



Fintech and Income Inequality Nexus: Can Financial Inclusion and Financial Freedom Help to Achieve SDGs


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ARTICLE INFO	ABSTRACT
Article History: Received: April 10, 2025 Revised: May 25, 2025 Accepted: June 09, 2025 Available Online: June 19, 2025	<p>Although theory proposes that financial market imperfections such as information asymmetries, market segmentation and transaction costs prevent poor people from escaping poverty by limiting their access to formal financial services, new financial technologies (Fintech) are seen as key enablers of financial inclusion. Indeed, the UN 2030 Agenda for Sustainable Development (UN-2030-ASD) highlights the importance of harnessing the potential of Fintech to reduce financial exclusion and income inequality. An examination was conducted using data collected for 155 developing countries between 2000 and 2023. The classification of these nations was based on the IMF country categorization outlined in the World Economic Outlook (2023). Information regarding Fin-Tech, Income Inequality, digital financial inclusion variables, financial freedom metrics, governance criteria and various other macroeconomic indicators was sourced from the World Development Indicators (WDI), the Standardized World Income Inequality Database known as SWIID, the Heritage Foundation Economic Freedom Index and the IMF Financial Access Survey (FAS). Robustness check is also applied for improved results. In analysis, the Fintech is negatively correlated with income inequality indicating potential areas where decreasing inequality can be observed. The moderating effect of financial freedom and financial Inclusion has negative effect on this relationship indicating that it helps Fintech in mitigating income disparities. Policymakers, financial institutions and technology providers can benefit from these results and can contribute to the society.</p>
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Introduction

The rapid evolution of financial technology, termed as FinTech, has introduced a number of innovations which has globally transformed the financial sector. This transformation is important in the context of income inequality which has affected the individuals and households of both developed and developing nations. Fin-Tech includes a wide range of applications such as mobile banking, digital payments, peer-to-peer lending and blockchain technology. Such applications allow easy access to financial services for individuals and households. In past, access to financial services has been manipulated as it has favored rich individuals and well-known businesses while a significant portion of the population is left underbanked. As access to financial services has been a crucial determining factor of economic opportunity and mobility, this discrimination has spread economic inequality. Although, FinTech promises that it has the ability to democratize financial services by providing affordable and accessible solutions to previously left out populations (Bollaert, Lopez-de-Silanes, & Schwienbacher, 2021). Millions of people in remote areas engaged in financial activities such as savings, credit, and insurance through mobile banking platforms which were out of reach earlier. Digital payment applications facilitate smoother and secure transactions which reduce the costs and inefficiencies associated with such transactions. Peer-to-peer lending platforms has avoided traditional banking mediators and the barriers to credit access for small businesses and individual entrepreneurs has been lowered. Moreover, blockchain technology being decentralized and having transparent nature, has the ability to create inclusive financial systems so that fraud is reduced and trust in financial transactions is increased (Boot, Hoffmann, Laeven, & Ratnovski, 2021).

The nature of the relationship between FinTech and income inequality is very complex. On one hand, FinTech has the ability to bridge the gap between the rich and the poor as it provides equal access to financial services. This access can allow individuals and small size businesses to manage their risks, invest in new opportunities and achieve stability and growth economically. Through enhanced financial inclusion, FinTech can contribute directly to poverty reduction and economic development, particularly in regions where traditional banking infrastructure is insufficient. Likewise, FinTech can foster financial literacy and inclusion among sidelined groups such as women, youth and rural populations and equitable economic participation is promoted. On the other hand, FinTech can also result in intensifying income inequality if it is not managed inclusively. The digital divide which is characterized by unequal access to technology and internet connectivity, poses a significant barrier to the equal distribution of FinTech benefits (Asher & Dong, 2022). Those who have no or limited access to digital devices or the internet may remain excluded from the advantages of FinTech innovations. Also, there remains a risk that FinTech solutions could be tailored to the needs of more wealthy users resulting in widening the gap that exists between the financially included and excluded population. Moreover, the lack of digital literacy can hinder the effective adoption of these technologies among poor populations (Jensen & Swain, 2022).

Regulation and policy frameworks help FinTech to contribute to reducing income inequality rather than making it worse. Policymakers need to create an environment that supports innovation and safeguards consumer protection, data privacy, and financial stability. Regulatory sandboxes achieve this balance by allowing the testing of FinTech innovations in a controlled environment. Moreover, international cooperation is needed to address the cross-border nature of Fin-Tech solutions and to match regulatory standards (Giglio, 2021). The COVID-19 pandemic has highlighted the importance of FinTech in promoting financial inclusion. The crisis has accelerated the adoption of digital financial services as physical banking became challenging due to lockdowns and social distancing measures. Fintech have played a vital role in easing government

aid distribution, enabling digital payments and providing digital lending solutions to support small businesses and individuals affected by the economic decline. This adoption has highlighted the ability of FinTech to build more resilient and inclusive financial systems in the post-pandemic world. Fintech encompasses a diverse array of innovations, including mobile banking, digital payments, block-chain technology, peer-to-peer lending, and robo-advisors, among others (Carbó-Valverde, Cuadros-Solas, & Francisco Rodríguez-Fernández, 2021).

FinTech promises to address income inequality by democratizing accessibility to financial services, nurturing economic empowerment and endorsing inclusive development. It is required to address the digital divide, enhancement of digital literacy and implementation of regulatory frameworks that are supportive. The FinTech and income inequality relationship is not linear and need continuous research as well as adaptive policy measures. We need to ensure that FinTech innovations are inclusive, reasonable and aligned with the wider goal of sustainable development. FinTech can be an influential instrument to reduce income inequality and achieve economic justice. Empirical studies are important to understand the impact of Fintech on income inequality. Quantitative analyses used data from sources such as World Banks Global Findex database has provided insights regarding the correlation between Fintech adoption and economic indicators such as income distribution, poverty and economic growth.

Inequality can be described through aspects such as the uneven allocation of wealth, power and status among different groups (Bapuji, Ertug, & Shaw, 2020). Income Inequality, However, in simpler terms refers to the unequal distribution of income among individuals or households (Kopp, 2023). The idea that, in the absence of asymmetric knowledge, transaction costs, and other market defects, financial institutions and markets are essential to the efficient allocation of capital resources is an essential principle of finance theory. This idea is expanded upon by the flow of funds conceptual framework, which explains how capital resources are distributed among families and businesses to promote economic growth. In fact, a large body of research from both established and emerging economies points to a close relationship between the flow of money, interest rates, and asset prices, and subsequently incomes and expenses (Murinde, 2012). Studies link income inequality to a number of problems, including a fall in capital investments and innovation, a sluggish pace of economic growth, an increase in violent crime, a reduction in social mobility, and health-related problems (Polacko, 2021). In the early 20th century, Pareto, an Italian economist, introduced the groundbreaking concept that 80% of the world's wealth was concentrated in the hands of merely 20% of the population (Quanmei, 2022). Economically, excessive income inequality can hinder overall economic growth by limiting access to opportunities and resources for a significant portion of the population (Shin, 2012).

Fin-Tech is the advancement of technology and innovation to assist banking and financial skills using cutting-edge technologies. (Boot, Hoffmann, Laeven, & Ratnovski, 2021). The rise of Fintech represents a paradigm shift in financial services, leveraging technology to enhance access, efficiency, and inclusivity in financial markets. The way that people and businesses interact with financial services has changed dramatically as a result of the development of Fin-Tech (Financial Technology). Innovations in technology, heightened competition, and shifting consumer tastes have all contributed to this shift (Mahmudi, 2024). Impacts of Fintech on financial decision making include improved accessibility and convenience for financial services, has enabled consumers to handle their money at any time and from any location. Digital wallets and mobile banking have all simplified the process of making purchases, saving money and managing assets for customers (Kou, Akdeniz, Dinçer, & Yüksel, 2021). The financial services industry now faces more competition as a result of Financial Technology's disruption of established financial institutions. Consumers have gained benefit from low costs and good quality financial products

and services as a result of ongoing competition (Giglio, 2021). FinTech has contributed to financial inclusion by giving access to financial services to those with low incomes and living in rural areas. (Mahmudi, 2024). FinTech has offered several advantages but it has also brought new risks and difficulties. For example, issues regarding biasness arise when artificial and machine learning are used in decision-making. Also, the need for stronger consumer protection laws by regulators are resulted from rapid growth of Fintech. The development of FinTech has significantly influenced financial decision-making by facilitating the use of more creative, convenient and accessible financial services. However, it has also brought up fresh threats and challenges that need to be treated in order to ensure the continued success of the financial industry (Soni , et al., 2022).

What is clear at this point, is that there is little research that uses finance theory to analyze whether FinTech might assist reduce financial exclusion and how this may eventually shed light on the intractable problem of disparities in income. According to (Demirgüç-Kunt & Singer, 2017), few studies have investigated the link between financial inclusion and inequality at the national level, and even fewer have investigated the role of FinTech in promoting financial inclusion and a more equitable income distribution. This research aims to meet the issue by examining the interaction between FinTech, financial inclusion, and income inequality across a wide panel of rich and developing nations using Global Findex survey data from 2011, 2014, and 2017. For Sustainable Development, the 2030 Agenda, was approved by all members of United Nations in 2015, which provides a shared plan for prosperity and peace for its people and its futuristic approach. There are the seventeen Sustainable Development Goals for developed as well as developing countries worldwide. They make strategies to eliminate poverty, improve health and education, reduce inequality and raise economic growth. (UN, 2015).

