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# Sustainable financial inclusion through social progress and regularity quality interaction – Implication for least developed countries

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ABSTRACT

Sustainable development through social progress is resolute in enhancing financial inclusion through spreading the affordable financial facilities. However, the Social Progress Index (SPI) reflects sustainable development by measuring a country's ability to meet basic human needs, support well-being, and provide opportunities for a better quality of life, beyond just economic growth, and pave the way for spreading access to affordable financial services. This study has considered least-developed countries due to their diverse socio-economic challenges and financial disparities. For this purpose, data from 2011 to 2023 is considered. Estimated results using the Driscoll-Kraay standard error and Panel Quantile Regression methods have validated the inverted U-shaped impact of social progress on financial inclusion. It implies that moderate levels of social progress can enhance financial access. However, excessive focus on social progress without adequate economic growth hinders financial service expansion, ultimately affecting overall economic stability and inclusion. This study incorporates regularity quality as a determinant of financial inclusion and a moderator of social progress. It negatively determines financial inclusion but, as a moderator, it boosts social progress towards sustainable financial inclusion. Furthermore, overall productive capacity and technology, mainly through internet usage as the model's control variables, are vital in promoting financial inclusion.

## 1. Introduction

Financial inclusion is imperative for cultivating growth by allocating impartial financial services accessibility to economic agents in underserved and disadvantaged areas in order to have access to inexpensive financial services (Nasir and Du, 2018). It is crucial for poor and least developed countries to focus on financial inclusion because it promotes economic growth by empowering individuals

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with the financial tools needed to invest in education, health, and businesses (Afonso and Blanco-Arana, 2024). By fostering access to financial services, these countries can reduce poverty, increase income levels, and improve economic resilience (Ediagbonya and Tioluwani, 2023). Financial inclusion also supports equity by enabling more people to participate in the formal economy which can lead to greater stability and development. Ultimately, it helps build a foundation for sustainable economy which is essential for these nations (Lee et al., 2023). Financial inclusion focuses on providing all individuals access to basic financial services, while financial development refers to the growth of financial institutions and markets.[1] Financial inclusion empowers individuals, promotes economic participation, and reduces inequality whereas financial development mainly benefits businesses (Oanh et al., 2023).

Sustainability is directly related to financial inclusion, especially in the least developed countries, as it would help to provide stability in the form of a place where people would be provided with an opportunity for financial services in order to improve their economic activities without denting the resources of the future (Huang et al., 2024). Integrating sustainable practices into financial systems paves the way towards inclusive growth by allowing proper focused participation by marginalized populations in the economy (Du et al., 2023). This study uses the Social Progress Index (SPI) to measure the sustainability of the development (De Sisto et al., 2024). However, governance has played a fundamental role in determining financial inclusion in the sense that high-quality institutions and sound policies set up proper structures for equitable access to financial services (Ngo et al., 2023). In the case of least developed countries, good governance brings trust and reliability in the financial systems thus leading to people engaging financially with the institutions. For example, regulatory quality is the most significant moderating factor for social development. Here, it will be gauged through the SPI. It can describe the ability to meet basic human needs and generally enhance well-being (Zeqiraj et al., 2022). An enabling environment for improvement in social progress and financial inclusion will only support rather than hinder efforts when it is put into a fine regulatory framework.

Internet use and productive capacity are included as control variables to strengthen the accuracy and reliability of the model. As for other influential factors, their inclusion ensures more precise estimates, reduces omitted variable bias, and clarifies the core relationships being studied. This ensures that the estimated effect of the main independent variable is more accurate and unbiased (Haans et al., 2016). The serviceability of the Internet is crucial because it enhances access to digital financial services (Njanike and Mpofu, 2024). It lowers barriers for unbanked populations to engage with FinTech (Akpa et al., 2024). Widespread use of the Internet facilitates access to financial products, enhances financial literacy, and supports the growth of Fintech innovations that can reach underserved populations and, ultimately, sustainable financial ecosystems emerge (Mohd Daud et al., 2024). Productive capacity, on the other hand, is demarcated as a country's ability to generate goods and services (Du et al., 2024). It directly influences financial inclusion by fostering economic growth and creating new opportunities for financial services expansion. As economies grow and industrial output increases more individuals and businesses require access to credit, savings, and investment products (Ghosh and Sahu, 2022). It also enables financial participation and drives the progress of more diverse and accessible financial markets, fostering overall inclusion (Magazzino and Santeramo, 2024).

This study is motivated by the need to explore how sustainable development, through the Social Progress Index (SPI), influences financial inclusion in least-developed countries. Unlike GDP, SPI offers a broader perspective on sustainability. The study addresses key questions: (1) How does SPI impact financial inclusion? (2) Does regulatory quality moderate this relationship? (3) How do productive capacity and internet use influence financial inclusion? However, this research is designed to test the quadratic impact of sustainable development through SPI on financial inclusion. The governance aspect is covered through regularity quality which is taken as a determinant of financial inclusion and a moderator of SPI. The interaction of regularity quality and SPI will assure sustainability in financial inclusion. Overall productive capacity and use of the Internet are considered as the model's control variables. For this purpose, the least developed countries (that have scored lowest in HDI) are considered. This research is significant for those countries as it provides valuable insights into how enhancing regulatory quality and SPI can drive financial inclusion offering a pathway for policymakers to greater economic resilience, inclusivity, and long-term growth. In this way, this study is closely aligned with Sustainable Development Goal (SDG) 8. This particular goal emphasizes promoting sustained and comprehensive economic growth, in the presence of productive employment, and a decent working environment for all.

To address these stated objectives, this study is separated into additional sections. The assessment of the literature and the research gap is identified in the second section. Data collection, estimation approach, theoretical model, and sample size are in Section 3. The fourth section contains estimated results. The fifth section and the last section is dedicated to the conclusion and some remarks to policy makers.

## 2. Review of the literature

Financial inclusion is vital for least developed countries as it enhances access to financial services thereby fostering economic growth, poverty reduction, and overall financial stability (Bekele, 2023). A supportive social setup plays a crucial role in fostering financial inclusion by promoting trust, awareness, and approachability to financial services within communities, especially for marginalized groups (Ozili, 2020). For a sustainable financial inclusion, sustainability in growth is the first condition (Ding et al., 2021) as it expands opportunities for access to financial services thus helping to reduce poverty and promote equitable development. Kanga et al. (2022), Nsiah and Tweneboah (2023), Jin et al. (2024), Adjei-Mantey and Opoku (2024), and Takmaz et al. (2024) have validated the positive impact of economic growth on financial inclusion. This is the one aspect. Oppositely, Lenka (2021) Murshed

[1] https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b

et al., (2023), Elouaourti and Ezzahid (2024), and Kumar and Ahuja (2024) have validated the adverse economic growth effects on financial inclusion. It suggests that prioritizing growth may divert resources from expanding financial services, particularly for marginalized groups, thus limiting their access to financial resources. This trade-off can hamper efforts to endorse financial inclusion, especially in lower-income or developing regions.

