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Digital Payment Systems and Economic Development in Nigeria

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Abstract

This paper assesses how digital payment channels relate to Nigeria's level of human development. In particular, it looks at how Point of Sale (POS) transactions, Web Payment (WP), and Mobile Payment (MP) each relate to the Human Development Index (HDI). The analysis draws on annual data for 2010–2024, sourced from Central Bank of Nigeria (CBN) statistical bulletins and Human Development Reports published by the United Nations Development Programme (UNDP). An ex-post facto design guided the study, and the Autoregressive Distributed Lag (ARDL) approach was used to estimate the relationships. Before estimation, descriptive statistics and an Augmented Dickey-Fuller (ADF) unit root test were run; the latter showed the variables were integrated of mixed order. A Johansen co-integration test pointed to a long-run relationship among the series, but the ARDL bounds test did not support this, finding no significant long-run equilibrium. Estimation results show that POS and web payments carry negative, statistically insignificant coefficients with respect to HDI, whereas mobile payments show a modest positive association. Overall, the evidence does not support a strong or dependable link between digital payment adoption and human development in Nigeria over the study period. The paper recommends stronger investment in digital infrastructure, broader financial inclusion, and improved cybersecurity to help digital payment systems deliver more developmental benefit.

Key words: digital payment channels, human development, Point of Sale (POS), transactions, Web Payment (WP), and Mobile Payment (MP).

Introduction

Banking systems across developing economies have been moving steadily away from conventional brick-and-mortar structures toward financial technology (fintech) platforms (Adeniji, 2025; Afaha, 2019). Adebisi, Zannu and Dada (2023) note that in Nigeria this movement has largely been propelled by the Central Bank of Nigeria's (CBN) cashless policy, which was

designed to curb reliance on physical cash, close transaction leakages, and cut operating costs. Early policy attention centered mainly on macroeconomic indicators such as financial inclusion and Gross Domestic Product (GDP) growth, but current economic thinking increasingly calls for indicators centered on human wellbeing. Because macroeconomic progress cannot realistically be separated from human welfare, understanding how digital financial tools feed into human capabilities — captured here through the Human Development Index (HDI) — is an issue of ongoing importance to both researchers and policymakers.

The explosive trajectory of alternative banking channels in Nigeria became profoundly visible following the historic 2023 currency demonetization and Naira crunch. Faced with an immediate scarcity of physical fiat notes, the consumer base rapidly migrated toward digital alternative networks (Adeniji, 2025). According to Chukwu, Chika and Anaike(2024), this has spurred a rise in establishment of fintech companies, with services such as online payments, mobile banking and digital lending. Oloyede and Lawal (2018) further affirmed that the early 2000s witnessed the emergence of fintech with the introduction of mobile money services which marked significant milestone.

Despite this exponential growth in transactional value, the exact relationship between digital payments and human welfare metrics introduces conflicting perspectives. Proponents of the Technology Acceptance Model (TAM) argue that digital alternative systems foster decentralized economic opportunities, allow marginalized households to save safely, and smooth consumption patterns, thereby driving the income and standard-of-living dimensions of the HDI. Conversely, critical financialization literature warns of a "digital illusion". High transactional failure rates (reaching up to 40% during peak infrastructure overloads), aggressive digital fraud, and a stark urban-rural digital divide threaten to trap low-income consumers in unstable informal financial traps. This dynamic can actively aggravate structural inequalities and impair long-term human asset accumulation.

Existing empirical work offers no consistent picture of how these individual payment channels connect to human development. Nwadike and Osuala (2023), for example, found that certain categories of electronic payments do influence development outcomes across Sub-Saharan Africa, although structural weaknesses produce noticeable regional variation. Within Nigeria specifically, Chukwu, Chika and Anaike (2024) reported that financial technology as a whole had no statistically meaningful effect on the country's HDI, attributing this to inadequate infrastructure and low digital literacy in rural areas. The picture becomes even more fragmented at the channel level: some studies report a positive but statistically weak link between mobile payments and welfare, while others find that web-based payment platforms are negatively associated with broader development outcomes, a pattern linked to elite capture and high transaction costs.

This fragmented empirical landscape underscores a substantial research gap. Much of the prevailing Nigerian fintech literature heavily prioritizes traditional macroeconomic aggregates, such as commercial bank profitability or gross national outputs, completely omitting direct linkages to welfare indicators like the HDI. Given that Nigeria historically exhibits a lower tier on the global human development scale despite its booming digital transaction values, a precise, channel-disaggregated inquiry is deeply necessary. This study directly addresses this gap by separating digital financial services into its primary interactive avenues to observe how micro-level payment innovations map onto macro-level human capabilities.

Objectives of the Study

In light of the above, this study sets out to:

1. Assess how Point of Sale (POS) transactions relate to Nigeria's Human Development Index (HDI).
2. Evaluate the relationship between Web Pay (WP) transactions and HDI in Nigeria.
3. Establish the extent to which Mobile Pay (MP) transactions relate to HDI in Nigeria.