As technological improvements continue, questions arise regarding the ability of Fintech innovations and financial freedom to accomplish Sustainable Development Goals (SDGs). This study aims to investigate the intricate relationship between Fintech, income inequality, and its impact on sustainable development.

Access to financial services has been manipulated in the past as it has favored rich individuals and renowned businesses while a significant portion of the population is left underbanked. Access to financial services has been a crucial defining factor of economic opportunity and mobility and this discrimination has spread financial difference. The research problem is focusing on the complex relationship between financial technology, income inequality and is exploring the moderating roles of financial inclusion and financial freedom in achieving sustainable development goals. It includes understanding the mechanisms through which Fintech can impact income distribution in terms of its effects on wealth accumulation, economic mobility and accessibility to opportunities for deprived populations. It has involved exploring the role of financial inclusion and financial freedom as possible ways for addressing income inequality and promoting inclusive financial progress. This study aims to expose actionable insights for policymakers and practitioners looking at how to achieve sustainable development goals.

The importance to study the relationship between Fintech, income inequality and the achievement of sustainable development goals is complicated and comprehensive. Fintech keeps on changing traditional financial institutions while improving the way financial services are offered. Analyzing the impact of Fintech on income distribution is important. This study spreads light on the economic and social effects of digital finance adoption by clarifying the relationship by which Fintech affect income inequality trends.

Financial inclusion is known by the access to cheap and easy financial services. It is widely recognized as a key aspect of poverty reduction, gender equality and growth of economy. Researchers can identify strategies through proper investigation that either Fintech platforms expand accessibility to banking, credit, insurance and investment opportunities or not. The research focuses on the eradication of social injustice and inequality among individuals.

Income inequality being global challenge has caused problems in social cohesion, political stability and human development. Knowing how much Fintech initiatives might lessen income inequalities and encourage inclusive growth, scholars can contribute to build more just societies through investigation.

Bridging the gap between Fintech research and sustainable development discourse has practical implications for policymakers, financial regulators and development practitioners. By using findings from economics, finance, technology and development studies, researchers can provide evidence-based recommendations for designing and implementing Fintech policies and programs that align with SDG targets. This interdisciplinary approach fosters association across sectors and disciplines which leads to more effective strategies for achieving sustainable development results that are inclusive in nature.

Literature Review

In present economic conditions, the fintech and income inequality relationship has become an important subject. This reflects an impact of financial technology on financial landscapes. Fintech which means “financial technology”, comprises of a broad range of inventions. It includes mobile banking, crowd lending, blockchain technology etc. These fintech innovations have transformed financial facilities by increasing access. There is a reduction in transaction costs (Puschmann, 2017). The literature on the relationship between Fintech and income inequality presents a complicated narrative. The supporters claim that Fintech promotes financial products and services by providing underbanked populations access to savings, credit, insurance and investment opportunities. For instance, M-Pesa in Kenya, a mobile money platform has significantly improved financial inclusion. It has enabled individuals to not only save but also transfer money and make payments online. Fintech is cheap and easy to access while traditional banking is time consuming and costly. (Vučinić, 2020). Crowdlending platforms have simplified credit accessibility for small businesses and individuals. They were excluded by banks due to lack of collateral or credit history. This technology has the ability to lessen inequality in income by empowering downgraded people groups and economic growth has been fostered at the grassroots level (Jensen & Swain, 2022).

On the contrary, (Demir, Pesqué-Cela, Altunbas, & Murinde, 2022) has highlight the possible worsening of income inequality through Fintech. It is due to the digital divide and the distribution of technological literacy unevenly. While fintech provides considerable benefits but its success depends upon digital tools accessibility. Also, the internet remains unevenly distributed globally on which Fintech is dependent. In developed countries, there is high penetration of smartphones and internet connectivity. It allows extensive use of Fintech services and the gap between those with and without accessibility gets wider (Carbó- Valverde, Cuadros-Solas, & Francisco Rodríguez-Fernández, 2021). Additionally, the dependance on algorithms driven by data in fintech has increased biasness and discrimination. Algorithms which are trained on historical data might continue existing biases and leads to unequal access of financial services and may cause systemic inequalities. For example, algorithms of credit scoring may stop minority groups from benefits because historically they have less credit accessibility and can continue a financial

exclusion cycle (Boot, Hoffmann, Laeven, & Ratnovski, 2021). The literature under study also inspects the role of regulatory frameworks in shaping the Fintech and income inequality relationship. Effective rules and regulations can moderate the risks associated with Fintech. These risks include fraud, concerns regarding data privacy and cyber-attacks. Mitigating such risks make ways for a more just financial system. However, the rapid pace of fintech innovation often surpasses regulatory development. This leads to regulatory gaps that can be easily exploited and result in inequality even after adoption of technology (Asher & Dong, 2022). The rise of crypto-currencies has presented a two-edged sword. Crypto-currencies have offered a substitute to traditional banking systems and it can facilitate cross-border transactions at lowest costs possible but their instability and association with speculative investment carry risks that can excessively disturb individuals who are low income (Carbó-Valverde, Cuadros-Solas, & Francisco Rodríguez-Fernández, 2021).

Empirical study provides diverse evidence on the impact of Fintech on income inequality. Some studies have indicated that adoption of fintech is associated with reduced income inequality in developing economies by enhanced financial inclusion and through economic participation. For example, a study on mobile banking in Sub-Saharan Africa has found that mobile money services have contributed to reduction in poverty and equality in income by providing financial services to populations of remote and rural areas. (Aker & Mbiti, 2010). Equally, other studies propose that fintech adoption increases inequality in income in developed economies. This is due to the concentration of fintech investments and benefits among individuals and urban areas. The difference in results emphasizes the importance of related factors, such as the level of economic growth, regulatory atmosphere and infrastructure, in determining the impact of fintech on income inequality (Bollaert, Lopez- de-Silanes, & Schwiendbacher, 2021).

Furthermore, the arrival of Fintech has converted the employment marketplace. Computerization and financial services driven by artificial intelligence have evacuated certain careers in the financial sector but it has also created new opportunities in fintech setups and financial services. This change is favoring people with digital skills and higher education. These skills are helping people getting good jobs and creating income inequality between skilled and unskilled employees. The economy which is facilitated by fintech platforms are offering flexible employment chances but often lacks job security and benefits. This is contributing to risky employment conditions for employees whose income is low (Demir, Pesqué-Cela, Altunbas, & Murinde, 2022).

Fintech promises of enhanced financial inclusion and reduced income differences but its potential to increase current discriminations cannot be ignored. Policymakers and legislators must navigate this opposition by endorsing reasonable access to digital technologies and must ensure a healthy regulatory framework which foster inclusive innovations of Fintech that give priority to the needs of sidelined communities. Future research should explore this complicated relationship and focus on longitudinal studies and cross-country comparisons to clarify the impacts of fintech on income inequality.

Over the past ten years, there has been a rapid transformation, drawing significant interest from scholars and policymakers due to its implications for financial inclusivity and income disparity. As per data from the World Bank, 1.7 billion adults globally lack access to fundamental education of financial amenities, predominantly situated in lower-income nations, and encompassing women, rural locales, and small-scale businesses (World Bank, 2017). Fintech services exhibit a favorable correlation with financial performance. Furthermore, these services exert a noteworthy influence on financial performance across various metrics such as CAR, ROA, ROE, BOPO, and FDR (Siska, 2022). Eighty percent of people own a mobile phone. In fact, most families have

mobile phones but have no access to clean water and electricity (World Bank, 2016). It indicates the access of Fin-Tech to even poor people across the world. The realm of Financial Technology (Fintech) has witnessed significant improvements in Pakistan, evident through the widespread acceptance of mobile financial services like Easy-paisa and Jazz-Cash, which have experienced a rapid expansion in recent times. Likewise, there is a growing interest in digital banking services, as numerous financial institutions have introduced mobile applications and online platforms to facilitate remote financial transactions for their clientele. Furthermore, microfinance entities are utilizing Fin-Tech tools to enhance operational efficiency and broaden their customer base, especially in remote and underprivileged regions (Zaidi & Shah, 2023).

Financial Technology (Fin-tech)

Financial technology, commonly known as fintech, has revolutionized the financial services industry by leveraging technology to improve financial activities. Fintech encompasses a broad range of innovations, including mobile banking, online lending, blockchain technology, and digital payment systems. According to Asher and Dong (2022), fintech has significantly enhanced the efficiency, accessibility, and convenience of financial services, fostering greater financial inclusion, especially in underserved markets. The rise of fintech can be attributed to the rapid advancements in information technology, the widespread adoption of smartphones, and the increasing demand for user-friendly financial solutions. The addition of artificial intelligence, big data analytics and machine learning into financial services has driven the growth and sophistication of fintech applications. It has enabled modified and well-organized financial services. The incorporation of institutional factors such as political stability, measures for anti-corruption and governmental efficiency is essential in persuading the landscape of Fintech and digital financial innovation. Fintech has played a crucial role in encouraging people to establish formal banking accounts which foster financial inclusion and reduce inequality in income (Giglio 2021). Findings from China indicate that Fin-Tech, as measured by a digital financial inclusion index, diminishes the income disparity between rural and urban areas by enabling rural entrepreneurial activities (Zhang, Zhang and He 2018). The progression of Financial Technology (Fintech) exhibits a favorable relationship with household earnings, with a more pronounced advantageous impact on rural households compared to their urban counterparts (ZHANG, et al. 2020). Studies have underscored the importance of a financial sector development strategy that is geared towards uplifting the disadvantaged (Asher and Dong 2022).

