Unveiling Turning Points: A Cross-Sectional Regression Approach to Financial Inclusion and Development

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This paper examines the corresponding roles of Traditional Financial Inclusion (TFI) and Digital Financial Inclusion (DFI) in driving socio-economic development across 97 developed and developing countries in 2014, 2017, and 2021. Most of the previous studies seem to deal only with the linear and non-linear relationships between financial inclusion and economic growth. In contrast, this study takes a multilayered approach by incorporating a Socio-Economic Development Index (SEDI). It analyzes the components of financial inclusivity, such as income, employment, and political stability, and how these factors contribute to social progress. The study ascertains how various dimensions of financial inclusion influence economic development by creating unique indices for TFII, DFII, and a combined Financial Inclusion Index (FII). Moreover, the paper utilizes a threshold estimation model to identify the key points where financial inclusion yields optimal socio-economic benefits. The results demonstrate that, thereby increasing savings and credit access as an agent of economic participation, the TFI is pivotal in countries with weaker financial systems. Meanwhile, DFI emerges as a powerful growth engine in economies with a strong digital infrastructure supporting mobile banking, fintech, and digital payment platforms for universal financial inclusion.

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Keywords: financial inclusion; traditional financial inclusion (tfi); digital financial inclusion (dfi); socio-economic development; threshold regression.

I.   INTRODUCTION

Financial inclusion, which generally means having access to and using formal financial services, has become an area of research interest among researchers/policy makers/other stakeholders. It is also crucial to achieving economic targets and ensuring that individuals and businesses can access and effectively use formal financial services (Sarma, 2012). It fosters broader opportunities for participation, especially for those at risk of exclusion, and drives growth and development. Thus, formal financial services have recently become a key factor for economic development, which can be further understood through two complementary forms: Traditional Financial Inclusion (TFI) and Digital Financial Inclusion (DFI).

Formal financial services have financed the economy well in the form of savings accounts, credit, and insurance provided through banks and credit unions. According to Sarma and Pais, 2011, the direct provision of formal financial services for the masses is necessary to improve economic participation, especially among low-income people. Financial services like saving accounts and loans can increase the living standards of a family

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and even prepare people better for any health shock. However, when there is overdependence on brick-and-mortar banking infrastructure, this excludes the vast majority, especially in rural or poor populations, from using the same services. One-third of adults do not have a bank account and are excluded from the formal financial sector (World Bank, 2018; Karim et al., 2022).

However, with technological progress, DFI has quickly emerged as a transformative intervention to overcome the inherent difficulties of traditional finance systems with advances in digital technologies. Fueled by mobile banking, payments platforms, and FinTech solutions, DFI has recently become very powerful, particularly in regions with poor access to traditional banking services (Gabor and Brooks, 2020). It offers financial services to unserved/underserved individuals and businesses, mainly in remote areas, through digital channels like mobile banking, financial technology solutions, and e-wallets. As a result of this transformation, financial inclusion through affordable and convenient financial services has expanded toward millions previously excluded from the financial access gap (Arner et al., 2022; Tay et al., 2022). It also can accelerate financial inclusion further and catalyze socio-economic development.

Socio-economic development is about improving people's living conditions, encompassing the dimensions that economic growth alone cannot provide, such as access (education and health care), poverty eradication, and participation in decision-making. Indicators like improved quality of life, reduced income inequality, and increased health intervention have sustainable advantages for the prosperity or stability of the nation. The COVID-19 pandemic has worsened existing inequalities and caused significant economic and social progress setbacks, especially among less developed countries, reversing years of gains in poverty reduction, education, health, and overall socio-economic development (World Bank, 2020). The research examining the impacts of financial inclusion on economic growth currently examines TFI and DFI in isolation, missing out on the complementary and combined impact of both systems on socio-economic development.

Additionally, much of the existing literature is country or region-specific, making it difficult to generalize results globally. However, challenges such as low digital literacy, inadequate infrastructure, and restrictive regulations prevent these services from reaching their full potential.

Empirical research on the impact of DFI on economic growth essentially treats the relationship as linear (Ahmad et al., 2021; Khera et al., 2021; Ozturk and Ullah, 2022). In this direction, Law and Singh (2014) propose that financial development can foster growth, but only up to a certain threshold, beyond which the marginal benefits may diminish or even turn negative. Similarly, (Khera et al., 2021) argue that financial development promotes growth initially, but then there comes a point where too much financial development can drag the economy down. Furthermore, studies such as those by (Nizam et al., 2020; Rapih and Wahyono, 2023) have explored the relationship between financial inclusion and economic growth, but often with limited scope, as this particular study analyzed only two specific years (2014 and 2017), leaving gaps in broader applicability. Thus, much of the existing research has concentrated narrowly on how financial inclusion contributes to economic growth, often overlooking its broader societal impacts. The findings from these studies reveal a more potential relationship between financial inclusion and economic growth than previous studies have accounted for, even if that relationship has diminishing returns.

Our study widens this by adding a Socio-economic Development Index (SEDI) that encompasses an aggregate representation of equitable development beyond merely economic indicators. The present study attempts to explore how such mechanisms could improve well-being and reduce inequality for inclusive development through analysis of TFI and DFI. We also attempt to find the threshold or turning points beyond which substantial improvements in socio-economic development are achieved for both TFI and DFI. In this respect, we developed three composite indices, namely the overall index of financial inclusion (FII), the Traditional Financial Inclusion Index (TFII), and the Digital Financial

Inclusion Index (DFII). These composite indexes represent a quantification of financial inclusion concerning 12 measures of financial service usage and access. The first one, in other words, stands for traditional financial inclusions through, say, banks, while DFII shows the same through digital channels, particularly with the emergence of FinTech. When taken as a whole, they paint an even more complete picture of how financial inclusion—both traditional and digital—contributes to general socioeconomic growth.

