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IMPACT OF FINANCIAL DEVELOPMENT AND FINANCIAL INCLUSION ON ECONOMIC GROWTH: A NON-LINEAR APPROACH

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Abstract
The "too much finance" hypothesis suggests that while financial development (like expanding credit, banking, and markets) generally supports economic growth, there's a threshold beyond which further financial expansion can actually harm economic growth. This study explores the impact of financial development and financial inclusion on economic growth in non-linear settings. Using the dataset covering 57 countries over the period 1990-2023. The study employs the system generalized method of moments (S-GMM) to avoid the issue of endogeneity. The result identifies a turning point beyond which financial development has a negative relation with economic growth. The results indicate that economic growth initially rises with increasing financial inclusion, but beyond a certain point, further increases in financial inclusion lead to a decline in economic growth. This study also helps to gain a great understanding of the topic, which may help in the macro-economic policies and their main objective is to achieve economic growth, which ultimately contributes to the well-being of society. The findings emphasize the importance of policymakers recognizing the nonlinear role of financial development and financial inclusion on economic growth. Policymakers in these countries need to develop macro-economic policies that will promote financial development and financial inclusion while enhancing the regulation and functioning of domestic financial markets to ensure that all citizens are adequately served through the available financial instruments, products, and service offerings. Under this policy framework, greater emphasis should be placed on enhancing productive sectors to stimulate and sustain economic growth.
Keywords: Financial Development; Financial Inclusion; Economic Growth; Non-linear Approach

1. INTRODUCTION

The finance–growth nexus has long been debated in economic literature, with scholars questioning whether financial development drives economic growth or merely follows it. A global analysis reveals that financial inclusion promotes economic growth only after surpassing specific thresholds below these levels, its impact may be minimal or even adverse Siddiki & Bala-Keffi (2024). Overall, the evidence suggests that financial inclusion does not uniformly lead to economic growth. Rather, its impact depends on threshold effects, structural reforms, and the interaction with financial stability, infrastructure, and governance. This underscores the need for context-specific policies that not only expand inclusion beyond basic levels but also strengthen financial infrastructure and prevent the risks associated with over-indebtedness. The classical view, advanced by Schumpeter (1911), emphasizes the role of financial institutions in mobilizing savings, facilitating investment, and spurring innovation, thereby accelerating growth. Similarly, the supply-leading hypothesis, Patrick (1966) argues that financial deepening expands credit access, improves resource allocation, and enhances productivity. In contrast, the demand-following hypothesis suggests that financial development evolves as economies grow and demand for financial services increases. Giri, A. K., Mohapatra, G., & Debata, B. (2023) explain that the relationship between financial development and economic growth has been widely studied, with recent literature emphasizing non-linear effects rather than a simple linear correlation. Evidence suggests that financial development can boost growth up to a certain threshold, after which excessive financial deepening may harm economic stability and growth.

Kumar, Kundan, and Paramanik (2020) Country-specific analyses further underscore this complexity. Evidence shows that financial development exerts positive effects in the long run; however, its impact is asymmetric, varying between positive and negative shocks. Recent studies also highlight a nonlinear relationship, where finance initially boosts growth but excessive expansion may harm it due to inefficiencies, rent-seeking, or financial instability Arcand et al., (2015). Thus, the finance–growth nexus reflects a dynamic interplay with effective financial systems that foster growth, while sustained growth stimulates further financial development.

Policymakers must balance financial deepening with prudential regulation to maximize benefits. This study aims to contribute to the domain of growth of society in the following aspects. Firstly, this study's theoretical significance is to examine the non-linear impact of financial development on economic growth. This relationship is not a straight line but an inverted U-shaped state that increases at a decreasing rate. After the degree of financial development reached a certain point, economic growth started decreasing. Secondly, the impact of financial inclusion on economic growth in a non-linear setting. The law of diminishing returns states that by increasing more and more input initially, the output increases, but eventually, the output starts decreasing. So, inverted U-shape relationship between financial inclusion and economic growth.

The main objective of financial development and macroeconomic fundamentals is to achieve growth. Carefully crafted and executed, these policies have the potential to foster society's development by decreasing inequality, raising living standards, and giving people more opportunities. The key is ensuring that economic policies are inclusive, which may benefit underprivileged communities in addition to wealthy individuals and businesses. Macro-economic policies achieve economic growth, and economic growth ultimately contributes to the well-being of society. For a more inclusive society, can be fostered by supply-side policies that reduce inequality, such as lowering discrimination, enhancing financial accessibility, or encouraging entrepreneurship. These policies can increase upward mobility, particularly for historically underprivileged groups like minorities, women, and people living in rural areas. Policies that boost the availability of capital to low-income people or groups, such as microfinance programs or small company grants, can encourage entrepreneurship and improve people's economic situations, which will raise social mobility, encourage investment, innovation, and the fight against poverty. Investor confidence increases, and economic growth is boosted by a stable financial system. Technological advancement facilitates increased productivity, the creation of new markets and industries, cost reduction, and economic growth. Generally, it is debated that two main drivers accelerate the process, such as technology and, secondly miracle happened through financial tools. This study focuses on financial inclusion policies, the historical development of financial institutions, information and communication technology policies, and renewable energy policies. The purpose of this study is to ascertain how these determinants' contributions affect emerging nations. The financial inclusion policies are the strategies and regulations implemented by the government to ensure that individuals and companies have access to financial goods and services through the use of digital platforms. These financial inclusion policies strive to lower obstacles to financial services and promote economic growth. However, successful implementation requires overcoming challenges related to infrastructure, regulations, and financial literacy. Previously, in many developing nations, poor infrastructure, such as a lack of reliable internet and electricity issues, hindered the expansion of digital financial services. This study emphasizes studying financial inclusion policies because these policies are vital to fostering economic growth.