Fin-Tech innovations make it possible for non-financial firms to offer financial services, including big, established technology companies (Big-Tech) and Fintech start-ups. Their influence extends to numerous sides of the financial industry, including risk management, retail and wholesale payments, equity capital raising, credit monitoring, investment management, and insurance (Jarvis and Han 2021). A fundamental principle in financial theory is the significant role that financial institutions and markets play in effectively distributing capital resources, particularly in the absence of information asymmetry, transaction costs, and other market imperfections (Goldstein 2023). The framework of the flow of funds expands on this principle to clarify how capital resources are distributed among households and businesses, eventually steering economic development (Estevez and Ecker 2023). In addition, Collection of taxes and governmental services through Fin-Tech is an effective and efficiently traceable process (Aker & Mbiti, 2010).

The impact of fintech on traditional financial institutions has been profound, leading to a paradigm shift in the financial sector. Fintech has introduced business models that has challenged the supremacy of conventional banks and providers of financial service. As Amnas, Selvam and Parayitam (2024) stated the emergence of crowd lending platforms, robo-advisors and banks that

are digital has eased financial services accessibility. Such platforms are offering customers more choices and at lowest costs possible. Traditional financial institutions have answered by investing in fintech innovations themselves through partnerships with fintech setups. Traditional financial institutions have combined digital solutions to their service and products. This mutual relationship between fintech firms and traditional banks highlights the transformative ability of fintech in reshaping the financial industry.

The influence of Fintech has extended beyond the realm of financial services. It is impacting regulatory frameworks and economic policies globally. The rapid evolution of Fintech has encouraged regulatory bodies to adapt and develop new strategies to ensure customer safety, financial stability and integrity of the market. Giglio (2021) highlighted the necessity for a stable regulatory method that nurtures invention while mitigating risks related to modern financial technologies. Also, Fintech has the ability to report bigger economic subjects such as financial inclusion and income disparity. Fintech can help bridge the gap between the underbanked and the formal financial system by contributing to economic development and social equity. Fintech makes it possible by providing affordable and accessible financial services to sidelined people. The current developments in Fintech continue to form the future of finance, presenting both opportunities and challenges for stakeholders across the financial system.

Income Inequality

Unequal distribution of wealth, status and influence is called income inequality. It is a significant problem that developing economies has encountered in the present time (Polacko, 2021). Bapuji, Ertug and Shaw (2020) said that income inequality is different from injustice in a sense that its focus is on the absence of equality across society's various groups rather than unjust treatment of individuals. Inequality is examined across a range of disciplines. The scope of this study involves social and economic inequality. In subject under study i.e., economic, it is quantified through disparities in income and assets amongst individuals, households, and countries. Social inequality refers to inequality in influence, power, and services like healthcare and education (Chancel, Piketty, Saez, & Zucman, 2022). Yenn (2022) argued that inequality can exert a significant influence on the lives of individuals as well as on societies overall. Deaton (2021) stated that in recent years, there has been a noticeable increase in inequality at both national and international levels. The composition of industries within a specific geographic area significantly influences the distribution of income within that region. Areas with a predominant focus on manufacturing often exhibit reduced levels of income inequality, in contrast to areas characterized by a prevalence of tertiary services, cultural and recreational activities, and knowledge-based business services, which tend to experience heightened levels of income inequality (Marchand, Dubé, & Breau, 2020).

Fintech's Potential Impact on Income Inequality

For a number of years, the correlation between technological progress and disparity has been a topic of discussion. In developing countries, crucial role is played by information, communication and financial technologies by reducing inequality in income. In 2022, Islam, Basher and Haque stated that the implementation of mobile financial services in Kenya resulted in a reduction of 2% in the proportion of households experiencing severe poverty. This decrease was primarily linked to enhanced savings opportunities and reduced expenses related to transactions. Apergis (2015) argued that poor gets benefitted as Fintech make ways for job creation and create opportunities for generating income. FinTech has the ability to mitigate income inequality across various threshold variables, with economic growth proving to have the most substantial mitigating effect (LIU,

HAO, GE, & MU, 2023). A group of scholars postulate that technological advancements hold the promise of reducing inequality through the creation of new job opportunities and improvements in efficiency (Ambrogio, Filice, Longo, & Padovano, 2022). To clarify, the adoption of new technology in the manufacturing sector has led to the development of fresh, well-compensated positions, ultimately mitigating the income gap (Salverda, et al., 2014). Moreover, advancements in technology such as the internet and online commerce have offered individuals from deprived communities new opportunities to engage in the global economy, thereby decreasing social and economic disparities (Chishti & Sinha, 2022). Research findings from both advanced and emerging economies consistently highlight a close relationship between the flow of funds and asset prices, as well as incomes and spending trends (Murinde, 2012). Market distortions and information asymmetry may affect allocation of capital resources; specific entities such as companies and households could face exclusion from formal financial markets, hindering equitable economic development (Lee, Tang, & Lee, 2023). At the global scale, the interaction between finance and development raises concerns, particularly in cases of ongoing financial exclusion and income difference. The 2030 UN Agenda for Sustainable Development, for example, highlights the importance of financial inclusion in achieving the Sustainable Development Goals (SDGs) and addressing inequality (SDG10) (Klapper, El-Zoghbi, & Hess, 2016).

Fintech innovation that are of moderate level have the capacity to reduce income inequality and promote income equality. Other significant levels of Fintech innovations might increase income inequality (Liu & Lawell, 2015). Quantitative analyses have been done to examine the impact of Fintech across several income levels. For example, the study by Demir, et al. 2022 through a quantile regression approach has analyzed the effects of Fintech on financial inclusion and income inequality. These findings have indicated that Fintech has a varying impact across different income levels but more significant benefits was observed in groups of lower income. This highlighted the potential of Fintech to act as a leveling force in income circulation. The degree of its impact may vary depending on the existing socio-economic landscape. This literature assessment aims to discover the present body of research on the relationship between Fintech and income inequality but with a precise focus on the moderating effects of Financial Inclusion and financial freedom. Besides, it aims to clarify the method in which these factors help to accomplish Sustainable Development Goals (SDGs) and emphasize the capacity of Fintech advancements to facilitate reasonable economic growth and constant improvement.

Financial Inclusion and Financial freedom

Fintech is a suitable instrument for achieving financial inclusion and reducing Income Inequality (Jensen & Swain, 2022). The birth of advanced financial technologies is known as a significant supporter of financial inclusion. The direct and indirect impact of Fintech on inequality is evident through its influence on financial inclusion. The mitigation of inequality across various quantiles of the distribution is driven by financial inclusion (Demir, Pesqué- Cela, Altunbas, & Murinde, 2022). Omar and Inaba (2020) has conducted a study on the implications of financial inclusion in lessening poverty and income inequality as well as the factors persuading these outcomes in 116 developing countries. These findings are strong evidence signifying that financial inclusion has played a vital role in diminishing poverty levels and income inequality within developing nations. The results that have been derived from the nonlinear long-term model has suggested that starting from a lower level of financial freedom and an increase in this parameter resulted in heightened inequality. It also pointed out that individuals at the higher income levels have experienced greater benefits compared to those at the lower end (Apergis, 2015).

Theoretical background

This research study is based on the Unified Theory of Acceptance and Use of Technology. The snowballing influence of financial institutions and markets on the behavior of the economy is examined by Institutional and Financialization theory. Fintech is a representation of Financialization in practice which is enabling advanced ways for controlling risk, allocation of assets and facilitating the transactions (Amnas, Selvam, & Parayitam, 2024). Fintech is criticized for its ability to worsen financial exclusion and give priority to specific groups which results in the increased inequality in the economy.

The theoretical framework suggests that the Fintech (IV) has an impact on income inequality (DV), which is influenced by the levels of financial freedom and financial freedom being moderate variables. It argues that the existence of financial inclusion systems and enhanced financial freedom could lessen the negative implications of inequality, thereby assisting in the achievement of Sustainable Development Goals through inclusive growth fostered by Fintech.

Research Methodology

Data and Methodology

This research aims to assess the impact of Fin-Tech on income inequality, with a particular emphasis on the moderating role of Financial Inclusion and financial freedom in emerging economies. An examination was conducted using data collected for 155 developing countries between 2000 and 2023. The classification of these nations was based on the IMF country categorization outlined in the World Economic Outlook (2023). The selection of these particular countries for the research was determined by the availability of data, the significance of emerging economies in the global economic landscape and existing research deficiencies. Information regarding Fin-Tech, Income Inequality, digital financial inclusion variables, financial freedom metrics, governance criteria, and various other macroeconomic indicators was sourced from the World Development Indicators (WDI), the Standardized World Income Inequality Database known as SWIID, the Heritage Foundation Economic Freedom Index, and the IMF Financial Access Survey (FAS). The timeframe of the analysis, spanning from 2000 to 2023, was determined based on the data accessibility for multiple explanatory variables.