Research Questions

The following questions guide this study:

(i) What effect does point of sale (POS) have on HDI?
(ii) What is the effect of web pay (WP) onHDI?
(iii) To what extent has mobile pay (MP) on HDI?

Significance

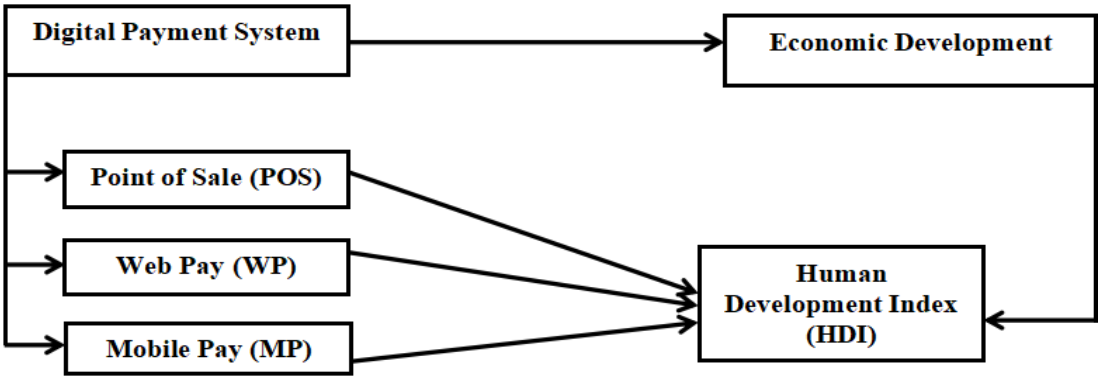
The benefits derivable from this study are discussed in line with the different users that will gain from it.

1. **For the Government and Policymakers:** The findings offer evidence that can inform the design of financial and monetary policies geared toward wider adoption of digital payments.
2. **For Financial Institutions and Fintech Companies:** They stand to gain a clearer picture of how digital payment systems shape economic activity and customer behaviour.
3. **For Businesses and Entrepreneurs (SMEs):** They may draw on the study's findings to better understand how digital payment adoption can lower transaction costs, streamline operations, and support higher sales.
4. **For Academics and Researchers:**The study adds current empirical evidence on the link between digital payment systems and economic development in Nigeria, offering a reference point for further scholarly work.

Conceptual Framework

The conceptual framework guiding this study is illustrated in Figure 2.1 below.

Fig 2.1: Operational Conceptual Framework



Source: Researcher's Conceptualization (2026)

Concept of Digital Payment Systems

Digital payment systems can be described as electronic means through which individuals and businesses settle financial transactions without physically handling cash (Adeniji, 2025). They operate through

channels such as mobile apps, internet banking, and point-of-sale terminals, all of which enable funds to move between payer and recipient. Adebisi, Zannu and Dada (2023) view digital payment systems as a core element of Nigeria's cashless economy agenda, one intended to boost efficiency, transparency, and financial inclusion. Mamudu (2021) similarly regards digital payments as a major driver of financial innovation, noting their role in lowering transaction costs and making financial exchange faster and more convenient.

Within Nigeria, the digital payment landscape has developed through several electronic channels — POS terminals, mobile banking, internet banking, and web-based platforms among them (Olubukola, Ikpefan, Akinrinola&Itai, 2023). These channels give users the ability to transact in real time, lessening the need to rely on cash. Adoption has also been helped along by the growth of fintech firms and regulatory backing from the Central Bank of Nigeria, spreading uptake across both urban and rural areas (Bawa&Abdullahi, 2025). That said, obstacles such as unreliable internet access, cybersecurity concerns, and limited digital literacy continue to slow full adoption.

Components of Digital Payment Systems

Digital payment systems consist of several key components that facilitate electronic transactions. These include Point of Sale (POS) systems, Web Payment (WP) platforms, and Mobile Payment (MP) systems, which are central to this study.

Point of Sale (POS):these are card-reading devices merchants use to receive payment for goods and services (Daasi, 2023). They are widely used in retail environments and have significantly increased access to formal financial services in Nigeria.

Web Payment (WP):they enable online transactions through secure internet platforms, allowing consumers to pay for goods and services via websites or online banking portals (Mamudu, 2021). Although they support digital literacy and also reduce the time it takes to process transaction, they can be limited by internet availability (Okonkwo&Uzochukwu, 2026).

Mobile Payment (MP):this involves initiating and completing transactions through mobile devices, whether via banking apps or USSD codes (Mamudu, 2021). It has proven especially valuable for extending financial inclusion to underserved populations (Iwedi, 2024).

Concept of Economic Development

Economic development, broadly defined, is the ongoing improvement of a population's economic, social, and institutional wellbeing (Chukwu, Chika &Anaike, 2024). It differs from economic growth which is largely concerned with rising output, such as GDP in that it also captures gains in living standards, education, and health.