Furthermore, previous research makes this clear that financial development has influenced economic growth in different ways. In modern literature, the importance of financial development refers to the overall growth and improvement in a country's financial sector, including its financial system, stock markets, insurance, and other financial intermediaries. A strong financial system always encourages savings, supports profitable investment for consumers and producers, and allows for the effective distribution of resources. The availability of goods and the increased need to save more are important for making wise financial decisions. It is challenging for policymakers to respond to the challenge of simultaneously pursuing financial development and economic growth, and facilitating the establishment and expansion of financial institutions and the financial market is the aim of financial development. Economic growth speeds up when the financial sector is developed, which is recognized broadly. Topcu, Coban (2017) & Adu, Marbuah, and Mensah (2013) indicate that financial development has a statistically significant and favorable impact on economic growth.

Financial development is captured with two important aspects, i.e., financial efficiency and financial depth. Financial efficiency is the capability of playing a principal role in transforming deposits into credit, and the financial depth captured through deposits and savings. Fung (2009) and Levine and Zervos (1996) claimed that improving economic growth requires a robust financial system. The four distinct characteristics of the financial zone development and economic growth have been provided by recent literature. Firstly, Robinson (1952) to cause economic growth, the financial sector should be strengthened, which is confirmed by the "demand following aspect". Secondly, the 'leading supply' component emphasizes the development of the financial zone on economic growth (Patrick, 1966). Thirdly, Fung (2009) the occurrence of two-way causality advances in the financial sector and economic growth. Fourthly, Lucas (1998) recommends the absence of any causation influences.

The primary objective of all policies is to promote economic growth, and these policies ultimately contribute to the well-being of society. To achieve these goals, society uses different tools such as financial development and financial inclusion. Historically, these tools of financial development and financial inclusion have played very important roles in boosting economic growth. This study analyzes how financial inclusion and financial development will continue to play a consistent role over time. But over time, the contributions of these tools towards growth exhibit diminishing or increasing returns. The decay will be positive, but the contribution decreases, and the contribution after some time will have a negative effect. The efficacy of these instruments is established historically, but can be boosted by using new tools. Financial tools such as financial development and financial inclusion have diminishing effects that are increasing at decreasing rates on economic growthUnderstanding the relationship between financial development and economic growth in a nonlinearity

setting and financial inclusion and economic growth in a non-linear setting. Exploring these relationships and outcomes of the study will provide valuable insights into the dynamics of economic systems, inform policy decisions, and help design strategies to foster sustainable and inclusive growth.
This study is organized as follows: Section 2 discusses the literature review and develops the hypothesis. Section 3 sheds light on data, sample, and methodology. Section 4 discusses the study results. The conclusion and recommendations for the future are covered in Section 5.

2. REVIEW OF LITERATURE AND HYPOTHESES DEVELOPMENT

The general viewpoint in debates is that financial development will affect economic growth in a linear relationship setting. Seeing around the world indicates that countries that have higher economic growth include India, China, and Vietnam, but their financial development is less than the US. The US has high financial development but low economic growth. This shows that the pattern of financial development does not uniformly affect cross-country. So, this relationship is non-linear. The non-linear relationship means that financial development boosts economic growth at increasing at decreasing rates because the law of diminishing returns states that adding more and more input results in a decrease in output, or the return will decrease. When financial inclusion increases, it means how many people involved will increase economic growth, as ten people, or a hundred, or ninety percent of people are involved in financial inclusion, the question arises, will economic growth be affected in the same manner. The law of diminishing returns states that adding additional inputs causes output to drop or, in rare situations, become negative, and so, the effect of financial inclusion is non-linear. Financial development starts means new products in a country will boost economic growth & a great jump in economic growth is due to introducing new products in a market, but over a period of time, the financial product starts to grow rapidly, so the impact of financial development will be the same or start gradually decreasing on economic growth. So, the relationship between financial development on economic growth is non-linear. To explore the impact of financial development on economic growth, the impact of financial inclusion on economic growth is non-linear, i.e., U-shape and inverted U-shape. This study will test the impact of variables in inverted U-shape settings. In non-linear relationships, there are two choices available such as: U-shape and Inverted U-shape.
The first choice shows that the relationship is a U-shaped and inverted U-shaped, called a parabolic relationship. The second condition explains that when the relationship does not become a complete U-shape or parabola, it means that the slope decreases, indicating that it does not move downward or doesn't show a decreasing trend. It implies that an increase in financial development will lead to an increase in economic growth.