II. LITERATURE REVIEW

Financial inclusion contributes to social and economic development by providing access to people, communities, and businesses with different affordable financial solutions that enhance resilience and foster economic growth. Access also increases social and economic progress, which reduces inequality and poverty (Rastogi et al., 2018). However, low-income earners still use informal systems (Levine, 2005; Demirguc-Kunt et al., 2017). Financial inclusion aims to ensure that growth funds are available for welfare in rural areas. In this direction, Dhakal and Nepal (2016) illustrate how microfinance can bridge the gap in moving from inclusion to financial access. Improved access to financial markets by poor populations allows people to access inclusive and affordable financial services such as savings and credit. These services help boost social and economic development among the rural population.

TFI and DFI address many social and economic problems; their focus differs from one economy to another due to varying economic challenges. TFI depends on banks, branches, and ATM networks to provide direct, face-to-face cash services. Efficiently organized banks facilitate the possibility of saving by people with low incomes and help them create valuable assets to bridge the gulf between the rich and the poor (Manders et al., 2012). Beck et al. (2007) postulate that sound banking services reduce poverty and the gap in income in urban areas. TFI also bolsters financial stability: it makes the system less volatile in economic shocks due to the cushioning effect (Levine, 2005; Han and Melecky, 2013; Jia et al., 2021).

However, TFI struggles to reach rural and remote areas because of high costs and logistical challenges (Cypher, 2014). Even though it plays a key role in providing financial access, its dependence on physical networks limits its ability to serve far-off populations (Allen et al., 2016). While TFI microfinance programs have helped rural communities, they fall short in tackling widespread financial exclusion (Dhakal and Nepal 2016).

On the other hand, DFI depends on high diffusion of mobile phones and a suite of internet platforms or digital wallets to leap over such geographic and infrastructural barriers to access in the delivery of finance, in particular to low-income communities that are characteristically under-banked. Mobile money services are technological advancements that have not only rearranged the existing structures but also mobilized resources to facilitate finance in a secure, safe, and convenient way of making transactions without using branches. Such innovations, according to Donovan (2012), have been able to affect proper impacts, especially in regions that are difficult for conventional facilities to penetrate. Ultimately, it reduces the transaction cost while increasing the availability of credit and savings opportunities, hence financial inclusion for individuals and the economically active poor, as Loukoianova et al. (2018) and Ozturk and Ullah (2022) attest to. Such an approach widens prospects for economic growth while educating people on how to create good financial habits of saving and reinvesting resources to achieve financial freedom, especially over extensive financial inclusions (Kulkarni and Ghosh, 2021).

Recent innovations such as digital banking and machine learning advancements have made financial inclusion more attainable for marginalized groups (Lee, 2024). However, this progress is not without challenges. FinTech, as an enabling factor with access to the internet and automated data processing, is indeed a very strong tool in the quest to further expand the reach of DFI (Barik and Pradhan, 2021;

Agiropoulos et al., 2022). This new development now allows for flexible, secure, and efficient economic services beyond the reach of traditional banks (Gomber et al., 2017).

However, DFI effectiveness depends on strong digital infrastructure, user literacy, and regulatory backing (Yue et al., 2022). Furthermore, threshold models are critical for understanding the limitations and prospects of digital technologies for resource mobilization in underserved areas (Fong et al., 2017). For example, Ozili (2018) claims that low-income users' poor Internet connectivity and lack of financial awareness impact DFI accessibility (Ozturk and Acaravci, 2013).

A critical look at the literature on TFI and DFI indicates that both are highly relevant for socio-economic development, with different strengths and limits. For example, TFI tends to perform well in markets characterized by low financial inclusion, where a physical branch is fundamental in delivering basic financial services that boost economic participation (Rapih and Wahyono, 2023). In turn, DFI can be maximized in countries with superior digital infrastructure, allowing for greater scalability and operational efficiency. In addition, Rapih and Wahyono's threshold model suggests that TFI is most effective in impoverished areas, but DFI reaches its full potential when digital access enables broader financial inclusion. This, in turn, promotes overall economic stability by reducing cash dependency and transaction hazards (Xu and Wang, 2023).

TFI faces high costs and limited geographical access, especially in disadvantaged areas. DFI requires strong internet access with widespread digital literacy backed by tight consumer data security practices (Ozili, 2018). Unless digital finance risks are managed properly, it may eventually lead to the exposure of vulnerable populations to financial crises that they are neither prepared nor set to comprehend (Demirguc-Kunt et al., 2018).

Approaches that balance TFI and DFI are, therefore, one of the needed dimensions of holistic socio-economic development. In an instance when there is no digital infrastructure at all, TFI is very relevant in the provision of the relevant financial services while promoting economic inclusiveness and stability, whereas DFI harnesses technology to make it cheaper and faster; access to financial services actually trickling down to low-income groups traditionally excluded from the same. To increase socio-economic impact, hybrid models can be created to scale up and reach a broader spectrum of economic contexts, such as those allowing TFI accessibility with DFI's scalability.

Thus, building on the backdrops of the existing literature, the study contributes to the literature in the following ways. First, we develop three broad indices: the TFII, the DFII, and an overall index of financial inclusion by combining TFII and DFII that covers 97 developed and developing countries for the years 2014, 2017, and 2021. Second, the distinct analysis of TFI and DFI provides a more profound understanding of how each type facilitates socio-economic development. The Socio-Economic Development Index (SEDI) builds on prior work by Ayasrah (2012), who developed SEDI as a comprehensive development measure, incorporating key social and economic indicators to reflect broader socio-economic progress. While aligning with this foundational approach, the current study adapts and extends SEDI by integrating specific indicators, namely, the Human Development Index (HDI), employment-to-population ratio, and log of GDP, alongside political stability and absence of violence, to capture a nuanced perspective of socio-economic advancement in the context of financial inclusion. This study uses a large cross-sectional sample and a threshold estimation model to explore how TFI and DFI, individually and when integrated, affect socio-economic development differently at varying levels of financial inclusion.

III.   METHODOLOGY

3.1 Data description

This paper draws on cross-country estimations and macroeconomic data based on 97 countries classified as developed or developing economies

according to the United Nations classifications (United Nations, 2019). The detailed classification of the sampled countries and their TFII, DFII, FII, and SEDI levels is in the supplementary data file (Table 1). Our choice of countries and years is primarily based on data from the following key sources: the United Nations Development Programme (UNDP), Human Development Reports, the World Bank's Global Findex Database, and the International Monetary Fund's (IMF) Financial Access Survey.

