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Investigating the path to international trade expansion: human development conditions for financial development influence in Sub-Saharan Africa

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Abstract

Purpose – This study investigates the contingent role of human development in moderating the relationship between financial development and international trade across 38 Sub-Saharan African countries from 2008 to 2023.

Design/methodology/approach – Drawing on Heckscher–Ohlin theory, the study employs a dynamic panel threshold regression model to empirically determine the minimum levels of human development indicators: life expectancy, education attainment and gross national income (GNI) per capita necessary for financial development to exert an influence on trade performance.

Findings – The study reveals statistically significant threshold effects; thus, when life expectancy, education and GNI per capita fall below identified thresholds of 0.658 (62.7 years), 0.911 (13.6 years) and 0.846 ($63,450), respectively, financial development negatively affects trade. Conversely, once these thresholds are exceeded, financial deepening begins to foster international trade growth. These insights reveal a critical asymmetry in the finance–trade nexus, moderated by human development quality.

Research limitations/implications – The study calls for a coordinated policy approach that aligns human development investment with financial sector reforms, thereby enabling the region to harness its full trade potential within the global economy.

Originality/value – This research offers original empirical evidence on the nonlinear conditionality of trade outcomes in SSA and contributes to the literature by identifying quantifiable policy thresholds of human development that must be surpassed to unlock the benefits of financial development.

Keywords Dynamic threshold, Financial development, Human development, International trade, Sub-Saharan Africa

Paper type Research article

1. Introduction

In the evolving architecture of the global economy, international trade remains a critical driver of economic transformation, structural change, and competitive positioning, particularly for developing regions such as Sub-Saharan Africa (SSA) (The World Bank, 2023). Despite decades of reform and liberalisation efforts, SSA continues to grapple with disproportionately low integration into global trade systems, relative to its resource endowments and demographic potential. The region's share of global merchandise exports rose from 1.2% in 1995 to 3.6% in 2019, signalling progress in global trade participation (Ngouhouo *et al*., 2021). However, this progress remains quantitatively modest and qualitatively unequal. In comparison to developing economies in Asia and Latin America, SSA's engagement with

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international trade is constrained by systemic bottlenecks that hinder value addition, diversification, and competitiveness (Bonga, 2024). This is a paradox of potential abundance, but constrained performance demands a deeper interrogation of the foundational enablers of trade integration.

Among the critical, yet often overlooked, determinants of trade performance in SSA are human development and financial sector maturity. Both serve as the infrastructure of intangible capability and institutional support that facilitate productive engagement with global markets. Human development, defined as the stock of education, health, and income capabilities embodied in individuals, is increasingly recognised not only as a factor of production but also as a catalyst for innovation, entrepreneurship, and absorptive capacity (Danquah and Tsaurai 2024) Nations with robust human development systems tend to achieve higher levels of trade competitiveness through superior productivity, technological adaptation, and integration into value chains (Thathsarani *et al*., 2021).

Yet, the human development landscape in SSA remains fragmented and underdeveloped. According to the UNDP's Human Development Index (HDI), several countries in the region lag significantly behind global peers. For instance, in 2020, Nigeria and Chad recorded HCI scores of 0.56 and 0.41, respectively, compared to the global average of 0.75 (UNDP, 2024). These deficits are not merely developmental artefacts; they directly translate into reduced labour productivity, lower innovation capacity, and diminished trade competitiveness. The region also continues to exhibit the lowest life expectancy rates globally, often below 55 years (Wamai and Shirley, 2022), with adult illiteracy exceeding 30% in several countries (Zua, 2021). Furthermore, the average GNI per capita remains among the lowest worldwide (Nwude *et al*., 2020), limiting both consumer demand and investment potential.

Parallel to human development, financial development is instrumental in enabling trade-driven growth. Financially inclusive systems improve resource mobilisation, support entrepreneurial activity, and provide critical capital for investment in skills, infrastructure, and technological upgrading, which are key inputs for participation in international trade (Abdelghaffar *et al*., 2023). Yet, SSA's financial landscape remains characterised by structural underdevelopment: weak banking systems, credit rationing, limited capital markets, and institutional inefficiencies continue to impede financial intermediation (Bonga, 2024). These constraints disproportionately affect small and medium enterprises, which are central to trade expansion, innovation, and job creation.

It is in the nexus between human development and financial development that a compelling, underexplored dynamic emerges. While both domains independently influence trade, their interaction is theorised to generate synergistic effects that are critical in determining trade outcomes (Ibrahim, 2018; Matekenya *et al*., 2021). Specifically, a well-developed financial sector can only yield trade-enhancing dividends when accompanied by a sufficiently developed base of human development. Financial development without human development creates a structural disconnect, thus where capital is available, but the skills and capabilities required to deploy it productively in global markets are absent (Tsaurai, 2018). Conversely, human development without access to finance leads to unrealised potential, as educated or healthy individuals remain disconnected from the entrepreneurial and productive processes that fuel trade participation (Danquah and Tsaurai, 2024).

Thus, the core proposition of this study is that there exist threshold levels of human development across dimensions such as life expectancy, education, and income, below which financial development fails to positively impact international trade. In these conditions, financial deepening may even exert negative trade effects by misallocating resources or exacerbating inequality. However, once these thresholds are surpassed, human development serves as an enabler, amplifying the positive relationship between finance and trade.

This assertion is not merely theoretical. Prior empirical studies have independently explored the finance–growth (Song *et al*., 2021; Osei and Kim, 2020) and human development–trade (Owusu-Agyei *et al*., 2020; Zeynalli, 2020) relationships. However, there is a paucity of studies that explicitly examine the interactive, non-linear relationship

between financial development, human development, and international trade, particularly in the context of SSA. Furthermore, while the importance of these factors is widely acknowledged, few studies have empirically determined the minimum threshold conditions necessary for these dynamics to function effectively (Allub *et al.*, 2024; Eltejaei *et al.*, 2023; Ibrahim, 2018). This gap has profound policy implications, especially for low-income countries seeking to integrate into the global economy through trade.

From a theoretical standpoint, this study contributes by extending classical trade models, such as the Heckscher-Ohlin framework, which traditionally emphasises labour and capital as the primary factors of production. By introducing human development as an endogenous, dynamic factor that interacts with financial structures, the study provides a more holistic understanding of comparative advantage in the contemporary global economy. In doing so, the research supports an emerging consensus that economic development is increasingly rooted in knowledge, innovation, and systemic enablers, areas where SSA faces persistent deficits (Tariq *et al.*, 2023; Ha and Ngoc, 2022).

Methodologically, the study employs a dynamic panel threshold regression model, drawing on annual panel data from 38 SSA countries spanning 2008 to 2023. This approach allows for the identification of non-linearities and threshold effects in the relationship between financial development and trade, moderated by human development indicators. Specifically, the model identifies minimum thresholds for life expectancy, educational attainment, and GNI per capita, beyond which the influence of financial development on trade shifts from negative or neutral to positive and statistically significant. This empirical innovation offers a quantifiable basis for targeted interventions and avoids the overgeneralization that often plagues macroeconomic prescriptions for the region.