Data analysis

The research employs panel data to examine the impact of Fin-Tech on income inequality, alongside investigating the moderating influence of financial inclusion and financial freedom on the following relationship through a combination of multiple techniques. To summarize of the characteristics and distributions of individual variables, descriptive analysis will be utilized. To establish the magnitude and direction of the linear relationships among the variables, the correlation analysis is used. The utilization of panel regression models, which incorporate Panel-Corrected Standard Errors (PCSE), is employed to evaluate the intricate interconnections between Fin-Tech, Financial freedom, financial inclusion and Income Inequality. While Ordinary Least Squares (OLS) regression may be utilized to examine the suggested relationships assuming homoscedasticity and linearity, panel regression models, especially when integrated with Panel-Corrected Standard Errors (PCSE), present a stronger methodology for management of the features of panel data.

Explanation of Variables

Measuring Financial Technology

A measuring financial technology involves assessing the adoption and usage of various digital and mobile technologies that facilitate financial transactions and services. The proxies used include Mobile cellular subscriptions per 100 people (MOB), Individuals using the internet as a percentage of the population (INT) and Broadband subscriptions per 100 people (BBS). These proxies will provide a representation of the technological infrastructure and digital connectivity that support modern financial systems.

Mobile technology penetration: Mobile cellular subscriptions will represent the number of mobile phone lines per 100 people within a population. This proxy is a good indicator of the accessibility and penetration of mobile technology. It is increasingly used for financial transactions especially in regions where traditional banking structure is lacking. High mobile penetration allows a wide section of the population to engage in mobile banking, payments and other financial services thus driving financial inclusion and economic activity.

Internet accessibility: Individuals using the internet (INT) measures the proportion of the population that has access to internet. This proxy is good for understanding the degree to which people have access to online financial services which includes digital banking, investment platforms and e-commerce. Internet usage is foundational element for a digital economy. Higher internet penetration characteristically relates with greater adoption of various online financial technologies. It reflects a better reach of digital financial services and that the population is engaged in a digital financial network.

Quality of accessibility: Broadband subscriptions (BBS) per 100 people indicate the availability and adoption of high-speed internet connections. This proxy impacts the quality and reliability of internet access which is essential for more advanced financial technologies. High broadband penetration supports the use of online financial applications such as real-time trading platforms, video consultations with financial advisors and other data services. Broadband connectivity enhances the user experience and effectiveness of digital financial services and contribute to greater financial inclusion and economic development.

The proxies mentioned above provide a multilayered measure of financial technology. Mobile cellular subscriptions (MOB) highlight the reach of mobile technology, individuals using the internet (INT) emphasize the level of internet access and broadband subscriptions (BBS) underscore the quality of that access. By examining these indicators, policymakers and researchers can gain insights into the infrastructure supporting financial technology, identify gaps in digital connectivity and design interventions to enhance financial inclusion and economic development through technological advancements.

Table 3.1 shows the PCA for FT. Table 3.1a tells that first component has an eigenvalue of 2.401, capturing 80.0% of the total variance. The substantial eigenvalue and proportion indicate that the first principal component explains the majority of the variability in the data. Second component has an eigenvalue of 0.414, accounting for 13.8% of the variance. The difference from Comp1's eigenvalue is 1.987, suggesting a significant drop in the amount of explained variance. The cumulative proportion for Comp2 is 93.9%, indicating that the first two components together explain almost all the variability in the data. Third component has an eigenvalue of 0.184, representing 6.1% of the variance. There is no difference listed for Comp3, and the cumulative proportion reaches 100%, meaning that all three components together account for all the variance

in the dataset. Overall, the PCA reveals that the first principal component (Comp1) is the most significant, explaining the vast majority of the variance, while the second and third components contribute relatively little additional explanatory power. Figure 3.1 displays the scree plot of eigenvalues, which indicate the number of components required to represent financial instability.

Table 3.1b shows the eigenvector loadings of comps 1, 2, and 3. First component has high positive loadings for all three variables: MOB (0.561), INT (0.607), and BBS (0.563). This suggests that first component is a weighted average of all three variables, indicating that these variables move together and collectively account for most of the variance. Second component shows a different pattern with loadings of MOB (0.715), INT (-0.013), and BBS (-0.699). Here, MOB and BBS have opposite signs, suggesting that Comp2 represents a contrast between these two variables. INT's near-zero loading indicates a minimal contribution to Comp2. Comp3 has loadings of MOB (0.417), INT (-0.795), and BBS (0.441). In this component, INT has a strong negative loading, while MOB and BBS have positive loadings.

This pattern suggests that Comp3 contrasts INT with MOB and BBS, with INT contributing most strongly but in the opposite direction to the other two variables. We choose comp1 to create FT since comps 2 and 3 have negative or weak values.

$$FT_{it} = 0.5610MOB_{it} + 0.6070INT_{it} + 0.5630BBS_{it} \quad \text{Eq. (1)}$$

TABLE 3.1 Principal component analysis (PCA) for Financial Technology

Eigenvalue of Matrix				
(a) Eigenvalues				
Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.401	1.987	0.800	0.800
Comp2	0.414	0.230	0.138	0.939
Comp3	0.184	.	0.061	1.000

(b) Principal components (eigenvectors)			
Variable	Comp1	Comp2	Comp3
MOB	0.561	0.715	0.417
INT	0.607	-0.013	-0.795
BBS	0.563	-0.699	0.441

Note: Mobile cellular subscriptions (Per 100 People) (MOB); Individuals using the internet (% of population) (INT) and Broad band subscriptions (Per 100 People) (BBS).

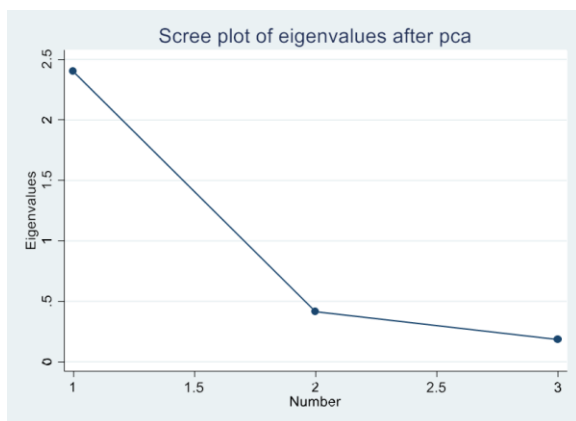


FIGURE 3.1 shows the variance explained by the different factors of Financial Technology (FT)

Measuring Income Inequality

Income inequality (IIE) is assessed through Gini coefficient of disposable income, which spans from zero (representing perfect equality) to hundred (representing complete inequality) (Suhrah, Chen, & Attaullah, 2024). This metric stands as the predominant measure of income inequality within the body of research examining the correlation between finance and inequality.

Measuring Financial Freedom

Financial Freedom defines the extent by which financial resources are freely controlled by individuals and businesses and also their freely engagement in economic activity. To measure Financial Freedom, this study followed (Ashour, Sayed, & Abbas, 2023) and used the Financial Freedom Index, a sub-component of The Heritage Foundation's Economic Freedom Index.

Measuring Digital Financial Inclusion

Measuring Digital Financial Inclusion involves assessing the accessibility and utilization of digital financial services among the population, using specific proxies such as automated teller machines per 100,000 adults (ATM), commercial bank branches per 100,000 adults (BRC), number of deposits with commercial banks per 1,000 adults (DCB) and life insurance premium volume to GDP (LIN). These proxies provide a comprehensive picture of which individuals can engage with financial services in a digital economy. The number of ATMs and commercial bank branches per capita reflects the physical infrastructure supporting financial transactions and indicates that how easily individuals can access banking services. The number of deposits per 1,000 adults measures the penetration of banking services and showcases that how many people are actively using these financial tools. Lastly, the life insurance premium volume as a percentage of GDP highlights the integration of financial services into the broader economy which illustrates the degree of financial planning and risk management among the public. These indicators offer valuable insights about digital financial inclusion and helps policymakers and stakeholders identify gaps as well as opportunities to improve financial accessibility and inclusion.

Control Variables

In statistical analyses, control variables are variables that can affect the relationship between independent and dependent variables. This study utilized control variables which are sourced from previous empirical research. The purpose of these variables is to evaluate their effects on sustainable economic development (Chinoda & Kapingura, 2023). These control variables include Inflation (INF), log of Trade (TRA), Unemployment (UNE), log of Total Population (POPT), Primary Education (SEP), Secondary Education (SES) and Natural resources (TNR). Primary education is measured by the net enrollment rate in primary schools (% net). High levels of primary school enrollment are often indicative of a country's commitment to basic education, which is foundational for long-term economic growth and social development. Inflation (INF) is measured by the annual percentage change in consumer prices. It reflects the rate at which the general level of prices for goods and services is rising and the purchasing power of currency is falling. Trade (TRA) is represented by the net trade in goods and services (BoP, Current US\$). It summarizes the balance of exports and imports and reflects a country's openness to international markets and role in global economy. Secondary Education (SES) is measured as the net enrolment rate in secondary schools (% net). It builds on primary education by providing youths with advanced knowledge and skills necessary for higher education and specialized occupations. Secondary education is often linked to improved economic outcomes which includes higher earnings potential and reduced poverty rates. Unemployment (UNE) is measured as the total

percentage of the labor force that is unemployed. High unemployment rates can signal economic distress and inefficiencies in labor markets which leads to reduced income levels and increased poverty. Total Population (POPT) is measured as the aggregate number of people in a country. Population size can influence a wide range of economic and social variables which includes market size, labor force availability and the demand for goods and services. A larger population can provide a broader base for economic activities but poses challenges in terms of resource distribution, infrastructure progress and social services establishment. Natural Resources (TNR) are quantified as the total natural resource's rents (% of GDP) which represents the economic value derived from the extraction of natural resources such as minerals, oil and gas. The abundance and management of natural resources can have profound implications for a country's economic development and income distribution. This research study aims to isolate the influence of Fintech, financial freedom and financial inclusion on Income Inequality while taking into consideration other relevant factors that might affect economic development and sustainable development goals.