Digitalization significantly boosts financial inclusion by providing wider, more affordable admittance, especially for underserved populations. As such, Agyekum et al. (2022), Kanga et al. (2022), Kouladoum et al. (2022), Bekele (2023), Nayak et al. (2024), Mohd Daud et al. (2024), Adjei-Mantey and Opoku (2024), and Njanike and Mpofu (2024) have validated the same phenomenon. Therefore, digital technology is crucial in enhancing the impact of financial inclusion on growth by improving access to financial services, minimizing transaction costs, and improving the efficiency of financial systems (Mohd Daud et al., 2024). In this way, digital technology helps individuals and businesses participate more actively in the economy, leading to greater financial inclusion (Song et al., 2024). Productivity can be another significant determinant for financial inclusion. However, overall productive capacity enhances financial inclusion by fostering economic growth, creating jobs, and expanding access to financial services for individuals and businesses (Kumbhakar and Mavrotas, 2008). The same notion is highlighted by Ghosh and Sahu (2022). Similarly, many other studies including Magazzino and Santeramo (2024) and Periola and Salami (2024) have endorsed the productive capacity for an improved pathway to financial inclusion. Further, Zheng and Chen (2023) have confirmed the positive association within financial inclusion and productivity in the energy sector.

The role of governance in sustainability of financial inclusion is crucial. Particularly, regulatory quality enhances financial inclusion by creating transparent, stable policies and legal frameworks that reduce barriers, expand access to services related to finance, and foster trust in the financial structure. Regarding this, Nguyen and Ha (2021), Emara and El Said (2021), Zeqiraj et al. (2022), and Ngo et al. (2023) have confirmed the positive impact of the combined composite index of governance indicators. Oppositely, Nsiah and Tweneboah (2023) have validated the adverse impacts of regularity quality on financial inclusion while Chinoda and Kapingura (2024) have found it insignificant and negative for determining digital financial inclusion. Among some other relevant studies, the outcomes of Anarfo et al. (2020) and Eldomiaty et al. (2020) are prominent. They have confirmed that financial regulation with financial stability positively influences financial inclusion. Further, Bibi et al. (2024) have authorized that governance independently reduces financial inclusion but, when it interacts with social inclusion, it then becomes beneficial for financial inclusion.

This study has incorporated the overall sustainable performance impact on financial inclusion. For this purpose, SPI is regressed over financial inclusion. Research studies including Murshed et al., (2023), Takmaz et al. (2024), and Jin et al. (2024) have tried to do so but with economic sustainability using GDP. SPI is superior to GDP in measuring sustainability as it assesses broader social and environmental dimensions by focusing on human well-being, inclusivity, and ecological balance whereas GDP only captures economic output. Further, the role of governance is measured through regularity quality and also incorporated as a moderator of SPI for sustainability in financial inclusion. Studies like Ngo et al. (2023) have tried to do it using a composite governance index. Regularity quality directly reflects the effectiveness of policies and regulations in promoting inclusive financial systems and offers a more focused and actionable approach than a composite index of all governance indicators. Further, Bibi et al. (2024) have relevant work but with a social inclusion index. SPI is superior to this because it offers a more comprehensive assessment of societal well-being by integrating diverse indicators that reflect environmental sustainability, health, education, and personal rights rather than focusing solely on economic measures or access to services.

Among the control variables of the model, overall productive capacity (based of eight other types of productive capacities) is included. The studies discussed above have used only a single factor-based productivity. The Internet is included as a control variable in the model, reflecting its significant role in the rapid expansion of technological advancements and its influence on economic and financial systems. In short, this study is particularly designed for least developed counties and the proposed functional form contains all those factors which can boost the development of these countries as financial inclusion promotes economic growth, reduces poverty, and improves access to essential financial services thus fostering overall development and stability.

## 3. Methods and data collection

### 3.1. Estimation approach

As an estimation approach, this study has incorporated Driscoll-Kraay standard error (S.E.) and Quantile Regression for Panel data (PQR). Following Driscoll and Kraay (1998) this method is designed to deliver robust outcomes when the series are cross-sectionally dependent, autocorrelation, and heteroskedasticity. This technique adjusts for these issues by using a nonparametric technique that estimates the standard errors robustly across time and cross-sectional units (Iqbal et al., 2024). A typical regression model where this method is applied looks like Eq. 1 below. In Eq. 1, $Y_{it}$ is the dependent variable for cross section $i$ and time $t$. While on the right-hand side, $\alpha$ is the intercept term. Further, $X_{it}$ is the independent variable for cross section $i$ and time $t$ while $\beta$ is the coefficient to be estimated (the effect of $X$ on $Y$). $\varepsilon_{it}$ is the error term which may be correlated across units and over time. This method uses a nonparametric covariance matrix estimator that accounts for correlations across both time and individual units. Specifically, it handles cross-sectional dependence by allowing the error terms ($\varepsilon_{it}$) of different units to be correlated with each other. It deals with autocorrelation by considering that errors for the same unit may be correlated across time. Lastly, it adjusts for heteroskedasticity by allowing the variance of the errors to vary across units and time. These adjustments ensure that the standard errors are robust and reliable even when the data exhibits complex error structures.

