

Green Investment Outcomes, External Debt, and Economic Resilience in Africa: A Dynamic Panel Analysis of Emerging African Economies

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ABSTRACT

Amid growing climate challenges and economic shocks, there is increasing interest in how green investment can support economic resilience in emerging African economies. However, the effectiveness of green finance in fostering macroeconomic stability remains underexplored, particularly in the presence of external debt pressures. This study investigates the dynamic relationship between green investment outcomes and economic resilience in selected African countries, with particular attention to the moderating role of external debt. Using quarterly panel data from 2004Q1 to 2023Q4, the analysis applies a Dynamic Autoregressive Distributed Lag (DARDL) model to estimate both short- and long-run effects. Green investment outcomes are measured using a composite index derived from progress on SDG 7 (clean energy), SDG 12 (sustainable consumption), and SDG 15 (life on land). The findings show that green investment enhances economic resilience in the short run, while its long-run effects are influenced by institutional and fiscal contexts. External debt negatively affects resilience directly, but its interaction with green investment turns significantly positive, suggesting that debt-financed green initiatives can help offset fiscal vulnerability when well-targeted. Trade openness and foreign direct investment also strengthen resilience, while institutional quality exhibits a nonlinear influence, dampening short-term gains but reinforcing long-run stability. These results underscore the importance of aligning green finance with debt sustainability and institutional reforms to achieve resilient and inclusive growth in Africa.

Keywords: Green Investment, Economic Resilience, External Debt, Institutional Quality, Africa

JEL Classifications: E32, F43, H63, O44, O55, Q56

INTRODUCTION

Amid intensifying climate risks and escalating environmental degradation, green investment has emerged as a strategic policy instrument in the global quest for sustainable development. Defined as the allocation of financial capital to environmentally responsible initiatives such as clean energy infrastructure, sustainable resource management, and biodiversity conservation green investment aims to balance economic growth with ecological preservation (OECD, 2017; Taghizadeh-Hesary & Yoshino, 2020). For emerging economies in Africa, which are disproportionately affected by climate variability, resource degradation, and weak infrastructure, green finance is not merely aspirational; it is essential for building future-ready, sustainable economies (AfDB, 2022).

Despite growing commitments to climate financing, Africa remains underfunded relative to its needs and global benchmarks. While global green investment exceeded USD 1.7 trillion in 2023, Sub-Saharan Africa accounted for less than 3% of that total, highlighting a stark financing gap in regions most vulnerable to climate change (Climate Policy Initiative, 2024). Comparatively, the European Union attracted more than USD 500 billion in green finance in the same period, while East Asia (particularly China) accounted for nearly USD 400 billion, emphasising a significant geographical imbalance in sustainable investment flows (IEA, 2024).

This underinvestment is compounded by Africa's rising external debt burden, which increasingly threatens macroeconomic stability and fiscal space. As of 2023, Africa's total external debt reached USD 1.13 trillion, up from USD 494 billion in 2010, an increase of over 129% in just over a decade (World Bank, 2024). On average, the continent's external debt-to-GNI ratio stands at 36%, with countries like Ghana, Zambia, and Kenya recording ratios exceeding 60%, compared to the global average of 28%. In many cases, high debt servicing obligations often consume over 20% of government revenues, have crowded out capital expenditures, including those linked to climate adaptation and green infrastructure (UNCTAD, 2025).

Against this backdrop, the effectiveness of green finance must be assessed not only by the volume of capital mobilised, but also by its developmental outcomes, especially in the context of high external debt. This study focuses on green investment outcomes, measured through progress on selected Sustainable Development Goals (SDGs), specifically SDG 7 (affordable and clean energy), SDG 12 (responsible consumption and production), and SDG 15 (life on land). These SDGs capture concrete environmental improvements associated with green finance, including renewable energy penetration, waste minimisation, and biodiversity protection (UNEP, 2022).

Simultaneously, the study emphasises economic resilience, understood as the capacity of an economy to absorb, adapt to, and recover from external shocks (Briguglio, 2016). In theory, green investments may foster macroeconomic resilience by stabilising production systems, promoting resource efficiency, and reducing ecological risks (Mazzucato & Semieniuk, 2018; Abbas et al., 2024). However, where high external debt burdens persist, the intended benefits of green finance may be undermined by fiscal constraints and procyclical macroeconomic adjustments.