Econometric Model

The model of this research is as under:

The functional form of model under consideration is as follows:

GINI=f (FinTech, Inflation, Population Growth, Education, Trade, Secondary Education, Primary Education, Unemployment)

The Econometric Model:

Through Empirical regression model based upon literature and theories by different researchers, the influence of Fintech on income inequality will be investigated using the following econometric equation:

$$\text{GINI}_{it} = \alpha_0 + \beta_1 \text{FT}_{it} + \beta_2 \text{LPOPT}_{it} + \beta_3 \text{LTRA}_{it} + \beta_4 \text{INF}_{it} + \beta_5 \text{SE}_{it} + \beta_6 \text{UNE}_{it} + \beta_7 \text{SES}_{it} + \beta_8 \text{TNR}_{it} + \epsilon \quad \text{Eq. (2)}$$

The Moderation Effect:

$$\text{GINI}_{it} = \alpha_0 + \beta_1 \text{FT}_{it} + \beta_2 \text{DFI}_{it} + \beta_3 \text{FF}_{it} + \beta_4 \text{FT}_{it} * \text{DFI}_{it} + \beta_5 \text{FT}_{it} * \text{FF}_{it} + \beta_6 \text{LPOPT}_{it} + \beta_7 \text{LTRA}_{it} + \beta_8 \text{INF}_{it} + \beta_9 \text{SE}_{it} + \beta_{10} \text{UNE}_{it} + \beta_{11} \text{SES}_{it} + \beta_{12} \text{TNR}_{it} + \epsilon \quad \text{Eq. (3)}$$

In the above equations, FT denotes Financial Technology (Fin-Tech), FF is the Financial Freedom Index (a sub-component of Heritage Foundation's economic freedom index), DFI is Digital Financial Inclusion, LPOPT represent the log of the total population, INF is the inflation rate, and LTRA denotes the log of Trade, SES is Secondary Education, SE is Primary education, UNE is Unemployment, TNR is Natural Resources whereas β is independent variable long run coefficient, ϵ is error term and i and t represent country and time respectively.

Table 3.1 summarizes the variables, definition, proxy used and the source of data.

Table 3.1 Variables and Measurement

Variables	Source	Measurement	References
DV: Income Inequality	The Standardized World Income Inequality Database (SWIID)	Economic inequality is measured using the Gini coefficient of disposable income, which ranges from 0 (perfect equality) to 1 (perfect inequality).	(Suhrab, Chen, & Attaullah, 2024)
IV: FinTech	World Development Indicators Database	An index which is composed of fixed broad band and fixed mobile cellular subs (per hundred persons) and individuals (% of population using internet).	(Suhrab, Chen, & Attaullah, 2024)
MV: Financial Inclusion (FI)	Global Financial Inclusion Database (Findex).	Automated teller machines per 100,000 adults (ATM), commercial bank branches per 100,000 adults (BRC), number of deposits with commercial banks per 1,000 adults (DCB), and life insurance premium volume to GDP (LIN)	(Ali, Hashmi, Nazir, Bilal, & Nazir, 2021)
Financial Freedom (FF)	Heritage Foundation.	To what extent businesses have control over their financial resources.	(Noman, et al. 2022)
CV: GDP Per Capita (GDPPC)	World Development Indicators Database	Divide economic output by population of a certain country under study.	(Suhrab, Chen, & Attaullah, 2024)
Inflation (INF)	World Development Indicators Database	The amount that goods and services have increased in price relative to a prior period is measured by inflation.	(Suhrab, Chen, & Attaullah, 2024)
Population Growth (POP)	World Development Indicators Database	Population Growth (Annual %)	(Demir, Pesqué-Cela, Altunbas, & Murinde, 2022)
Education (EDU)	World Development Indicators Database	School Enrollment, primary (% net)	(Suhrab, Chen, & Attaullah, 2024)
Trade (TRA)	World Development Indicators Database	Net trade in goods and services (BoP, Current US\$)	(Suhrab, Chen, & Attaullah, 2024)
Secondary Enrolments (SES)	World Development Indicators Database	School enrollment, secondary (% net)	
Primary Enrolments (SEP)	World Development Indicators Database	School Enrollment, primary (% net)	
Unemployment	World Development Indicators Database	Unemployment, total (% of total labor force) (national estimate)	

Empirical Results

The research objective addressed by this study revolves around the impact of financial technology (Fin-Tech) on income inequality and exploring the moderating roles of financial inclusion and financial freedom on their relationship and how this helps in achieving sustainable development goals (SDGs). This section of the study will provide a complete explanation of the findings and analysis derived from the exploration of secondary sources.

Descriptive Statistics

The dataset contains various socioeconomic variables, each described with their respective number of observations (Obs), mean, standard deviation (Std. Dev.), minimum (Min), and maximum (Max) values.

Table 4.1 provides a comprehensive descriptive statistical analysis of each variable. The mean value of LIIIE is 3.712, indicating the central tendency of the income inequality index in its logarithmic form. The relatively low standard deviation suggests that income inequality is fairly consistent across the observations. The range between the minimum (3.199) and maximum (4.181) values shows moderate variability in income inequality levels.

The average number of mobile subscriptions is 70.122 per 100 people, with a high standard deviation indicating significant variation in mobile subscription rates. The minimum value of 0 suggests that there are regions with no mobile subscriptions, while the maximum value exceeds 221, pointing to areas with extremely high mobile penetration. Internet usage varies widely, with an average of 26.913 users per 100 people. The high standard deviation indicates large disparities in internet penetration across different regions. The data spans from 0 to 100, reflecting the entire spectrum from no internet access to full coverage. On average, there are

5.233 bank branches per 100,000 adults. The high standard deviation suggests substantial variability in the availability of bank branches, with some areas having no branches and others having up to 61 branches, indicating significant disparities in financial infrastructure. The digital financial inclusion index, which is standardized, has a mean of 0 and a standard deviation of 1. The values range from -1.285 to 7.872, reflecting diverse financial conditions across the observations.

The financial freedom index averages at 44.464, with a standard deviation of 16.542. The index ranges from 10 to 90, indicating substantial differences in financial freedom across different regions or countries.

The logarithm of trade shows a mean value of 22.009, with moderate variability indicated by the standard deviation of 2.14. The minimum and maximum values reflect considerable differences in trade volumes across the sample. The average logarithm of total population is 15.487, with a standard deviation of 2.222. The population sizes vary significantly, as indicated by the range from 9.17 to 21.072. The mean inflation rate is 7.561%, with a very high standard deviation of 22.449%, indicating extreme volatility in inflation rates. The values range from deflation (-16.86%) to hyperinflation (557.202%), showing significant economic instability in some regions. Secondary education enrollment averages at 62.717%, with substantial variability as indicated by the standard deviation of 24.32%. Enrollment rates range from very low (3.28%) to almost complete (99.84%), highlighting disparities in educational attainment. The mean primary education enrollment rate is 87.165%, with a standard deviation of 12.918%. The range from 26.828% to 99.923% reflects wide differences in primary education coverage across different regions. The average unemployment rate is 8.751%, with a standard deviation of 7.104%, indicating variability in joblessness. The minimum value of 0.1% suggests near-full employment in some areas, while the maximum of 57% indicates severe unemployment in others. Total natural resources rents average at 8.769% of GDP, with a high standard deviation of 11.963%, indicating substantial differences in resource dependency. The values range from 0 to 88.592%, showing some economies heavily reliant on natural resources.

Overall, the descriptive statistics highlight significant variability across all variables, reflecting diverse socioeconomic conditions across the dataset. These insights are essential for understanding the broader economic context and developing targeted policies to address issues such as income inequality, financial inclusion, and sustainable development.

Table 4.1 Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
LIIE	3.712	.174	3.199	4.181
MOB	70.122	50.679	0	221.309
INT	26.913	26.932	0	100
BBS	5.233	7.742	0	61.256
DFI	0	1	-1.285	7.872
FF	44.464	16.542	10	90
LTRA	22.009	2.14	12.391	27.08
LPOPT	15.487	2.222	9.17	21.072
INF	7.561	22.449	-16.86	557.202
SES	62.717	24.32	3.28	99.84
SEP	87.165	12.918	26.828	99.923
UNE	8.751	7.104	.1	57
TNR	8.769	11.963	0	88.592

Note: Std. Dev is the standard deviation; Min and Max shows the minimum and maximum value of all variables, respectively; LIIE is log of Gini Coefficient; independent variables are Mobile cellular subscriptions (Per 100 People) (MOB); Individuals using the internet (% of population) (INT) and Broad band subscriptions (Per 100 People) (BBS), Financial Freedom Score (FF), Digital Financial Inclusion (DFI) ; Unemployment (UNE); Secondary Education (SES); Primary Education (SEP); Total Natural Resources (TNR); Log of population growth rate (LPOPT), inflation (annual %) for consumer prices (INF), log of Trade (LTRA). ***, ** and * show statistical significance at the 1, 5 and 10 percent level respectively.