For the purposes of this study, economic development is proxied by the Human Development Index (HDI), a composite measure produced by the United Nations Development Programme (UNDP) that combines life expectancy, educational attainment, and income per capita. The UNDP designed HDI specifically to move the development conversation beyond narrow economic indicators toward outcomes centered on people.

Theoretical Framework

This study is anchored on the Technology Acceptance Model, first developed by Davis (1989), which offers a useful lens for understanding technology adoption behaviour. The model holds that two cognitive factors chiefly determine whether a technology is adopted and used: Perceived Usefulness (PU), which is how much a user believes the technology will improve their productivity or wellbeing;

and Perceived Ease of Use (PEOU) which illustrates how effortless the user judges the technology to be. Applied here, the model helps explain how the move from cash to digital payment channels could shape Nigeria's HDI. Where digital payment tools are seen as both useful and easy to use, they reduce transaction costs, cut down on financial friction, and save individuals the time and expense of travelling to conduct transactions. This freed-up income and efficiency can, in turn, expand opportunities for micro-entrepreneurship. As daily financial activity becomes smoother, people are better positioned to channel resources into education, healthcare, and an improved standard of living which are the very components that make up HDI.

Empirical Review

Adeniji (2025) investigated the link between digital payment systems and Nigeria's economic growth over the 2012–2024 period, drawing on secondary time-series data from the CBN and World Bank and applying an ex-post facto design together with an ARDL model to capture short- and long-run effects. Variables considered included POS transactions, ATM usage, and mobile payments, and the study found that, overall, digital payment channels had a significant positive effect on real GDP — mobile payments contributing the largest share of that effect.

Using an ex-post facto design and annual data spanning 2009–2023, Rogers-Banigo and James (2025) examined how electronic payment channels relate to economic development in Nigeria, measuring development through per capita income and estimating the relationship with both OLS and ARDL techniques. Their results showed positive, though statistically insignificant, effects for ATM usage, mobile payments, and electronic transfers, whereas POS transactions had a negative effect in the short run.

Sulaiman, Adebayo and Osunkunle (2025) studied electronic financial services in relation to Nigeria's economic growth, drawing on CBN statistical bulletin data for 2010–2023 and applying an ex-post facto design alongside descriptive statistics, multiple regression, and post-estimation diagnostics. They found web-based online transactions to have a significant positive effect on GDP, POS transactions a positive but insignificant effect, and ATM usage a negative effect on GDP.

Olubukola, Ikpefan, Akinrinola and Itai (2023) looked at how digital financial services affect the Nigerian economy, using CBN statistical bulletin data and an OLS regression within an ex-post facto framework. Mobile banking, POS, and ATM transaction volumes all showed a positive relationship with GDP — ATM volume having the strongest effect — while web-based transaction volume was found to relate negatively to GDP.

Okoh, Olopade and Eseyin (2023) examined digital payments and economic growth in Nigeria across 2009–2020, using annual time-series data and the ARDL bounds testing approach to capture both short- and long-run relationships. Mobile payments emerged as having a statistically significant positive effect on growth, while ATM transactions had a comparatively weaker influence. They concluded that greater adoption of digital payment platforms tends to support productivity gains and sustained economic growth.

Working with cross-country panel data, Anirudh and Pavel (2022) applied panel regression analysis to explore the link between digital payment adoption and economic growth, finding a strong, statistically significant positive relationship across the developing economies in their sample.

Mamudu (2021) explored the effect of electronic banking payments on the Nigerian economy using the Phillips-Perron test, Johansen co-integration, Granger causality, and an error correction model. The results pointed to a significant positive effect on GDP from ATM payment value, web/internet transfer value, mobile payment value, and the national electronic funds transfer value.

Gap in Literature

Taken together, the studies reviewed above leave a clear gap. Most of the reviewed studies which includesAdeniji (2025), Sulaiman et al. (2025), Olubukola et al. (2023), Okoh et al. (2023), and Mamudu (2021) relied on GDP (for economic growth), while Rogers-Banigo and James (2025) used per capita income to measure economic development. This study departs from that pattern by adopting HDI, which captures welfare, education, and living-standard improvements that GDP alone does not. It also narrows in on POS, WP, and MP specifically, rather than the ATM- and transfer-heavy combinations used in earlier work. Linking these three channels directly to HDI is intended to give a fuller picture of how digital financial innovation contributes to sustainable economic development.

Research Design

This study follows an ex-post facto, quantitative longitudinal design to examine the relationship between digital payment systems and economic development in Nigeria, using annual data from 2010 to 2024 drawn from CBN statistical bulletins and UNDP annual reports. Data analysis combined descriptive and inferential techniques: descriptive statistics summarized the characteristics of each variable, an Augmented Dickey-Fuller (ADF) test checked for stationarity, and an Autoregressive Distributed Lag (ARDL) model was used for inferential estimation.