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \tag{1}$$

PQR, on the other hand, allows for different effects at various points (quantiles) of the distribution of the dependent variable (Koenker, 2004). As highlighted by Li et al. (2023), unlike ordinary least squares (OLS), which focuses on estimating the average effect, panel quantile regression examines how the relationship between variables differs across the distribution (e.g., the median, lower quartiles, and upper quartiles). This method is particularly useful when the effects of independent variables vary across the outcome distribution or when outliers influence the results (Iqbal and Kalim, 2023). This method is being used with the specification fixed effect to account for unobserved individual heterogeneity (Powell, 2022). This approach is based on Eq. 2 below. In Eq. 2, on the left-hand side, $Q_\tau(Y_{it}|X_{it})$ is the conditional τ-th quantile of the dependent variable $Y_{it}$ given the independent variables $X_{it}$. However, $Y_{it}$ is the dependent variable and $X_{it}$ is the vector of independent variables. Further, on the right-hand side, $\beta_\tau$ is the vector of coefficients to be estimated for the τ-th quantile. At the same time $\alpha_i$ is the individual-specific fixed effect, which captures unobserved heterogeneity.

$$Q_\tau(Y_{it}|X_{it}) = X_{it}\beta_\tau + \alpha_i \tag{2}$$

In summary, the incorporation of the Driscoll-Kraay S.E. method addresses heteroskedasticity, autocorrelation, and cross-sectional dependence ensuring robust inference in panel data. PQR, on the other hand, captures heterogeneous effects across the conditional distribution of the dependent variable by providing a comprehensive understanding of the relationship between variables beyond the mean estimates. However, using Driscoll-Kraay S.E. and PQR methods this study will estimate Eq. 3. Financial inclusion is taken as outcome variable. Studies together with Murshed et al., (2023) and Takmaz et al. (2024) have considered it as a dependent variable. Input variables of this study are presented on the right-hand side of Eq. 3 where $\beta_0$ represents the expected outcome variable value when all independent variables are zero. Further $\beta_2$ and $\beta_2$ are the coefficients of social progress index and its square respectively. It allows for capturing non-linear relationships, providing deeper insights into how variables can have varying effects at different levels which can reveal turning points or diminishing returns (Stewart, 2012). In this research, a quadratic function captures that the initial improvements in social progress enhance financial inclusion but, beyond a certain point, further increases may have diminishing effects, particularly for least developed countries. Literature of financial inclusion does not hold any particular evidence about the quadratic impact of social progress. This study employs the SPI as sustainable development, aligning with numerous studies that utilize economic growth as an indicator of sustainability. Hence, studies including Nsiah and Tweneboah (2023) and Kumar and Ahuja (2024) have confirmed unfavorable and favorable impacts of growth on financial inclusion respectively. $\beta_3$, $\beta_4$ and $\beta_5$ are the coefficients of internet use, overall productive capacity, and regularity quality with the assumption that these indicators are the increasing determinants. This assumption is aligned with Nayak et al. (2024) and Mohd Daud et al. (2024) regarding internet use; Ghosh and Sahu (2022) and Zheng and Chen (2023) regarding productive capacity; and Zeqiraj et al. (2022) and Ngo et al. (2023) about regularity quality. $\beta_6$ shows the interaction term of social progress with regularity quality. It allows for the examination of moderating effects and captures the complex relationships between variables that additive models may overlook. Interaction terms can improve model fit by accounting for variability in the data and provide actionable intuitions by identifying conditions under which certain effects are most significant. Additionally, they align the analysis with theoretical frameworks that propose conditional relationships, enhancing both the rigor and applicability of the findings. An interaction term is used to assess how the proposed relationship changes at various levels of another independent variable. By including an interaction term, the combined effects of two variables allows for more understanding of their joint influence on the outcome (De Sisto et al., 2024).

$$FIN_{it} = \beta_0 + \beta_1\, SPI_{it} + \beta_2\, SPI_{it}^2 + \beta_3\, INT_{it} + \beta_4\, PRO_{it} + \beta_5\, RGQ_{it} + \beta_6\, SPI_{it} * RGQ_{it} + \varepsilon_{it} \tag{3}$$

In this study Dawson's methodology for demonstrating the moderating effect is incorporated (Dawson, 2014). It involves estimating the interaction between an input and a moderator variable to assess how the connection between the input and the outcome variable fluctuates at different levels of the moderator. It is based on Eq. 4, where $Y_{it}$ and $X_{it}$ are the variables. Noticeably, $M_{it}$ is the moderator, and $\varepsilon_{it}$ is the error term. This approach allows one to identify how varying levels of the moderating variable influence the strength or direction of the relationship between the input and the outcome variable.

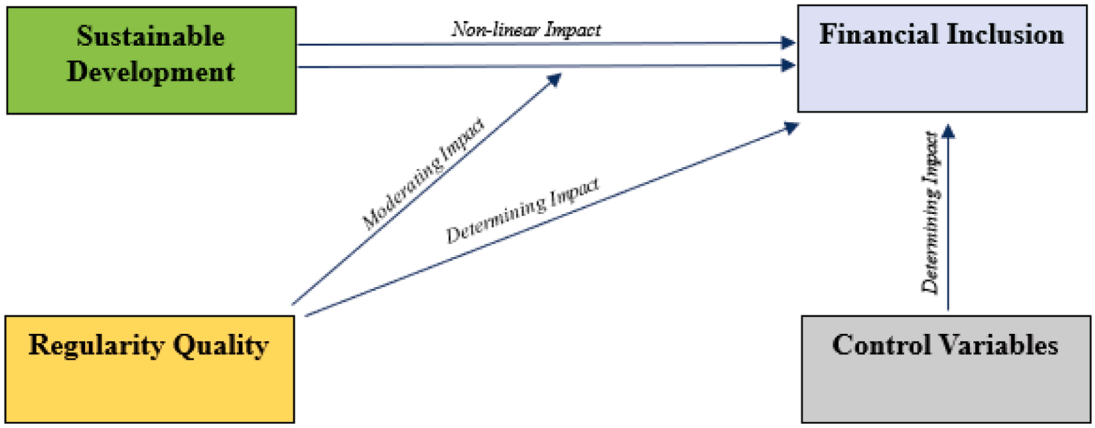


**Fig. 1.** Conceptual Model.

$$Y_{it} = \alpha + \beta_1 X_{it} + \beta_2 M_{it} + \beta_3 (X_{it} * M_{it}) + \varepsilon_{it} \quad (4)$$

### 3.2. Theoretical model

Fig. 1 has been constructed to understand the functional relationship in the proposed model to illustrate the non-linear impact of SPI on financial inclusion with regularity quality acting as both a determinant of financial inclusion and a moderator of SPI. This model aligns with the study's framework, highlighting the U-shaped relationship where initial increases in SPI may reduce financial inclusion due to inefficiencies but, beyond a threshold, SPI improvements enhance inclusivity by fostering access to resources and opportunities (Murshed et al., 2023; Takmaz et al., 2024). Regularity quality strengthens this relationship by providing a regulatory framework that enhances financial inclusion and moderates the SPI-financial inclusion link. A strong regulatory environment amplifies SPI's positive effects by ensuring the sustainable development benefits are widely distributed. Fig. 1 is explicitly referenced to visually clarify these dynamics thus strengthening the connection between the theoretical model and its practical relevance. Additionally, regularity quality is introduced both as a determinant and a moderator of SPI. It is assumed that higher regularity quality enhances financial inclusion directly and moderates the SPI and financial inclusion relationship and making the impact of SPI more favorable to achieving higher levels of financial inclusion (Bibi et al., 2024). This framework integrates sustainable development and governance as key components in shaping inclusive financial outcomes, particularly in the context of non-linear dynamics.