3.2 Variable Definition and Data Source

Dependent variable: Socio-Economic Development Index (SEDI)

The Socio-Economic Development Index (SEDI) (mentioned in Table 1) is a composite measure developed using four key indicators: the Human Development Index (HDI), the employment-to-population ratio, log-GDP, and political stability and absence of violence/terrorism. This index was developed in line with the process mentioned by Swanson's (2007) framework for building comprehensive socio-economic indices. By aggregating these indicators, SEDI provides a better picture extending beyond traditional indicators such as HDI by accounting for economic inclusion and stability factors. In constructing the SEDI index, we employed Principal Component Analysis (PCA) for dimensionality reduction and weight assignment to each indicator, followed by normalization to ensure comparability and consistency across the data.

The HDI, developed by the United Nations Development Program (UNDP), offers a human-centered perspective on development by assessing life expectancy, education, and income levels fundamental to understanding socio-economic well-being (UNDP, 1990; Swanson, 2007). However, the employment- to-population ratio, an aggregate measure of labor market engagement and economic inclusion, was sourced from the World Development Indicators (WDI) database. This also aligns with Swanson (2007), who stated that workforce participation is one of the determining factors of social and economic stability, with low unemployment rates leading to lower poverty and overall social well-being (Razavi, 2012). GDP per capita (current US$), taken as log GDP, was included to represent economic output while controlling for extreme values, as using the logarithmic form enables more balanced comparisons across countries of differing economic sizes, highlighting proportional shifts in economic strength (Fischer, 1993). However, Political stability and the absence of violence/terrorism, measured through perceptions of unrest and violence, are crucial for sustainable development, as a secure environment supports investment, economic growth, and institutional trust (Kaufmann et al., 2011). Including these diverse factors aligns with Nardo et al. (2005) guidance on composite indicators, enabling SEDI to provide a balanced assessment that incorporates traditional and often-overlooked aspects of development for meaningful cross-country comparisons.

Table 1: Indicators for construction of the Socio-Economic Development Index (SEDI)

Dependent Variable	Indicators	Data Sources
Socio-Economic Development Index (SEDI)	Human Development Index (HDI)	United Nations Development Programme (UNDP), Human Development Reports
	Employment to population ratio, 15+, total (%) (modeled ILO estimate)	World Development Indicators (WDI)
	GDP per capita (current US$) (Taken as log GDP)	World Development Indicators (WDI)
	Political Stability and Absence of Violence/Terrorism: Estimate	World Bank

Source: Author's Compilation.

Independent variables: TFII, DFII and FII

The study developed three separate financial inclusion indices, the Traditional Financial Inclusion Index (TFII), the Digital Financial Inclusion Index (DFII), and the overall Financial Inclusion Index (FII), around 2014, 2017, and 2021. Each index reflects a particular perspective on financial access and usage along traditional and digital dimensions. TFII and DFII comprise 12 indicators grouped into two main sub-dimensions of access and usage to account for their balanced relevance in the total financial inclusion landscape.

The TFII measures indicate traditional financial access and usage by focusing on indicators such as the number of Automated Teller Machines (ATMs) and commercial bank branches per 100,000 adults and account ownership among adults (% age 15+). The access dimension focuses on the availability of traditional banking infrastructure, a key enabler of any economic participation. Similarly, the usage dimension includes indicators on savings (% 15+), borrowed adult (% 15+), and owning a debit or credit card (% 15+), showing the actual practice of use of these financial instruments. Data for TFII indicators was sourced from the IMF's Financial Access Survey (FAS) and the World Bank's Global Findex Database.

Similarly, the DFII covers digital financial access and usage indicators. The access dimension includes account ownership at a financial institution or through a mobile money service provider for adults aged 25 and above, fixed broadband subscriptions (per 100 people), and telephone subscriptions (per 100 people), reflecting the coverage of the underlying infrastructure required to facilitate financial transactions. The usage dimension reflects active digital engagement, such as Internet usage (% of the population), mobile-based utility payments (% 15+), and made or received digital payments by adults (% 15+), with data sourced from the World Bank's Global Findex Database, as shown in (Table 2). By encompassing both access and usage, DFII provides insight into the transformative role of digital platforms in financial inclusion, particularly in regions where traditional banking access is limited.

Finally, by combining TFII and DFII, the FII offers a holistic view of overall financial inclusion by encompassing traditional and digital financial services. These indices give a holistic view of financial inclusion progress, enabling policymakers and researchers to estimate where overall gains have been made against areas that demand more effort.

Table 2: Indicators and Data sources for the construction of TFII and DFII

INDEPENDENT VARIABLES			
Traditional Financial Inclusion Index (TFII)		Digital Financial Inclusion Index (DFII)	
Access		Access	
Measures/ Indicators	Data Sources	Measures/Indicators	Data Sources
Automated teller machines (ATMs) (per 100,000 adults)	IMF Financial Access Survey (FAS)	Fixed broadband subscriptions (per 100 people)	World Bank
Commercial bank branches (per 100,000 adults)	IMF Financial Access Survey (FAS)	Fixed telephone subscriptions (per 100 people)	World Bank
Accounts % (15+)	IMF Financial Access Survey (FAS)	Account ownership at a financial institution or with a mobile-money-service provider, older adults (% of population ages 25+)	World Bank Global Findex Database
Usage	Sources	Usage	Sources

Saved adults % (15+)	World Bank Global Findex Database	Individuals using the Internet (% of the population)	World Bank Global Findex Database
Borrowed adult % (15+)	World Bank Global Findex Database	Made a utility payment: using a mobile phone (% age 15+)	World Bank Global Findex Database
Owns a debit or credit card adults % (15+)	World Bank Global Findex Database	Made or received digital payment adult % (15+)	World Bank Global Findex Database.