2.2 Cobb-Douglas Production Function

The model is widely used in economics to explain how input like capital and labor contributes to output (GDP or production). According to CDPF theory, a non-linear relationship exists between financial development and economic growth, and a non-linear relationship exists between financial inclusion and economic growth. The following function can represent this:

Equation 1

$$\boldsymbol{Y = A.K^{\alpha}.L^{\beta}}$$

Here, Y is the total output (GDP or production), A is the total factor of production (technology, efficiency, institutions), K includes capital input (machine, infrastructure, and financial capital), L is labor input, $\dot{\alpha}$ and $\boldsymbol{\beta}$ are the elasticity of output with respect to labor and capital. If $\propto +\beta = 1$, it indicates that doubling the capital and labor will double the output. If $\propto +\beta > 1$, then there is an increasing return to scale. If $\propto +\beta < 1$, then there is a decrease in returns to scale. When the labor is fixed at some point, K capital increases, the output (Y) rises, but at a diminishing rate, showing the principle of diminishing marginal return. The principle of diminishing returns states that when more and more units of variable inputs (labor and capital) are added to fixed inputs (land, machinery), the additional output (marginal product) produced by an extra unit of input will eventually decrease. In contrast to prior studies, the linkage between financial development and economic growth is studied in a linear setting. This study will investigate the impact of financial development on economic growth in a non-linear setting. From the previous studies, between financial development and economic growth is significant relationship is present, this is not rejected, but amongst economists, the sign of this relationship has been controversial. Botev, J., Égert, B., & Jawadi, F. (2019) study used a sample of developing, emerging, and advanced economies. The study's objective is to investigate whether, at the highest levels of financial development, the relationship between financial development and economic growth can be negative. The positive financial development and economic growth linkage is indicated by the fact that more finance will help individuals to increase household and firm lending, encourage investments with high returns, minimize the adjustment cost, and improve the allocation of capital. The result estimation is based on various non-linear threshold regression models. Giri, A. K., Mohapatra, G., & Debata, B. (2023) financial development and economic growth have been widely studied, with recent literature emphasizing non-linear effects rather than a simple linear correlation. Evidence suggests that financial development can boost growth up to a certain threshold, after which excessive financial deepening may harm economic stability and growth, and findings suggest valuable guidance for stakeholders and policymakers in formulating both short-term and long-term strategies for promoting financial development and technological innovation aimed at achieving sustainable long-term economic growth.

Ibrahim, M., & Alagidede, P. (2018) studied the non-linearities in the financial development and economic growth nexus in 29 SSA countries from the period 1980-2014. Moyo, C., Khobai, H., Kolisi, N., & Mbeki, Z. (2018) used the non-linear ARDL co-integration technique in Brazil from the period 1985-2015 to explore the financial development and economic growth relationship. The finding indicates that the banking system is a financial intermediary between household sectors and businesses or government sectors, which plays an important role in economic growth through the channels of productivity improvement and allocation. Kumar, K., & Paramanik, R. N. (2020) study examines the financial development and economic growth nexus in a non-linear setting. Global, D. P. S. K. K. (2018) study explores the non-linear relationship between financial development and economic growth is an inverted U-shape in nature. Nain, M. Z., & Kamaiah, B. (2014) studied the nexus between financial development and economic growth in the context of the Indian economy. The non-linear relationship between financial development and economic growth explains that by increasing the level of financial development, initially the economic growth increases, and after some point the economic growth starts to decrease because the law of diminishing returns explains that by increasing more and more input, initially output increases but eventually starts decreasing and sometimes becomes negative.

In the previous literature, the financial inclusion and economic growth linkage is explored in a linear setting. This study's objective is to investigate the non-linear relationship between financial inclusion and economic growth. Financial inclusion is defined as the number of people involved in financial activities that will affect economic growth, but after some time, this effect gradually decreases. So, this relationship is non-linear in nature, and financial inclusion always has a positive impact on economic growth. Makina, D., & Walle, Y. M. (2019) study shows the U-shape effect of financial inclusion and used three different dimensions to explore the effect of financial inclusion on economic growth. Firstly, access to financial services. Secondly, the financial services usage, and lastly, the delivery of products and services timely.

Chen, Z., Zhu, H., Zhao, W., Cao, B., & Cai, Y. (2022) studied the dynamic non-linear relationship between financial inclusion and economic growth from 30 provinces of China, and the findings indicate a U-shape relationship between variables. Ndombi Avouba, F. G., Akougbe, A. I. S., & Ndombi Ondze, C. L. I. L. (2023) study the non-linearity between financial inclusion and economic growth. The major concern of policymakers in several countries is financial inclusion because access to financial services and their global use by the household sector can enhance growth. Hounguevou, Y., & Eggoh, J. (2022) study examined the non-linearity between financial inclusion and economic growth. The non-linearity explains that by increasing the level of financial inclusion, initially the economic growth increases, but at a certain point, by increasing a higher level of financial inclusion, the economic growth has no increasing effect, it starts decreasing, or in some cases it becomes negative. The increases in financial development and financial inclusion do not always lead to proportional increases in economic growth, but the effect changes depending on the level of financial development and financial inclusion. Hence, the hypothesis is developed.

H1: The relationship between financial development and economic growth is non-linear in nature.

H2: The relationship between financial inclusion and economic growth is non-linear in nature

Table 1: Summary of previous relevant studies

Shows the summary of previous studies that adopted the relevant methodology. It highlights the key focus, methodologies, and major findings of each study. By comparing these works, the table identifies common trends and gaps in the literature.