### 3.3. Variables and sample size

This study depends on secondary data collected from different sources from 2011 to 2023. Table 1 is to grasp variables of the study accompanied by symbols short descriptions and data sources. Financial inclusion (FIN) is taken as the outcome variable it states to the accessibility of useful, affordable financial services. It includes banking, credit, insurance, and savings. Sustainable development is taken through the Social Progress Index (SPI). It reflects a country's social and environmental consequences, assessing its ability to meet basic human needs, basics of well-being, and opportunities for individuals to improve their lives. Internet usage (INT) and overall productive capacities (PRO) are engaged as controlling aspects of the model. The control variables are measured through individuals using the Internet (as share of population) while productive capacities consist of eight different types of capacities including structural change, energy, human capital, institutions, natural capital, ICT, transport, and the private sector. Using overall productive capacity instead of its individual segments provides a comprehensive measure that captures the combined impact of multiple critical factors, ensuring a more holistic understanding of economic productivity and offering a broader perspective on how to collectively influence financial inclusion. Further, regularity quality is taken as a determinant of financial inclusion and a moderator of SPI. It echoes the aptitude of the government sector to construct and apply sound regulation policies.

## 4. Results and interpretations

This section will start by interpreting the descriptive statistics provided in Table 2. Table 2 comprises the mean, median, Std. Dev., variance, skewness, and kurtosis for the variables in this study. The mean represents the average value thus giving an overall sense of the central tendency of the data. The median ($P_{50}$) shows the mid value of ordered data thus signifying that half of the data points fall above and half below this value thereby making it less sensitive to outliers than the mean. Considering the estimates of Table 2, standard deviation (Std. Dev.) measures how values spread out from the mean thus indicating the level of variability in the dataset. Similarly, variance quantifies the overall dispersion of data points around the mean thereby providing a broader understanding of variability in the dataset. Noticeably, mean value (except for regularity quality_ is larger than the Std. Dev. This suggests low variability in the data whereas the mean is less than the Std. Dev. for regularity quality. This indicates high variability and greater dispersion around the mean. Further, both negative and positive values of skewness validate the departure from symmetry. Both negative and positive values of skewness clearly demonstrate a departure from symmetry. The existence of outliers in the data is validated by Kurtosis. The ideal value for kurtosis is 3 which indicates a normal distribution with a balanced number of extreme values (mesokurtic). Values higher than 3 suggest a distribution with heavy tails (leptokurtic) although values lower than 3 indicate lighter tails (platykurtic). However, for the present study, all the variables have outliers. So, in the light of descriptive aspect of the study, the PQR will provide robust outcomes.

In support of the descriptive analysis, Figs. 2 and 3 have been constructed to provide a visual representation of the key associations and relationships in the study. Focusing on Fig. 2, it illustrates the relationships among the regressors, highlighting the degree of

**Table 1**
Explanation of the Variables.

| Variables (Symbol) | Definition | Source |
|---|---|---|
| Sustainable Development (SPI) | Ability to prioritize the social and environmental needs of citizens, focusing on outcomes rather than economic indicators. | SPI |
| Financial Inclusion (FIN) | The access and usability of financial services by all segments of society. | IMF |
| Internet Use (INT) | Individuals using the Internet (% of population). | WDI |
| Productive Capacity (PRO) | Overall productive capacity influenced by factors like capital, labor, and technology, etc. | UNCTAD |
| Regularity Quality (RGQ) | The aptitude of the government to frame and implement sound regulation policies. | WGI |

**Table 2**
Descriptive Statistics.

| Variables | Mean | $P_{50}$ | Std. Dev. | Variance | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| **FIN** | 0.1859 | 0.1886 | 0.0519 | 0.0026 | −0.2757 | 2.7269 |
| **SPI** | 44.345 | 45.580 | 6.901 | 47.6352 | −0.5855 | 2.694 |
| **INT** | 16.854 | 14.190 | 13.531 | 183.103 | 1.1264 | 4.0812 |
| **PRO** | 22.742 | 22.744 | 2.941 | 8.6526 | 0.4754 | 4.0259 |
| **RGQ** | −0.8878 | −0.8093 | 0.4811 | 0.2314 | −0.7458 | 3.6998 |

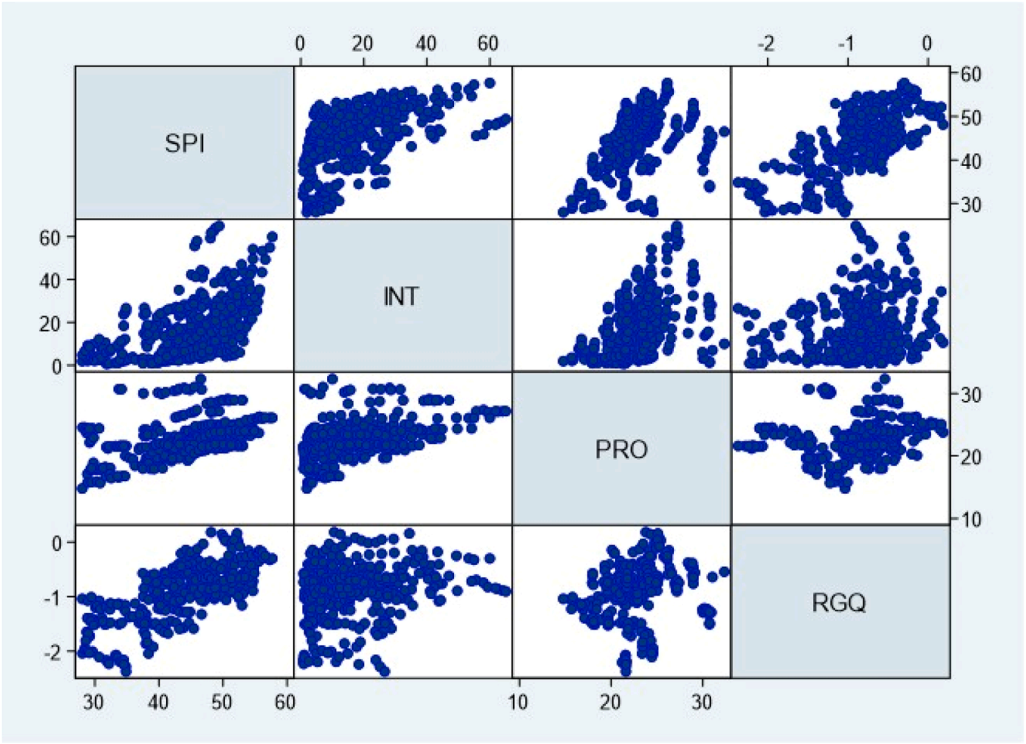


**Fig. 2.** Combined Satter Plot Among Regressors.

association between them. The figure shows no significant correlations among the regressors which is a positive indication for the model. The lack of strong association suggests that multicollinearity (a situation where independent variables are highly correlated with each other) is not a concern for this model. By ruling out multicollinearity, the proposed model is validated for further analysis consequently confirming that the regressors independently contribute to the explanatory power of the model.