Moreover, we used a three-stage principal component analysis (PCA) approach to obtain financial inclusion indices for all countries and years, representing various aspects of access/quality at every stage.

$$\text{PC Score} = \sum_{i=1}^{n} LiXi \qquad (1)$$

In this equation, the PC score is the total effect of standardized explanatory variables *(X)* each by multiplying its corresponding loading *(L),* where *n* denotes the total number of explanatory variables within each category.

In the first PCA stage, the two aspects of financial inclusion—access and usage—were assessed independently for traditional and digital financial services. The indicators for these sub-dimensions capture large-scale financial access and usage features in various countries. These sub-indices were then normalized by rescaling the scores to be between 0 and 1 for each country, in other words, using a min-max normalization method.

$$\text{NormalizedScore} = X - Xmin / Xmax - Xmin \qquad (2)$$

The access and usage sub-dimensions in the second stage were calculated separately to create the TFII and DFII, respectively. At this point, weights are assigned to each sub-dimension, and the scores are again normalized between 0 and 1 across all countries and years using Equation 2.

In the final stage, PCA is used to construct FII by combining TFII and DFII indices. At this stage, weightage is put on dimensions to represent a more comprehensive view of TFI and DFI. Furthermore, scores are normalized to 0 and 1, where 0 signifies complete financial exclusion, and 1 indicates full financial inclusion. Such a structured approach produces a comprehensive cross-country measure of financial inclusion over time. The weights assigned to each indicator and dimensions of indices are attached in the supplementary data (Table 2-7).

Model specification

$$\text{SEDI}_{it} = \beta_0 + \beta_1 \text{TFII}_{it} + \beta_2 X_{it} + e_{it} \qquad (1)$$

$$\text{SEDI}_{it} = \beta_0 + \beta_1 \text{DFII}_{it} + \beta_2 X_{it} + e_{it} \qquad (2)$$

$$\text{SEDI}_{it} = \beta_0 + \beta_1 \text{FII}_{it} + \beta_2 X_{it} + e_{it} \qquad (3)$$

SEDI it in models 1-3 represents the Socio-Economic Development Index for country *i,* in time *t* serving as a comprehensive measure of the country's socio-economic development level. These indices provide an overall indication of how advanced a country is in terms of both social and economic progress. The independent variables in this model include *TFIIit,* the traditional financial inclusion index, capturing the access and usage to conventional financial services in country *i* in time *t, DFII*$_{it}$, the digital financial inclusion index, represents the access to and use of digital financial platforms in countries *i* in time *t,* and *FIIit* is the financial inclusion index that combines TFII and DFII measures to reflect a complete picture of financial inclusivity.

Additionally, X_{it} serves as a control variable, accounting for other relevant socio-economic factors influencing *SEDIit* in country *i* in time *t.* At the same time, e_{it} denotes the error term, capturing unobserved factors impacting *SEDIit*.

Hypothesis

To further investigate potential nonlinear relationships, a threshold effect hypothesis was formulated to test for shifts in the influence of financial inclusion indices on *SEDIit* across different inclusion levels.

$$H_o = \delta_1 = \delta_2$$

$$H_1 = \delta_1 \neq \delta_2$$

In this model, δ represents vectors of the parameters.

In this analysis, the null hypothesis (H_o), proposes that the relationship between TFI, DFI, FII, and the SEDI is linear. This means it assumes that as financial inclusion increases, its impact on SEDI progresses proportionately, without abrupt changes or "threshold" points. However, if the alternative hypothesis (H1) is true, there might be a threshold effect. In this case, the impact of financial inclusion on SEDI would not follow a straight, linear path but instead could shift once a certain level or "tipping point" of financial inclusion is reached. This suggests that there could be different states or "regimes" in the data, where the relationship changes depending on the level of financial inclusion.

3.3 Model Estimation

Employing a cross-sectional sample splitting and threshold estimation method developed by Hansen (1996, 2000), this study examines the relationships between TFII, DFII, FII, and the SEDI for years including 2014, 2017, and 2021. This is because TFII, DFII, and FII were used as threshold variables for analysis. Threshold regression models capture different patterns of variables' interaction, providing a more flexible approach to modelling non-linear relationships (Chong and Yan, 2014).

Consequently, models 4, 5, and 6 were developed to test the hypothesis mentioned earlier. These are particularly suitable for testing the proposed hypothesis and exploring the contingency effects of financial inclusion on socio-economic development. The model, grounded in threshold regression, is structured as follows.

$$SEDI_{it} = \beta_0 + \beta_1 TFII_{it} + \beta_2 X_{it} + e_{it}; TFII \leq \gamma \quad (4)$$

$$SEDI_{it} = \beta_0 + \beta_1 TFII_{it} + \beta_2 X_{it} + e_{it}; TFII \geq \gamma$$

$$SEDI_{it} = \beta_0 + \beta_1 DFII_{it} + \beta_2 X_{it} + e_{it}; DFII \leq \gamma \quad (5)$$

$$SEDI_{it} = \beta_0 + \beta_1 DFII_{it} + \beta_2 X_{it} + e_{it}; DFII \geq \gamma$$

$$SEDI_{it} = \beta_0 + \beta_1 FII_{it} + \beta_2 X_{it} + e_{it}; FII \leq \gamma \quad (6)$$

$$SEDI_{it} = \beta_0 + \beta_1 FII_{it} + \beta_2 X_{it} + e_{it}; FII \geq \gamma$$

Here, γ denotes the unknown threshold parameter. The empirical models mentioned above enable the impact of each type of financial inclusion to differ based on whether countries fall below or exceed the unknown threshold γ.

Models (4), (5), and (6) can only be estimated after rejecting the null hypothesis of linearity (H0: δ1=δ2). To do this, a bootstrap procedure was employed to test the null hypothesis of a linear model with an alternative threshold regression model. If the null hypothesis is rejected, that is, the first sample split, the sample was divided into two regimes, that is, $TFII_{it}$, $DFII_{it}$ and $FII_{it} \leq \gamma$ for the first regime, and $TFIIit$, $DFII_{it,}$ and $FII_{it} > \gamma$ for the second regime. Furthermore, the model was re-estimated after dividing the original sample according to the identified threshold (the second sample split). This process was repeated until rejecting the null hypothesis was no longer possible.