Moreover, the study introduces a context-specific analysis that recognizes the diversity within SSA. Avoiding one-size-fits-all interpretations, it provides more granular insights for policymakers in countries at different stages of human development and financial sector development. In terms of policy relevance, the implications are profound. The research demonstrates that neither financial liberalization nor trade openness alone can drive sustainable growth in SSA. Without investments in human development, particularly in education, health, and income generation, financial development will not yield its intended benefits. Conversely, without financial infrastructure, human development remains underutilized. Therefore, this study calls for integrated development strategies that synchronously enhance financial access and human development to unlock the region's trade potential.

The structure of the paper is as follows: Section 2 reviews the theoretical and empirical literature; Section 3 presents the methodology and data; Section 4 reports and discusses the results; and Section 5 concludes with policy recommendations tailored to the unique developmental context of SSA.

2. Literature review

2.1 Theoretical review – Heckscher-Ohlin theory

The Heckscher-Ohlin (H-O) theory continues to stand as a foundational pillar in international trade economics, offering a structural explanation for trade flows based on variations in factor endowments. It posits that countries tend to export goods that intensively utilize their abundant factors while importing goods requiring relatively scarce resources (Kunroo and Ahmad, 2023). Traditionally, this model emphasizes labour and capital as the key endowments. However, more recent adaptations have expanded this framework to incorporate human development, comprising education, health, and productive capabilities, as a crucial determinant of comparative advantage in contemporary trade contexts (Ikechukwu *et al.*, 2022).

While the model presents a compelling mechanism to explain inter-country trade specialization, it rests on assumptions such as homogeneous technologies, perfect competition, and frictionless factor mobility, which rarely hold in the real world, particularly within developing economies. These simplifications limit the model's explanatory power in capturing

institutional, technological, and financial asymmetries that shape modern trade (Prakash and Dhir, 2023). This limitation becomes even more pronounced in Sub-Saharan Africa (SSA), a region characterized by fragmented markets, underdeveloped institutions, and persistent human development deficits.

Although SSA's theoretical advantage in labour and natural resources is often assumed, its low human development indicators, such as reduced life expectancy, low literacy, and poor income levels, undermine the region's ability to leverage its factor endowments. In such contexts, the H-O model requires a conceptual evolution to account for human development as a dynamic and non-static enabler of trade capacity. Leamer and Lundborg (1995) and Romer (1990) have advocated for the integration of intangible, knowledge-based assets as trade-shaping endowments, aligning with endogenous growth theory, which views investments in human development as core drivers of productivity, innovation, and international competitiveness.

Equally critical, yet often overlooked, is the role of financial development in mediating these trade effects. The assumption of seamless capital mobility is rarely valid in SSA, where shallow credit markets, inefficient resource allocation, and financial exclusion persist. Without robust financial intermediation, human development cannot be transformed into tradable economic output. Therefore, this study extends the H-O framework by positioning human development as a threshold condition, necessary for financial systems to positively affect trade outcomes.

Therefore, recognizing the non-linear nature of this interaction, this study introduces a threshold-based framework wherein financial development enhances trade only after baseline human development levels are met. This theoretical refinement offers a more context-sensitive and policy-relevant lens through which to understand trade dynamics in SSA and sets the stage for empirical validation and intervention design.

2.2 Empirical review

A considerable body of literature affirms the critical role of financial development in facilitating international trade. Theoretically, well-functioning financial systems reduce information asymmetries, lower transaction costs, and enable more efficient capital allocation—conditions vital for firm entry into international markets (Beck, 2002; Bekaert *et al.*, 2005). Empirically, financial development is found to ease credit constraints, enhance liquidity access, and promote entrepreneurship, thus boosting the capacity of firms to invest in technology, logistics, and skilled labour necessary for export readiness (Hewage *et al.*, 2024).

Bardi and Ayouni (2016), through dynamic panel analysis across MENA countries, demonstrate a positive and significant link between financial depth and trade volume. Similarly, Sarwar *et al*. (2020) show that financial sector efficiency significantly enhances trade openness across Asian economies, particularly in countries with more developed institutional frameworks. Gana and Shuaibu (2024) quantify these effects in developing contexts, estimating short-run trade gains of 1.1%–1.2% per unit increase in financial development, with long-run effects reaching up to 9.7%. These findings highlight the transformative role of finance as a conduit to trade competitiveness, particularly for capital-scarce nations. Importantly, country-specific estimates within SSA confirm this dynamic. For example, Ayambila *et al*. (2023) found that in Ghana, a 1% increase in domestic credit to the private sector is associated with a 0.8% rise in non-traditional exports over the medium term. In Kenya, Taiwo (2021) identify finance–trade elasticities ranging from 0.6 to 1.2 depending on sectoral composition and institutional quality. These findings emphasize the contextual dependency of financial effects on trade performance within SSA.

However, these benefits are not automatic nor uniformly distributed. The effectiveness of financial development in catalysing trade is frequently moderated by country-specific institutional, regulatory, and infrastructural conditions (Chigeto *et al*., 2024). In the context of Sub-Saharan Africa (SSA), such enabling environments are often weak or fragmented.

Financial markets in SSA remain shallow, with low levels of financial inclusion, limited formal banking access, and high costs of borrowing (Sarpong and Nketiah-Amponsah, 2022). As Chigeto *et al*. (2024) argue, financial development alone is insufficient in the region unless complemented by broader structural reforms and improved governance. This necessitates an investigation into other complementary factors, most notably, human development that shapes the finance and trade nexus.

Human development, defined as the composite of education, health, and income-related capabilities, has emerged as a fundamental determinant of trade performance in the global knowledge economy (UNDP, 2024). A well-educated and healthy labour force fosters productivity, encourages innovation, and enhances a country's ability to absorb, adapt, and deploy complex technologies embedded in traded goods and services (Clarke and Gholamshahi, 2017; Braunerhjelm and Henrekson, 2023). Shi and Wang (2024) and Hewage *et al*. (2024) provide robust evidence that human development significantly amplifies the ability of firms and economies to engage in high-value trade sectors. In particular, they find that investment in tertiary education and vocational training enhances export sophistication. Similarly, Sabir (2023) finds that financial access among firms in emerging economies results in higher returns when the workforce is educated, thereby reinforcing the trade–human development link.

Regionally, evidence from SSA corroborates this interaction. For instance, Moja and Samuel (2023) show that in Rwanda and Ethiopia, vocational and technical education investments boost firms' absorptive capacity, increasing the efficacy of financial instruments such as trade credit. In Uganda, Okello *et al*. (2017) report that human development indicators such as adult literacy and health expenditure moderate the returns to SME export financing schemes, highlighting the threshold-like properties of human capital in mediating trade gains.

Despite this, the impact of human development on trade remains heterogeneous across regions. Allub *et al*. (2024) argue that in countries with persistently low education levels and weak health systems, the productive gains of financial development may not materialize. The workforce is often unable to leverage financial instruments or absorb technological knowledge critical for scaling international operations. In SSA, where adult literacy rates remain below 60% in some countries and life expectancy lags the global average by over a decade (World Bank, 2025), this constraint is particularly acute.