Moving on to Fig. 3, it comprises four distinct diagrams that provide a deeper understanding of the core relationships of the study. The first three parts of the figure depict the quadratic relationships between SPI and financial inclusion, regulatory quality, and financial inclusion, and SPI and regulatory quality, respectively. These relationships are all characterized by an inverted U-shaped curve, suggesting that the relationships initially grow stronger but then weaken after reaching a certain point. It is demonstrated within a 95 % confidence interval, showing the statistical significance and robustness of the findings. The inverted U-shape implies that there may be diminishing returns at higher levels of sustainable development or regulatory quality where further increases may not necessarily lead to continued improvements in financial inclusion. The last section of Fig. 3 emphasizes the moderating role of regulatory quality in the relationship between sustainable development and financial inclusion. This part of the analysis shows that when regulatory quality moderates the association the relationship between sustainable development and financial inclusion transforms. It illustrates a shift in the pattern, indicating that regulatory quality can alter the direct impact of sustainable development on financial inclusion.

Fig. 4 complements these findings by presenting histograms of the variables used in the study which show deviations from normality in their distribution. This departure from a normal distribution pattern further justifies the use of the Panel Quantile Regression (PQR) approach in the study. The PQR method is particularly suited for managing such distributional characteristics, allowing for more robust and reliable estimates that account for non-normal data distribution and ensuring the validity of the overall analysis.

In Table 3, cross-sectional dependence is assessed to determine if errors across different units are correlated. Cross-sectional

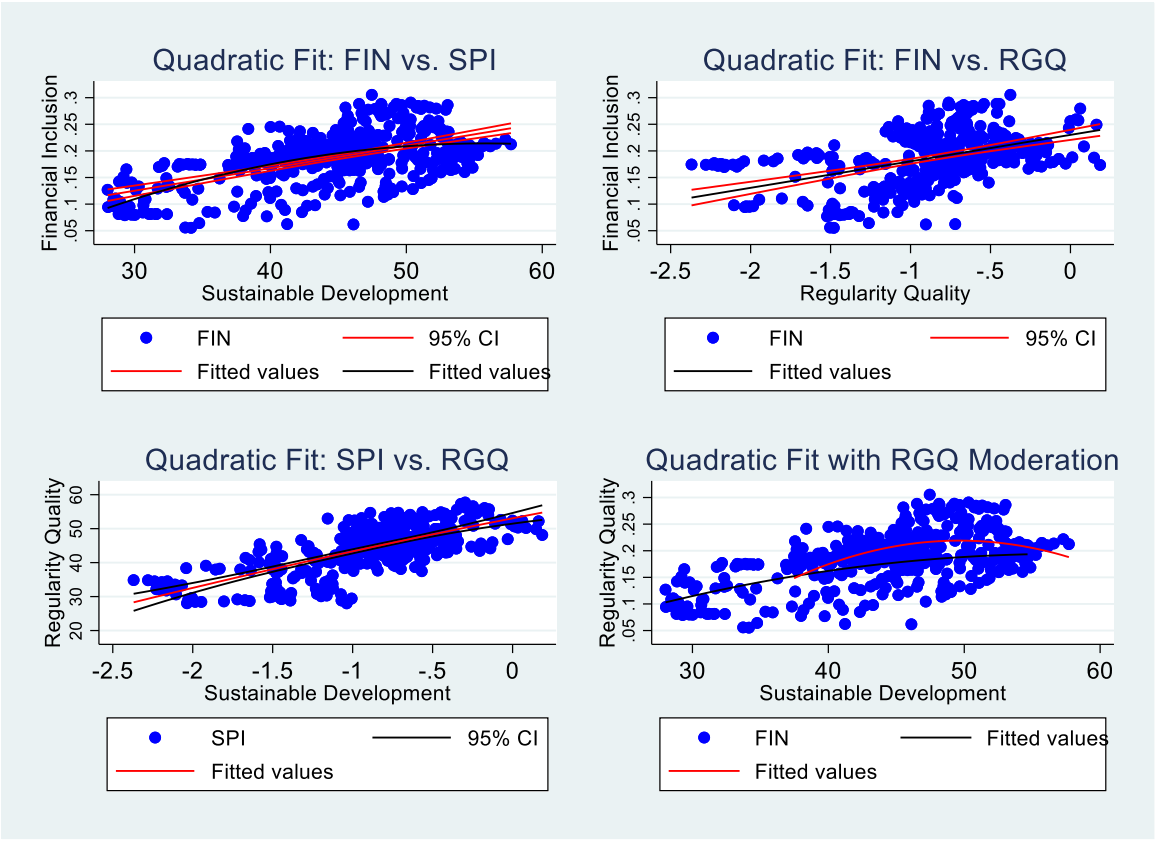


**Fig. 3.** Moderating Effect Association Pattern.

dependence is a critical issue in panel data analysis as it implies that the behavior of one unit may influence, or be influenced by, the behavior of other units (El Khoury et al., 2025). When such dependence exists, it violates the assumption of independence among the cross-sectional units which is a standard assumption in many econometric models. Ignoring cross-sectional dependence can lead to biased estimates, incorrect inference, and unreliable results. Therefore, the presence of cross-sectional dependence necessitates the use of econometric techniques, such as Driscoll-Kraay S.E, to adjust for this interdependence and ensure robust and reliable estimation results. Addressing this issue is essential for the accuracy and validity of the conclusions drawn from the analysis. The test statistic for cross-sectional dependence is found to be statistically significant, indicating that the errors are not independent across units. In other words, the relationship or patterns observed in one cross-sectional unit are likely to affect or be affected by other units (least developing countries). This violation suggests that common shocks or unobserved factors might be driving these dependencies, making it crucial to account for cross-sectional correlation in the model specification.