Authors	Country	Sample period	Econometric Techniques	Findings
Botev, J., Égert, B., & Jawadi, F. (2019)	100 countries	Mid-1990s to 2012.	Dynamic threshold models GMM	Positive effect
Ibrahim, M., & Alagidede, P. (2018).	29 sub-Saharan Africa countries	1980–2014	Splitting and threshold estimation technique	Positively and significantly
Moyo, C., Khobai, H., Kolisi, N., & Mbeki, Z. (2018).	Brazil	1985 – 2015	Nonlinear Autoregressive Distributed Lag (NARDL) model	Negatively and positively
Kumar, K., & Paramanik, R. N. (2020)	Indian	Q1: 1996 to Q3: 2018	Non-linear Autoregressive Distributed Lag (NARDL)	Positive
Global, D. P. S. K. K. (2018).	65 developing countries	period post 2007-2008	Generalized Method-of-Moment (GMM).	U-shaped relationship exists.
Nain, M. Z., & Kamaiah, B. (2014).	India	1990–2010.	Generalized Method-of-Moment (GMM).	No causal relationship
Makina, D., & Walle, Y. M. (2019)	42 Africa	2004-2014	GMM estimation	Positive
Chen, Z., Zhu, H., Zhao, W., Cao, B., & Cai, Y. (2022).	30 provinces in China	2004 to 2019	Panel vector autoregression model (PVAR)	U-shaped relationship
Ndombi Avouba, F. G., Akougbe, A. I. S., & Ndombi Ondze, C. L. I. L. (2023)	SSA WAEMU zone	2014–2018	PCSE (panel-corrected standard error) model	U-shaped relationship
Hounguevou, Y., & Eggoh, J. (2022)	110 developing countries	2004 to 2021	Panel smooth threshold regression (PSTR) and dynamic panel GMM estimator	Non-linear relationship

3. MATERIALS AND METHODS

3.1 Data source and Sample

This study uses 57 countries over the period 1990–2023, using annual data obtained from the World Development Indicators (WDI). The study period and country sample were selected to capture relevant economic trends in line with the study's objectives. The dependent variable is economic growth, and the independent variables are financial development, financial inclusion, and renewable energy consumption. The control variables used in this study are trade openness and interest rate. The proxies used for each variable are shown in Table 2:

Table 2: Description of Variables and Corresponding Data Sources

Describes the variables used in this study along with their respective data sources. These details ensure transparency and consistency in the research methodology.

Variables	Measurement	Source
Economic Growth (EG)	GDP per capita (constant 2015 US$)	WDI
Financial Inclusion Index (FII)	• Usage (Money account) • Usage (Made a deposit /Loan) • Usage (Depositors with commercial banks/ savings • Access (Number of commercial bank branches per 1,000 km2) • Access (Number of ATMs per 1,000 km2) • Access (Number of commercial bank branches per 100,000 adults) • Access (Number of ATMs per 100,000 adults)	WDI
Financial Development Index (FDI)	• Broad Money (% of GDP) • Domestic Credit provided by the financial sector (% of GDP) • Ratio of deposit money bank to deposit bank assets plus central bank assets (%)	WDI
Renewable Energy Consumption (REC)	Renewable energy consumption (% of total final energy consumption)	Energy Information Administration (EIA)
Trade Openness (TO)	Trade (% of GDP)	WDI
Interest Rate	Real interest rate (%)	WDI

Abbreviation: WDI; World Development Indicators

3.2 Econometric Models and Methodology Discussion

Non-linear Impact of Financial Development and Economic Growth

This econometric equation 2 explains the non-linear impact of financial development and economic growth. The abbreviations used in this study are presented in Table A1:

This equation is in a non-linear setting.

Equation 2:

$$EG_{it} = \beta_{\circ} + \beta_1 EG_{it-1} + \beta_2 FD_{it} + +\beta_2 FD^2{}_{it} + \beta_3 FII_{it} + \beta_4 REC_{it} + \beta_5 TO_{it} + \beta_6 RINST_{it} + \epsilon_{it}$$

The impact of financial Inclusion and economic growth: A Non-linear approach

In non-linear contexts, this equation is:

Equation 3:

$$EG_{it} = \beta_{\circ} + \beta_1 EG_{it-1} + \beta_2 FD_{it} + + \beta_3 FI_{it} + \beta_2 FI^2{}_{it} + \beta_4 REC_{it} + \beta_5 TO_{it} + \beta_6 RINST_{it} + \epsilon_{it}$$

3.3 Constructing Financial Development and Financial Inclusion PCA

This study used a single proxy and index of financial development to comprehensively capture the effect. The test of PCA is shown in Table 3 for financial development & component matrix obtained through Principal Component Analysis (PCA), showing the factor loadings of each variable. It illustrates how strongly each variable contributes to the extracted components. Table 5 for the financial inclusion index and Table 6 component matrix resulting from PCA, emphasizing the factor loadings and the extent to which each variable contributes to the component.

Table 3: Financial Inclusion Index

Components	Initial Eigan values			Extraction Sums of Squared Loading		
	Total	Proportion (%)	Cumulative (%)	Total	Proportion (%)	Cumulative (%)
1	3.162001	0.3374	0.3374	3.162001	0.3374	0.3374
2	2.362006	0.2777	0.6151			
3	1.943961	0.2119	0.8270			
4	1.483357	0.1189	0.9460			
5	0.832649	0.0513	0.9973			
6	0.359363	0.0027	1.0000			
7	0.018663	0.0000	1.0000			

Component Matrix		
		Component
i.	Usage(Money account)	0.451188
ii.	Usage(Made a deposit /Loan)	0.469443
iii.	Usage(Depositors with commercial banks/ savings)	0.716115
iv.	Access(Number of commercial bank branches per 1,000 km2)	0.931508
v.	Access(Number of ATMs per 1,000 km2)	0.668173
vi.	Access(Number of commercial bank branches per 100,000 adults)	0.705709
vii.	Access(Number of ATMs per 100,000 adults)	0.707107