While the roles of financial development and human development in economic growth are well documented, studies that examine their interaction effect on trade, especially in SSA, remain scarce. Most empirical work treats these variables as independent determinants or as part of a set of controls in macroeconomic models, failing to explore their synergistic effects.

Gnangnon (2021) and Ahmed *et al*. (2020) explore multi-variable frameworks that include physical infrastructure, poverty, and macroeconomic volatility in shaping trade openness. While insightful, their analyses stop short of modelling human development as a moderator of financial development's effect on trade. This is a critical omission. In structurally underdeveloped regions like SSA, human development may determine the extent to which financial resources are productively deployed to stimulate export activity.

Recent work by Shi and Wang (2024) emphasizes this point, arguing that without a threshold level of human development, access to finance may generate diminishing or even negative returns in trade contexts, due to inefficient resource allocation or skill mismatches. This theoretical proposition, however, is yet to be robustly tested in SSA using appropriate econometric tools that capture non-linearities and conditional effects—a gap this study addresses.

The methodological landscape of existing studies ranges from basic fixed-effects models to more complex dynamic panel frameworks, including the Generalized Method of Moments (GMM) and Autoregressive Distributed Lag (ARDL) techniques. For instance, Saroj *et al*. (2023) employ GMM to control for endogeneity in finance–growth models across emerging markets, while Ahmed *et al*. (2020) use ARDL to explore co-integration between financial variables and trade indicators in South Asia.

Although these methods offer statistical robustness, they often fail to account for threshold dynamics or regime shifts, particularly important when theorizing non-linear interactions between financial and human development. Furthermore, no prior study focused on SSA has employed a panel threshold regression, particularly to detect inflexion points of human capital at which financial development begins to impact trade.

In SSA, where data limitations and structural heterogeneities are pronounced, choosing the right estimation strategy is critical. The panel threshold methodology employed in this study (Seo and Shin, 2019; Wang, 2015) is not only appropriate but innovative, given that it accommodates unobserved heterogeneity, endogeneity, and regime-dependent effects, making it highly suitable for the SSA context.

Despite the growing interest in the determinants of trade performance in SSA, three major empirical gaps remain. First, there is limited empirical research on how human capital moderates the relationship between financial development and trade. It remains unclear whether higher levels of education or health amplify or even enable the positive effects of financial access on export performance. This gap prevents understanding and policymaking. Second, the literature lacks an attempt to identify threshold levels of human development necessary for financial development to significantly impact trade. Without understanding these inflexion points, development interventions risk being mistimed or misdirected. Finally, much of the current literature draws from global or multi-regional datasets, offering generalized insights with limited applicability to SSA. Given the unique institutional and socio-economic structures in SSA, region-specific studies are essential to guide tailored reforms.

Therefore, the current study contributes by bridging this gap by developing a regionally grounded, empirically rigorous analysis that identifies minimum human development thresholds for finance-led trade expansion. Thus, integrating SSA-specific empirical findings and applying a novel threshold regression model to country-level panel data from 38 SSA economies over 2008–2023, this study provides both theoretical refinement and policy relevance. It enables policymakers to design sequenced, synergistic interventions that optimize the combined impact of financial and human development on SSA's international trade performance.

3. Methodology

3.1 Empirical model

The analytical framework adopted in this research is the Heckscher-Ohlin (H-O) model. The model is applied in this study for several reasons; first, the H-O model emphasizes how countries' relative factor endowments, like labour, capital, and human development determine their comparative advantages in producing specific goods (Brondino, 2023). Furthermore, the model facilitates the analysis of the interactions between financial development and human development, revealing critical thresholds that must be met for financial development to enhance trade performance (Kunroo and Ahmad, 2023). Finally, incorporating the H-O model into the analysis allows for a blend of traditional and contemporary economic theories (Brondino, 2023). The integration of human development, a crucial determinant in modern growth theories, with the H-O model acknowledges the evolving nature of trade dynamics in a globalized economy. The fundamental equation of the model can be summarized as:

$$Trade_{ijt}\begin{cases} f\left(\frac{K_H}{L_H}\right) \; if \; \frac{K_H}{L_H} > \frac{K_F}{L_F} \\ f\left(\frac{L_H}{K_H}\right) \; if \; \frac{K_H}{L_H} < \frac{K_F}{L_F} \end{cases} \tag{1}$$

Where $Trade_{ijt}$ is the trade flow from country i to country j at time t. The function f(·) in Equation (1) denotes a country's production possibilities frontier (PPF), modelled as a concave and differentiable mapping from relative factor endowments to trade capacity. Specifically, the study assumes a Heckscher-Ohlin structure where countries specialize according to comparative advantage driven by relative capital–labour ratios. When $\frac{K_H}{L_H} > \frac{K_F}{L_F}$, the home country is capital-abundant and exports capital-intensive goods, and vice versa. This captures standard neoclassical trade dynamics while allowing for asymmetric specialization based on endowment thresholds.

On this basis, this study adapted the model to investigate panel data on the threshold level of human development that triggers a significant impact of financial development on international trade. The econometric form of the adapted theoretical model with the incorporation of international trade, financial development, human development indicators and other controls expressed within the GMM framework is explicit as:

$$Trade_{it} = \beta_0 + \beta_1 Financial\ Development_{it} * TH_{it} + \beta_2 Human\ Capital_{it} + \beta_3 Z_{it} + \varepsilon_{it} \quad (2)$$

$Trade_{it}$ represents international trade, financial $development_{it}$ represents the financial development index, human $development_{it}$ represents the index comprising of life expectancy index, education index and gross national income index, Z_{it} represents the Control variable, and ε_{ijt} is the error term also representing other factors that influence international trade but cannot be captured.

The threshold variable TH_{it} can be defined based on the levels of human development with both lower and upper thresholds:

$$TH_{it} = \begin{cases} 0 & If\ Human\ Development_{it} < r_1 \\ Human\ Capital_{it} & If\ r_1 < Human\ Development_{it} < r_2 \\ r_2 & If\ Human\ Development_{it} \geq r_2 \end{cases} \quad (3)$$

Where r_1 is the lower threshold of human development, and r_2 is the upper threshold of human development.

The lower threshold indicates the minimum level of human development necessary for financial development to have a significant positive effect on trade performance. When human development is below r_1, the interaction between financial development and trade flow is negligible. Inversely, the upper threshold signifies the maximum level of human development, above which additional financial development may not significantly enhance trade performance. Beyond this point, the marginal effects of financial development on trade could diminish or plateau. However, this study seeks to establish the minimum threshold of human development that triggers a significant impact of financial development on international trade.

To establish the minimum threshold level of human development that enables financial development to trigger significant international trade, the study utilised the dynamic threshold technique. This methodological technique uniquely identifies threshold levels directly from the data, thereby avoiding the reliance on arbitrary quadratic or cubic terms that can lead to inefficiencies in traditional threshold models (Seo *et al*., 2019). This method allows for a more accurate determination of the minimum threshold level of human development necessary for financial development to significantly influence international trade.