Pairwise Correlation

Correlation is a statistical technique for evaluating connections between variables and provides valuable insights into the magnitude and direction of their relationships. By conducting correlation analysis, a comprehensive understanding is found regarding the impact of variations in one variable on others. This clarifies complicated associations within the datasets. The correlation matrix in “Table 4.2” illustrates the pairwise correlations among the variables which is examined.

Mobile Subscriptions (MOB) has a negative correlation with LIIE i.e., $r = -0.200^*$. This indicates that higher mobile subscription rates are associated with lower levels of income inequality. The widespread availability and use of mobile phones can improve accessibility to information, financial services and economic opportunities which can help in the reduction of income differences. Internet Users (INT) also shows a negative correlation with LIIE i.e., $r = -0.289^*$. Increased internet penetration is related to reduce income inequality. The internet can facilitate education, remote work, e-commerce and access to various services which can contribute to narrowing the income gap. Bank Branches (BBS) has a stronger negative correlation with LIIE i.e., $r = -0.374^*$. More bank branches per 100,000 adults are associated with lower income inequality. This suggests that improved access to banking services can promote financial inclusion and economic participation thereby reducing income differences. Digital Financial Inclusion Index (DFI) is negatively correlated with LIIE i.e., $r = -0.187^*$. A higher score on the DFI

indicates better financial conditions and is linked with lower income inequality. Enhanced financial conditions provide broader access to financial resources and services which can help in reducing inequality in income. Logarithm of Trade (LTRA) shows a negative correlation with LIIE i.e., $r = -0.175^*$. Higher trade levels are associated with lower income inequality. Trade can boost economic growth and create job opportunities which helps in reducing income differences. Logarithm of Population Total (LPOPT) has a very weak negative correlation with LIIE i.e., $r = -0.051^*$. Although the correlation is weak, it suggests that larger populations might be slightly associated with lower levels of income inequality, possibly due to more diverse economic opportunities and resources. Inflation (INF) has no significant correlation with LIIE i.e., $r = 0.000$. This indicates that inflation rates do not have a visible direct impact on income inequality in the dataset. Secondary Education Enrolment (SES) shows a negative correlation with LIIE i.e., $r = -0.310^*$. Higher enrolment in secondary education is associated with lower income inequality. Education is a key driver of social mobility and can help reduce income disparities by providing individuals with better skills and opportunities. Natural Resources (TNR) has a negative correlation with LIIE i.e., $r = -0.063^*$. Higher natural resource rents are associated with lower income inequality. This suggests that natural resource wealth with proper management can contribute to reducing income differences by generating revenues that can be used for public investments and social programs.

Financial Freedom (FF) shows a positive correlation of 0.181^* . This indicates that higher levels of financial freedom are associated with higher levels of income inequality. Financial freedom includes factors such as ease of financial transactions, protection of property rights and market freedom which might enable those with better access to financial resources and markets to accumulate more wealth and potentially widening the income gap. Primary Education Enrolment (SEP) also has a weak positive correlation with LIIE i.e., $r = 0.000$. While this correlation is almost negligible, it suggests that primary education enrolment rates have little to no direct relationship with income inequality within the dataset. Unemployment (UNE) has an almost non-existent positive correlation with LIIE i.e., $r = 0.001$. This suggests that the unemployment rate does not have a significant direct impact on income inequality in this context.

In summary, the variables positively correlated with LIIE, such as financial freedom, indicate potential areas where increasing inequality can be observed. Conversely, the negatively correlated variables, such as internet use and education enrolments, highlight factors that can contribute to reducing income inequality. Understanding these correlations can help in designing policies and interventions aimed at promoting economic equality. Importantly, the results confirm the absence of multicollinearity issues among independent variables.

Table: 4.2 Pairwise Correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) LIIE	1.000												
MOB	-0.200*	1.000											
INT	-0.289*	0.791*	1.000										
BBS	-0.374*	0.580*	0.760*	1.000									
DFI	-0.187*	0.338*	0.422*	0.350*	1.000								
(6) FF	0.181*	0.189*	0.200*	0.168*	-0.031	1.000							
(7) LTRA	-0.175*	0.220*	0.188*	0.068	0.125*	-0.061	1.000						
(8) LPOPT	-0.051*	-0.032	-0.081*	-0.105*	0.024	-0.063*	0.553*	1.000					
(9) INF	0.000	-0.085*	-0.080*	-0.056*	0.016	-0.159*	-0.063	0.105*	1.000				
(10) SES	-0.310*	0.564*	0.653*	0.562*	0.390*	0.223*	0.230*	-0.168*	-0.078*	1.000			
(11) SEP	0.000	0.381*	0.358*	0.282*	0.267*	0.116*	0.065	-0.067*	-0.033	0.652*	1.000		
(12) UNE	0.001	-0.066*	0.027	-0.010	-0.061	0.151*	-0.205*	-0.235*	-0.053*	0.205*	0.061*	1.000	
(13) TNR	-0.063*	-0.043*	-0.086*	-0.156*	0.097*	-0.247*	0.317*	0.148*	0.067*	-0.093*	-0.099*	-0.147*	1.000

Note: ***, **, and * shows the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.

Regression Results

The regression results are displayed in two separate tables. “Table 4.3” outlines the direct impacts of Financial Technology on Income Inequality, in combination with additional macroeconomic factors. It is important to highlight that Digital Financial Inclusion and Financial Freedom are not taken into account in “Table 4.3”. “Table 4.4” examines the moderating role of Digital Financial Inclusion and Financial Freedom in determining the effect of Financial Technology on Income Inequality, along with the impact of financial freedom on sustainable economic expansion. This table provides a comprehensive understanding of how Digital Financial Inclusion and Financial Freedom can possibly alter the relationships among crucial variables and provide insights of the intricate nature of the model.

The regression analysis explores the relationship between the Logarithm of Income Inequality Index (LIIE) and various independent variables which includes Mobile Subscriptions (MOB), Internet Users (INT), Bank Branches (BBS), Digital Financial Index (FTI), Logarithm of Trade (LTRA), Logarithm of Population Total (LPOPT), Inflation (INF), Secondary Education Enrolment (SES), Primary Education Enrolment (SEP), Unemployment (UNE) and Total Natural Resources Rents (TNR). The regression results are interpreted for each model specification.

Does Fintech impact income inequality?

In the first model, MOB has a negative coefficient of -0.000491 which is statistically significant and a standard error of 0.0001 which indicates that an increase in mobile subscriptions per 100 people is associated with a decrease in income inequality. This supports the idea that economic opportunities and access to financial services can be improved through mobile connectivity and income gaps can be minimized. The model has a 0.4519 R-square value which suggests that approximately 45.19% of the variance in LIIE is explained by the included variables. The 105.04 Wald chi2 value and the 0.0000 Prob. Value indicates that the model is statistically significant.

In the second model, INT has a significantly negative effect on LIIE, with a 0.00142 coefficient and a 0.000259 standard error. This suggests that if there is an increase in internet users per 100 people then it will lead to a reduction in income inequality. Internet access could facilitate education, remote work and access to markets which contributes to a more unbiased income distribution. The 0.4704 R-squared value is indicating a higher explanatory power as compared to the first model. The 115.62 Wald chi2 value and the 0.0000 Prob. Value supports that the model statistically significant.

The third model includes BBS, which has a significant negative coefficient of -0.00437 and a 0.00100 standard error. This result proposes that an increase in the number of bank branches per 100,000 adults is related with a decrease in income inequality. Access to banking services can improve financial inclusion and provide persons with improved financial management and investment opportunities. The 0.4060 R-squared value is lower than the previous two models but the 85.31 Wald chi2 value and the 0.0000 Prob. Value support that model is overall significant.

In the fourth model, FTI has a significant negative coefficient of -0.0392, with a 0.00770 standard error. This is indicating that better financial conditions (represented by the Financial Technology Index) are associated with lower income inequality. Better financial conditions can lead to better access to credit, investment opportunities and economic growth and income disparities can be reduced. The 0.4520 R-squared value suggests that the model explains a substantial portion of the variance in LIIE, with the 96.26 Wald chi2 value and the 0.0000 Prob. Value confirms its statistical significance.

Across all models, LTRA, LPOPT, INF, SES, UNE, and TNR do not show statistically significant coefficients which indicates their direct effects on income inequality not robust in these specifications. However, SEP consistently shows a positive and significant effect on LIIE with coefficients ranging from 0.00352 to 0.00575 and standard errors around 0.0013 to 0.0014. This suggests that higher primary education enrolments rates are associated with higher income inequality which may reflect the limitations of primary education alone in addressing income differences without educational and economic opportunities.

Overall, the regression results highlight the significant impact of technological and financial access variables (MOB, INT, BBS, FTI) on reducing income inequality. These findings highlight the importance of promoting mobile connectivity, internet access, banking services and promising financial conditions to accomplish a more reasonable income distribution.

Does Financial Inclusion moderate the relationship between Fin-Tech and income inequality?

