

Research Article

Nexus Between Financial Inclusion and Financial Innovation: Empirical Insights from G20 Countries

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Abstract

The relationship between financial innovation and financial inclusion remains an underexplored area in economic research, despite ongoing debates about the interconnectedness of these two critical factors. Financial innovation, characterized by the development and adoption of new financial products, services, and technologies, has the potential to significantly enhance financial inclusion by improving access, affordability, and convenience of financial services. However, empirical evidence on how these innovations directly influence the extent and quality of financial inclusion across different economies, particularly among the G20 countries, is limited. This study examines the relationship between financial innovation and financial inclusion within the context of G20 countries. To attain the objective, the paper constructs a Financial Inclusion Index (FII) to provide a comprehensive view of financial inclusion. Similarly, the Financial Innovation is measured using a financial innovation index computed by means of internet accessibility and mobile accessibility by following PCA method. In pursuit of the study's goals, it utilizes secondary data spanning from 2014 to 2022, which was obtained from the World Bank and the IMF Financial Access Survey (FAS). The findings reveal a significant relationship between financial inclusion and innovation among the G20 nations. The result also reveals that financial innovation positively impacts financial inclusion. However, the findings are limited to examining the nexus between financial inclusion and financial innovation within selected G20 countries. As an original contribution to the field, this research encompasses various dimensions that previous authors have considered. This study addresses this gap by examining the empirical nexus between financial innovation and financial inclusion, aiming to provide insights into how technological advancements shape financial accessibility and inclusion outcomes in diverse economic contexts.

Keywords

Financial Innovation, Financial Inclusion, Economic Growth, G20 Countries

1. Introduction

The financial ecosystem of a nation plays a pivotal role in its economic development. It provides a payment mechanism that promotes trade and business. A dynamic financial system encompasses a variety of financial instruments, efficient

institutions, and a broad array of financial services that are closely integrated with the economy [40] More specifically, a well-functioning financial system continuously adapts and evolves, spreading innovative financial assets and offering

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innovative solutions and services to the population. Thus, a country's economic and financial development is immensely motivated by rapid innovation, particularly the financial innovation in the system [40]. Previous study reported that human development and financial inclusion move in the same direction [58]. Financial innovation is vital for economic development as it improves financial accessibility, simplifies financial transactions in international trade, and boosts financial efficiency. Like other innovations, financial innovation involves continually incorporating changes within the financial sector by enhancing and diversifying financial products and services [9]. It primarily involves the development of novel financial products, augmented procedures, and well-organized systems within the financial sector to meet stakeholders' emerging needs [64]. Financial innovation is often considered the "engine" that drives a financial system toward achieving the goal of a "real economy" [38]. Incorporating innovative financial resources and infrastructure within the financial system enhances the effectiveness of financial services and the growth of capital markets, significantly contributing to economic growth [40].

At a macroeconomic level, financial innovation enhances liquidity and improves the allocation of capital, which is essential for economic growth and stability [38, 39]. Financial innovation promotes economic growth by enabling the mobilization of investment, efficient financial intermediation, capital accumulation, and improved overall efficacy within financial institutions. Financial innovation is a key catalyst for financial development [32]. Furthermore, financial innovation is imperative in improving financial inclusion and accessibility. The advent of digital finance and fintech offers several opportunities to reach underbanked populations and integrate them into the formal financial ecosystem [10]. Digital payment systems, mobile access, and Internet connectivity are crucial for improving financial inclusion in developing economies. Increased Internet access enables digital platforms like fintech apps, online banking, and mobile wallets, reducing financial barriers for marginalized groups in remote areas. Mobile access facilitates seamless financial transactions and offers a range of services. These advancements have spurred innovative solutions such as mobile banking and peer-to-peer lending, lowering transaction costs, enhancing transparency, and broadening economic participation. Consequently, mobile and Internet accessibility has accelerated financial inclusion and innovation, fostering a more equitable global financial ecosystem.

Considering the relative significance of innovation in the financial system, several international organizations, including G20 members, have taken steps to foster an enabling environment for the development of financial innovation while mitigating potential risks. In the G20 context, adopting innovative financial instruments can help manage and alleviate the risks associated with global financial integration [61]. The G20 has underscored the need for

innovative financial instruments and mechanisms to channelize private capital towards sustainable investments. Such investment includes the development of green bonds, environmental impact bonds, and other innovative financial products that align with the United Nations Sustainable Development Goals (SDGs) [55]. Such environmentally responsive activity aligns with the G20's strategic action plan for Sustainable Development, underscoring innovative financial solutions' pivotal role in elevating sustainable growth [65].

Recently, financial inclusion has captured significant attention from policymakers, researchers, central banks, and financial institutions due to its pivotal role in improving the global financial sector [19]. The World Bank's Universal Financial Access initiative underscores financial inclusion as a cornerstone for poverty reduction and inclusive economic growth. Financial inclusion accelerates economic development by facilitating efficient resource allocation, improving financial efficacy, minimizing financing costs, reducing information costs for loans and advances, and enhancing institutional efficiency in fund management [59].