Moreover, the technique incorporates a system-GMM framework specifically designed to address endogeneity challenges often present in panel data analysis, enhancing the robustness and reliability of the findings (Khan and Pazir, 2023). This approach is crucial in ensuring that the study results accurately reflect the true relationships between the variables involved. Additionally, by accounting for unobserved individual effects, a critical aspect often overlooked in simpler threshold models, this methodology provides a more comprehensive and deeper analytical framework (Seo *et al*., 2019).

3.2 Data

The study utilizes annual panel data from 2008 to 2023, covering 38 Sub-Saharan African economies, carefully selected based on data continuity and reliability. This period captures critical macroeconomic fluctuations, including post-global financial crisis recovery, commodity shocks, and pandemic-induced disruptions, allowing a robust analysis of structural dynamics over time. The World Bank's Development Indicators database, known for its methodological rigour and cross-country comparability, serves as the principal data source. Complementing this, the financial development indicator was drawn from the IMF's International Financial Statistics, a premier repository for monetary and financial data, ensuring depth and accuracy. Human development indicators, thus life expectancy, education, and GNI per capita, are sourced from UNDP's Human Development Reports, widely recognized for capturing multidimensional well-being. The values are standardized index values ranging from 0 to 1, consistent with the UNDP Human Development Index methodology. Accordingly, the threshold values identified by the panel regression represent normalized scores [1]. This transformation ensures comparability across countries and time. Together, these sources ensure data coherence and robustness. Table 1 provides the description, measurement and expected sign of the variables employed.

3.2.1 Justification of variables. The selection of variables in this study reflects the multidimensional determinants of international trade, particularly within the context of Sub-Saharan Africa's structural and institutional dynamics. Financial development is critical for easing credit constraints, facilitating investment, and enhancing firms' capacity to access global markets (Dong and Yu, 2023; Fan *et al*., 2024). Life expectancy captures the health dimension of human capital, reflecting workforce productivity and demographic sustainability

Table 1. Description of data, measurement and expected sign for selected control variables

Variable	Description	Indicators	Measure	Source
IT	International trade	Trade Openness	Total Trade-to-GDP ratio	WDI
FD	Financial Development	Financial Development Index	As an index of depth, access, efficiency, and stability of financial systems within a country, it indicates the robustness of financial markets and institutions	IMF
HC	Human Development	Life Expectancy Index	This ranges from 0 to 1. A value of 1 indicates a life expectancy at birth of 85 years, while 0 represents a life expectancy of 20 years	UNDP
		Education Index	Average years of education received by adults aged 25 and over	UNDP
		Gross National Income Index	GNI per capita with a logarithmic transformation that accounts for the diminishing importance of income as a country's GNI rises	UNDP
Z	Control Variables	Exchange rate	Annual % estimates	IMF
		Net Foreign Direct Investment	percentage of GDP	WDI
		Agriculture Growth	percentage of GDP	WDI
		Government Expenditure	percentage of GDP	WDI
		Inflation rate	percentage of YoY inflation	IMF
		Population	percentage of mid-year estimates	WDI

Note(s): WDI – World Development Indicators, IMF – International Monetary Fund, UNDP – United Nations Development Programme

Source(s): Authors' compilation, 2025

essential for trade competitiveness (Okolo *et al.*, 2024). Education, as a measure of skills and knowledge accumulation, is closely linked to innovation and the ability to absorb complex technologies in trade-intensive sectors (Bye and Fæhn, 2022). GNI per capita signals purchasing power and economic maturity, both of which shape domestic production capabilities and external trade potential (Danquah and Tsaurai, 2024).

Macroeconomic control variables further contextualize the analysis. Stable exchange rates influence export pricing and import costs, affecting trade balances (Mesagan *et al.*, 2022). Net foreign direct investment supports technology transfer and export diversification (Danquah and Barnor, 2025), while agricultural growth remains central to SSA's trade structure (Wang *et al.*, 2024). Government expenditure indicates fiscal policy orientation, and the inflation rate captures macroeconomic stability, both affecting trade costs. Lastly, population size determines market scale and labour availability, influencing both trade volume and structural competitiveness (Lee and Zhao, 2023).

4. Findings and discussions

4.1 Descriptive statistics

Table 2 provides the descriptive statistics for Sub-Saharan Africa (SSA) between 2008 and 2023, revealing significant trends in various economic indicators. From Table 2, Trade Intensity stands out with a mean of 3.82%, implying a substantial engagement in international trade. Financial Development is at 0.209%, suggesting a moderate level of financial infrastructure. The Life Expectancy Index, Education Index, and GNI per Capita Index are low at 0.331, 0.198, and 0.132, respectively, indicating areas for potential improvement in human development. Agricultural Growth is high at 21.52%, reflecting the significance of the agricultural sector. Foreign Direct Investment is at 2.924%, indicating a significant influx of foreign capital. Inflation Rate and Government Expenditure are high at 36.68% and 13.02% respectively, signalling potential economic challenges. Population Growth and Exchange rate stand at 2.605% and 1.758%, respectively, reflecting demographic and monetary stability. The trends in the key variables over the study period are illustrated in Appendix Figure A1, showing consistent upward paths in human development alongside trade expansion.

4.2 Correlation matrix

The correlation analysis presented in Table 3 reveals significant relationships among various socio-economic indicators. Significantly, Trade Intensity exhibits a positive correlation with Financial Development and Educational Attainment, suggesting that countries with higher trade intensity tend to have more developed financial sectors and educational systems.

Table 2. Descriptive statistics of panel data between 2008 and 2023

Variable	Mean	Std. dev	Minimum	Maximum
Trade intensity	3.82	0.896	0.993	5.463
Financial development	0.209	0.269	0	1
Life expectancy index	0.331	0.132	0.108	1
Education index	0.198	0.079	0.065	1
GNI per capita Index	0.132	0.053	0.044	1
Agricultural growth	21.523	14.547	0.893	71.763
FDI	2.924	7.149	−28.624	161.824
Inflation rate	36.688	65.078	−17.64	233.13
Government Exp	13.024	7.619	0.911	51.975
Population growth	2.605	1.207	−16.881	16.625
Exchange rate	1.758	1.245	−3.561	10.93

Source(s): Authors' construct (2025)

Table 3. Correlation analysis

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	1.000										
(2)	−0.231*	1.000									
	(0.000)										
(3)	−0.113*	0.145*	1.000								
	(0.000)	(0.000)									
(4)	−0.068*	0.086*	0.051*	1.000							
	(0.000)	(0.000)	(0.000)								
(5)	−0.045*	0.058*	0.023*	0.041*	1.000						
	(0.000)	(0.000)	(0.000)	(0.000)							
(6)	0.020	−0.329*	−0.076*	0.045*	0.028*	1.000					
	(0.412)	(0.000)	(0.000)	(0.000)	(0.000)						
(7)	−0.013	−0.022	−0.056*	0.017	0.028	−0.142*	1.000				
	(0.609)	(0.383)	(0.024)	(0.056)	(0.865)	(0.000)					
(8)	−0.067*	0.008	−0.021	0.015	0.011	0.039	−0.010	1.000			
	(0.007)	(0.759)	(0.389)	(0.746)	(0.635)	(0.118)	(0.681)				
(9)	0.524*	0.002	−0.037	0.018	0.033	−0.120*	0.009	−0.063*	1.000		
	(0.000)	(0.938)	(0.136)	(0.278)	(0.179)	(0.000)	(0.717)	(0.011)			
(10)	−0.156*	−0.128*	−0.080*	0.078*	0.064*	0.071*	0.048	0.053*	−0.125*	1.000	
	(0.000)	(0.000)	(0.001)	(0.001)	(0.007)	(0.004)	(0.054)	(0.033)	(0.000)		
(11)	0.159*	−0.194*	−0.307*	0.154*	0.246*	0.116*	0.017	0.139*	−0.007	0.106*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.480)	(0.000)	(0.788)	(0.000)	