Digital Financial Inclusion (DFI) is increasingly recognized as a critical component in the economic framework, particularly in its capacity to influence the relationship between financial technology (FinTech) and income inequality. The introduction of the interaction term (DFT) in the regression models serves to assess this moderating effect. The results from Models 1 and 3 reveal significant negative coefficients for DFT, specifically -0.0267^{***} and -0.0349^* respectively, indicating a robust moderating influence. This negative coefficient signifies that with increase in digital financial inclusion the impact of financial technology on income inequality develops more obvious in a negative direction.

On one hand, financial technology encompasses innovations such as mobile banking, online payment systems and blockchain technology which has been praised to serve financial services. However, its effects on income inequality are complex. In some situations, Fintech can reduce inequality by providing previously underbanked populations access to financial services which foster economic growth. On the other hand, without satisfactory inclusion measures, Fintech can worsen existing inequalities by mainly helping those who already have access to digital infrastructure and literacy and leaving behind the sidelined groups.

Digital Financial Inclusion aims to bridge this gap by ensuring that digital financial services are accessible to a broader segment of the population which includes those in lower-income brackets and underserved communities. The interaction term (DFT) essentially captures the extent digital financial inclusion can modify the relationship between financial technology and income inequality. The negative coefficients indicate that when digital financial inclusion improves then the adverse effects of financial technology on income inequality are mitigated. This suggests that DFI ensures that the benefits of FinTech are more equitably distributed. In practical terms, this means that policies and initiatives aimed at enhancing digital financial inclusion can significantly influence the overall economic landscape. For example, programs that promote digital literacy as well as expand mobile internet coverage and offer affordable digital financial services can help low-income persons and communities to leverage financial technology effectively. These efforts can result in a more inclusive financial system where the advantages of Fintech are not confined to the economically advantaged but are extended to those who traditionally were excluded from formal financial systems.

The significant negative coefficients of DFT i.e., -0.0267^{***} in Model 1 and -0.0349^* in Model 3 has highlighted the importance of such inclusion efforts. They reveal that in environments where

digital financial inclusion is higher, the harmful impact of financial technology on income inequality is lessened. This can be interpreted as evidence that DFI can act as a barrier against role of FinTech in increasing income inequality. By incorporating more people into the digital financial system, DFI helps to ensure that technological developments in finance lead to more reasonable economic conclusions. Also, these findings highlight that there is a need for a comprehensive approach to financial technology execution. Simply introducing advanced financial technologies and not addressing the inclusion aspect may not produce the desired unbiased benefits. Policymakers and financial institutions should prioritize strategies that promote widespread digital financial inclusion. This could involve investing in digital infrastructure which fosters public-private partnerships to reach underserved areas and then creating regulatory frameworks that support inclusive financial invention.

The moderating effect of digital financial inclusion on the relationship between financial technology and income inequality, as evidenced by the significant negative interaction term coefficients, emphasizes the critical role of DFI in shaping equitable economic development. Enhancing digital financial inclusion can mitigate the negative impacts of FinTech on income inequality, ensuring that technological advancements contribute to a more inclusive and just financial system. Thus, strategic efforts to promote DFI should be integral to the deployment and expansion of financial technologies to foster inclusive growth and reduce income disparities.

Does financial freedom moderate the relationship between Fin-Tech and income inequality?

In assessing the moderating impact of financial freedom on the relationship between financial technology and income inequality, the introduction of the interaction term (FFT) in Models 2 and 4 yields significant insights. The negative coefficients of -0.00268 and -0.00850, significant at the 5% and 10% levels respectively, underscore the crucial role financial freedom plays in this dynamic. Financial freedom, in this context, can be understood as the degree to which individuals and businesses can make financial decisions free of government intervention. This encompasses aspects such as ease of capital movement, low levels of corruption, efficient regulation, and overall transparency in financial systems. The statistical significance of these coefficients indicates that as financial freedom increases, the beneficial impact of financial technology on reducing income inequality is moderated, becoming less pronounced. In simpler terms, higher levels of financial freedom tend to diminish the positive effects that financial technology can have on bridging the income gap. This could be interpreted through several lenses.

In environments with higher financial freedom, the advantages provided by financial technology may be more accessible to those already at the upper end of the income spectrum, thereby perpetuating or even exacerbating existing inequalities. Advanced financial tools and technologies may be readily adopted by those with greater financial literacy and resources and may widen the gap between the rich and the poor. The wealthy may benefit from innovations such as digital banking, investment platforms and other fintech solutions which can provide significant returns on investment and access to more profitable financial opportunities. Financial freedom could amplify the market dynamics that favor capital over labor which leads to increased income concentration among those who can control financial and technical investment. There tends to be a higher return on capital than on labor in free financial markets. This phenomenon is well-documented in financial literature. When financial freedom is high, the introduction of financial technology can worsen returns to capital, profiting investors and capital holders over wage earners unreasonably and ultimately result in increasing income inequality.

In Models 2 and 4, the significant negative coefficients for FFT suggest that the interaction between financial technology and financial freedom is complex and multifaceted. It may reflect a scenario where financial technology while democratizing access to financial services also needs a helpful regulatory and educational framework to ensure reasonable benefits. In financially free environments, the lack of such frameworks reflects that the introduction of financial technology fails to benefit the low-income people effectively.

This moderation effect also raises important policy implications. Policymakers who aims to leverage financial technology to reduce income inequality should consider not only to promote financial technology but also ensure that financial freedom does not accidentally widen the gap between different income groups. This involves implementation of measures to enhance financial literacy across all segments of society as well as providing targeted support to low-income groups so that they adopt and benefit from financial technologies. This also includes ensuring that regulatory frameworks are there to prevent the domination of technological benefits by the wealthy. The findings propose a necessity for a balanced approach to financial regulation. While financial freedom is crucial for innovation and economic growth but unchecked financial freedom can lead to adverse distributional consequences. A regulatory approach that promotes innovation while safeguarding against inequality is essential. This should include progressive taxation, inclusive financial policies and targeted subsidies for technology adoption among the disadvantaged.

In conclusion, the negative coefficients highlight the significant moderating impact of financial freedom on the relationship between financial technology and income inequality. This suggests that financial technology has the potential to reduce income inequality but its effectiveness is depending upon the level of financial freedom in the environment. Too much financial freedom may weaken the beneficial effects of financial technology which emphasize the need for a balanced inclusive policy framework to ensure that the benefits of technological improvements are fairly circulated across all income groups.

Table 4.3 Regression Results

VARIABLES	(1) LIIE	(2) LIIE	(3) LIIE	(4) LIIE
MOB	-0.000491*** (1.00e-04)			
INT		-0.00142*** (0.000259)		
BBS			-0.00437*** (0.00100)	
FTI				-0.0392*** (0.00770)
LTRA	-0.00236 (0.00321)	0.000301 (0.00323)	0.00616 (0.00382)	0.00264 (0.00349)
LPOPT	-0.0155 (0.0176)	-0.0161 (0.0178)	-0.0250 (0.0173)	-0.0131 (0.0178)
INF	0.000323 (0.000328)	0.000264 (0.000322)	-0.000748 (0.000601)	-0.000945 (0.000591)
SES	-0.000799 (0.000560)	-0.000284 (0.000572)	-0.00123* (0.000657)	-0.000723 (0.000665)
SEP	0.00427*** (0.00131)	0.00352*** (0.00130)	0.00575*** (0.00139)	0.00392*** (0.00140)
UNE	0.000801 (0.00182)	0.00132 (0.00173)	0.00145 (0.00210)	0.000552 (0.00207)
TNR	0.00135	-3.78e-05	-0.000331	-0.000406

	(0.000898)	(0.000970)	(0.00103)	(0.00100)
Constant	3.699***	3.712***	3.573***	3.573***
	(0.309)	(0.311)	(0.315)	(0.317)
R-squared	0.4519	0.4704	0.4060	0.4520
Wald chi2	105.04	115.62	85.31	96.26
Prob. Value	0.0000	0.0000	0.0000	0.0000

Note: This table reports the results related to the panel regression dynamic panel model based on; LIIE is log of Gini Coefficient; independent variables are Mobile cellular subscriptions (Per 100 People) (MOB); Individuals using the internet (% of population) (INT) and Broad band subscriptions (Per 100 People) (BBS), Unemployment (UNE); Secondary Education (SES); Primary Education (SEP); Total Natural Resources (TNR); Log of population growth rate (LPOPT), inflation (annual %) for consumer prices (INF), log of Trade (LTRA). ***, ** and * show statistical significance at the 1, 5 and 10 percent level respectively, the values of standard errors are presented in parentheses.