Table 5: Financial Development Index

Components	Initial Eigan values			Extraction Sums of Squared Loading		
	Total	Proportion (%)	Cumulative (%)	Total	Proportion (%)	Cumulative (%)
1	1.431134	0.4770	0.4770	1.431134	0.4770	0.4770
2	0.841266	0.2804	0.7575			
3	0.727600	0.2425	1.0000			
Component Matrix						
				Component		
i.	Broad Money (% of GDP) M2					0.614867
ii.	Domestic Credit provided by the financial sector (% of GDP) DCF					0.835950
iii.	Ratio of deposit money bank to deposit bank assets plus central bank assets (%) ASS					0.751964

Tables 5 and 6 show that the three alternative proxies are used for financial development to create an index. Approximately 99% of the variation in the original data can be explained by the three indices that were developed from the first three principal components. The index derived from the first principal component (FD Index 1) accounts for approximately 47.7% of the total variance in the dataset. A value of 0.4 or greater for the scoring coefficients was applied to identify variables with significant factor loadings. The first principles components could be thought of as representing the variables, (Domestic Credit provided by financial sector (% of GDP) and (Broad Money (% of GDP) M2. The second and third indexes, which denote FD Index2 and FD Index3, explain about 28.1% and 24.2% respectively, of the total variance of the data. By the above criteria, FD Index2 is a composite index representing the following variables: (Broad Money (% of GDP), M2, and Ratio of deposit money bank to deposit bank assets plus central bank assets (%) ASS). FD Index3 is a composite index representing the variable (Domestic Credit provided by financial sector (% of GDP) and Ratio of deposit money bank to deposit bank assets plus central bank assets (%) ASS).

3.4 Empirical Analysis

To prevent spurious regression, all variables were initially examined for data stationarity using panel unit root tests. Table 7 presents the results of the panel unit root tests with trend and lag specifications, incorporated to strengthen the robustness of the findings. The statistical results of the unit root test suggest the stationarity of the variables at the level. The stationarity of data has been tested by using ADF-Fisher and LLC tests, and the results are presented in Table 7. Table 8 presents the results of the descriptive statistics. The correlation matrix among the study variables is presented in Table 9. The analysis offers insights into the magnitude and direction of the linear relationships between economic growth and its potential determinants.

Table 7: Panel unit-root tests

Variable	Test for Unit Root in	Test	Statistic	p-value
FD^2	Level	LLC (Levin-Lin-Chu)	-2.60338**	0.0046
		IPS (Im-Pesaran-Shin)	-1.22071	0.1111
		Fisher-ADF	1.42923**	0.0346
		Fisher-PP	1.40352**	0.0475
FD Index	Level	LLC (Levin-Lin-Chu)	-3.7086**	0.0001
		IPS (Im-Pesaran-Shin)	-1.08827	0.1382
		Fisher-ADF	1.39492**	0.0076
		Fisher-PP	1.37383**	0.0020
EG	Level	LLC (Levin-Lin-Chu)	-2.94484**	0.0016
		IPS (Im-Pesaran-Shin)	-0.89843	0.1845
		Fisher-ADF	1.33627**	0.0200
		Fisher-PP	1.56130**	0.0037
FI Index	Level	LLC (Levin-Lin-Chu)	-3.13614**	0.0009

		IPS (Im-Pesaran-Shin)	4.28113	1.0000
		Fisher-ADF	2.46923***	0.0000
		Fisher-PP	7.83760**	0.0009
FI^2	Level	LLC (Levin-Lin-Chu)	-7.23253***	0.0000
		IPS (Im-Pesaran-Shin)	-0.04380	0.4825
		Fisher-ADF	1.58359 **	0.0038
		Fisher-PP	1.26187	0.2050
RINST	Level	LLC (Levin-Lin-Chu)	-5.75839**	0.0000
		IPS (Im-Pesaran-Shin)	-7.1978**	0.0000
		Fisher-ADF	2.13962**	0.0000
		Fisher-PP	2.52520**	0.0000
REC	Level	LLC (Levin-Lin-Chu)	-14.2897**	0.0000
		IPS (Im-Pesaran-Shin)	4.28113	1.0000
		Fisher-ADF	4.20671**	0.0000
		Fisher-PP	6.38815**	0.0000
TO	Level	LLC (Levin-Lin-Chu)	-3.18300**	0.0007
		IPS (Im-Pesaran-Shin)	0.10823	0.5431
		Fisher-ADF	1.15924**	0.0000
		Fisher-PP	1.23226**	0.0001

*****, **, * indicates statistical significance at 1%, 5% and 10% respectively.**
Source: Author's calculations.
Abbreviation: ADF; Augmented Dickey-Fuller test, PP; Phillips-Perron test, FD; Financial Development, EG; Economic Growth, FI; Financial Inclusion, RINST; Real interest rate, REC; Renewable Energy Consumption, TO; Trade openness
*** p< 0.01
**p<0.05
*P<0.1

Table 8: Descriptive statistics

	EG	FDI	FI	REC	TO	RINST
Mean	9.601600	8.548191	2.370544	2.774491	4.276266	4.296021
Median	9.755046	0.013521	2.351567	2.839078	4.259749	4.284685
Max.	11.62998	3.496246	3.078871	4.417635	5.976911	4.995340
Mini.	6.270796	3.203722	2.009564	1.029619	2.594376	3.711663
Std. Dev.	1.092084	1.196609	0.080913	0.803877	0.557926	0.097493
Skewness	-0.523221	0.013940	2.988990	-0.174040	0.065698	0.976998
Kurtosis	2.675234	2.524349	20.28156	2.139986	3.280983	13.22520
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Obs.	1938	1938	1938	1938	1938	1938