The estimated results of the study are presented in Table 4. It contains the outcomes of two simultaneous econometric approaches. Driscoll and Kraay standard error is the baseline approach while the PQR is applied for the robustness test. Both techniques have provided similar findings. PQR handles non-normal data distributions, capturing the effects at various quantiles, while the Driscoll-Kraay method corrects for cross-sectional dependence and heteroscedasticity.

Consequently, divergent to the supposition of this study, it is validated for the least developed countries that continue expansion in sustainable development via social progress initially improve the financial inclusion situation but later on it deteriorates. This finding suggests that while promoting sustainable development can enhance financial inclusion in the short term, policymakers need to be cautious of over-regulation or structural inefficiencies that emerge at advanced stages of development. Tailored interventions should focus on maintaining a balance between growth and inclusivity, ensuring that financial systems remain accessible and adaptive to evolving social conditions. This finding also has empirical support; Takmaz et al. (2024) and Jin et al. (2024) advocate positively while Nayak et al. (2024) and Mohd Daud et al. (2024) are in favor of negative impact. However, it reflects the dual nature of progress. Initially, social progress fosters financial inclusion by improving access to basic needs, social equity, and well-being which are foundational for inclusive financial systems. However, beyond a threshold, further advancement in social development may introduce complexities (such as governing inefficiencies, unequal benefits, or over-saturation of financial services) that hinder accessibility and inclusivity.

In this study, regularity quality is considered as a determinant of financial inclusion and a moderator of social progress. Independent regularity quality is responsible for reducing financial inclusion in least-developed countries and endorsed by Nsiah and

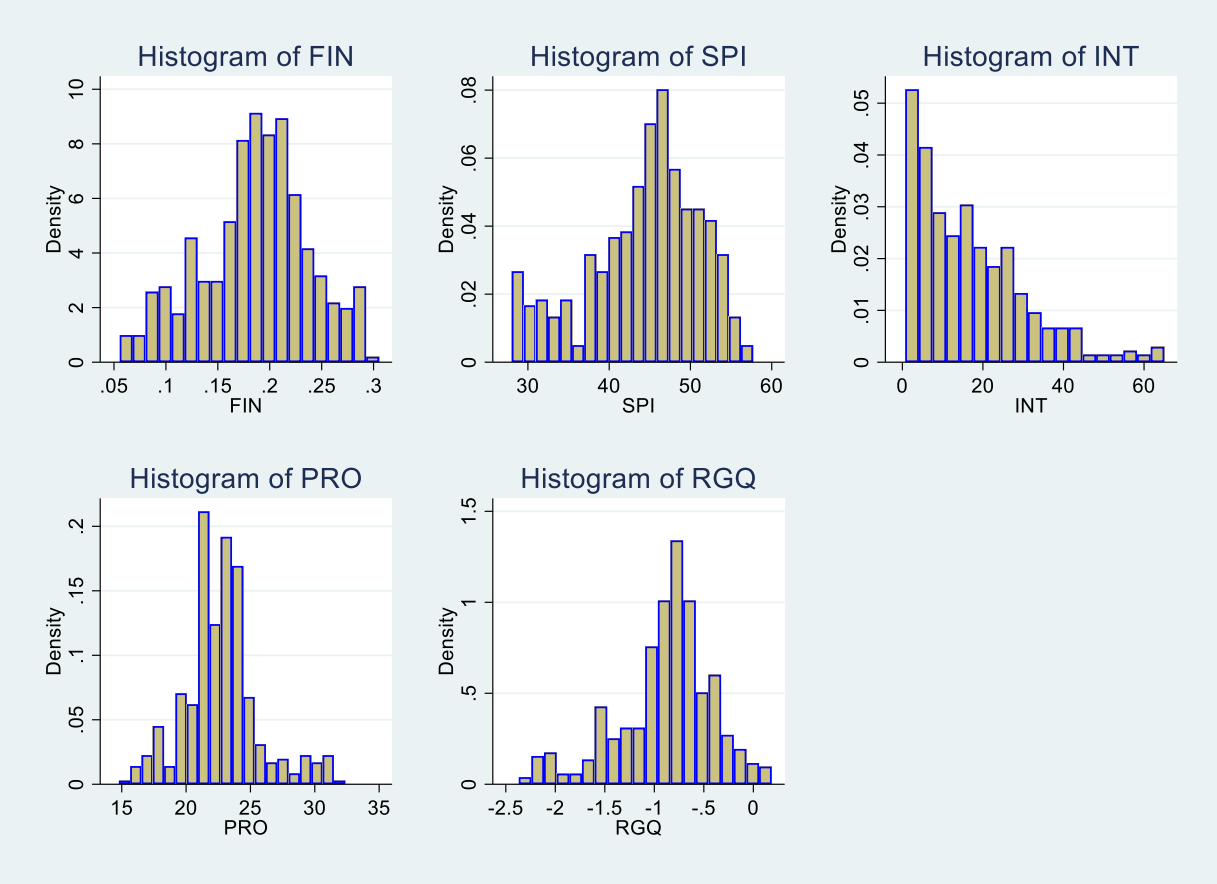


**Fig. 4.** Normality Test.

**Table 3**
Cross Sectional Dependence Test.

| | FIN | | SPI | | INT | | PRO | | RGQ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** |
| Breusch-Pagan LM | 1617.05 | 0.000 | 4561.01 | 0.000 | 4676.81 | 0.000 | 3480.20 | 0.000 | 1972.38 | 0.000 |
| Pesaran scaled LM | 37.777 | 0.000 | 134.313 | 0.000 | 138.110 | 0.000 | 98.872 | 0.000 | 49.429 | 0.000 |
| Bias-corrected scaled LM | 36.485 | 0.000 | 133.022 | 0.000 | 136.819 | 0.000 | 97.580 | 0.000 | 48.137 | 0.000 |
| Pesaran CD | 11.177 | 0.296 | 62.460 | 0.000 | 64.027 | 0.609 | 37.273 | 0.000 | 13.941 | 0.000 |

**Table 4**
Estimated Results.

| **Variables** | **Driscoll-Kaary Results** | | | **PQR Results** | | |
|---|---|---|---|---|---|---|
| | **Coeff.** | **S.E** | **Prob.** | **Coeff.** | **S.E** | **Prob.** |
| **SPI** | 0.028 * ** | 0.0040 | 0.000 | 0.026 * ** | 0.0011 | 0.000 |
| **SPI$^2$** | −0.00028 * ** | 4.19E−05 | 0.000 | −0.00027 * ** | 1.05E−05 | 0.000 |
| **INT** | 0.0010 * ** | 8.91E−05 | 0.000 | 0.00062 * ** | 8.01E−05 | 0.000 |
| **PRO** | 0.0018 * ** | 0.00054 | 0.006 | 0.0040 * ** | 0.00037 | 0.000 |
| **RGQ** | −0.064 * ** | 0.015 | 0.001 | −0.041 * * | 0.0182 | 0.023 |
| **SPI*RGQ** | 0.0021 * ** | 0.00035 | 0.000 | 0.0013 * ** | 0.00040 | 0.001 |
| **C** | −0.514 | 0.104 | 0.000 | — | — | — |

* ** , * *, * , shows 1 %, 5 % and 10 % level of significance respectively.

