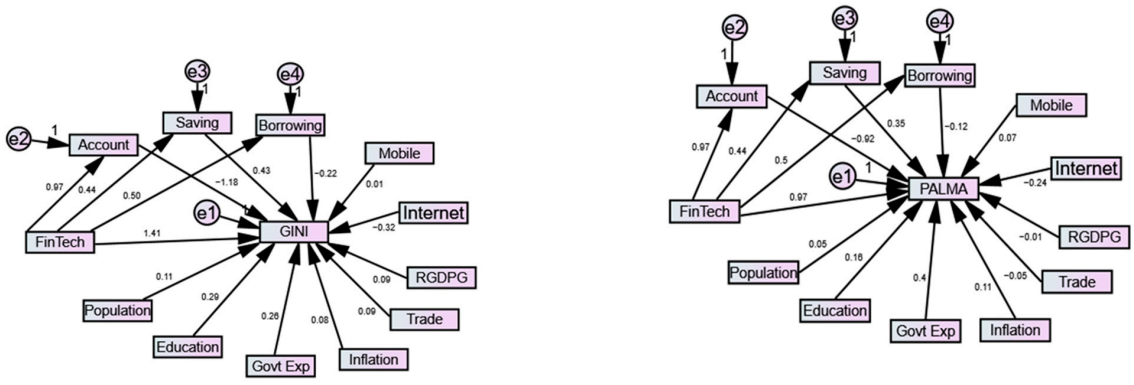
The robust result of the two methodologies tells us that financial technology broadens the income gap in African countries because FinTech may be directly benefiting the rich rather than the poor. On the other hand, in Table 4, we show the relationship between financial inclusion and income inequalities in African countries. The study results show that accounts and borrowing negatively affect income inequality, implying that in Africa, the recent expansion of financial inclusion benefits the poor and helps to narrow the income gap on the continent. While saving affects income inequality positively, other control variables, such as government expenditure and education, significantly positively affect

income inequality. This implies that the unfair allocation of government expenditure and the educational gaps on the continent worsen the income gap.

Table 4. The impact of FinTech on financial inclusion and income inequality using a structural equation model.

			GINI					PALMA Ratio	
			Estimate	***p*-Value**				**Estimate**	***p*-Value**
Account	<---	FinTech	0.974	***	Account	<---	FinTech	0.974	***
Saving	<---	FinTech	0.44	***	Saving	<---	FinTech	0.44	***
Borrowing	<---	FinTech	0.496	***	Borrowing	<---	FinTech	0.496	***
GINI	<---	FinTech	1.407	***	PALMA	<---	FinTech	0.967	**
GINI	<---	Account	−1.176	***	PALMA	<---	Account	−0.924	**
GINI	<---	Saving	0.429	***	PALMA	<---	Saving	0.354	***
GINI	<---	Borrowing	−0.223	**	PALMA	<---	Borrowing	−0.12	0.194
GINI	<---	Trade	0.087	0.163	PALMA	<---	Govt Exp	0.396	***
GINI	<---	Inflation	0.077	0.213	PALMA	<---	Inflation	0.113	0.159
GINI	<---	Govt Exp	0.259	***	PALMA	<---	Trade	−0.049	0.543
GINI	<---	Population	0.115	*	PALMA	<---	RGDPG	−0.014	0.862
GINI	<---	Education	0.29	***	PALMA	<---	Internet	−0.238	**
GINI	<---	RGDPG	0.093	0.134	PALMA	<---	Mobile	0.068	0.397
GINI	<---	Internet	−0.323	***	PALMA	<---	Population	0.047	0.553
GINI	<---	Mobile	0.015	0.813	PALMA	<---	Education	0.161	**
Variables		Total effect FinTech		Indirect effect FinTech	Variable		Total effect FinTech		Indirect effect FinTech
Account		0.974		0	Account		0.974		0
Saving		0.44		0	Saving		0.44		0
Borrowing		0.496		0	Borrowing		0.496		0
GINI		0.34		−1.067	PALMA		0.164		−0.804
Model fit indices—GINI					Model fit indices—Palma				
NFI 0.901, RFI 0.946, IFI 0.934, TLI 0.912 CFI 0.957, REMSA 0.002, SRMR 0.005					NFI 0.897, RFI 0.901, IFI 0.9721, TLI 0.943 CFI 0.905, REMSA 0.002, SRMR 0.004				

Where ***, **, * represents the 1%, 5%, 10% level of significance, respectively. Source: authors' computation using AMOS SPSS, 2023.



(**a**) **GINI** (**b**) **PALMA**

Figure 1. Path analysis output results. Source: authors' SEM estimates using AMOS SPSS, 2023. Note: "e1, e2, e3, and e4" represent the error terms in each structural model.

5. Conclusions

One of the biggest problems facing today's world economies is the growth of income inequality. The literature suggests that economic, financial, demographic, institutional, technological, and regulatory factors are the plausible drivers of income disparities. The prior literature documents that financial services play a significant role in the growth of economic sectors by providing them with the necessary financial support and ensuring losses. However, the optimal distribution of capital resources can be undermined by market inefficiencies and information asymmetries; therefore, some businesses and individuals may be excluded from the formal financial system, which will affect the fair distribution of income. Recent advancements in financial technology (FinTech) renewed attention to the relationship between the financial services industry and income inequality. This research study explores the impact of FinTech development and financial inclusion on income inequalities in African countries between the years 2011, 2014, and 2017 using the pooled ordinary least squares (OLS) and structural equation modeling regression techniques.

We provide several findings. First, we show that FinTech positively significantly affects income inequalities in African countries. Second, the impact of financial inclusion on income inequalities in African countries is conditional depending on the measures of financial inclusion. Thus, the account and borrowing aspects of financial inclusion show a reduction in the income inequalities in African countries, whereas the saving aspect of financial inclusion shows an increase in the income inequalities in African economies. Third, FinTech helps to significantly boost financial inclusion in Africa. Finally, financial inclusion plays a significant mediation role for the negative relationship between FinTech and income inequality in African economies.

The relationship between FinTech, financial inclusion, and income inequality is a recent topic in finance research and the literature is at the infant stage. Therefore, our research study findings expand the literature on the causal relationship between FinTech, financial inclusion, and income inequality. The study results demonstrate that FinTech increases income gaps, which means that those who use FinTech services are more economically advantaged than those who do not. The findings increase societal awareness that using FinTech enhances economic advantages. Our study results also provide valuable implications for policy makers in African countries by providing valuable information on how the adoption of FinTech development and financial inclusion impacts societal income gaps. We encourage the policy makers and regulators in African countries to design policies that enhance financial inclusion, such as an easy FinTech application system, and to launch a simple, innovative formal financial service that is easily used by each household irrespective of their income, knowledge, and location, thereby helping to reduce the income inequality gap.

We recognize that the relationship between FinTech and income inequality is complex, and potentially omitted variables may affect the results. For example, our data only covers three discreet years and was collected by various institutions. Data collection biases and measurement errors may impact our results. In addition, the FinTech industry is growing fast and the relationship between FinTech and income inequality may change in later years. We believe more research on this topic is needed in order to improve our understanding of this complex relationship.

Finally, our study comes with limitations concerning addressing this causal relationship separately in rural and urban areas. In fact, the development of financial inclusion and FinTech, as well as the level of income inequalities, varies between urban and rural dwellers. Therefore, for future research, we recommend specifically surveying these variables in rural and urban areas separately. Future research can also incorporate qualitative data to provide additional context to the quantitative findings in the literature.

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