Table shows: Descriptive statistics results

Table 9 Correlation Matrix

	EG	FD	FI	REC	TO	RINST
EG	1					
FD	0.8813	1				
FI	0.8546	0.3020	1			
REC	0.6770	0.2050	0.0378	1		
TO	0.0748	0.0138	0.0011	0.0101	1	
RINST	0.0267	0.0361	0.0024	-0.0073	-0.0416	1

3.5 Regression Analysis

To examine the nonlinear impact of financial development on economic growth from equation 2. The result for equation 2 is shown in Tables 10,11,12, and 13. Firstly, the Hausman test is applied to determine the appropriate estimation method between the fixed effects and random effects models. Table 10 shows that the Hausman test yields a value of 0.0009, which is significant at $p < 0.05$. Therefore, the null hypothesis is rejected, indicating that the fixed effects model is more appropriate. Consequently, this study employs the fixed effects model. Table 10 shows the endogeneity check for each independent variable. Table 11 explains that System-GMM is preferable. Table 13 indicates that the Wald test is conducted to evaluate the parameter estimates and determine whether the variables included in the model are statistically significant. The null hypothesis indicates that $\boldsymbol{\beta}1 = \boldsymbol{\beta}2 = \boldsymbol{\beta}3 = 0$. If

the p-value is less than 0.05, then reject the null hypothesis. The p-value is 0.0000 indicates that the value of the parameters is not zero, and these parameters/variables are significant in the model. Table 12 indicates the nonlinear impact of financial development on economic growth explained in equation 1. The System-GMM results indicate that the Sargan/Hassen Test has a **ρ**-value of 0.23334 (> 0.05); hence, the null hypothesis that instruments are exogenous cannot be rejected. The instruments used are the second lag of economic growth, the first lag of the financial development index, the first lag of the squared term financial development index, the first lag of the financial inclusion index, and renewable energy consumption. The Arellano-Bond test indicates that AR (1) is significant and AR (2) is insignificant, which supports the null hypothesis of no autocorrelation. The assumption of non-linear model is for FD^2 (Ho: $\beta 1 = \beta 2$) no threshold, (H1: $\beta 1 \neq \beta 2$) 1 threshold, $\beta 1 < 0$, $\beta 2 > 0$ shows U-shape relationship and $\beta 1 > 0$, $\beta 2 < 0$ Inverted U-shape relationship. The coefficient of financial development and squared terms are significant and meet the condition that $\beta 1 > 0$, $\beta 2 < 0$, i.e., FDI has $\beta 1 = \beta 1 = 0.093988$ and FDI^2 has $\beta 2 = -0.068961$. Hence, prove the validity of the Inverted U-shape relationship in the panel dataset of 57 countries, which implies that initially, the economic growth increases as the financial development increases, but after a certain level, the increase in financial development causes a decrease in economic growth. To check the turning point where economic growth starts decreasing, the Turning point for FDI^2 is 0.6617, and results from the threshold regression suggest a non-linear relationship, with a critical value of 66.17 serving as the transition point between positive and negative growth effects. Which is calculated by using:

$$Y=\exp(-\beta 1/2\beta 2)$$

That means 66 index points is the threshold. Below 66, financial development raises economic growth. Beyond 66, it starts hurting economic growth. The financial development indicator shows a significant and negative coefficient, confirming its importance in the Cobb-Douglas production function (CDPF) fitting towards which law of diminishing returns states that by increasing financial development while holding other factors constant, the economic growth increases, but at a decreasing rate. The earlier work exploring the non-linear impact of financial development and economic growth in the Cobb-Douglas production function is missing, which contributes to the novelty of the idea.

The non-linear impact of financial inclusion on economic growth results is shown in Table 14, the Hausman-Test and Endogeneity check for individual independent variables. Table 15 explains the preference for system GMM. Table 17 Wald test and the non-linear impact of Financial Inclusion on Economic growth is shown in Table 16. The coefficient of financial inclusion and squared terms are significant and meet the condition that $\beta 1 > 0$, $\beta 2 < 0$, i.e., FII has $\beta 1 = 0.126710$ and FII^2 has $\beta 2 = -0.097586$. Hence, prove the validity of the Inverted U-shape relationship in the panel dataset of 57 countries, which implies that initially, the economic growth increases as the financial inclusion increases, but after a certain level, the increase in financial inclusion causes a decrease in economic growth. To check the turning point where economic growth starts decreasing, the Turning point for FII^2 is 0.6449. That means 64 index points is the threshold. Results from the threshold regression suggest a non-linear relationship, with a critical value of 64.49 serving as the transition point between positive and negative growth effects. Below 64, financial inclusion raises economic growth. Beyond 64, it starts decreasing economic growth. The financial inclusion indicator shows a significant and negative coefficient, confirming its importance in the Cobb-Douglas production function (CDPF) fitting towards which law of diminishing returns states that by increasing financial inclusion while holding other factors constant, the economic growth increases, but at a decreasing rate. The earlier work exploring the non-linear impact of financial inclusion and economic growth in the Cobb-Douglas production function is missing what contributed to the novelty of the idea.