Financial inclusion means providing affordable, accessible financial products to those previously excluded [31]. Included individuals enjoy benefits like smoother transactions, business growth from external financing, and savings security. It integrates the unbanked into the formal financial system through various services and investment opportunities. To draw people into this system, financial institutions must broaden their offerings, adopting innovative financial instruments and improving operational efficiency and payment methods. Thus, institutions continuously seek to enhance services and meet the diverse needs of society.[64] highlights that financial innovation involves introducing and promoting new financial tools, technologies, and markets. Prior studies have documented a strong association between financial innovation and economic growth [12, 50-53]. Most of the existing studies specifically focused on examining the impact of financial innovation on economic growth [21, 40, 52] and the influence of financial innovation and institutional quality on financial development [3]. These studies have primarily been conducted in South Asia and Sub-Saharan Africa. However, an extensive review of the financial innovation related studies reveals that there exists a limited studies on the nexus between financial innovation and financial inclusion, especially in the G20 context. The G20, with its diverse mix of developed and emerging economies, offers a unique and valuable setting for such research. Findings derived from such a study are likely more comprehensive and realistic. Moreover, the survey of pertinent studies has indicated that the literature on the identified research problem is likely scant, and the present study would attempt to replenish the gap based on empirical evidence.

The present study on the nexus between financial innovation and financial inclusion within G20 countries is

motivated by several factors. Studies suggested that financial innovation can bridge the gap between the unbanked and underbanked populations [10, 52]. Financial innovations, such as mobile money platforms and digital banking solutions, have the potential to minimize geographical barriers and bring affordable financial services to remote and underserved populations [10]. Despite the continuous effort to promote financial inclusion, it has been observed that 1.7 billion adults globally remain unbanked. Moreover, more than a billion individuals in South Africa who are members of the African Union under G20 lack access to formal financial services [67]. A similar picture is reflected in Asia, where over a billion people in this region also lack such access, a situation emphasized in the World Bank's recent blogs. Therefore, focusing specifically on the G20 countries is strategically significant, as it offers an optimal context for a comprehensive analysis of essential dynamics. Moreover, the G20 forum encompasses diverse economies, from developed to emerging, allowing a broad and enlightening analysis. Several other factors drive the decision to focus specifically on G20 countries: Firstly, the G20 members collectively represent around 85% of global GDP, over 75% of world trade, and encompass about two-thirds of the world's population. Secondly, their collaborative efforts, represented by initiatives like the Global Partnership for Financial Inclusion [25], underscore their pivotal role in enhancing access to financial services. Thirdly, their combined leadership in adopting digital financial technologies presents a valuable perspective on innovative approaches to financial inclusion [5, 25]. Fourthly, the G20 country's strategic intention for developing and investing in sustainable projects, such as green bonds and environmental impact bonds, underscores their pivotal role in elevating sustainable growth [69]. Finally, secondary data related to financial innovation and financial inclusion are available in the World Bank and International Monetary Fund (IMF) from 2014, making it more feasible to conduct comprehensive research and analysis.

The study is novel in many ways. First, it enhances the debate on the link between financial innovation and inclusion in diverse economies. Second, it uniquely focuses on G20 countries, marking the first empirical investigation into their relationship. Third, rather than analyzing a single country, this research employs an innovative methodology using data from G20 countries from 2014 to 2022. Finally, its findings aim to provide critical insights into the relationship between financial innovation and inclusion, serving as a resource for policymakers, regulators, and academics. This study explores the connection between financial innovation and inclusion in the G20 context.

The subsequent sections of the study have been framed as follows: Section 2 presents the literature review related to the topic. Section 3 describes the research methodology. Section 4 outlines the empirical results and discussions. Section 5 provides the conclusion and policy implications.

2. Literature Review

2.1. Concept and Measurement of Financial Inclusion

Financial inclusion has been defined in several ways across different studies, but all have identical information content in terms of conclusion [46]. It focuses on making financial services accessible and affordable for everyone, particularly those less privileged. The World Bank (2014) defined financial inclusion as the proportion of households and businesses that use banking and financial services, which reflects the penetration level of financial services among the general population and the business sector. [56] documented that financial inclusion incorporates the access, usage, and delivery of the right financial services at a reasonable cost to the marginalized segment of society. This broader perspective identifies the multifarious nature of financial inclusion. Financial inclusion ensures timely and adequate access to financial services at affordable cost, especially for marginalized communities [11].

Sarma defined financial inclusion as a multidimensional concept encompassing accessibility, availability, and usage of financial services [57]. Based on the above parameter, Sarma developed a model for the computation of the financial inclusion index [57]. A string of literature argued that this model is mathematically sound and comparable across different countries over time. Similarly, [17] developed a financial inclusion index by assessing three sub-indices related to usage, access, and barriers through a two-stage principal component analysis to determine dimension weights. Several researchers, including [18] and [36], have developed different indices based on different financial dimensions and methodologies.

2.2. Concept of Financial Innovation

Financial innovation is a foundation stone of financial sector development and a crucial driver of economic activities. This is because innovations enhance savings, capital accumulation, and productivity, which in turn stimulate economic growth [21]. Financial innovation represents developing new financial products, enhancing existing processes, and implementing efficient systems within the financial sector to address participants' evolving needs [64]. It incorporates all high-tech, financial, systematic, and profit-oriented activities, crucial for developing new markets with value-added financial resources [44]. However, since nothing is completely new, financial innovations often involve augmenting existing products or developing innovative solutions to ensure efficiency and profitability.

In the realm of the financial system, financial innovation serves as a catalyst for accelerating operational advancements, such as mobile and Internet banking services [54]. Different entities such as NGOs, microfinance institutions, and

high-tech organizational firms are instrumental in propelling innovation within the financial sector. Such innovation collectively contributes to economic development by facilitating the inclusion of individuals in economic development [40]. The integration of diverse segments of the population into the financial system fosters financial inclusion and promotes economic progress.

2.3. Empirical Literature and Hypothesis Development

This section reviews the empirical literature that has examined the relationship between the relevant variables. Based on the findings, it formulates specific hypotheses that the current research study aims to test.