IV.   RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics of the variables used in the study have been summarized in Table 3.

Table 3: Descriptive Statistics

Variables	Measurement unit	Obs.	Mean	Std. Dev.	Min	Max
SEDI	Scale from 0 to 1	291	.652	.228	0	1
TFII	Scale from 0 to 1	291	.334	.219	0	1
DFII	Scale from 0 to 1	291	.561	.283	0	1

FII	Scale from 0 to 1	291	.459	.251	0	1
Inflation	%	291	6.059	12.635	-11.876	150.001
Population growth	%	291	.953	1.442	-4.257	11.794
FDI	% of GDP	291	5.428	14.799	-14.409	222.764

4.2 Sample Splitting Results

(Table 4–6) present the non-linearity test results for each financial inclusion index. The testing procedure was performed using the "wild bootstrap-t method" to assess whether the null hypothesis of linearity can be rejected in favour of the alternative hypothesis, which posits a non-linear threshold relationship. However, Threshold regression analysis is essential in examining the non-linear relationships between traditional, digital financial inclusion and SEDI. As highlighted by (Hansen 1996, 2000), a linear approach may fail to capture the complexities of the relationship, mainly because financial inclusion can have different effects at varying levels of inclusion.

Bootstrap methods are often used in threshold regression analyses to deal with the test statistics' small sample sizes, heteroscedasticity, and complex distributions. In the context of threshold tests, wild bootstrap was used, employing Rademacher weights (performed in Stata) to ensure robustness. In regression models, especially in threshold models where the relationship changes at certain points, the distribution of the test statistics (like the t-statistics or Wald tests) may not follow standard normal or chi-squared distributions. The bootstrap method creates empirical distributions by resampling the data many times, allowing for more accurate inference when the assumptions of normality and homoscedasticity do not hold.

Heteroscedasticity (non-constant variance of residuals) is common in financial inclusion data because countries at different levels of financial inclusion might show different variability in socio-economic outcomes. Thus, Wild Bootstrap, with Rademacher weights, is especially useful for handling heteroscedasticity, as it adjusts for variations in the error structure without relying on homoscedasticity assumptions.

4.3 First Sample Split (Main Threshold):

The results of the first sample split consistently show significant results for all the financial inclusion indices (TFII, DFII, and FII) (high t-statistics and low p-values). The significant *p-values* show that the null hypothesis of a linear relationship is rejected, and there is clear evidence of a threshold effect for all the threshold variables. The threshold estimates identify the point at which the relationship changes, indicating that the impact of financial inclusion on SEDI differs below and above this threshold.

4.4 Second Sample Split (Checking for Additional Thresholds)

The bootstrap p-values for the second sample split of TFII, DFII, and FII threshold variables are insignificant, indicating that a single threshold (two-regime model) is sufficient for all the models across all three years. Therefore, the non-linear threshold regression model was accepted. This is where the procedure stops; when the null hypothesis can no longer be rejected, it indicates that the model has captured the key thresholds.

No further significant non-linearities exist in the data.

Table 4: Threshold analysis for Traditional Financial Inclusion Index (TFII)

	2014		2017		2021
	First sample split	Second sample split	First sample split	Second sample split	First sample split
t-statistics	2.3370	-0.5445	2.2415	-0.1532	2.3660
Bootstrap P value	0.010***	0.6970	0.040***	0.7475	0.000***
Threshold estimates	0.237	0.460	0.289	0.463	0.339
95% confidence interval	[.1601, 1.34]		[.01044, 1.511]		[.2585, 1.158]

*The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.*

Table 5: Threshold analysis for Digital Financial Inclusion Index (DFII)

	2014		2017		2021	
	First sample split	Second sample split	First sample split	Second sample split	First sample split	Second sample split
t-statistics	6.7794	-0.7552	4.5644	1.3850	4.0421	1.3698
Bootstrap P value	0.000***	0.5300	0.010***	0.2929	0.000***	0.1818
Threshold estimates	0.630	0.808	0.464	0.688	0.694	0.779
95% confidence interval	[0.4308, 0.8613]		[0.3219, 1.25]		[0.3363, 1.149]	

*The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.*

Table 6: Threshold analysis for Financial Inclusion Index (FII)

	2014		2017		2021	
	First sample split	Second sample split	First sample split	Second sample split	First sample split	Second sample split
t-statistics Bootstrap P	4.2443	1.3454	4.4175	-1.2286	3.8020	-0.5142
value Threshold	0.000***	0.1900	0.0101***	0.3939	0.000**	0.3636
estimates 95%	0.426	0.502	0.524	0.767	0.569	0.645
confidence interval	[.3283, 1.052]		[.4282, 1.18]		[.4172, 1.308]	

*The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.*

4.5 Regression results using Threshold variables

The threshold regression results for each financial inclusion index (shown in tables 7, 8, and 9) for the years 2014, 2017, and 2021 demonstrate that all three indices of financial inclusion are positive and statistically significant drivers of SEDI, regardless of whether they are below or above the threshold levels. In (Table 7), the threshold regression analysis for TFII highlights the non-linear relationship between traditional financial inclusion and SEDI. The analysis shows that TFII positively and statistically significantly impacts socio-economic development in this context. Still, the magnitude of this effect varies depending on whether countries are below or above a certain threshold of financial inclusion. Across all three years, 2014, 2017, and 2021, countries with lower levels of financial inclusion (below the threshold) experienced a much stronger positive effect of TFII on economic development. This finding indicates that in these countries, improvements in financial inclusion have a substantial impact on boosting economic activity and development. The impact of TFII on SEDI is stronger in countries below the threshold, typically less developed countries that seem to benefit more from traditional financial services. As Rapih and Wahyono (2023) noted, countries with low levels of TFII (mainly underdeveloped countries) depend more on the advantages of traditional financial services to chase their capital stability. This could be because, in countries with initially low financial inclusion, expanding access to financial services enables more individuals and businesses to participate in the formal economy, thereby driving growth and development.