Model Specification

The econometric model used to capture this relationship is built within a multiple regression framework, structured to isolate the individual and combined effects of each payment channel on HDI.
The functional relationship is expressed as:

$HDI_t = f(POS_t, WP_t, MP_t)$

To transform this functional relationship, the mathematical model is formulated as follows:

$HDI_t = \beta_0 + \beta_1 POS_t + \beta_2 WP_t + \beta_3 MP_t + \mu$

By introducing the stochastic error term (μ) to account for other unobserved variables that may influence human development, the final structural econometric model is specified as:

$HDI_t = \beta_0 + \beta_1 POS_t + \beta_2 WP_t + \beta_3 MP_t + \mu$

Where:

HDI_t = Human Development Index at time t (Dependent variable)
POS_t = Value or volume of Point of Sale transactions at time t (Independent variable)
WP_t = Value or volume of Web Pay/Internet transactions at time t (Independent variable)
MP_t = Value or volume of Mobile Pay transactions at time t (Independent variable)
β_0 = Intercept/Constant parameter
$\beta_1\beta_2$, β_3, = coefficients of the respective independent variables
μ= Stochastic error term

A-Priori Expectation

The structural parameters are theoretically expected to exhibit the following signs based on economic theory and financial innovation frameworks:

$\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$

Interpretation: The coefficients β_1, β_2, and β_3 are each expected to carry a positive sign, implying that greater adoption and efficiency of POS, WP, and MP systems should translate into gains in human development.

Descriptive Statistics
Date: 06/10/26 Time: 12:46
Sample: 2010 2024

	LNPOS	LNWP	LNMP	HDI
Mean	7.308472	7.616329	7.482774	0.527400
Median	7.251210	5.218191	7.004882	0.530000
Maximum	12.31615	14.44714	12.88083	0.567000
Minimum	2.543176	3.220874	1.894617	0.482000
Std. Dev.	2.968480	4.480272	3.450502	0.022658
Skewness	0.117862	0.609161	0.058569	-0.111151
Kurtosis	2.039023	1.535405	1.917572	3.150132
Jarque-Bera	0.611902	2.268343	0.740857	0.044973
Probability	0.736423	0.321688	0.690438	0.977764
Sum	109.6271	114.2449	112.2416	7.911000
Sum Sq. Dev.	123.3662	281.0197	166.6835	0.007188
Observations	15	15	15	15

Source: E-Views Output (2026)

The descriptive statistics indicate that the average values of LNPOS, LNWP, LNMP, and HDI during the study period were 7.31, 7.62, 7.48, and 0.527 respectively. The standard deviation values show that LNWP exhibited the highest level of variability, while HDI was relatively stable over the period. The skewness values reveal that LNPOS, LNWP, and LNMP were slightly positively skewed, whereas HDI was slightly negatively skewed, indicating that all variables were approximately symmetric. Furthermore, the kurtosis values suggest that LNPOS, LNWP, and LNMP were platykurtic (flatter than normal distribution), while HDI was approximately mesokurtic. Because the Jarque-Bera probability for every variable exceeds 0.05, none of the series depart meaningfully from normality, supporting their use in the econometric analysis that follows.

Table 4.2 ADF Unit Root Test

VARIABLES	ADF t-Statistics	5% LEVEL	P-value	ORDER OF INTEGRATION
LnPOS	-4.198308	-3.828975	0.0285	I(1)
LnWP	-4.193508	-3.828975	0.0288	I(1)
LnMP	-4.988988	-3.933364	0.0119	I(0)
HDI	-3.871169	-3.119910	0.0138	I(1)

Source: See Appendix.

The ADF results show that every variable is stationary — each t-statistic is more negative than its 5% critical value, with a probability below 0.05. LnPOS, LnWP, and HDI only achieved stationarity after first differencing (I(1)), while LnMP was already stationary at level (I(0)). This mix of I(0) and I(1) variables is precisely the condition under which the ARDL approach is appropriate, which justifies its use here.

Co-integration Test

The Johansen co-integration test examines whether a long-run equilibrium relation exists among LnPOS, LnWP, LnMP, and HDI.

Table 4.3: Johansen Co-integration Test Result

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value 5%	Prob.**	Max-Eigen Statistic
None *	0.999358	122.8671	47.85613	0.0000	95.55844
At most 1	0.725826	27.30869	29.79707	0.0943	16.82192
At most 2	0.503848	10.48677	15.49471	0.2451	9.111343
At most 3	0.100397	1.375424	3.841466	0.2409	1.375424

Source: See Appendix

According to the Johansen test, the variables do share a long-run relationship: the trace statistic of 122.8671 for the 'None' hypothesis comfortably exceeds the 5% critical value of 47.85613 ($p = 0.0000$), so the null of no co-integration is rejected. This confirms at least one co-integrating equation linking LnPOS, LnWP, LnMP, and HDI, meaning the series tend to move together over the long run and settle into a stable equilibrium.