Financial innovation and financial inclusion

Numerous studies have evaluated the link between financial inclusion, innovation, and economic growth. Research shows that financial innovation, indicated by internet users, mobile accessibility, and R&D expenditure (% of GDP), is crucial for enhancing financial inclusion through new products, effective intermediation, reduced information costs, and improved financial effectiveness [2, 3, 50].

Prior literature has reported a significant positive association between financial innovation, financial inclusion, and economic growth [6, 40]. The research underscores that adopting innovative financial technologies, such as mobile banking and digital payment systems, has substantially increased access to financial services, particularly for individuals and businesses in underserved areas [10]. Similarly, [47] examined the impact of financial innovation on financial inclusion in sub-Saharan Africa and found a favourable link between financial innovation and effective financial inclusion. Furthermore, [22] revealed that countries with a higher level of financial innovation tend to have higher financial inclusion rates. This finding is consistent with the results of [7, 8], who demonstrated the positive link between ICT enabled financial innovation and financial inclusion. Interestingly, the literature has also highlighted that access to mobile banking, ATMs, and mobile money innovations significantly positively impact financial inclusion [21]. Based on the prior literature, the present study has expected a positive association between financial innovation and financial inclusion, and accordingly, it has framed the following hypothesis:

There exists a positive association between financial innovation and financial inclusion (H_{A1}).

Trade openness and financial inclusion

Trade openness is considered a significant source of economic growth and development [52]. It represents the extent to which a nation relies on international trade. A higher level of trade openness implies a profound reliance on international trade. Trade openness, which is typically measured by the sum of exports and imports of goods and services (% of GDP), improves the productivity of domestic

businesses through technological advancement, knowledge sharing, and a healthy competitive environment across the globe [52].

Current literature advocates a positive association between trade openness and an inclusive financial system. [33] reported a positive association between trade openness and financial inclusion indicators, such as the number of bank accounts and the use of digital financial services. Similarly, [14-16, 30] observed that greater trade openness is associated with higher levels of financial development, including better access to credit. Interestingly, certain studies also highlighted that trade openness tends to increase as a country's financial inclusion level increases [26]. Accordingly, we hypothesize that:

There exists a positive association between trade openness and financial inclusion (H_{A2}).

Economic growth and financial inclusion

Economic growth is crucial for financial inclusion. As incomes rise, more individuals access essential services like bank accounts and credit, promoting further economic activity and stability. Additionally, growth improves household economic life, encouraging the use of financial products. Several empirical investigations have been carried out to navigate the critical interplay between financial inclusion and economic growth. Most studies reflect a significantly positive relationship between economic growth and financial inclusion, including [62] and [63]. Economic growth, all things being equal, is expected to ensure an increase in financial inclusion [1]. [6] documented a significant positive association between economic growth (GDP per capita) and financial inclusion. [71] also confirmed the positive relationship and suggested that nations with higher economic growth (GDP per capita) tend to have more developed eco-financial infrastructure. This finding is similar to [20], who argued that better economic conditions are directly associated with better financial inclusion. However, there has been evidence of insignificant results with economic growth and financial inclusion [43]. Based on the above discussion, we developed the following hypothesis:

There exists a positive association between economic growth and financial inclusion (H_{A3}).

Government expenditure and financial inclusion:

Government plays a pivotal role in the development of every nation. Governments can implement policies that facilitate access to financial services, thereby contributing to their citizens' overall well-being and economic empowerment. Government expenditure means monetary spending by the government on infrastructure, education, technology, and social welfare programs. It is theoretically assumed that optimum expenditure by the government in the financial sector can raise the income of households, which will encourage them to use innovative financial products and services.

Prior literature has reported a significant positive association between government expenditure and financial

inclusion. Researchers like [48] and [29] acknowledged the positive association between government expenditure and financial inclusion. Similarly, [42] spotted that higher government expenditure on financial infrastructure and social programs is associated with increased financial inclusion, particularly regarding account ownership and innovative financial services. Likewise, [37] revealed that higher government spending on education, health, and social protection positively correlates with improved financial inclusion indicators, such as the number of bank branches and ATMs. Therefore, considering the relative significance of the government expenditure, we hypothesize that:

There is a positive association between Government expenditure and financial inclusion (H_{A4}).

Inflation and financial inclusion

Inflation is a crucial factor in any country's financial development and has a significant influence on financial inclusion. A low level of inflation is estimated to improve a nation's financial inclusion scenario [41].

Several empirical investigations argued that there is a negative association between inflation and financial inclusion. [28] documented that inflation significantly negatively impacts inclusive financial development. Similarly, [37] argued that inflation hinders financial stability and limits financial inclusion. Recently, [70] and [13] reported a

significant negative effect of inflation on financial sector development. The above findings collectively highlighted the detrimental impact of inflation on financial inclusion. Accordingly, the study has framed the following hypothesis:

There is a significant negative association between Inflation and financial inclusion (H_{A5}).

3. Research Methodology

3.1. Sample Selection and Data Source

In the present study, a dataset encompassing 81 G20 countries, including the newly inducted African Union, was considered to explore the nexus between financial innovation and financial inclusion. This study used nine years annual data from 2014 to 2022. Data were collected from the Financial Access Survey (FAS) database maintained by the International Monetary Fund (IMF) and the World Bank. The variables presented in the study were primarily selected based on the available empirical literature, with certain modifications to fulfill the study's objectives. The availability of relevant data predominantly influenced the selection of nations for analysis.

3.2. Variables Used in the Study

Table 1. Description of variables.