Table 4.4 Regression Results (Interaction)

VARIABLES	(1) LIIE	(2) LIIE	(3) LIIE	(4) LIIE
FTI	-0.0133 (0.0139)	-0.0529** (0.0263)	-0.259*** (0.0899)	-0.607* (0.320)
DFI	-0.0626*** (0.0128)		-0.0399 (0.0476)	
DFT	-0.0267*** (0.00746)		-0.0349* (0.0411)	
FF		0.00111** (0.000475)		-0.00184 (0.00301)
FFT		-0.00268 (0.0445)		-0.00850* (0.00474)
LTRA	-0.00173 (0.00366)	0.00189 (0.00359)	-0.00949 (0.0186)	-0.0156 (0.0166)
LPOPT	0.0110 (0.0258)	-0.0121 (0.0159)	-0.0402 (0.0302)	-0.0295 (0.0300)
INF	9.24e-05 (0.000530)	-0.00106 (0.000653)	-0.0100*** (0.00320)	-0.00430 (0.00283)
SES	-0.000164 (0.00115)	-0.000721 (0.000731)	0.00197 (0.00367)	-0.000317 (0.00487)
SEP	-0.00406** (0.00178)	0.00300** (0.00148)	0.0238*** (0.00515)	0.0258*** (0.00665)
UNE	-0.000175 (0.00199)	0.00103 (0.00221)	0.0148* (0.00857)	0.0113** (0.00469)
TNR	0.000581 (0.00116)	0.000166 (0.00105)	0.0107*** (0.00308)	0.00885*** (0.00287)
Constant	3.919*** (0.442)	3.606*** (0.289)	2.225*** (0.543)	2.189*** (0.605)
Wald chi2	77.49	100.32		
Prob. value	0.0000	0.0000		
R-squared	0.6132	0.4684	0.4182	0.1694
Wu-Hausman test			32.3334	9.5767
Prob .value			0.0000	0.0024
Sargan test			0.3673	0.5805
Prob .value			0.8551	0.4461

Robustness checks

To assess the robustness of results, this study conducted a series of panel-corrected standard errors (PCSE) regressions. We employed four models, each focusing on different variable combinations, to ensure the findings aren't driven by a single model specification.

The results consistently reveal a significant negative impact of FT on income inequality, highlighting its crucial role in promoting economic development. Other factors exhibiting a positive and significant effect include unemployment, population growth, natural resources and inflation. These findings collectively demonstrate the robustness of the results, indicating that the negative relationship between FT and income inequality holds even after accounting for potential biases and alternative model specifications.

Table 4.5 PCSE regression (Robustness)

VARIABLES	(1) EIGI	(2) EIGI	(3) EIGI	(4) EIGI
MOB	-0.000253** (9.82e-05)			
INT		-0.000761*** (0.000261)		
BBS			-0.00202** (0.000845)	
FTI				-0.0230*** (0.00734)
GDPC	0.00186 (0.00128)	0.00216* (0.00127)	0.00218* (0.00131)	0.00231* (0.00129)
GDPC2	-9.40e-05 (0.000160)	-0.000151 (0.000162)	-7.00e-05 (0.000201)	-0.000136 (0.000200)
LTRA	0.00231 (0.00279)	0.00339 (0.00280)	0.00566* (0.00317)	0.00386 (0.00287)
LPOPT	-0.00129 (0.0104)	-0.00126 (0.0104)	-0.00730 (0.0108)	-0.00247 (0.0104)
INF	0.000218 (0.000251)	0.000166 (0.000250)	-0.000327 (0.000460)	-0.000489 (0.000459)
SES	-0.000617 (0.000551)	-0.000509 (0.000549)	-0.000752 (0.000539)	-0.000406 (0.000559)
SEP	0.00283*** (0.00108)	0.00225** (0.00113)	0.00388*** (0.00109)	0.00256** (0.00116)
UNE	0.00218 (0.00150)	0.00241* (0.00146)	0.00216 (0.00165)	0.00163 (0.00165)
TNR	0.000362 (0.00100)	-0.000712 (0.00103)	-0.000804 (0.00110)	-0.00102 (0.00108)
Constant	0.179 (0.204)	0.211 (0.204)	0.123 (0.208)	0.170 (0.203)
Wald chi2	58.69	61.43	52.48	58.30
Prob. value	0.0000	0.0000	0.0000	0.0000
R-squared	0.3888	0.3952	0.3619	0.4108

Conclusion and Recommendations

Conclusion

The primary goal of this research was to look into the impact of Financial Technology on Income Inequality, as well as the moderating role of Financial Freedom and Financial Inclusion in achieving the sustainable development goal.

In this study, independent variables; Mobile cellular subscriptions (Per 100 People) (MOB); Individuals using the internet (% of population) (INT) and Broad band subscriptions (Per 100 People) (BBS) were used to construct a Financial Technology Index through PCA. The moderating variables were financial freedom score (FF) and Digital Financial Inclusion. This study also utilized macroeconomic factors to control the economic growth including population growth rate (POP), inflation (annual %) for consumer prices (INF), log of Trade (LTRA), Secondary and Primary enrolments (SEP)(SES) and Unemployment (UNE). Income Inequality (represented by log of IIE) was used as dependent variable.

This study used secondary data for 155 developing countries for the period 2000-2023 from World Bank WDI, Financial Access Survey of IMF and Heritage Foundation for conducting this research in order to identify the significant relationship between variables of this study.

This study used Stata. Various statistical tests were employed including correlation, simple OLS regression, panel regression, panel corrected standard error (PCSE) and two stage least square (2SLS) regression for data analysis and identifying the extent and direction of relationship between study's variables.

In correlation analysis, the variables negatively correlated with LIIE, such as FTI, financial freedom, DFI indicate potential areas where decreasing inequality can be observed. Understanding these correlations can help in designing policies and interventions aimed at promoting economic equality. Importantly, the results confirm the absence of multicollinearity issues among independent variable.

The results consistently reveal a significant negative impact of FT on income inequality, highlighting its crucial role in promoting economic development. Other factors exhibiting a positive and significant effect include unemployment, population growth, natural resources and inflation. The Wu-Hausman test does provide strong evidence of endogeneity bias. These findings collectively demonstrate the robustness of the results, indicating that the negative relationship between FT and income inequality holds even after accounting for potential biases and alternative model specifications.

Research Implications

Theoretical Implications:

The nexus between financial technology and income inequality presents significant theoretical implications in the context of achieving Sustainable Development Goals (SDGs). FinTech has the potential to transform financial services and making them more accessible and affordable while addressing income inequality. Though, the effectiveness of Fintech in achieving reasonable results is depending upon the levels of financial inclusion and financial freedom within a society.

The regression results highlight the significant impact of technological and financial access variables (MOB, INT, BBS, FTI) on reducing income inequality. These findings highlight the importance of encouraging mobile connectivity, internet access, banking services and promising financial conditions to achieve a more reasonable income distribution. Increasing digital financial inclusion can lessen the negative impacts of Fintech on income inequality and ensures that technological improvements contribute to a just financial system. Thus, strategic efforts to promote DFI should be essential for the expansion of financial technologies to foster inclusive growth and reduce income differences. The statistical significance of observed coefficients indicates that when financial freedom increases then the beneficial impact of financial technology

on reducing income inequality is moderated and become less pronounced. In simple terms, higher levels of financial freedom tend to reduce the positive effects that financial technology can have on bridging the income gap.

Achievement of sustainable development goals such as reduction of poverty and ensuring decent work and economic growth mainly rely on inclusive financial systems. With the help of financial inclusion and freedom, FinTech can empower people, promote entrepreneurship and facilitate economic participation. This theoretical framework highlights the need for policymakers to design strategies that enhance financial inclusion and freedom, ensuring that benefits of Fintech are widespread and are contributing to achieving SDGs successfully.

Financial inclusion aims to provide underserved populations access to essential financial services which includes savings accounts, credit, insurance and digital payment systems. The practical implication of enhancing financial inclusion through Fintech is profound. By leveraging mobile technology and digital platforms, FinTech can reach remote and sidelined communities that traditional banking services often overlook. This inclusion enables individuals to save securely, access credit for small businesses and manage financial risks through insurance products. As a result, financial inclusion can drive economic participation, enhance income stability and reduce poverty by directly contributing to SDG 1 i.e. No Poverty and SDG 8 i.e., Decent Work and Economic Growth.

Inclusive financial systems facilitate the empowerment of women and other disadvantaged groups which aligns with SDG 5 i.e., Gender Equality. Digital financial services can provide women with the tools to manage their finances independently, start businesses and participate more in economic activities. This empowerment has not only enhanced individual welfare but also promoted broader economic growth and social stability. Financial freedom which is the ability to make independent financial decisions without excessive restrictions, is another central element in this relationship. Fintech can enhance financial freedom by offering innovative financial products and services that are accessible, affordable and user-friendly. This democratization of financial services can foster entrepreneurship, stimulate investment and encourage innovation and contribute to economic growth and job creation. For case, crowd lending platforms can provide entrepreneurs with alternative funding sources and bypass traditional banking channels that are inaccessible. This fosters a dynamic and inclusive financial ecosystem and supports SDG 9 i.e., Industry, Innovation, and Infrastructure and SDG 10 i.e., Reduced Inequalities.

While the potential benefits are significant, the practical implementation of Fintech for financial inclusion and freedom requires addressing several challenges. Digital literacy, cybersecurity, regulatory frameworks and infrastructure development are critical areas that need attention. Ensuring that all population segments can access and effectively use Fintech solutions is vital for maximizing their positive impact.

FinTech, when coupled with deliberate efforts to enhance financial inclusion and financial freedom, holds substantial potential to reduce income inequality and support the achievement of the SDGs. Policymakers, financial institutions and technology providers must collaborate to create inclusive, secure, and empowering financial systems that benefit all individuals particularly those who are most vulnerable. By doing so, the promise of FinTech can be realized in a way that promotes equitable and sustainable development.

In conclusion, although Fintech has the potential to transform the way income inequality is addressed by increasing financial inclusion and freedom, its benefits depend on overcoming a

number of complications and taking a comprehensive approach to research and policymaking. Stakeholders can maximize the positive effects of Fintech on income distribution and can contribute to global efforts to achieve the SDGs by addressing these limitations and implementing recommendations based on evidence.

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