Table 4.4: ARDL Bounds Test

Test Statistic	Value
F-Stat	2.289793
5% F-Stat Upper Bound I(1)	3.67
5% F-Stat Lower Bound I(0)	2.79

Source: See Appendix

By contrast, the ARDL bounds test tells a different story: the computed F-statistic of 2.289793 falls below both the I(0) lower bound of 2.79 and the I(1) upper bound of 3.67 at the 5% level, placing it in the inconclusive/no-cointegration zone. In other words, this test does not find sufficient evidence of a long-run relationship among LnPOS, LnWP, LnMP, and HDI, suggesting that whatever relationship exists among these variables is confined to the short run.

Table 4.5: ARDL Long-run Test

	Coefficient
LnPOS	-0.024022
LnWP	-0.007598
LnMP	0.033991

Source: See Appendix.

The long-run ARDL coefficients reveal thatLnPOS carries a negative but statistically insignificant sign, hinting that POS transactions might even work slightly against development over the long run. LnWP is likewise negative and insignificant, suggesting web payments contribute little to long-run HDI. LnMP, on the other hand, is positive, pointing to a modest favourable effect from mobile payments. Given that the bounds test found no genuine co-integration, however, these long-run estimates should be read with caution rather than taken as evidence of a stable equilibrium relationship.

Table 4.6: Error Correction Model

	Value
CointEq(-1)*	45.14569
Prob.	0.0837

Source: See Appendix

The error correction term, CointEq(-1), comes out positive at 45.14569 with a p-value of 0.0837 — above the conventional 5% threshold — so it is not statistically significant. That weak, unreliable adjustment coefficient suggests that, in practice, deviations from equilibrium are not being corrected in any meaningful way within the short run, pointing to limited movement back toward long-run stability.

Table 4.7: Overall ARDL Model

	Coefficient	Prob.
HDI(-1)	9.266188	0.3521
HDI(-2)	36.87950	0.3566
LNPOS	-0.364943	0.3626
LNPOS(-1)	0.466178	0.3670
LNPOS(-2)	0.983265	0.3469
LNWP	-0.014081	0.3214
LNWP(-1)	0.220618	0.3560
LNWP(-2)	0.136470	0.3470
LNMP	0.078135	0.3770
LNMP(-1)	-0.783171	0.3606
LNMP(-2)	-0.829522	0.3479
C	-22.19699	0.3617

Source: See Appendix.

The overall ARDL results show that all the variables, including their lagged values, are statistically insignificant since their probability values are greater than 0.05. Specifically, current and lagged values of LNPOS, LNWP, and LNMP all exhibit mixed positive and negative coefficients, indicating unstable and inconsistent effects on HDI over time. The lagged dependent variables (HDI(-1) and HDI(-2)) are also positive but insignificant, suggesting weak persistence in HDI dynamics. When taken altogether, these results imply that digital payment variables have no statistically significant short-run effect on HDI in Nigeria over the period studied, and the model does not provide strong evidence of meaningful temporal influence.

Table 4.8: Diagnostic Tests Result

Statistic	Value
R-squared	0.971054
Adjusted R-squared	0.652644
F-statistic	3.049697
Prob(F-statistic)	0.421586
Durbin-Watson stat	2.648577

Source: See Appendix

The diagnostic results show a very high R-squared of 0.971054 which suggests that the model accounts for roughly 97% of the variations in HDI, but this drops considerably once adjusted for degrees of freedom (adjusted R-squared of 0.652644), pointing to a less robust fit than the headline figure implies. The F-statistic of 3.049697 (p= 0.421586)indicates that the overall model is not statistically significant. The Durbin-Watson statistic of 2.648577 points to the absence of serious positive autocorrelation, though it slightly indicates possible mild negative autocorrelation in the residuals.

Conclusion

Based on the findings of this study, it is concluded that digital payment systems exert mixed effects on economic development in Nigeria. The descriptive and stationarity results confirm that the variables are suitable for econometric analysis, while the co-integration test suggests a long-run relationship among the variables. However, the ARDL bounds test indicates no strong evidence of a stable long-run equilibrium among the variables. Specifically, POS and web payment systems show negative and insignificant long-run effects on Human Development Index (HDI), while mobile payments exhibit a weak positive influence. The error correction mechanism further reveals a weak and statistically insignificant adjustment speed toward long-run equilibrium, implying limited short-run correction of disequilibrium. Overall, while digital payment systems contribute in varying degrees to economic development, their impact on HDI in Nigeria is not strong or consistent, suggesting that other structural and institutional factors may be influencing development outcomes more significantly.