Variables name	Symbol	Nature	Proxy/ measurement	Empirical justification
Financial Inclusion	FII	Dependent	Financial Inclusion Index by (Index constructed using Principal Component Analysis technique).	[21, 46]
Financial innovation index	FIIN	Independent	Financial Innovation Index by using internet accessibility and mobile accessibility	[46, 52]
Economic growth	LnGDP	Control	Log value of GDP per capita, constant 2010 dollars	[46]
Govt. Expenditure (% of GDP)	GE	Control	General Government final consumption expenditure as a percentage of GDP	[40, 46]
Trade Openness	LnTO	Control	Sum of exports and imports of goods and services (% of GDP). (Taken as Log value)	[46]
Inflation rate	Inf	Control	Inflation, consumer prices (annual %)	[40]

Source: Authors' compilation

The present study has identified the variables based on the related literature and the variables are categorized as the independent, dependent, and control variables. A detailed description of the study variables has been presented in Table 1.

3.3. Model Estimation

The present study has developed the following model for assaying the nexus between financial innovation and financial inclusion.

$$FII = \alpha + \beta_1 FIIN_i + \beta_2 LnGDP_i + \beta_3 GE_i + \beta_4 LnTO_i + \beta_5 Inf_i + \mu_i$$

4. Result and Discussions

4.1. Descriptive Statistics

Table 2 demonstrates the descriptive statistics investigating the distribution of the analysed variables. FII had a lower mean, with an SD of 1.000. FIIN shows a mean of 0.021 and an SD of 0.489. LnGDP had a mean of 8.268 and an SD of 8.298. GE reported a mean of 7.747 and an SD of 8.176. LnTO had a mean of 2.094 and an SD of 1.975. Lastly, the Inf had a mean of 5.158 and an SD of 28.650. The other details are provided in the following table.

Table 2. Descriptive Statistics.

Variables	Mean	SD	Var	Min.	Max.
FII	0.008	1.000	1.000	-0.253	9.005
FIIN	0.021	0.489	0.240	-1.896	3.456
LnGDP	8.268	8.298	68.864	0.036	90.991
GE	7.747	8.176	66.850	0.010	36.140
LnTO	2.094	1.975	3.901	-4.196	5.263
Inf	5.158	28.650	820.804	-4.800	557.200

Source: Authors' compilation

4.2. Regression Analysis

Table 3 presents the outcomes of the stepwise multiple regression analysis to determine the impact of the relevant predictor and control variables upon FII.

In Model 1, which was statistically significant ($F=263.22$, $p < 0.001$), the predictor, i.e., FIIN, along with the control variables, explained 62% of the variance in FII ($R^2 = 0.62$). FIIN ($\beta = 0.781$, $p < 0.001$), LnGDP ($\beta = 0.102$, $p < 0.001$), GE ($\beta = -0.154$, $p < 0.001$), and LnTO ($\beta = 0.083$, $p < 0.05$) were significant predictors. However, GE showed a prediction of negative directionality. Inf was found not to be a significant predictor of FII, but a prediction of negative directionality was noted.

Model 2 was found to be statistically significant ($F=1090.674$, $p < 0.001$), and FIIN continued to be a significant predictor ($\beta = 0.775$, $p < 0.001$) of FII in this model. The main feature of this model is that the controlling variables were removed and only the primary predictor was retained. After removing the controlling variables, model 2 has a slightly reduced explanatory power (variance-explained) with

an R^2 of 0.60. Though this model shows a slight decrease in the R^2 (of -0.02), the change in R^2 was statistically significant, indicating the need for controlling the other four variables.

Indicating the significance of the control variables in the model, it can be stated that (from model 1), while controlling for LnGDP, GE, LnTO and Inf, FIIN is a significant and positive predictor of FII ($\beta = 0.781$, $p < 0.001$).

Hence, the first, second and third hypotheses have been accepted. The fourth hypothesis was partially accepted because government expenditure (GE) significantly impacts financial inclusion with negative directionality. The fifth hypothesis could not be accepted.

Table 3. Regression analysis for the variables with FII as the criterion.

Variables	β	t	p
<i>Model 1 ($F = 263.22^{**}$, $R^2 = 0.62$)</i>			
FIIN	0.781	31.561	0.000**
LnGDP	0.102	4.334	0.000**
GE	-0.154	-4.050	0.000**
LnTO	0.083	2.215	0.027*
Inf	-0.015	-0.660	0.510
<i>Model 2 ($F = 1090.674^{**}$, $R^2 = 0.60$)</i>			
FIIN	0.775	33.025	0.000**

Note: ** and * indicate Significance at 0.1% and 5%, respectively.

Source: Authors' compilation

Discussions:

The findings of this study explain the nexus between financial innovation and financial inclusion among the G20 countries. The results found that financial innovation is positively associated with financial inclusion, which supports H_1 . This means an environment where innovation can flourish shall play a vital role in increasing financial accessibility [34, 68]. A positive association was found between economic growth and financial inclusion, concurring with existing research that links higher economic performance to better financial outreach [66]. Thus, the result is in favour of H_3 . As the G20 countries continue to grow economically, the mechanisms for financial inclusion also improve, possibly due to increased investments in financial infrastructure and services [49].

Trade openness was another factor positively associated with financial inclusion (which led to the acceptance of H_2). This implies that greater integration into the global economy

may enhance financial services, making them more accessible and inclusive [37]. The role of international trade in promoting economic interaction can lead to a more robust financial system that benefits a broader population segment [45]. However, government expenditure showed a significant pessimistic prediction of financial inclusion, which contrasts with the existing literature [23]. Thus, the result partially accepts H₄. This signifies the presence of inefficiencies in public spending or allocation that do not directly support inclusive financial practices [24]. Flawed government policies or corruption can be an explanation behind this finding. More research in this area could help explore the channels through which the dynamics of public expenditure impacts financial inclusion can be better understood.