In contrast, the effect is less pronounced for countries with higher levels of financial inclusion (above the threshold), while the relationship between TFII and SEDI remains positive. This pattern suggests that these countries might rely less on traditional financial services and possibly have more diversified or advanced financial systems. Moreover, after reaching a certain level of financial inclusion, the marginal benefits of further increasing financial access begin to taper off. This could be attributed to the fact that in countries with more developed financial systems,

much of the population is already integrated into the formal financial sector, and the additional growth benefits of further expansion may be limited.

However, the inflation rate (control variable) lowers TFI development, especially in 2021, which has a significant financial development, showing that inflation will undermine financial stability. For example, studies by Sahay et al. (2015) underscore that inflation can reduce the benefits of financial inclusion for the population, especially in developing countries where high inflation erodes savings and limits access to financial services. Population growth also displays unintended effects; its negative coefficients for 2017 and 2021 indicate that rapid population growth can pressure financial systems. The impact of FDI on TFII is positive but moderate, particularly in 2017, and its influence is minor relative to those of other factors, suggesting that while foreign investment is beneficial for financial development, it is less prominent than domestic economic parameters such as inflation control and population management.

Overall, the findings suggest that the growth-enhancing effects of TFII are particularly significant in less developed and emerging economies, where financial inclusion is lower. In such countries, greater access to finance is a powerful instrument of growth-friendly policy. However, in those countries that have already reached higher levels of inclusion, the emphasis will be on improving efficiency and depth instead of covering more individuals.

Table 7: Regression analysis employing TFII as a threshold variable

Variable	2014			2017			2021		
	Linear OLS without threshold	Regime 1 TFII<=.237	Regime 2 TFI>.237	Linear OLS without threshold	Regime 1 TFII<=0.289	Regime 2 TFII >0.289	Linear OLS without thresholds	Regime 1 TFII<=0.339	Regime 2 TFII>0.339
Constant/Intercept	0.452*** (0.037)	0.321*** (0.06)	0.753*** (0.058)	0.477*** (0.042)	0.305*** (0.097)	0.724** (0.066)	0.307*** (0.038)	0.41*** (0.092)	0.551*** (0.087)
TFII	0.692*** (0.075)	0.73** (0.312)	0.231*** (0.104)	0.65*** (0.077)	0.892** (0.398)	0.291** (0.115)	0.728*** (0.074)	0.755** (0.319)	0.525*** (0.144)
Inflation rate	-0.004 (0.003)	0.001 (.003)	-0.021*** (0.005)	-0.005 (0.003)	0.002 (0.005)	-0.021*** (0.005)	-0.001** (0.001)	0 (0.001)	-0.006*** (0.002)
Population growth	-0.011 (0.01)	.004 (0.011)	-0.011 (0.021)	-0.041*** (0.014)	-0.016 (0.024)	-0.024 (0.02)	-0.019 (0.012)	-0.037 (0.026)	-0.034** (0.017)
FDI	0.001 (0.001)	0.013 (0.009)	0 (0.001)	0.004** (0.002)	0.016* (0.009)	0.002 (0.001)	0.003* (0.002)	0.007 (0.008)	0.002 (0.002)
R-square	0.576	0.167	0.404	0.610	0.285	0.491	0.679	0.370	0.474
No. of Observations	97	43	54	97	43	54	97	48	49

Standard errors are shown in parentheses. The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.

In (table 8), the threshold regression results for DFII across the years 2014, 2017, and 2021 present a nuanced understanding of how DFI impacts SEDI, with varying effects across different levels of DFII. For 2014, the model divided countries into two regimes based on their DFII levels. Countries with low DFII (Regime 1) experience a strong positive effect of DFI on development, as expanding access to digital financial services opens new opportunities for economic participation, investment, and consumption, particularly in developing economies. However, in (Regime 2), where countries have higher levels of DFII, the effect remains positive. Still, it is somewhat reduced, suggesting diminishing returns as these countries may have already captured the core benefits of DFI. Moving to 2017, in Regime 1 (low DFII), the positive impact persists, but it is more pronounced compared to the results of 2014. As highlighted by (Aziz and Naima, 2021), this could be because there are numerous obstacles to the sustainability of DFI in less developed nations, including inadequate internet, lack of digital literacy, and technological infrastructure.

However, by 2021, the results show a shift, particularly in Regime 2. While countries in Regime 1 and Regime 2 continue to experience positive effects of DFII on SEDI, the impact in Regime 2 (countries with the highest levels of DFII) becomes most pronounced. This suggests that countries with advanced digital financial systems are seeing renewed and substantial growth benefits, likely due to the deep integration of digital finance into all sectors of the economy, the adoption of cutting-edge financial technologies, and the expanded access to global markets. The results from 2021 indicate that rather than diminishing returns, countries with very high DFI are leveraging DFI to drive significant and sustained economic growth. This aligns with the findings by Law and Singh (2014), who demonstrated that financial development can foster growth, but only up to a certain threshold. This pattern highlights the evolving nature of DFI, where countries at various stages (low, moderate, and high) experience different growth dynamics, with the strongest effects observed in countries with the most advanced digital financial infrastructures by 2021. Furthermore, the impact of inflation itself is negative overall, with stronger significance in 2021, particularly in Regime 2, which means that higher levels of DFII (denoting more financial activity) are associated with a greater negative effect on inflation on SEDI. In Regime 2, population growth hampers SEDI in high DFI environments.

However, FDI has a favorable impact on SEDI but shows a relatively weak, perhaps even insignificant relationship, particularly in instances where DFII is high, indicating that more than the foreign direct investment is needed to drive socio-economic development in a setting with a relatively developed domestic financial system. This highlights the role of domestic finance institutions, policy frameworks, and local economic drivers rather than reliance on external investment.

Thus, these results suggest that DFII is a determinant of SEDI, yet its impact is not linear, and the benefits decrease as the financial system matures. This indicates that structural policy interventions should help make financial systems more performing, inclusive, and resilient rather than merely growing financial activity. Addressing macroeconomic stability (controlling inflation) and demographic pressures (controlling population growth) is equally important to promote sustainable long-term socio-economic development.