Tweneboah (2023). As a moderator of social progress, it improves it and assures sustainability in financial inclusion. As a determinant of financial inclusion and a moderator of social progress. When considered independently, weak regulatory quality in least-developed countries often restricts access to financial services due to inefficiencies, corruption, or rigid policies thereby reducing financial inclusion. However, when regulatory quality moderates social progress, it improves governance structures, enforces better legal frameworks, and ensures transparency. It fosters trust in financial systems thereby enhancing the positive effects of social progress on financial inclusion. Economically, effective regulatory quality ensures that financial systems are sustainable by promoting inclusivity, reducing inequality, and enhancing long-term economic stability (Bibi et al., 2024).

The overall productive capacity and internet use are considered control variables of the model while both of them positively determine financial inclusion. Their positive contribution to financial inclusion may also stem from decreasing barriers to accessing financial services through internet use, especially in unbanked or underbanked regions. Digital banking, mobile payments, and Fintech solutions are provided through the web, contributing to financial outreach, cutting transaction costs, and offering on-the-spot services. From an economic point of view, it encourages financial inclusion since access becomes even simpler for both the individual and the firm, unlocking even more entrepreneurship as well as boosting economic growth. This is supported by many studies including, among others, Nayak et al. (2024) and Mohd Daud et al. (2024). The theoretical justification of productive capacity, according to the findings by Ghosh and Sahu (2022) and Zheng and Chen (2023), is that it fosters economic activities among people and businesses. With the increased productive capacity of goods and services, incomes are higher and therefore demand for financial services such as savings and credit, as well as insurance, increases. Economically, higher productive capacity leads to a more active economy, supporting financial inclusion by fostering more participants in the formal financial sector. This, in turn, can contribute to sustainable economic development.

To demonstrate the moderating effect Fig. 5 is created. The red colored line is the after-effect of the moderation. It infers that regularity quality, along with SPI, not only improves financial inclusion conditions but also paves the way for increasing returns. Its interaction terms bring delay in the turning point and provide enough margin to the policymakers to boost sustainable practices to the maximum levels. The quantile process, derived from the results of quantile regression, is illustrated in Fig. 6. The diverse slope patterns of regressors clearly demonstrate how they shape the dynamics of the dependent variable across its different quantiles. These steep and flat patterns offer insights for policymakers to understand the determining behavior of regressors to propose robust policy implications. SPI follows inverted U-shaped behavior with different intensities. The effectiveness of internet use is decreasing in higher quantiles while increasing productive capacity. Opposite to median-based results, regularity quality is increasing financial inclusion in different dependent variable quantiles. Similarly, its interaction term with SPI is negative.

## 5. Conclusion and policy implications

This study has targeted LDCs to test the quadratic impact of SPI on financial inclusion besides regularity quality as a moderator of SPI and determinant of financial inclusion. This study is significant for the sampled countries as it provides insights into how sustainable development, moderated by regulatory quality, can enhance financial inclusion thereby offering a pathway to improved economic resilience and growth. The empirical findings have confirmed the inverted U-shaped impact of the SPI on financial inclusion. It suggests that at lower levels of social progress improvements enhance financial inclusion. However, beyond a certain level, a further upsurge in social progress may lead to diminishing returns on financial inclusion efforts. Regularity quality, on the other hand, negatively influences financial inclusion but, as a moderator, it potentially improves the social progress towards an increasing pathway for enhanced financial inclusion. Further, this study supports SDG 8 by promoting sustainable financial inclusion which enhances access to affordable financial services, reduces financial disparities, and fosters inclusive economic growth, especially in least-developed countries with diverse socio-economic challenges.