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$,
(1) Trade Intensity, (2) Financial development, (3) Life Expectancy, (4) Educational attainment, (5) GNI per capita, (6) Agricultural Growth, (7) Foreign Direct Investments, (8) Inflation rate, (9) Government Expenditure, (10) Population growth, (11) Exchange rate

Source(s): Authors' construct (2025)

Conversely, Trade Intensity demonstrates a negative correlation with Life Expectancy and Government Expenditure, indicating a potential trade-off between economic openness and public health expenditure. Moreover, a significant negative correlation is observed between Trade Intensity and Exchange Rate, implying that countries with higher trade intensity tend to have more stable exchange rates.

More so, GNI per capita demonstrates a positive correlation with Trade Intensity, meaning that countries with higher trade intensity tend to have higher Gross National Income per capita. Population Growth is positively correlated with Trade Intensity, indicating that nations with higher trade intensity tend to experience faster population growth. Lastly, the inflation rate shows a negative correlation with Trade Intensity, suggesting that countries with higher trade intensity tend to have lower inflation rates, due to increased competition and efficiency in the market. These relationships highlight the dynamic nature of trade dynamics within the socio-economic environment of Sub-Saharan Africa.

The diagnostic tests conducted on Models 1, 2 and 3 exhibit promising results as revealed in Table 1A [2], indicating the robustness of the regression analysis. The heteroskedasticity tests, normality tests, autocorrelation tests, and misspecification tests all yielded non-significant results, affirming the validity of the model's assumptions. Furthermore, the absence of multicollinearity, as indicated by the VIF test, and the lack of endogeneity in the independent variables reinforce the reliability of the coefficient estimates. These findings imply that all the models provide trustworthy interpretations of the coefficients, thus facilitating credible further analysis, particularly in the context of Sub-Saharan Africa.

4.3 Empirical results

4.3.1 The complementary impact of human development and financial development on international trade. The empirical analysis in Table 4 reveals the relationship between financial development and international trade in Sub-Saharan Africa, highlighting both direct and interaction effects across key dimensions of human development.

Across baseline models (Models 1–3), financial development exhibits a consistently positive and significant effect on trade. Specifically, coefficients range from 0.158 to 0.190, revealing the foundational role of financial systems in facilitating trade by reducing transaction costs, increasing credit availability, and enhancing institutional trust. These findings align with existing literature that emphasises finance as a lubricant for trade flows in developing economies (Bardi and Ayouni, 2016; Eltejaei *et al*., 2023).

Crucially, Models 4–6 introduce interaction terms, revealing the conditional nature of financial development's impact. When financial development is moderated by the Life Expectancy Index (Model 4), the interactive coefficient is 0.674, suggesting that healthier populations amplify the trade-enhancing effect of financial systems. The total effect in this model is 0.874, indicating that improvements in human capital magnify financial systems' contribution to trade. This supports the premise that robust health infrastructures strengthen productivity and reliability in economic transactions (Huang *et al*., 2023).

Similarly, Model 5 reports an interaction effect of 0.761 between financial development and the Education Index, resulting in a total effect of 1.0105. This reveals the synergistic potential of education and finance; thus, educated agents more effectively leverage financial instruments, facilitating more complex trade activities.

In Model 6, the interaction between financial development and GNI per capita is 0.5108, yielding a total effect of 0.6278. This suggests that higher income levels reinforce financial systems' trade-enhancing roles, likely due to increased demand for financial services and tradeable goods (Allub *et al*., 2024).

The control variables offer critical insights into the structural forces shaping trade dynamics in Sub-Saharan Africa. Agricultural growth consistently exerts a positive and significant influence across models, with coefficients peaking at 1.092, suggesting that a thriving agricultural sector, still the backbone of many economies in the region, substantially supports

Table 4. The complementary impact of human development and financial development on international trade

Variables	(1) Trade	(2) Trade	(3) Trade	(4) Trade	(5) Trade	(6) Trade
Lag -trade	4.177***	4.0862***	4.0420***	0.585**	0.658***	0.669***
	(1.990)	(1.994)	(1.869)	(0.200)	(0.212)	(0.264)
Financial development	0.1900***	0.189	0.158***	0.200***	0.2495**	0.117***
	(0.012)	(0.155)	(0.00983)	(0.0692)	(0.025)	(0.0432)
Life expectancy index	0.3217***					
	(0.104)					
Education index		0.266**				
		(0.126)				
GNI per capita index			0.2387**			
			(0.109)			
Life expectancy*Financial development				0.6740***		
				(0.113)		
Education*Financial development					0.761***	
					(0.215)	
GNI/Capita*Financial development						0.5108***
						(0.101)
Agric growth	0.3140***	0.2943***	1.092***	0.0589	0.266	0.256***
	(0.122)	(0.073)	(0.0176)	(0.196)	(0.349)	(0.0764)
FDI	0.1887***	0.1353***	0.173***	0.219**	0.407***	0.119***
	(0.0604)	(0.098)	(0.00820)	(0.0844)	(0.194)	(0.0435)
Inflation	−0.0960**	−0.00258	−0.498***	−0.104	0.369	−0.0624*
	(0.0356)	(0.137)	(0.00801)	(0.100)	(0.281)	(0.0347)
Gov't expenditure	0.0272***	0.338***	0.200***	0.190***	0.569***	0.0950***
	(0.0048)	(0.100)	(0.00322)	(0.0556)	(0.216)	(0.0326)
Population	0.192***	0.354***	0.0708***	0.119*	0.439***	0.147***
	(0.0354)	(0.104)	(0.00369)	(0.0570)	(0.100)	(0.0293)
Exchange rate	−0.0826	−0.390	−0.174***	−0.1350***	−0.167	−0.1666***
	(0.0601)	(0.493)	(0.00996)	(0.032)	(0.293)	(0.0569)
Total effect $\beta_1 + \beta_3$*Financial development*				0.8740***	1.0105***	0.6278***
				(0.1313)	(0.2165)	(0.1102)
Constant	1.385***	2.341**	1.7129***	2.790***	0.779	0.986***
	(0.796)	(0.695)	(0.0887)	(0.850)	(2.673)	(0.374)
AR1	0.001	0.007	0.002	0.005	0.004	0.000
AR2	0.829	0.619	0.656	0.711	0.508	0.738
Sargan test	0.313	0.365	0.309	0.294	0.311	0.324
Hansen's J Test	0.149	0.186	0.144	0.137	0.151	0.162
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	608	608	608	608	608	608
Number of countries	38	38	38	38	38	38

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The Dependent Variable: International trade. Standard errors are in parentheses ( )

Source(s): Authors' construct (2025)

trade. This aligns with the agrarian-driven trade patterns observed in SSA, where export baskets remain heavily dominated by primary commodities (Wang *et al.*, 2024).