Table 8: Regression analysis employing DFII as a threshold variable

Variable	2014			2017			2021		
	Linear OLS without threshold	Regime 1 DFII<=.630	Regime 2 DFII>.630	Linear OLS without threshold	Regime 1 DFII<=0.464	Regime 2 DFII >0.464	Linear OLS without thresholds	Regime 1 DFII<= 0.694	Regime 2 DFII>0.694
Constant/Intercept	0.364*** (0.032)	0.311*** (0.043)	0.583*** (0.148)	0.323*** (0.042)	0.219** (0.1)	0.161* (0.094)	0.2*** (0.052)	0.144 (0.106)	0.159 (0.171)
DFII	0.623*** (0.045)	0.617*** (0.091)	0.392** (0.182)	0.646*** (0.054)	0.95*** (0.208)	0.852*** (0.117)	0.729*** (0.067)	0.687*** (0.17)	0.811*** (0.197)
Inflation rate	-0.002 (0.002)	-0.001 (0.002)	-0.017 (0.01)	-0.006** (0.003)	0.001 (0.006)	-0.005 (0.003)	-0.001* (0.001)	0 (0.001)	-0.003* (0.001)
Population growth	-0.004 (0.008)	-0.003 (0.009)	-0.017 (0.024)	-0.01 (0.012)	-0.019 (0.028)	-0.021 (0.015)	"0.016 (0.012)	0.012 (0.024)	-0.036** (0.014)
FDI	0 (0.001)	0.013** (0.006)	0(0)	0.001 (0.001)	0.011 (0.008)	0 (0.001)	0.001 (0.002)	0.007 (0.006)	-0.001 (0.002)
R-square	0.731	0.483	0.244	0.733	0.502	0.660	0.726	0.395	0.466
No of Observations	97	61	36	97	39	58	97	48	49

Standard errors are shown in parentheses. The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.

Table 9 presents regression results using FII as a threshold variable to explore its impact on SEDI over 2014, 2017, and 2021. FII maintains a statistically significant relationship with SEDI in the linear OLS models, with a coefficient range between 0.68 and 0.725 across models. This suggests that financial inclusion positively impacts socio-economic development each year. In Regime 1, the coefficients are stronger, for example, 0.79 in 2017, implying that the effect of an increase in financial inclusion on development is larger when the financial system is less inclusive. Instead, in Regime 2, the coefficients are generally lower, indicating diminishing returns as financial inclusion becomes more inclusive. For example, in 2021, the coefficient in Regime 2 is equal to 0.655. In contrast, the coefficient in the linear model is 0.725, which tells us that after it reaches a certain level, any improvement in the FII would not lead to a prominent improvement in SEDI. Furthermore, the control variables reveal heterogeneous impacts with inflation reducing SEDI across all levels. In contrast, the inflation effects are strongest at higher levels of FII, indicating that inflation impedes the advantages of financial inclusion.

Overall, in all the threshold results, Inflation tends to have a negative or insignificant effect on growth, especially in the threshold regimes. When inflation does show significance, it typically hampers growth, which aligns with existing economic literature, suggesting that high inflation reduces purchasing power, creates economic uncertainty, and discourages domestic and foreign investment. Moreover, as highlighted by (Barro, 1996), inflation is often seen as a risk factor for foreign investors, as it increases economic uncertainty and reduces investment incentives.

Population growth is showing a continuously negative impact in the baseline model and in threshold regimes for every year, where it negatively impacts development. In line with the findings of (Bloom and Canning, 2004; Sachs, 2015), rapid population growth in developing countries tends to strain resources, cause overcrowding, and lower quality of life. In short, while financial inclusion plays a key role in

fostering growth, macroeconomic factors- FDI, inflation, and population growth also significantly shape economic outcomes. Their influence highlights the complexity of socio-economic development, where multiple elements must align for sustained progress.

Table 9: Regression analysis employing FII as a threshold variable

Variable	2014			2017			2021		
	Linear OLS without threshold	Regime 1 DFII <=0.426	Regime 2 FII>0.426	Linear OLS without threshold	Regime 1 FII <=0.524	Regime 2 FII>0.524	Linear OLS without thresholds	Regime 1 FII <=0.569	Regime 2 FII > 0.569
Constant/ Intercept	0.385*** (0.034)	0.31*** (0.05)	0.586*** (0.08)	0.376*** (0.041)	0.273*** (0.078)	0.644** (0.113)	0.297*** (0.048)	0.233** (0.101)	0.385*** (0.141)
FII	0.68*** (0.052)	0.68*** (0.16)	0.427*** (0.116)	0.674*** (0.062)	0.79*** (0.179)	0.349** (0.15)	0.725*** (0.073)	0.795*** (0.209)	0.655*** (0.186)
Inflation rate	-0.003 (0.002)	-0.001 (0.003)	-0.008 (0.007)	-0.005* (0.003)	-0.004 (0.004)	-0.014* (0.007)	-0.001 (0.001)	0 (0.001)	-0.005** (0.002)
Population growth	-0.005 (0.008)	0.002 (0.001)	-0.031 (0.021)	-0.021 (0.013)	0.004 (0.021)	-0.029 (0.019)	-0.022* (0.013)	-0.007 (0.024)	-0.029* (0.015)
FDI	0.001 (0.001)	0.012* (0.007)	0 (0)	0.002 (0.002)	0.009 (0.007)	0.002 (0.001)	0.002 (0.002)	0.007 (0.007)	0.001 (0.002)
R-square	0.692	0.322	0.352	0.698	0.398	0.364	0.698	0.426	0.480
No of Observations	97	50	47	97	56	41	97	51	46

*Standard errors are shown in parentheses. The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.*

The results indicate that all three financial inclusion indices, Traditional, Digital, and Combined, significantly positively impact the Socio-Economic Development Index (SEDI) until a certain threshold beyond which such influence diminishes. This is consistent with prior research that argued for an inverted-U relationship; for instance, (Law and Singh,2014; Rapih and Wahyono, 2023), some financial inclusion encourages socio-economic development until a certain inflexion point beyond which the benefits wane. In general, the results indicate a nonlinear relationship where TFII's impact on SEDI is stronger in countries with lower initial levels of financial inclusion (Regime 1). This implies that lower-inclusion countries stand to gain more from traditional financial inclusion, which could be because financial services are increasingly accessible to underserved populations, boosting socio-economic development. In contrast, for countries with already high levels of financial inclusion (Regime 2), the marginal impact of increasing TFII is smaller, suggesting a potential saturation effect.