Inflation was not a significant predictor of financial inclusion (Thus, the H₅ could not be accepted.), although it indicated a negative directionality. This finding concurs with [4], who found that GDP per capita increased financial inclusion while GDP growth and interest rate spread reduced the same. This suggests that while inflation can influence financial behaviour, it may not be a primary determinant of financial inclusion within the G20 context [27].

Hence, the study could determine the critical role that financial innovation plays in boosting financial inclusion and explain how other economic variables interact with financial access. The findings can assist policymakers who attempt to bring more effective strategies to promote inclusive financial systems.

5. Conclusion and Implications

The present study extends the empirical literature by providing empirical evidence on the nexus between financial innovation and financial inclusion in the G20 countries. To conclude, the current study highlights the significant impact of financial innovation on promoting financial inclusion within G20 countries. The positive relationship between economic growth, trade openness, and financial inclusion emphasizes the nature of economic progress and access to financial systems. Government expenditure showed a negative relationship with financial innovations, suggesting potential inefficiencies. Inflation was not found to be a significant predictor of financial innovations. Policymakers should focus on creating an environment that encourages innovation and addresses the impacts of economic and policy variables to boost financial inclusion effectively. Future research could further dissect these relationships and explore how new, related business and financial constructs are linked with financial innovations.

The empirical findings lead to several practical implications. First, they affect stakeholders like policymakers, academics, and researchers, highlighting the link between financial innovation and inclusion. Second, regulatory authorities must create an enabling environment for financial institutions to adopt advanced technology. Third,

governments should develop policies that ensure financial sector stability. Lastly, financial institutions should adopt advanced financial services adaptable to other countries.

The study has some limitations. First, it samples only G20 countries, limiting generalization. Second, it uses just internet and mobile access as proxies for the financial innovation index. Third, due to time constraints, the dataset spans only nine years with predetermined variables. Lastly, the chosen econometric tool has limitations that may affect results.

It has sketched a roadmap for future studies as well. At first, as the study has incorporated only 81 sample countries from G20 members, future research may be conducted by incorporating more samples to get better insights into the nexus between financial innovation and inclusion. Second, the excluded variables, such as research and development expenditure, institutional quality, gross capital formation, and money supply, may be incorporated in posterior studies to obtain more categorical results on each variable. Third, future researchers can use different indicators to measure financial innovation and, thus, incorporate innovative findings. Finally, future researchers can investigate the nexus between financial innovation and financial inclusion in other emerging economies to compare and enrich the current study's findings.

Abbreviations

ATM	Automated Teller Machine
FAS	Financial Access Survey
FII	Financial Inclusion Index
G20	Group of 20
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IMF	International Monetary Fund
PCA	Principal Component Analysis
R&D	Research and Development

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix: Construction of Financial Inclusion Index (FII) and Financial Innovation Index

Financial Inclusion Index (FII):

To empirically investigate the nexus between financial innovation and financial inclusion, we constructed a financial inclusion index (FII). The study considered three key indicators: availability, accessibility (Geographic penetration), and usage of financial services.

Firstly, the study measured the degree of availability of financial services by incorporating two indicators: the number of commercial banks per 100,000 adults [46, 60] and the

number of ATMs per 100,000 adults [17, 60]. Secondly, for measuring accessibility (Geographic Penetration), we have used the two indicators namely, number of commercial bank branches per 1000 square km [35, 36, 60] and the number of ATMs per 1000 square km [35, 36, 60]. Thirdly, to capture the

usage dimension more comprehensively, we consider two indicators - outstanding loans from commercial banks (% of GDP) and outstanding deposits with commercial banks (% of GDP) [62]. Table A1 represents the detailed descriptions of each aspect along with literature support and sources.

Table A1. Description of variables for Financial Inclusion Index by PCA method.

Indicators	Description	Empirical Justification	Sources of data
Availability	Number of commercial bank branches per 100,000 adults.	[46]	FAS
	Number of ATMs per 100,000 adults.	[46]	FAS
Geographic Penetration (For measuring Accessibility)	Number of commercial bank branches per 1000 km ²	[35, 36]	FAS
	Number of ATMs per 1000 km ²	[35, 36]	FAS
Usage	Outstanding deposits with commercial banks (% of GDP)	[35]	FAS
	Outstanding loans from commercial banks (% of GDP)	[62]	FAS

Source: Authors' compilation

Financial Innovation Index:

To attain the study's objectives, the present study developed a financial innovation index based on two parameters: internet accessibility and mobile accessibility. The Principal

Component Analysis technique was used to construct the financial innovation index. Table A2 depicts the indicators' descriptions along with their proxy and literature supports.

Table A2. Description of variables for construction of financial innovation index.

Indicators	Proxy/ Measurement	Empirical justifications
Internet accessibility	Fixed broadband subscriptions per 100 people	[46]
Mobile Accessibility	Number of mobile cellular subscriptions per 100 people	[46]

Source: Authors' compilation

Table A3. Descriptions of other pertinent variables used in the study and their sources.