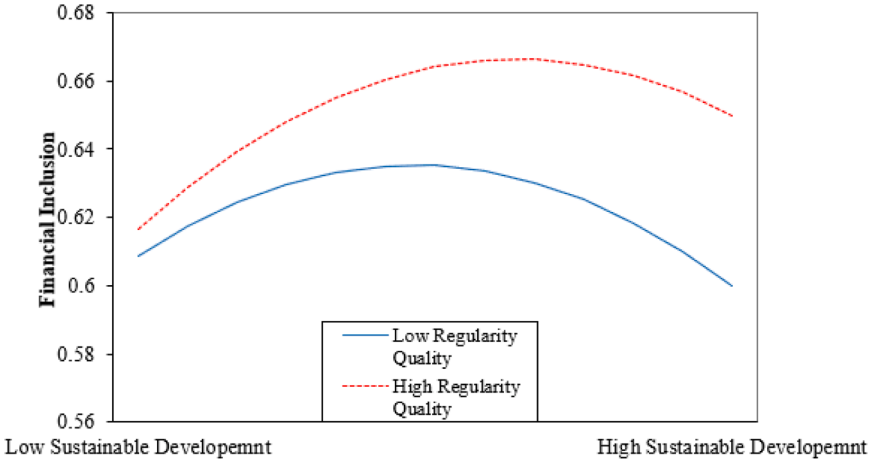


**Fig. 5.** Moderating Effect Demonstration.

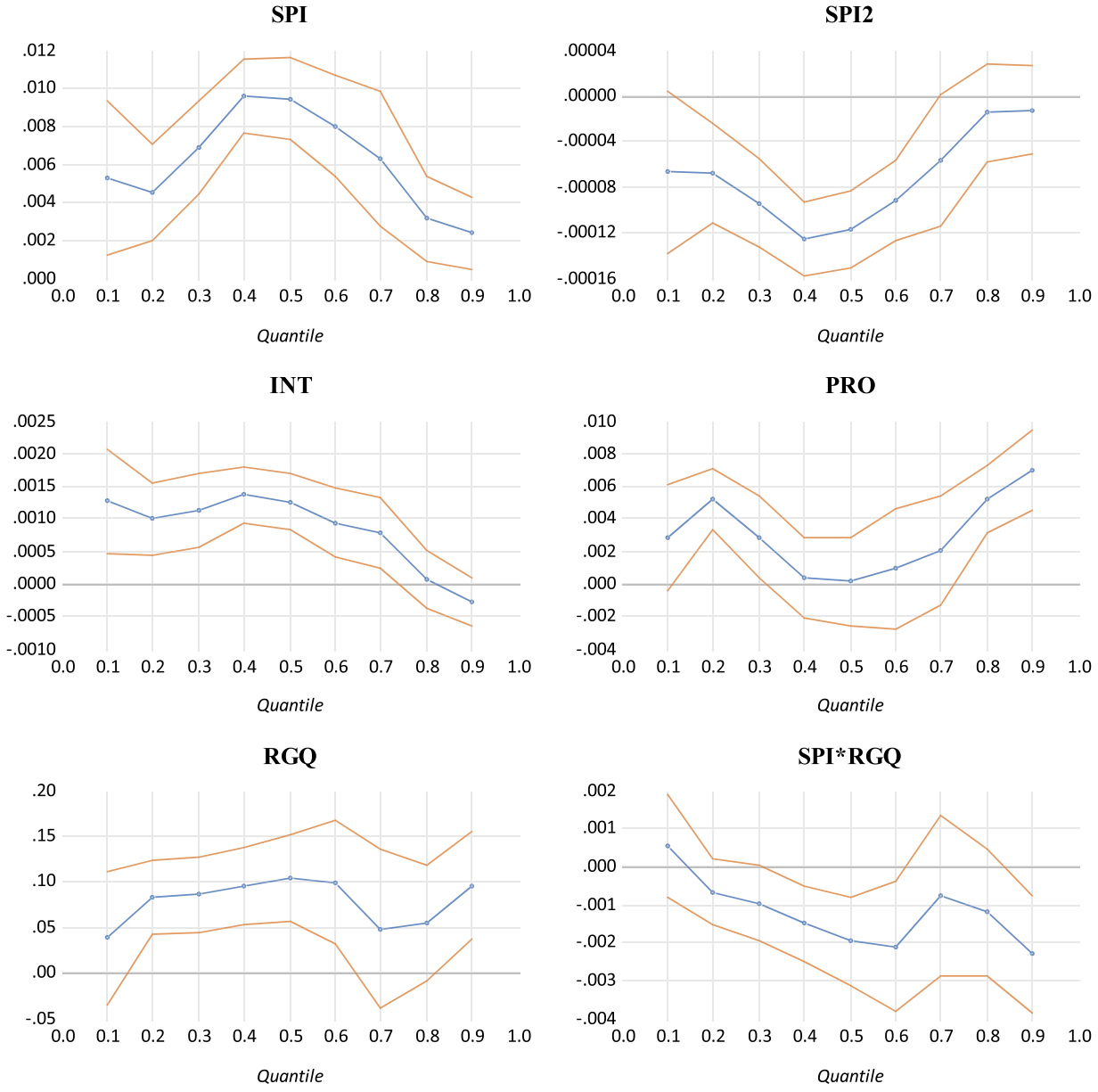


**Fig. 6.** Quantile Process of Regressors.

The findings suggest that regulatory quality is crucially important to any financial inclusion outcomes. Thus, policymaking efforts through the development of transparent, accountable, and efficient regulations in governance structures should be emphasized. Effective, structured, and consistent regulations will promote trust in the financial system among financial institutions and its counterparts. By building a better quality of regulation, governments would create an environment where financial services become accessible to all, especially in the underserved societies, hence increasing engagement in formal financial activities that promotes broader economic growth. Moreover, since regulation quality plays a moderating role in the relationship between sustainable development and financial inclusion it makes it dynamic for governments to design regulations not only fostering economic and social progress but also connecting these achievements to financial inclusion. Good governance structures ensure that any sustainable development progress as noted will be converted to increased access to these financial services. It is precisely in adopting this dual approach that the governments of the least developed countries can help create a financial system which is more inclusive, resilient, and better placed to serve all parts of society, especially the least developed countries.

Another key factor policymakers must consider is the role of technological advancement especially with regard to more extensive and wider-spaced access to internet connectivity which has become one of the key financial inclusion generators. Nowadays, the Internet opens new avenues for offering financial services, especially in areas where the traditional banking infrastructure is limited

and comprises many remote or under-served regions. Supplemental access to the Internet can substantially increase the reach and effectiveness of such services and allow individuals and small businesses to fully participate in the financial system. In this way, technology can be used to the advantage of policymakers to ensure that those most in need of such services are able to take advantage of them despite geographical location. Entrepreneurship promotion and productive capacities strengthening must also be on the agenda as these will drive growth without the alarming possibility of overdevelopment. As financial inclusion grows a broader economic progress accompanies it. Access to education and growing digital literacy rank among the most important controlling factors to it. Such investments would allow policymakers to reap maximum benefits from financial inclusion and nurture an environment where people do not only access but also utilize financial services appropriately to improve their economic well-being.

### *5.1. Limitations and future research direction*

The research focuses on LDCs which limits the applicability of the findings to more developed or emerging markets. These economies may have more advanced financial systems, governance structures, and technology access. Future research could explore the non-linear impact of sustainable development on financial inclusion in developed and emerging markets to compare findings across different economic contexts. Additionally, examining governance indicators, digital finance, and the role of informal sectors in future studies could offer deeper insights into the evolving relationship between sustainable development and financial inclusion in diverse settings.

## Ethical declarations

none

## Ethical Approval

The entire research process is in line with our institutional research ethics policy. We declare that all ethical standards are met and complied with in true letter and spirit.

## Informed Consent

All participants in this study volunteered themselves during the entire research process, and their consent was taken at inception.

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## CRediT authorship contribution statement

**Saleem Irfan:** Writing – original draft, Visualization, Validation. **Iqbal Mubasher:** Writing – original draft, Methodology, Formal analysis, Data curation. **Ul-Durar Shajara:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Investigation, Conceptualization. **Massacci Alberto:** Writing – original draft, Methodology, Formal analysis. **Naveed Shabana:** Writing – review & editing, Validation, Investigation.

## Declaration of Competing Interest

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.

## Appendix (A1)

| Burkina Faso | Mauritania | Gambia |
|---|---|---|
| Burundi | Côte d'Ivoire | Ethiopia |
| Central African Republic | Sudan | Congo (Democratic Republic) |
| Chad | Lesotho | Madagascar |
| Guinea | Nigeria | Djibouti |
| Mali | Tanzania (United Republic of) | Liberia |
| Mozambique | Rwanda | Malawi |
| Niger | Senegal | Guinea-Bissau |
| Sierra Leone | Togo | Benin |
| South Sudan | Pakistan | Eritrea |
| Yemen | | |

## Data availability

Data will be made available on request.

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