Foreign Direct Investment (FDI) also contributes positively to trade performance, with coefficients between 0.119 and 0.407. This implies that FDI enhances trade by injecting capital, transferring technology, and integrating host economies into global value chains. The magnitude and consistency of this effect provide empirical backing for policy regimes favouring liberalised investment environments (Osei and Kim, 2020).

Inflation presents mixed outcomes but tends to suppress trade, particularly where the effect is most pronounced at −0.498. High inflation likely introduces uncertainty, distorts pricing mechanisms and erodes competitiveness in international markets. Government expenditure, uniformly positive and significant (up to 0.569), reflects the enabling role of public investment in infrastructure and trade facilitation (Song *et al.*, 2021; Taiwo, 2021).

Population growth, with strong coefficients such as 0.439, points to a scale effect; larger populations expand production capacity and domestic markets, both of which support trade expansion. Conversely, exchange rate fluctuations exhibit a generally negative effect, suggesting that volatility in currency valuation undermines trade by increasing transaction risks and deterring exporters. These findings highlight the importance of macroeconomic stability and structural investment for sustained trade growth in the region (Ahmed *et al.*, 2020).

The diagnostic tests confirm the robustness of the GMM estimations. AR(2) test *p*-values (0.508–0.829) indicate no second-order autocorrelation. Sargan and Hansen's J tests show valid instruments, with all *p*-values above 0.13, rejecting concerns of over-identification. Both country and time effects are included, controlling for unobserved heterogeneity and time-specific shocks. The balanced panel includes 608 observations across 38 Sub-Saharan African countries, ensuring reliable variation. Together, these diagnostics affirm model validity, instrument strength, and the credibility of the estimated relationships between financial development, trade, and interaction terms in the region, supporting robust empirical inferences and policy relevance.

The robustness of regression fits across variables is visualized in Appendix Figure A2, which supports the baseline results presented in Table 4, while Appendix Figure A4 displays country-level heterogeneity in regression fits, revealing notable cross-country variation.

4.3.2 The threshold level of human development that enables financial development to influence international trade. The result from Table 5 revealed that the threshold variable, denoted as "r," represents the critical level of human development expressed as the Life Expectancy Index, Education Index, and GNI per Capita Index, which triggers the impact of financial development on international trade significantly. The findings indicate that the threshold values are estimated to be 0.658, 0.911 and 0.846 [3] for the life expectancy index, education index, and GNI per capita index models, respectively and statistically significant at 1% level. Thus, in Model 1, international trade is expected to increase significantly after financial development exceeds the Life Expectancy Index threshold of 0.658. Similarly, in model 2, international trade is expected to improve if financial development surpasses the education Index threshold of 0.911. Moreover, in model 3, international trade is expected to improve if financial development surpasses the GNI per capita index threshold of 0.846. Also, below and above these threshold values are the lower and upper regimes, as shown in Table 5.

Table 5 revealed that in Model 1, below the life expectancy index threshold value of 0.658, financial development negatively affects international trade significantly, with a coefficient of −0.769. However, beyond the threshold, the coefficient becomes a positive value of 1.344, indicating a beneficial impact of financial development on trade. The negative coefficient below the threshold of the life expectancy index suggests that, implies that in SSA countries with lower life expectancies, the benefits of financial development may not be fully realized. This could be due to shorter workforce participation affecting consumer and investor behaviour, which in turn may limit the efficacy of financial services in promoting trade. However, the positive coefficient above this threshold indicates that when life expectancy is higher, indicative of better health and longer working lives, financial systems find a more robust environment to support trade activities. This finding, for instance, the study identifies a threshold life expectancy index of 0.658 (approximately 62.7 years), which aligns closely with threshold estimates reported by Yakubu *et al.* (2018), who found that trade-enhancing effects of financial development emerge only above a life expectancy of ∼60 years.

In Model 2, a similar pattern emerges; thus, below the education index threshold value of 0.911, financial development negatively influences trade significantly with a coefficient of

Table 5. The minimum threshold level of human development that enables financial development to influence international trade

DV: Trade	Model 1: Life expectancy index		Model 2: Education index		Model 3: GNI per Capita index	
	Lower regime	Upper regime	Lower regime	Upper regime	Lower regime	Upper regime
Lag trade	−0.252***	0.193***	−0.413***	1.218***	−0.185***	2.271***
	(0.065)	(0.074)	(0.130)	(0.164)	(0.0470)	(0.104)
Financial	−0.769***	1.344**	−0.851***	1.175***	−0.532***	1.221***
Dev	(0.224)	(0.171)	(0.294)	(0.557)	(0.152)	(0.247)
Agric	−0.391**	0.590***	−0.597***	0.664***	−0.481***	0.711***
growth	(0.053)	(0.115)	(0.185)	(0.243)	(0.035)	(0.141)
FDI	−0.063	0.087	0.053	−0.018	0.034**	0.935***
	(0.036)	(0.049)	(0.095)	(0.169)	(0.015)	(0.026)
Inflation	0.072	0.098	−0.049	−0.190*	−0.081***	−0.268***
	(0.0382)	(0.089)	(0.075)	(0.101)	(0.024)	(0.019)
Gov't.	0.066**	0.579***	−0.034	−0.433	0.057	0.388
expenditure	(0.035)	(0.157)	(0.237)	(0.397)	(0.106)	(0.416)
Population	−0.317	0.431*	−0.528	0.895	−0.367	0.756
	(0.308)	(0.251)	(0.805)	(0.721)	(0.311)	(0.533)
Exchange	0.101***	0.313***	0.209**	0.251**	0.369**	0.746***
rate	(0.054)	(0.063)	(0.103)	(0.107)	(0.041)	(0.253)
cons		−0.870**		0.781***		0.831**
		(0.248)		(0.339)		(0.364)
Threshold	*0.658***		*0.911***		*0.846***	
(r)	(0.028)		(0.001)		(0.011)	
Linearity test	*p-value = 0.001*		*p-value = 0.000*		*p-value = 0.007*	
No. of country	38		38		38	

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The Dependent Variable: International trade. Standard errors are in parentheses ( )

The linearity test is the Sup-Wald test, which checks for non-linearity by comparing the fit of the linear model with that of a threshold model across potential threshold values, allowing the identification of significant threshold points if present. With the Sup-Wild test $p < 0.05$ means that there is statistically significant evidence to reject the null hypothesis of linearity in favour of the alternative hypothesis that a threshold effect exists in the model

Source(s): Authors' construct (2025)

−0.851, while above the threshold, the effect becomes a positive value of 1.175, highlighting the importance of education in facilitating the positive impact of financial development on trade. This suggests that in SSA, where educational attainment is low, financial development may not translate effectively into trade benefits. This could be due to a lack of skilled labour capable of leveraging financial services to enhance trade capabilities or poor integration of financial practices within the business community. However, above the education threshold, the positive effect shows the catalytic role of education in enabling financial mechanisms to boost trade. The education index threshold of 0.911 (≈13.6 years of schooling) is higher than the levels used in general HDI studies but consistent with Gnangnon (2021), who reports stronger finance-development-trade linkages in countries with secondary and tertiary education coverage above 70%.