Table 18 shows the whole picture of the results. Financial development promotes economic growth up to a point, but excessive financialization can generate diminishing returns or even negative impacts, as results show that the turning point of FD = 0.6617. At low levels, financial inclusion may stimulate growth by unlocking underutilized resources and expanding market participation. At high financial inclusion levels without safeguards, the negative and constraining channels/ beyond certain thresholds, the turning point for FI = 0.6449, from where the economic growth starts to decrease for the following reasons, which include, however, (i)risks emerge because more regulation increases default. (ii) over-indebtedness is expanding access without credit literacy. (iii) informal credit traps and misallocation of resources include excessive lending may favor consumption over productivity, and (iv) weak institutional capacity includes financial instability, such as micro-finance crises can dampen benefits or even reverse them. This produces inverted U-shaped or threshold effects, consistent with diminishing returns to financial deepening. This has major policy implications, suggesting the need for balanced financial deepening, regulatory frameworks, and country-specific strategies.

Result of Non-linear Impact of Financial Development on Economic Growth

Table 10: Hausman-Test & Endogeneity check for individual independent variables

Hausman-Test Chi-Sq. Statistics	Chi-Sqi. d.f.	Prob.					
18.628997	4	0.0009					
Variables	**Coefficient**	**Std. Error**	**t-Statistics**	**Prob.**	**R-Square**	**Adjusted R-Square**	**Prob(F-statistics)**
Resd_FDI	1.0003	0.0863	11.6231	0.0000	0.9795	0.9785	0.0000

Resd_FD²	1.000000	0.0013	5.7400	0.0000	0.9975	0.9985	0.0000
Resd_FI	0.0351	0.0001	2.8265	0.0048	0.9486	0.9470	0.0000
Res_REC	3.5801	0.1110	3.2108	0.0012	0.9795	0.9785	0.0000

Table 11 System GMM

Methods	**Lagged Variable**	**Co-efficient values**	**Prob.**	
Pooled [OLS]	EG (-1)	0.990923	0.0000	Upper Bound
Fixed Effect Model	EG (-1)	0.981049	0.0000	Lower Bound
Difference-GMM	EG (-1)	0.976783	0.0000	Prob(J-statistics) 0.464834
System-GMM	D-GMM < FEM, then use System-GMM			

Table 12 Non-linear Impact of Financial Development on Economic Growth

Variables	**System GMM Model 1**		
	Coefficient	**Std. Error**	**Prob.**
Constant	1.27213***	0.143712	0.000
EG (-1)	0.882058***	0.079982	0.000
FDI	0.093988***	0.050079	0.000
FII	0.180093**	0.0693912	0.000
REC	0.241199**	0.042367	0.000
FDI²	-0.068961***	0.028515	0.000
Sargan/Hassen Test	0.23334		
AR (1)	0.0000		
AR (2)	0.9738		
Turning Point Y=(-β1/2β2)	0.6617		
Turning Point Y=exp(-β1/2β2)	1.00032		

Note: *, **, and *** represent the significance at 10,5 and 1% level respectively. **Source**: authors estimation: EG (-2) FDI (-1) FII (-1) REC (-1) FDI² (-1)

Table 13 Wald test

Test Type	**Null Hypothesis (H◦)**	**Chi-Square Statistics**	**Df**	**p-value**
Wald Test (Whole model)	All slope coefficients = 0	13.95	4	0.000

Endogeneity Diagnostics (Wald test)			
Panel Analysis			
Value		**Df**	**Probability**
F-statistics	248.1461	(4, 1933)	0.0000***
Chi-square	892.5846	4	0.0000***
Normalized restriction (= 0), Null Hypothesis = C(n)=0			
Restriction Terms	**Values**	**Std. Err.**	
C (1)	2.666	0.012	
C (2)	-0.333	0.011	
C (3)	0.048	0.010	
C (4)	0.076	0.025	

Non-linear impact of Financial Inclusion on Economic growth explained by equation 2

Firstly, apply the Hausman test to check which method is used, the fixed effect and random effect models. The hypothesis is:

Table 14: Endogeneity check for individual independent variables

Hausman-Test Chi-Sq. Statistics	Chi-Sqi. d.f.	Prob.					

16.268731	4	0.0027					
Variables	**Coefficient**	**Std. Error**	**t-Statistics**	**Prob.**	**R-Square**	**Adjusted R-Square**	**Prob(F-statistics)**
Resd_FD	1.0003	0.0863	11.6231	0.0000	0.9795	0.9785	0.0000
Resd_FI	0.0351	0.0001	2.8265	0.0048	0.9486	0.9470	0.0000
Resd_ FI^2	1.000000	0.0013	5.0001	0.0000	0.9975	0.9985	0.0000
Res_REC	3.5801	0.1110	3.2108	0.0012	0.9795	0.9785	0.0000

Table 15 System GMM

Methods	**Lagged Variable**	**Co-efficient values**	**Prob.**	
Pooled [OLS]	EG (-1)	0.991552	0.0000	Upper Bound
Fixed Effect Model	EG (-1)	0.982340	0.0000	Lower Bound
Difference-GMM	EG (-1)	0.971615	0.0000	Prob(J-statistics) 0.231271
System-GMM	D-GMM < FEM, then use System-GMM			

Table 16 Non-linear impact of Financial Inclusion on Economic growth

Variables	**System GMM Model 1**		
	Coefficient	**Std. Error**	**Prob.**
Constant	1.509721***	0.152178	0.000
EG (-1)	0.930203***	0.317929	0.000
FDI	0.073881**	0.400935	0.000
FII	0.126710**	0.171449	0.000
REC	0.382081**	0.002795	0.000
FII^2	-0.097586**	0.030488	0.000
Sargan/Hassen Test	0.193026		
AR (1)	0.0002		
AR (2)	0.9991		
Turning Point Y=(-β1/2β2)	0.6449		
Turning Point Y=exp(-β1/2β2)	1.91455		