Recommendations

This study recommends that:

1. The Central Bank of Nigeria and financial institutions should improve POS infrastructure. This is especially necessary for rural and semi-urban areas as such improvement willensure stable network connectivity and reduce transaction failures that limit developmental impact.
2. Policymakers should strengthen cybersecurity frameworks and improve internet accessibility and affordability. This is important because weak trust in digital payment systems, and poor connectivity may reduce their developmental contribution to the country.at large
3. The government and fintech operators should further promote mobile payment adoption through financial inclusion policies, mobile literacy programmes, and reduced transaction costs to enhance its contribution to human development.

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Appendices

The data adopted include the following: point of sale (POS); web pay (WP); mobile pay (MP), and human development index (HDI).

Table 4.1: Variables of the Study

YEAR	POS(₦' B)	WP(₦' B)	MP(₦' B)	HDI
2010	12.72	25.05	6.65	0.482
2011	31.02	59.61	18.98	0.492
2012	48.01	31.57	31.51	0.511
2013	161.02	47.32	142.80	0.521
2014	312.07	74.04	346.47	0.525
2015	448.51	91.58	442.35	0.527
2016	759.00	132.36	756.90	0.530
2017	1,409.81	184.60	1,102.00	0.516
2018	2,383.11	675.92	1,974.25	0.531
2019	3,204.75	478.14	5,080.96	0.538
2020	4,727.08	392,340.25	14,987.74	0.535
2021	24,455.42	545,039.69	53,208.27	0.535
2022	41,035.80	783,660.03	111,122.11	0.534
2023	110,347.10	1,097,133.04	219,800.08	0.567
2024	223,272.82	1,880,678.76	392,711.93	0.567

Source: CBN Statistical Bulletin & World Development Indicators

POS Stationarity Test

Null Hypothesis: D(LNPOS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.198308	0.0285
Test critical values:	1% level	-4.886426	
	5% level	-3.828975	
	10% level	-3.362984	

*MacKinnon (1996) one-sided p-values.

Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 13

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNPOS,2)

Method: Least Squares

Date: 06/10/26 Time: 12:09

Sample (adjusted): 2012 2024

Included observations: 13 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPOS(-1))	-1.253899	0.298668	-4.198308	0.0018
C	0.701127	0.320965	2.184435	0.0538
@TREND("2010")	0.019897	0.029833	0.666944	0.5199

R-squared	0.638897	Mean dependent var	-0.014361
Adjusted R-squared	0.566677	S.D. dependent var	0.608492
S.E. of regression	0.400553	Akaike info criterion	1.207235
Sum squared resid	1.604431	Schwarz criterion	1.337608
Log likelihood	-4.847029	Hannan-Quinn criter.	1.180438
F-statistic	8.846483	Durbin-Watson stat	1.985302
Prob(F-statistic)	0.006140		

WP Stationarity Test

Null Hypothesis: D(LNWP) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.193508	0.0288
Test critical values:	1% level	-4.886426	
	5% level	-3.828975	
	10% level	-3.362984	

***MacKinnon (1996) one-sided p-values.**

Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 13

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNWP,2)

Method: Least Squares

Date: 06/10/26 Time: 12:13

Sample (adjusted): 2012 2024

Included observations: 13 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNWP(-1))	-1.279773	0.305180	-4.193508	0.0018
C	-0.043271	1.231478	-0.035137	0.9727
@TREND("2010")	0.133768	0.143439	0.932575	0.3730
R-squared	0.637530	Mean dependent var		-0.025232
Adjusted R-squared	0.565036	S.D. dependent var		2.851921
S.E. of regression	1.880894	Akaike info criterion		4.300545
Sum squared resid	35.37761	Schwarz criterion		4.430918
Log likelihood	-24.95354	Hannan-Quinn criter.		4.273748
F-statistic	8.794242	Durbin-Watson stat		1.959741
Prob(F-statistic)	0.006257			

MP Stationarity Test

Null Hypothesis: LNMP has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 3 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.988988	0.0119
Test critical values:	1% level	-5.124875	
	5% level	-3.933364	
	10% level	-3.420030	

***MacKinnon (1996) one-sided p-values.**

Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 11

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNMP)				
Method: Least Squares				
Date: 06/10/26 Time: 12:15				
Sample (adjusted): 2014 2024				
Included observations: 11 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNMP(-1)	-1.193155	0.239158	-4.988988	0.0041
D(LNMP(-1))	0.897859	0.148037	6.065117	0.0018
D(LNMP(-2))	0.462749	0.183983	2.515168	0.0535
D(LNMP(-3))	0.531589	0.173039	3.072080	0.0277
C	0.987723	0.201940	4.891174	0.0045
@TREND("2010")	0.898787	0.173445	5.181973	0.0035
R-squared	0.912017	Mean dependent var		0.719944
Adjusted R-squared	0.824034	S.D. dependent var		0.304424
S.E. of regression	0.127701	Akaike info criterion		-0.975801
Sum squared resid	0.081537	Schwarz criterion		-0.758768
Log likelihood	11.36691	Hannan-Quinn criter.		-1.112611
F-statistic	10.36580	Durbin-Watson stat		2.982058
Prob(F-statistic)	0.011318			