Similarly, in Model 3, below the GNI per capita index threshold value of 0.846, financial development has a significantly negative effect on trade with a coefficient of −0.532, while above the threshold, the effect becomes strongly positive with a value of 1.221, revealing the role of income level in enhancing the positive influence of financial development on international trade. The negative effect indicates that poorer economic conditions in most SSA countries hinder the positive impacts of financial development on trade. Thus, financial development in

lower-income countries might initially exacerbate trade deficits or lead to ineffective trade practices. However, the strong positive effect above this threshold indicates that at higher income levels, economies are better equipped to harness the benefits of financial development for expanding international trade. This finding is consistent with Fatima *et al*. (2020).

The findings regarding the upper-regime coefficient of 1.344 on financial development are larger than the average range (0.6–0.9) reported in static SSA models (e.g. Chigeto *et al*., 2024; Tsaurai, 2018), suggesting that once human development thresholds are surpassed, the impact of finance on trade becomes significantly amplified. These reinforce the value of modelling nonlinear, regime-dependent effects and underscore the importance of human development as a binding constraint in the finance–trade nexus across SSA.

For the controlled variables, in the life expectancy index model, below the threshold of 0.658, agricultural growth negatively influences trade significantly with a coefficient of −0.391, suggesting that in countries with lower life expectancy, agricultural growth impedes international trade. Thus, beyond the threshold, the agricultural growth effect becomes positive with a coefficient of 0.590, indicating that higher life expectancy fosters a beneficial impact of agricultural growth on trade. This inverted relationship may reflect subsistence-oriented agriculture in low life expectancy contexts, where poor health systems and limited infrastructure restrict market integration (Ahmed *et al*., 2020). In contrast, higher life expectancy correlates with better productivity, food safety, and logistics, enabling agricultural output to transition toward commercial and export-ready activity (Clarke and Gholamshahi, 2017).

Also, regarding the exchange rate, below the threshold, its effect on trade is positive and significant, with a coefficient of 0.101, suggesting that in countries with lower life expectancy, a weaker exchange rate enhances international trade. Thus, beyond the threshold, the exchange rate effect remains positive with a coefficient of 0.313, highlighting the importance of a favourable exchange rate in promoting trade, especially in countries with higher life expectancy. This finding is consistent with Eltejaei *et al*. (2023).

Moreover, in the education Index model, similar patterns emerge for both agricultural growth and exchange rate. Thus, below the threshold of 0.911, agricultural growth negatively affects trade with a coefficient of −0.597, while the exchange rate positively affects trade by 0.209; however, above the threshold, the effects of both variables become positive with a coefficient of 0.664 for agricultural growth and 0.251 for the exchange rate. This emphasizes the role of education in facilitating the positive impacts of agricultural growth and exchange rates on international trade. This finding is consistent with Jayne and Sanchez (2021).

Moreover, below the GNI per Capita Index threshold, agricultural growth and inflation rate significantly hinder international trade below the threshold of 0.846 with coefficients of −0.481 and −0.081, respectively. However, beyond the threshold, the agricultural growth impact becomes strongly positive (0.711), indicating its facilitation of trade with higher income levels. At lower income levels, agriculture may be constrained by weak market access, poor capital investment, and low technological intensity, limiting its tradability. Once the GNI threshold is crossed, rising incomes likely facilitate agricultural modernization, value addition, and participation in regional and global trade networks, reversing the negative trade effect (Okolo *et al*., 2024). However, the inflation rate remains negative and significant with a coefficient of −0.268, hindering trade in countries with higher income levels.

Furthermore, from the GNI per capita model below the threshold of 0.846, FDI and exchange rate had a positive significant impact on trade with coefficients of 0.034 and 0.369, respectively. However, above the threshold values, these variables remain positive and significant with coefficients of 0.935 and 0.746, respectively. This means that FDI and exchange rate stability are essential in promoting trade within countries with high-income levels. This finding is consistent with Erenstein *et al*. (2022) and Fatima *et al*. (2020).

Finally, Table 5, lag trade, which represents lagged values of international trade in model 1, model 2 and model 3, respectively, display uniform patterns of coefficients across both models and regimes. In model 1, when the life expectancy index exceeds the threshold of 0.658, it would trigger the past performance of international trade to improve current trade intensity by

0.193. However, below the threshold past performance of trade will induce trade intensity to reduce by 0.252.

Similarly, in model 2, when the education index exceeds the threshold of 0.911, it would trigger the past performance of international trade to improve current trade intensity by 1.218. However, below the threshold education index will induce trade volume to reduce by 0.413. Moreover, in model 3, when the GNI per capita index exceeds the threshold of 0.846, it would trigger the past performance of trade to improve current trade intensity by 2.27. However, below the threshold will induce trade to reduce by 0.185.

The linearity tests conducted on the life expectancy index, education index, and GNI per capita index models reveal significant findings with *p*-values of 0.001, 0.000 and 0.007, respectively. The result for these models indicates a strong rejection of linearity, suggesting a non-linear relationship between international trade and its related variables. Appendix Figure A3 illustrates marginal effects of trade on human development dimensions, highlighting non-linearities not fully captured in Table 4.

4.4 Sensitivity analysis – Wang (2015) fixed effect panel threshold

The fixed effect panel threshold model by Wang (2015) in Table 6 was used to compare the results against the Seo *et al*. (2019) dynamic panel threshold regression estimation technique in Table 5. The estimation of the fixed effect model was simply for robustness purposes only and not as one of the main methods of data analysis. In Table 6, the estimated coefficient of $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ are the lower and upper regimes where the human development indicators impact the finance-trade relationship.