Note: *, **, and *** represent the significance at 10,5 and 1% level respectively. **Source**: authors estimation: EG (-2) FDI (-1) FII (-1) REC (-1) FII^2 (-1)

Table 17 Wald test

Test Type	**Null Hypothesis (H◦)**	**Chi-Square Statistics**	**Df**	**p-value**
Wald Test (Whole model)	All slope coefficients = 0	13.95	4	0.000

Endogeneity Diagnostics (Wald test)			
Panel Analysis			
	Value	**Df**	**Probability**
F-statistics	238.8127	(4, 1933)	0.0000***
Chi-square	955.2508	4	0.0000***
Normalized restriction (= 0), Null Hypothesis = C(n)=0			
Restriction Terms		**Values**	**Std. Err.**
C (1)		6.876	0.012
C (2)		-1.733	0.002
C (3)		0.929	0.004
C (4)		0.089	0.012

Table 18 System-GMM results

Variables	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5
EG(-1)	0.893371***	0.889697 ***	0.897444 ***	0.882058***	0.930203***
FDI	0.083323**	0.083994**	0.084164**	0.093988***	0.073881**
FII	0.133631**	0.120221 **	0.180093**		0.126710**
REC	0.340564**	0.200533**	0.241199**		0.382081**
ICT * FDI		0.850266**			
ICT*FI			0.930012***		
FD^2				-0.068961***	
FI^2					-0.097586**
Sargan/Hassen Test	0.11232	0.93800	0.68500	0.23334	0.193026
AR (1)	0.0000	0.0000	0.0000	0.0000	0.0002
AR (2)	0.8103	0.5901	0.6850	0.7760	0.9991
Turning Point $Y=(-\beta 1/2\beta 2)$				0.6617	0.6449
Turning Point $Y=\exp(-\beta 1/2\beta 2)$				1.00032	1.91455

4. CONCLUSION AND POLICY IMPLICATIONS

This study empirically analyzes the non-linear impact of financial development and financial inclusion on economic growth throughout 1990-2023 by employing the system generalized method of moments (S-GMM) for 57 countries. In this study, financial development and financial inclusion are also included in PCA for creating an index. The well-developed financial system is vital for channeling resources toward the most productive sectors of the economy. Efficient financial markets facilitate trading, hedging, diversification, risk pooling, and the mobilization of savings functions that collectively stimulate investment and innovation, but financial development, by enhancing resource allocation and increasing returns to savings, may paradoxically reduce overall savings rates and thus hinder economic growth. The financial development significantly influences growth, but its impact depends crucially on the levels of these factors, such as initial income per capita, human capital, and the level of financial development itself, that may determine when finance becomes a catalyst or a constraint. In particular, when initial per capita income, human capital, and financial development rise from their threshold levels, the growth benefits of finance are minimal. These results highlight that foundational economic conditions are necessary preconditions for finance to serve as a true engine of long-term growth.

The concept of financial inclusion has emerged as a cornerstone of sustainable economic development, particularly in developing regions. By ensuring that individuals and businesses have access to affordable and effective financial services such as savings, credit, payments, and insurance, financial inclusion fosters greater economic participation and supports the achievement of several United Nations Sustainable Development Goals (SDGs). For developing economies, promoting financial inclusion is not merely a social objective but an essential economic strategy for expanding investment, encouraging entrepreneurship, and alleviating poverty. The turning point of financial inclusion begins to accelerate growth, and when might its effects taper off or reverse. By addressing these questions, this study contributes to a global understanding of how financial inclusion operates within varying economic and institutional realities. It challenges the "one-size-fits-all" approach and emphasizes the importance of tailoring financial inclusion policies to a country's development stage and financial maturity. This study is limited to the period 1990–2023, as data for most countries are unavailable before this timeframe. Future investigations could enhance model robustness through the addition of control variables. In addition, based on the foundation laid in this study, future studies could examine the effect of financial development and other explanatory indicators on economic growth in various economic and geographical regions.

Declarations

Hybrid

I confirm that I understand journal International Economics and Economic Policy is a hybrid journal. When research is accepted for publication, there is a choice to publish using either immediate gold open access or the traditional publishing route.

Competing Interests

Yes, the authors have competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper. "The authors declare that they have no known

competing financial interests or personal relationships that could have appeared to influence the work reported in this paper."

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Data Availability

Yes, I have research data to declare. "Data that support the empirical findings of the current study were extracted from the World Development Indicators (WDI) themes of The World Bank."

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Saddaf Adalat: has contributed to the research study, design, Conceptualization, data collection, Methodology, conclusion, recommendations, and Formal analysis. The final draft of the manuscript was read and approved by both authors, Writing – original draft. Dr. Jaleel Ahmed Malik has contributed to the research study, design, Conceptualization, data collection, Methodology, conclusion, recommendations, and Formal analysis. The final draft of the manuscript was read and approved by both authors.

Annexure

List of Acronyms

EG	Economic Growth
FD	Financial development
FI	Financial Inclusion
REC	Renewable Energy consumption
TO	Trade openness
RISNT	Interest rate

Note: This table lists the acronyms referenced throughout the paper

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