HDI Stationarity Test

Null Hypothesis: D(HDI) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=3)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.871169	0.0138
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	
***MacKinnon (1996) one-sided p-values.**			
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 13			
Augmented Dickey-Fuller Test Equation			
Dependent Variable: D(HDI,2)			
Method: Least Squares			
Date: 06/10/26 Time: 12:20			
Sample (adjusted): 2012 2024			
Included observations: 13 after adjustments			

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	-1.160541	0.299791	-3.871169	0.0026
C	0.006819	0.003863	1.764992	0.1053
R-squared	0.576694	Mean dependent var		-0.000769
Adjusted R-squared	0.538212	S.D. dependent var		0.017664
S.E. of regression	0.012004	Akaike info criterion		-5.866559
Sum squared resid	0.001585	Schwarz criterion		-5.779644
Log likelihood	40.13263	Hannan-Quinn criter.		-5.884424
F-statistic	14.98595	Durbin-Watson stat		1.980996
Prob(F-statistic)	0.002603			

JOHANSEN COINTEGRATION OUTPUT

Date: 06/10/26 Time: 12:48				
Sample (adjusted): 2012 2024				
Included observations: 13 after adjustments				
Trend assumption: Linear deterministic trend				
Series: LNPOS LNWP LNMP HDI				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.999358	122.8671	47.85613	0.0000
At most 1	0.725826	27.30869	29.79707	0.0943
At most 2	0.503848	10.48677	15.49471	0.2451
At most 3	0.100397	1.375424	3.841466	0.2409
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level				
*** denotes rejection of the hypothesis at the 0.05 level**				
****MacKinnon-Haug-Michelis (1999) p-values**				

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.999358	95.55844	27.58434	0.0000
At most 1	0.725826	16.82192	21.13162	0.1806
At most 2	0.503848	9.111343	14.26460	0.2770
At most 3	0.100397	1.375424	3.841466	0.2409

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level
*** denotes rejection of the hypothesis at the 0.05 level**
****MacKinnon-Haug-Michelis (1999) p-values**

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNPOS	LNWP	LNMP	HDI
-11.75932	-3.736767	16.69084	-495.2750
-2.574802	-0.063405	1.536090	133.1780
0.920377	0.495331	-1.954410	46.61292
-18.80183	-3.366479	22.39760	-516.7044

Unrestricted Adjustment Coefficients (alpha):

D(LNPOS)	-0.273170	-0.003043	0.034290	-0.011800
D(LNWP)	0.061161	0.203721	-0.814336	-0.207472
D(LNMP)	-0.126851	-0.057226	0.032215	-0.081602
D(HDI)	-0.002938	-0.008485	0.001107	0.000913

1 Cointegrating Equation(s): Log likelihood 66.46064

Normalized cointegrating coefficients (standard error in parentheses)

LNPOS	LNWP	LNMP	HDI
1.000000	0.317771	-1.419371	42.11766
	(0.00122)	(0.00240)	(0.21098)

Adjustment coefficients (standard error in parentheses)

D(LNPOS)	3.212293
	(0.27331)
D(LNWP)	-0.719206
	(5.96651)
D(LNMP)	1.491680
	(1.20010)
D(HDI)	0.034553
	(0.04660)

2 Cointegrating Equation(s): Log likelihood 74.87160

Normalized cointegrating coefficients (standard error in parentheses)

LNPOS	LNWP	LNMP	HDI
1.000000	0.000000	-0.527468	-59.60660
		(0.08400)	(14.9905)
0.000000	1.000000	-2.806751	320.1184
		(0.26435)	(47.1757)

Adjustment coefficients (standard error in parentheses)

D(LNPOS)	3.220128	1.020966
	(0.27944)	(0.08676)
D(LNWP)	-1.243746	-0.241460
	(6.03712)	(1.87429)
D(LNMP)	1.639024	0.477641
	(1.20063)	(0.37275)

D(HDI)	0.056399	0.011518	
	(0.02802)	(0.00870)	
3 Cointegrating Equation(s):		Log likelihood	79.42727
Normalized cointegrating coefficients (standard error in parentheses)			
LNPOS	LNWP	LNMP	HDI
1.000000	0.000000	0.000000	323.1881
			(169.870)
0.000000	1.000000	0.000000	2357.036
			(912.590)
0.000000	0.000000	1.000000	725.7209
			(323.854)
Adjustment coefficients (standard error in parentheses)			
D(LNPOS)	3.251688	1.037951	-4.631128
	(0.23251)	(0.07260)	(0.32499)
D(LNWP)	-1.993243	-0.644826	2.925301
	(4.78032)	(1.49273)	(6.68164)
D(LNMP)	1.668674	0.493597	-2.268112
	(1.19513)	(0.37320)	(1.67047)
D(HDI)	0.057418	0.012066	-0.064240
	(0.02765)	(0.00863)	(0.03864)