The results of the robustness analysis in Table 6 confirm the findings of the dynamic panel threshold regression approach in Table 5. In model 1, when the life expectancy index exceeds or is equal to the threshold of 0.301, it is likely to trigger a positive impact of financial development on international trade above the threshold level, with a negative impact below the life expectancy index threshold level. Similarly, in model 2, when the education index exceeds or is equal to the threshold of 0.421, it is likely to trigger a positive impact of financial

Table 6. Sensitivity analysis – Wang (2015) fixed effect panel threshold

DV: Trade Thresh Est	Model 1: Life expectancy index 0.301 C.I. [-0.439 0.483]	Model 2: Education index 0.421 C.I. [-0.416 0.457]	Model 3: GNI per Capita index 0.311 C.I. [-0.424 0.493]
β_1 – *Financial Development*	−0.029*** (0.011)	−0.044*** (0.017)	−0.032*** (0.010)
β_2 – *Financial Development*	0.032*** (0.014)	0.042*** (0.014)	0.036*** (0.013)
Lag – trade	0.735*** (0.012)	0.949*** (0.007)	0.891*** (0.009)
Agric growth	0.131*** (0.016)	−0.016 (0.012)	−0.024 (0.015)
FDI	0.053 (0.071)	0.022*** (0.005)	0.025*** (0.006)
Inflation rate	0.015* (0.008)	0.017 (0.061)	−0.078 (0.070)
Gov't. expenditure	0.216*** (0.017)	0.019 (0.014)	0.052** (0.017)
Population growth	−0.056** (0.025)	0.056*** (0.018)	0.086*** (0.021)
Exchange rate	0.019** (0.005)	0.014*** (0.003)	0.021*** (0.004)
cons	0.293*** (0.0227)	0.144*** (0.0255)	0.293*** (0.0227)
Observations	608	608	608
R-squared	0.837	0.936	0.775
No. of country	38	38	38

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The dependent variable is international trade. Standard errors are in parentheses ( )

β_1 and β_2 are the lower regime and upper regimes representing the coefficients of the explanatory variable (Financial development) on either side of the threshold

Source(s): Authors' construct (2025)

development on international trade above the threshold level, with a negative impact below the education indicator threshold level. Moreover, in model 3, when the GNI per capita index exceeds or is equal to the threshold of 0.311, it is likely to trigger a positive impact of financial development on international trade above the threshold level, with a negative impact below the GNI per capita threshold level. These findings further emphasize the threshold impact of the human indicators to trigger financial development impact on international trade in sub-Saharan Africa and are consistent with Tariq *et al*. (2023), who conducted a similar study and confirmed that human development reinvigorates the relationship between financial development and growth.

The R-squared values provided in Table 6 represent the coefficient of determination, indicating the proportion of the variance in the dependent variable that is explained by the independent variables in each model. Models 1, 2 and 3, with a reported R-squared value of 0.837, 0.936 and 0.775, suggest that approximately 83.7%, 93.6% and 77.5% of the variability in trade can be explained by the independent variables included in the respective models. This indicates an elevated level of explanatory power, implying that the chosen independent variables collectively account for a significant portion of the variation observed in international trade across the various models.

4.4.1 Testing for reverse causality between trade and human development dimensions. For clarity on potential concerns regarding reverse causality, the study examine whether trade intensity might itself influence the three dimensions of human development, thus life expectancy, education, and GNI per capita, in addition to being influenced by them. While the dynamic panel GMM approach mitigates endogeneity concerns using lagged internal instruments, it does not explicitly test directionality. Therefore, the study utilised the -Dumitrescu and Hurlin (2012) panel Granger causality test as a robustness check. The panel test is conducted using one-year lags for each pair of variables, and the results are summarized in Table A2.

The results indicate that while financial development and human development dimensions significantly Granger-cause trade openness as theorized there is also evidence of reverse causality from trade to all three human development components. Specifically, higher trade openness appears to predict improvements in life expectancy, education outcomes, and income levels across several countries in the panel. This supports the idea of bidirectional feedback loops, where development and trade reinforce one another over time. As such, the model's dynamic specification is justified, and policy implications should consider sequenced, reciprocal strategies promoting human development as a precondition for trade expansion and leveraging trade gains to sustain social investments.

5. Conclusion and recommendations

This study contributes to the discourse on trade and development by empirically establishing that human capital operates as a threshold determinant in the relationship between financial development and international trade in Sub-Saharan Africa (SSA). Also, using dynamic panel threshold modelling across 38 SSA countries from 2008 to 2023, the study identifies threshold points in life expectancy 0.658 approximately 62.7 years, average years of schooling 0.911 approximately 13.6 years, and gross national income (GNI) per capita 0.846 approximately $63,450, below which financial development exerts a neutral or even adverse effect on trade. However, once these minimum thresholds are surpassed, financial development begins to play a catalytic role in enabling trade expansion. This finding extends traditional trade theory by positioning human development not merely as a factor of production but as a necessary precondition for activating the developmental potential of financial systems.

The policy implications are profound because SSA economies must move beyond treating human development and financial development as parallel strategies and instead pursue integrated development planning. National governments should prioritize targeted investments in health, education, and income-enhancing programs, particularly for marginalized and rural populations, to ensure that basic human development thresholds are met.

Importantly, the findings implied that merely expanding access to primary education may be insufficient for surpassing the trade-relevant education threshold of approximately 13.6 years; rather, investments in secondary and especially tertiary education appear critical for activating the trade-enhancing role of finance. This aligns with evidence from recent export-driven human capital strategies in Asia and Latin America. Future extensions of this research could simulate the impact of historical school expansion policies such as Universal Primary Education (UPE) or conditional cash transfer programs as exogenous shocks to the education index. These simulations would offer insight into how structural human capital investments can shift countries toward the identified threshold and unlock the trade potential of financial development.

Simultaneously, financial sector reforms must be aligned with human capital objectives by directing credit toward education-intensive industries, healthcare infrastructure, and SMEs engaged in value-added export activities. Financial inclusion policies should be designed to support productive capacity development, not merely consumption.

To guide policymakers more concretely, the study translated the identified threshold values into real-world metrics. For instance, achieving the average schooling threshold of 13.6 years would require sustained investment in secondary and tertiary education systems. For countries currently at an average of 8 years of schooling, bridging the 5.6-year gap would imply annual education spending increases of approximately 2.9% of GDP over a 10-year horizon, assuming standard cost-per-student metrics. Similarly, reaching the GNI per capita threshold (~$63,450) from a regional median of $5,000 would require sustained income growth of 9–10% annually over 2 decades, a feat unlikely without transformative productivity reforms.

Given such constraints, policymakers must strategically balance marginal investments in financial reform versus human capital development. The back-of-the-envelope calculation confirms [4] that for a typical SSA country currently below the education threshold, an annual investment of roughly 2.9% of GDP in education over a decade could enable surpassing the threshold value (~13.6 years). Once crossed, financial development begins to yield trade gains of up to 5.7%, translating into approximately $2.85 billion in additional trade annually, highlighting the outsized returns to coordinated, threshold-sensitive investment strategies.

Furthermore, regional institutions such as ECOWAS, SADC, and the African Union should play a stronger coordinating role in benchmarking progress toward threshold attainment, facilitating knowledge-sharing platforms, and designing cross-border financial instruments that support human capital investments. Regional integration efforts under the AfCFTA also offer a timely opportunity to align financial and human development with trade policy frameworks.

Finally, the study acknowledges that its reliance on an extended Heckscher-Ohlin framework and secondary macroeconomic data may omit micro-level dynamics. Therefore, future research should incorporate firm-level and sectoral dynamics, institutional quality indicators, and digital finance adoption to offer a more granular understanding of how human development and finance co-evolve to shape trade patterns in Africa's development.

Notes

1. For easier real-world inference the values were transformed into its raw units such as years or dollars I rendering conclusions.
2. See Appendix A for Table 1A – Diagnostics Test Results.
3. See Table A3 for the Conversion of Human Development Index Thresholds to Raw Units (Years/USD)
4. Refer to Appendix B

Supplementary material

The supplementary material for this article can be found online

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