Variables name	Proxy/ measurement	Data Sources
Financial Inclusion	Financial Inclusion Index by using the PCA Method	IMF (FAS)
Financial innovation	Financial Innovation Index by using internet accessibility and mobile accessibility	WDI
Trade Openness	The sum of exports and imports of goods and services (% of GDP).	WDI
Economic growth	GDP per capita, constant 2010 dollars	WDI
Govt. Expenditure (% of GDP)	General Government final consumption expenditure as a percentage of GDP	WDI
Inflation rate	Inflation, consumer prices (annual %)	WDI

Source: Authors' compilation

References

- [1] Adams, R. (2002). Economic Growth, Inequality and Poverty: Findings from a New Data Set, *Policy Research Working Paper 2972*. World Bank, February 2002
<https://documents.worldbank.org/curated/en/168041468761746890/.pdf>
- [2] Akcali, B. Y, and Sismanoglu, E. (2015). Innovation and the effect of research and development (R&D) expenditure on growth in some developing and developed countries. *Procedia-Social and Behavioral Sciences* 195: 768–75.
<http://dx.doi.org/10.1016/j.sbspro.2015.06.474>
- [3] Alawi, S. M., Wajih A., Rukhma S., and Madeeha, S. (2022). Impact of Financial Innovation and Institutional Quality on Financial Development in Emerging Markets. *Journal of Risk and Financial Management* 15: 115.
<https://doi.org/10.3390/jrfm15030115>
- [4] Alber, N. (2019). Determinants of Financial Inclusion: The Case of 125 Countries from 2004 to 2017. *Global Issues in Banking and Finance*. <https://doi.org/10.2139/ssrn.3476373>
- [5] Alhassan, A., Li, L., Reddy, K., Duppati, G. (2021). The relationship between political instability and financial inclusion: evidence from Middle East and North Africa. *International Journal of Finance and Economics*. 26(1), 353–37. <http://dx.doi.org/10.1002/ijfe.1793>
- [6] Allen, F., Carletti, E., Cull, R., Qian, J. Q., Senbet, L., & Valenzuela, P. (2014). The African financial development and financial inclusion gaps. *Journal of African Economies*, 23(5), 614-642. <https://doi.org/10.1093/jae/eju015>
- [7] Andrianaivo, M., & Kpodar, K. (2011). ICT, financial inclusion, and growth: Evidence from African countries. *International Monetary Fund*.
<https://doi.org/10.5089/9781463925551.001>
- [8] Andrianaivo, M., & Kpodar, K. (2012). Mobile phones, financial inclusion, and growth. *Review of Economics and Institutions*, 3(2), 1-30. <https://doi.org/10.5202/rei.v3i2.45>
- [9] Ang, J. B., & Kumar, S. (2014). Financial development and barriers to the cross-border diffusion of financial innovation. *Journal of Banking & Finance* 39: 43–56.
<https://doi.org/10.1016/j.jbankfin.2013.10.011>
- [10] Arner, D. W., Barberis, J., & Buckley, R. P. (2015). The evolution of Fintech: A new post-crisis paradigm? *University of Hong Kong Faculty of Law Research Paper No. 2015/047*.
<https://dx.doi.org/10.2139/ssrn.2676553>
- [11] Arun, T., & Kamath, R. (2015). Financial inclusion: Policies and practices. *IIMB Management Review*, 27(4), 267–287.
<https://doi.org/10.1016/j.iimb.2015.09.004>
- [12] Bara, A., Mugano, G., & Roux, P. (2016). Financial innovation and economic growth in the SADC. *African Journal of Science Technology Innovation and Development*
<http://dx.doi.org/10.1080/20421338.2016.1226705>
- [13] Batayneh, K., Salamat, W., Momani, Q. M. (2021). The impact of inflation on the financial sector development: Empirical evidence from Jordan. *Cogent Economics & Finance*.
<https://doi.org/10.1080/23322039.2021.1970869>
- [14] Beck, T., Chen, T., Lin, C., & Song, F. M. (2020). Financial innovation: The bright and the dark sides. *Journal of Banking & Finance*, 117, 105822.
<https://econpapers.repec.org/scripts/redis.pf?u>
- [15] Beck, T., Demirgüç-Kunt, A., & Levine, R. (2007). Finance, inequality and the poor. *Journal of Economic Growth*, 12(1), 27-49. <https://doi.org/10.1007/s10887-007-9010-6>
- [16] Blach, J. (2011). Financial innovations and their role in the modern financial system Identification and systematization of the problem e-Finanse. *Financial Internet Quarterly*, 7(3), 13–26.
<https://www.researchgate.net/journal/Financial-Internet-Quarterly>
- [17] Cánara, N., Tuesta, D. (2014). Measuring financial inclusion: a multidimensional index. *BBVA Research Working Paper 14/26*. Madrid, Spain. <https://www.bbvaesear>
- [18] Chakravarty, S. R. & Pal, R. (2013). Financial inclusion in India: an axiomatic approach. *Journal of Policy Modelling*, 35(5). <https://doi.org/10.1016/j.jpolmod.2012.12.007>
- [19] Chauvet, L., & Jacolin, L. (2015). Financial inclusion and firms performance. FERDI conference paper. *Banque de France*.
<https://publications.banque-france.fr/sites/default/files/>
- [20] Demirgüç-Kunt, A., & Klapper, L. (2013). Measuring financial inclusion: Explaining variation in use of financial services across and within countries. *Brookings Papers on Economic Activity*, 279-340. <https://doi.org/10.1353/eca.2013.0002>
- [21] Domeher D., Konadu E. Y., & Aawaar, G. (2022). Financial innovations and economic growth: Does financial inclusion play a mediating role? *Cogent Business & Management*, 9: 1, 2049670, <https://doi.org/10.1080/23311975.2022.2049670>
- [22] Gabor, D., & Brooks, S. (2017). The digital revolution in financial inclusion: International development in the fintech era. *New Political Economy*, 22(4), 423-436.
<https://doi.org/10.1080/13563467.2017.1259298>
- [23] Gebrehiwot, K., & Makina, D. (2019). Macroeconomic Determinants of Financial Inclusion. *Extending Financial Inclusion in Africa*.
<https://doi.org/10.1016/B978-0-12-814164-9.00008-6>
- [24] Gioacchino, D., Sabani, L., & Tedeschi, S. (2019). Individual preferences for public education spending: Does personal income matter? *Economic Modelling*.
<https://doi.org/10.1016/J.ECONMOD.2019.01.007>
- [25] Global Partnership for Financial Inclusion (GPFI), (2020). G20 2020 Financial Inclusion Action Plan.
<https://www.gpfi.org>
- [26] Hajilee M., Niroomand, F. (2019). On the link between financial market inclusion and trade openness: An asymmetric analysis, *Economic Analysis and Policy*, Volume 62,
<https://doi.org/10.1016/j.eap.2018.10.001>