ARDL OUTPUT

Dependent Variable: HDI

Method: ARDL
Date: 06/10/26 Time: 12:54
Sample (adjusted): 2012 2024
Included observations: 13 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNPOS LNWP LNMP
Fixed regressors: C
Number of models evalulated: 54
Selected Model: ARDL(2, 2, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
HDI(-1)	9.266188	5.720432	1.619841	0.3521
HDI(-2)	36.87950	23.13083	1.594387	0.3566
LNPOS	-0.364943	0.233701	-1.561580	0.3626
LNPOS(-1)	0.466178	0.303108	1.537995	0.3670
LNPOS(-2)	0.983265	0.596082	1.649546	0.3469
LNWP	-0.014081	0.007782	-1.809388	0.3214
LNWP(-1)	0.220618	0.138088	1.597658	0.3560
LNWP(-2)	0.136470	0.082755	1.649086	0.3470
LNMP	0.078135	0.052559	1.486614	0.3770
LNMP(-1)	-0.783171	0.498111	-1.572284	0.3606
LNMP(-2)	-0.829522	0.504521	-1.644176	0.3479
C	-22.19699	14.17040	-1.566433	0.3617
R-squared	0.971054	Mean dependent var		0.533615
Adjusted R-squared	0.652644	S.D. dependent var		0.016761
S.E. of regression	0.009878	Akaike info criterion		-7.115753
Sum squared resid	9.76E-05	Schwarz criterion		-6.594261
Log likelihood	58.25239	Hannan-Quinn criter.		-7.222943
F-statistic	3.049697	Durbin-Watson stat		2.648577
Prob(F-statistic)	0.421586			

***Note: p-values and any subsequent tests do not account for model selection.**

ARDL LONG RUN & BOUNDS TEST

ARDL Long Run Form and Bounds Test

Dependent Variable: D(HDI)
Selected Model: ARDL(2, 2, 2, 2)
Case 2: Restricted Constant and No Trend
Date: 06/10/26 Time: 12:57
Sample: 2010 2024
Included observations: 13

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-22.19699	14.17040	-1.566433	0.3617
HDI(-1)*	45.14569	28.84120	1.565319	0.3619
LNPOS(-1)	1.084500	0.665833	1.628788	0.3505
LNWP(-1)	0.343006	0.213680	1.605231	0.3547

LNMP(-1)	-1.534558	0.951694	-1.612449	0.3534
D(HDI(-1))	-36.87950	23.13083	-1.594387	0.3566
D(LNPOS)	-0.364943	0.233701	-1.561580	0.3626
D(LNPOS(-1))	-0.983265	0.596082	-1.649546	0.3469
D(LNWP)	-0.014081	0.007782	-1.809388	0.3214
D(LNWP(-1))	-0.136470	0.082755	-1.649086	0.3470
D(LNMP)	0.078135	0.052559	1.486614	0.3770
D(LNMP(-1))	0.829522	0.504521	1.644176	0.3479

*** p-value incompatible with t-Bounds distribution.**

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPOS	-0.024022	0.000851	-28.21385	0.0226
LNWP	-0.007598	0.000145	-52.55478	0.0121
LNMP	0.033991	0.000842	40.34960	0.0158
C	0.491675	0.000807	609.1078	0.0010

EC = HDI - (-0.0240*LNPOS -0.0076*LNWP + 0.0340*LNMP + 0.4917)

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	2.289793	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	13		Finite Sample: n=35	
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816
			Finite Sample: n=30	
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

ARDL ERROR CORRECTION

ARDL Error Correction Regression
Dependent Variable: D(HDI)
Selected Model: ARDL(2, 2, 2, 2)
Case 2: Restricted Constant and No Trend
Date: 06/10/26 Time: 12:58
Sample: 2010 2024
Included observations: 13
ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	-36.87950	4.832144	-7.632119	0.0829
D(LNPOS)	-0.364943	0.049560	-7.363649	0.0859
D(LNPOS(-1))	-0.983265	0.128775	-7.635530	0.0829
D(LNWP)	-0.014081	0.001724	-8.170004	0.0775
D(LNWP(-1))	-0.136470	0.017522	-7.788450	0.0813
D(LNMP)	0.078135	0.010745	7.271993	0.0870
D(LNMP(-1))	0.829522	0.108238	7.663834	0.0826
CointEq(-1)*	45.14569	5.966892	7.566030	0.0837
R-squared	0.939999	Mean dependent var		0.005769
Adjusted R-squared	0.855997	S.D. dependent var		0.011642
S.E. of regression	0.004418	Akaike info criterion		-7.731137
Sum squared resid	9.76E-05	Schwarz criterion		-7.383476
Log likelihood	58.25239	Hannan-Quinn criter.		-7.802597
Durbin-Watson stat	2.648577			

*** p-value incompatible with t-Bounds distribution.**

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	2.289793	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66