4.6 Results of Robustness Check

For the robustness check, we averaged the data across three years, and the results confirmed that the findings (Tables 10 and 11) are consistent with previous empirical studies. TFII and DFII positively affect socio-economic development wherever below or above threshold financial inclusion levels. These results further affirm that expanding TFI and DFI continues to positively impact socio-economic development without causing any negative effects, even at higher levels of financial inclusion. This implies that the development dividend regarding financial inclusion has not yet been exhausted. This suggests that further advancements in financial inclusion can still yield developmental benefits. Furthermore, we conducted an additional analysis using a two-year average for the variables, following the three-year average analysis. The results obtained from both analyses were almost identical, reinforcing the consistency and reliability of the results. This indicates that the relationship between the key variables is not sensitive to the period used, adding further confidence to the robustness of our findings.

Table 10: Robustness test for TFII using three years average (2014, 2017 and 2021)

Variable	Linear OLS without threshold	Regime 1 TFII<0.354	Regime 2 TFII> 0.354
Constant/intercept	0.458*** (0.041)	0.32*** (0.074)	0.678*** (0.101)
TFII	0.678*** (0.079)	1.064*** (0.241)	0.364** (0.165)
Inflation rate	-0.002 (0.002)	0 (0.002)	-0.014*** (0.004)
Population growth	-0.034** (0.014)	-0.015 (0.02)	_0.022 (0.025)
FDI	0.002* (0.001)	0.011 (0.008)	0.001 (0.001)
R square	0.624	0.464	0.466
No of observations	97	56	41

Standard errors are shown in parentheses. The notation ***, **, and* signifies significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Robustness test for DFII using three years average (2014, 2017 and 2021)

Variable	Linear OLS without threshold	Regime 1 DFII< 0.456	Regime 2 DFII>0.456
Constant/intercept	0.295*** (0.041)	0.147** (0.093)	0.207*** (0.072)
DFII	0.679*** (0.054)	0.975*** (0.214)	0.796*** (0.93)
Inflation rate	-0.003** (0.001)	-0.001 (0.003)	-0.002 (0.002)
Population growth	-0.007 (0.012)	0.009 (0.024)	-0.037** (0.017)
FDI	0 (0.001)	0.012 (0.009)	0 (0.001)
R square	0.752	0.428	0.669
No of observations	97	36	61

Standard errors are shown in parentheses. The notation ***, **, and * signifies significance at the 1%, 5%, and 10% levels, respectively.

V. CONCLUSION AND POLICY IMPLICATIONS

This study investigates how TFI and DFI affect the SEDI for 2014, 2017, and 2021, utilizing data from 97 developed and developing countries. The research was motivated by existing research that only analyzed how financial inclusion influenced economic growth or analyzed the TFI and DFI in isolation. However, the study's innovation lies in introducing the SEDI, a more comprehensive measure than a traditional indicator of economic growth and integrating the TFI and DFI as a holistic measure of financial inclusion. This allowed us to look at the impact of TFI alongside DFI and how both contribute to economic growth, social progress, and access to financial services. We further strengthen the analysis by extending the time period to another year, 2021, besides 2014 and 2017, to develop a more defined perspective on how financial inclusion develops over time, eventually affecting socio-economic transformation. This also captures the growing impact of digital shifts in financial inclusion.

Further, using cross-sectional sample splitting and threshold estimation techniques established by Hansen (1996, 2000) in stata-17, this study adds considerably nuanced insights into how financial inclusiveness influences socio-economic development. It also highlights the turning point in the aforementioned expansion. Therefore, it can be concluded from the findings of this study that TFI and DFI are necessary for boosting socio-economic development. Two important conclusions stand out: First, TFI is essential in countries with less developed financial sectors, demonstrating that increased access to formal banking is helpful in these environments, especially for savings and loans. Second, DFI becomes increasingly important as countries develop stronger digital infrastructure. In this context, the recent data reveal that in 2021, countries with higher levels of DFI obtained more significant socio-economic benefits.

In conclusion, sustainable DFI in emerging markets requires an appropriate multi-dimensional strategy involving multi-stakeholders. One of the core pillars of this effort is establishing a strong digital infrastructure. This means prioritizing investment in telecommunications and internet access to make digital financial services available to more people, especially those in rural and remote communities who often have limited access. In addition to infrastructure, an equally important need is a regulatory system that encourages innovation but does not compromise user safety. Thus, for DFI to succeed, it should assure people that they feel comfortable transacting with peace of mind that data will be private and not cost anyone exorbitant charges. However, while we must

create an ecosystem where start-ups and innovators can prosper, government agencies and financial institutions must balance crafting guidelines that promote growth with strategies that mitigate against some of the risks associated with digital platforms, such as fraud or abuse. Additionally, policymakers and financial institutions must craft regulations through a unified approach to secure digital platforms from malicious activities and other associated risks. In this regard, all stakeholders must ensure a collaborative effort to build a resilient and inclusive economy.

Though comprehensive, this study is not free from limitations that future research should address. One of this study's primary limitations has been the data deficiency for some indicators. Due to the unavailability of the data, certain countries and the socio-economic indicators that could provide a deeper understanding were excluded. Consequently, the study's ability to make regional and global comparisons was constrained, which could further validate the findings. Moreover, while this study conducted a threshold analysis using data from three specific years, it could not adequately capture the complex temporal patterns or examine how threshold points might shift over shorter or longer intervals. Future studies can use more frequent data points to reveal deeper trends in how financial inclusion affects socioeconomic outcomes over time. Finally, broadening the context to consider other factors, such as regulatory environments, digital capability initiatives, and regional development strategies, could deepen understanding of the interplay between financial inclusion and socio-economic development across various settings.

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Data Availability Declaration

The data supporting the findings of this study are available in the supplementary file in Word format.

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