- [27] Khan, H., Khan S., and Zuojun, F. (2020). Institutional Quality and Financial Development: Evidence from Developing and Emerging Economies. *Global Business Review*. <https://doi.org/10.1177/0972150919892366>
- [28] Kim, H. Lin, C., & Suen, B. (2010). Dynamic relationship between inflation and financial development. *Macroeconomics Dynamics*, 343-364. <https://doi.org/10.1018/S1365100509090312>
- [29] Klapper, L., Lusardi, A., & van Oudheusden, P. (2016). Financial literacy around the world: Insights from the Standard & Poor's Ratings Services Global Financial Literacy Survey. *Global Financial Literacy Excellence Center*. <https://gflec.org/wp-content/uploads/2015/>
- [30] Kose, M. A., Prasad, E. S., Rogoff, K., & Wei, S.-J. (2009). Financial globalization: A reappraisal. *IMF Staff Papers*, 56(1), 8-62. <https://doi.org/10.1057/imfsp.2008.36>
- [31] Kumar, B., & Mohanty, B. (2011). Financial Inclusion and Inclusive Development in SAARC Countries with Special Reference to India. *Vilakshan: The XIMB Journal of Management* 8: 13-22. <https://www.emeraldgrouppublishing.com>
- [32] Laeven, L., Levine, R., Michalopoulos, S. (2015). Financial innovation and endogenous growth. *Journal of Finance Intermediation*. <https://doi.org/10.1016/j.jfi.2014.04.001>
- [33] Le, T. H., Kim, J., & Lee, M. (2019). Institutional quality, trade openness, and financial sector development in Asia: An empirical investigation. *Emerging Markets Finance and Trade*, 55(13), 3095-3111. <https://www.adb.org/publications>
- [34] Lee, N., Sameen, H., & Cowling, M. (2015). Access to finance for innovative SMEs since the financial crisis. *Research Policy*, 44, 370-380. <https://doi.org/10.1016/J.RESPOL.2014.09.008>
- [35] Lenka, S. K. (2021). Relationship between financial inclusion and financial development in India: Is there any link? *Journal of Public Affairs*. <https://doi.org/10.1002/pa.2722>
- [36] Lenka, S. K. and Bairwa, A. K., (2016). Does financial inclusion affect monetary policy in SAARC countries? *Cogent Economics & Finance*. <https://doi.org/10.1080/23322039.2015.1127011>
- [37] Mehrotra, A., & Yetman, J. (2015). Financial inclusion—issues for central banks. *Bank for International Settlements Quarterly Review*. <https://www.bis.org/publ/>
- [38] Merton R. C. (1992). Financial innovation and economic performance. *Journal of Applied Corporate Finance*. <https://doi.org/10.1111/j.1745-6622.1992.tb00214.x>
- [39] Michalopoulos S, Laeven L, Levine R (2011). Financial innovation and endogenous growth. *National Bureau of Economic Research*, USA. <https://www.nber.org/system/files.pdf>
- [40] Nazir, M. R., Tan, Y., & Nazir, M. I. (2021). Financial innovation and economic growth: Empirical evidence from China, India and Pakistan. *International Journal of Finance & Economics*. <https://doi.org/10.1002/ijfe.2107>
- [41] Ndoricimpa, A. (2017). Threshold Effects of Inflation on Economic Growth in Africa: Evidence from a Dynamic Panel Threshold Regression Approach. Working Paper Series N°249. *African Development Bank*, Abidjan, Côte d'Ivoire. <https://www.afdb.org/sites/default/files/documents/>
- [42] Neaime, S., & Gaysset, I. (2018). Financial inclusion and stability in the Middle East and North Africa: Evidence from poverty and inequality. *Finance Research Letters*. <https://doi.org/10.1016/j.frl.2017.09.007>
- [43] Nsiah, A. Y., & Tweneboah, G. (2023). Determinants of Financial Inclusion in Africa: Is Institutional Quality Relevant? *Cogent Social Sciences*. <https://doi.org/10.1080/23311886.2023.2184305>
- [44] OECD. (2004). Financing innovative SMEs in a global economy. Paper presented at the 2nd OECD conference of ministers responsible for small and medium-sized enterprises (SMEs). Istanbul, Turkey. <http://citeseerx.ist.psu.edu/viewdoc/download>
- [45] Okenna, N., & Adesanya, B. (2020). International Trade and the Economies of Developing Countries. *American International Journal of Multidisciplinary Scientific Research* <https://doi.org/10.46281/aijmsr.v6i2.747>
- [46] Omar, M. A., and Inaba, K. (2020). Does financial inclusion reduce poverty and income inequalities in developing countries? A panel data analysis. *Economic Structures*, 9, 37. <https://doi.org/10.1186/s40008-020-00214-4>
- [47] Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, 18(4), 329-340. <https://doi.org/10.1016/j.bir.2017.12.003>
- [48] Ozili, P. K. (2020). Financial inclusion research around the world: A review. *Forum for Social Economics*, 49(4), 457-479. <https://doi.org/10.1080/07360932.2019.1704314>
- [49] Pradhan, R. (2019). Investigating the causal relationship between transportation infrastructure, financial penetration and economic growth in G-20 countries. *Research in Transportation Economics*. <https://doi.org/10.1016/j.retrec.2019.100766>
- [50] Qamruzzaman, Md., and Jianguo Wei. (2017). Financial innovation and economic growth in Bangladesh. *Financial Innovation*. <https://doi.org/10.1186/s40854-017-0070-0>
- [51] Qamruzzaman, Md., and Jianguo Wei. (2018a). Does Foreign Direct Investment, Financial Innovation, and Trade Openness Coexist in the Development Process: Evidence from Selected Asian and African Countries? *British Journal of Economics, Finance and Management Sciences* [http://www.ajournal.co.uk/EFpdfs/EFvolume16\(1\)/EFVol.16%20\(1\)%20Article%207.pdf](http://www.ajournal.co.uk/EFpdfs/EFvolume16(1)/EFVol.16%20(1)%20Article%207.pdf)
- [52] Qamruzzaman, Md., and Jianguo Wei. (2018b). Nexus between financial innovation and economic growth in South Asia: Evidence from ARDL and nonlinear ARDL approaches. *Financial Innovation* 4: 20. <https://doi.org/10.1186/s40854-018-0103-3>

- [53] Qamruzzaman, Md., and Jianguo Wei. (2018c). Financial Innovation, Stock Market Development, and Economic Growth: An Application of ARDL Model. *International Journal of Financial Studies*. <https://doi.org/10.3390/ijfs6030069>
- [54] Raffaelli, R., & Glynn, M. (2013). Institutional innovation: Novel, useful, and legitimate. Paper presented at the institutional analysis conference, Harvard Business School. <https://www.hbs.edu/faculty/Pages/item.aspx?num=45225>
- [55] Sachs, J. D., Woo, W. T., Gomez-Echeverri, L., & Yoshino, N. (2019). Why is green finance important? *ADB Working Paper Series*, 917. <https://doi.org/10.2139/ssrn.3327150>
- [56] Sahay, R., Cihak, M., N'Diaye, P., Barajas A., Mitra, S., Kyobe, A., Mooi, Y., Yousefi, R. (2015). Financial inclusion: Can it meet multiple macroeconomic goals? Washington, DC: *International Monetary Fund*. <https://www.imf.org/>
- [57] Sarma, M. (2008). Index of Financial Inclusion. *ICRIER Working Paper No 215*, New Delhi, India. <https://www.icrier.org>
- [58] Sarma, M., & Pais, J. (2011). Financial inclusion and development. *Journal of International Development*. <https://doi.org/10.1002/jid.1698>
- [59] Sarma, M., and Pais, J. (2008). Financial Inclusion and Development: A Cross Country Analysis. New Delhi: *Madras Schools of Economics*. <https://www.icrier.org/pdf/Mandira%20.pdf>
- [60] Sarma, M. (2012). Index of Financial Inclusion—A measure of financial sector inclusiveness. Working Paper Jawaharlal Nehru University. Delhi, India. https://Finance_Trade_Development/working_paper_series/wp
- [61] Schueffel, P. (2017). Taming the Beast: A Scientific Definition of Fintech. *Journal of Innovation Management*, 4(4), 32-54. <http://dx.doi.org/10.2139/ssrn.3097312>
- [62] Sharma, D. (2016). Nexus between financial inclusion and economic growth: Evidence from the emerging Indian economy. *Journal of Financial Economic Policy*, 8(1), 13–36. <https://doi.org/10.1108/JFEP-01-2015-0004>
- [63] Sharma, R. (2020). Financial Inclusion and Economic Growth: Evidence-Based Research. *Vision: The Journal of Business Perspective*. <https://doi.org/10.1177/0972262920933503>
- [64] Tufano, P. (2003). Financial Innovation. *The Handbook of the Economics of Finance*. [http://dx.doi.org/10.1016/S1574-0102\(03\)01010-0](http://dx.doi.org/10.1016/S1574-0102(03)01010-0)
- [65] United Nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. <https://sustainabledevelopment.un.org>
- [66] Van, L., Vo, A., Nguyen, N., & Vo, D. (2019). Financial Inclusion and Economic GROWTH: An International Evidence. *Emerging Markets Finance and Trade*. <https://doi.org/10.1080/1540496x.2019.1697672>
- [67] Verhoef, G., Hidden, K. (2022). Savings groups in South Africa. *Transforming Africa*. <https://doi.org/10.1108/978-1-80262-053-520221017>
- [68] Wanof, M. (2023). Digital Technology Innovation in Improving Financial Access for Low-Income Communities. *Technology and Society Perspectives (TACIT)*. <https://doi.org/10.61100/tacit.v1i1.35>
- [69] Zadek, S., & Robins, N. (2018). Making waves: Aligning the financial system with sustainable development. *United Nations Environment Program*. <https://www.unepfi.org/publications/>
- [70] Zermeno, M., Martínez, F., & Preciado, V. (2018). Effects of inflation on financial sector performance: New evidence from panel quantile regressions. *Investigación Económica*. <http://dx.doi.org/10.22201/fe.01851667p.2018.303.64156>
- [71] Zins, A., & Weill, L. (2016). The determinants of financial inclusion in Africa. *Review of Development Finance*, 6(1), 46-57. <https://doi.org/10.1016/j.rdf.2016.05.001>