This study addresses these dynamics by conducting a cross-country panel analysis of emerging African economies to examine whether and how green investment outcomes, in the presence of external debt, contribute to economic resilience. Utilising quarterly data from 2004Q1 to 2023Q4 and employing robust econometric techniques such as dynamic panel ARDL estimators, the study investigates the direct and moderating effects of debt on the green finance–resilience nexus. By integrating environmental progress and debt sustainability into a unified empirical framework, this research offers critical insights for policymakers seeking to align climate finance strategies with long-term economic stability in Africa.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Empirical Literature Review

The nexus between green finance and macroeconomic outcomes, particularly economic resilience, has gained growing attention in recent development literature. Green finance through mechanisms such as green bonds, concessional loans, and public-private partnerships has been linked to sustainable economic transformation, especially in climate-vulnerable regions (Taghizadeh-Hesary & Yoshino, 2020). Several studies emphasise that green investments contribute to long-term economic stability by promoting energy efficiency, diversifying productive capacity, and reducing dependence on environmentally harmful industries (Mazzucato & Semieniuk, 2018; Abbas et al., 2024).

In the African context, however, the empirical evidence remains limited. Li et al. (2022) found that green financial instruments have the potential to improve environmental outcomes in Sub-Saharan Africa, but their macroeconomic impact is constrained by institutional weaknesses and fragmented policy frameworks. Similarly, Mungai et al. (2020) showed that investments aligned with SDG 7 and SDG 15 can improve agricultural productivity and energy access, thereby strengthening economic inclusivity. However, their study stops short of examining resilience to macroeconomic shocks or the role of external debt.

The issue of external debt in relation to green investment and macroeconomic stability has also drawn academic attention. Essers et al. (2021) argue that rising sovereign debt levels in developing economies reduce fiscal space for climate investment and increase exposure to financial volatility. Seghini (2024) finds that countries with high external debt levels are less likely to implement long-term green transitions due to short-term debt servicing pressures. In Africa, debt sustainability has emerged as a central constraint, as countries allocate significant

portions of their revenues to debt repayments, undermining climate action and resilience-building efforts (UNCTAD, 2025).

Although the individual relationships between green investment, economic stability, and external debt have been partially addressed, few studies have examined their **joint dynamics**, especially in a panel setting covering African economies. This study fills this gap by explicitly modelling how green investment outcomes (measured by environmental performance on SDGs 7, 12, and 15) interact with external debt to influence economic resilience.

Theoretical Framework

This study is grounded in two interrelated theoretical perspectives: the Post-Keynesian structuralist growth theory and the ecological modernisation theory. From a Post-Keynesian structuralist standpoint, public investment, especially in infrastructure and sustainability, can serve as a counter-cyclical tool to stabilise economies in the face of external shocks (Ocampo, 2005). Green investment, when strategically deployed, enhances the productive base of the economy, strengthens demand through multiplier effects, and reduces vulnerability by diversifying energy sources and industrial inputs. However, under high external debt burdens, the ability of green investment to play this stabilising role may be impaired due to procyclical austerity, crowding-out effects, and reduced fiscal autonomy (Reinhart & Rogoff, 2010).

In parallel, ecological modernisation theory posits that environmental innovation and sustainable practices are not inherently growth-constraining but can instead be sources of competitive advantage and systemic resilience (Mol & Spaargaren, 2000). In this view, green investment catalyses structural transformation by integrating ecological considerations into economic planning, thus building adaptive capacity and long-run sustainability. Nevertheless, this transition depends critically on enabling conditions such as institutional quality, access to green finance, and manageable debt dynamics.

Together, these theories support the central proposition of this study, which is that green investment outcomes can enhance economic resilience in African countries, but their effectiveness is moderated by the burden of external debt. The conceptual framework guiding the study is thus built on the interaction between environmental performance, fiscal sustainability, and macroeconomic adaptability, providing a multidimensional lens for evaluating resilience.

METHODOLOGY

Data Sources and Variable Description

This study utilises quarterly panel data spanning from 2004Q1 to 2023Q4 for a sample of 12 emerging African economies. The countries were selected based on data availability and their growing role in green investment within their respective regional blocs. Specifically, Algeria and Morocco (Arab Maghreb Union, AMU) were chosen for their relatively diversified economies and renewable energy investments; Egypt and Ethiopia (COMESA) for their regional financial and infrastructural significance; Kenya and Tanzania (EAC) for their leadership in clean energy and agricultural modernisation; the Democratic Republic of Congo and Cameroon (ECCAS) for their resource endowments and rising energy investment; Nigeria and Ghana (ECOWAS) for their size and dynamism as West Africa's leading economies; and South Africa and Angola (SADC) for their industrial capacity and resource-driven growth. This bloc-based selection ensures a balanced representation of Africa's major sub-regions, thereby enhancing the robustness and generalizability of the study's findings.

Data were compiled from internationally recognised sources, including the World Bank's World Development Indicators (WDI), the World Governance Indicators (WGI), and the United Nations Sustainable Development Goals (SDG) indicators, while the World Bank Statistical Performance Indicators (SPIs) were consulted to ensure reliability and comparability across countries.

The dependent variable, *Economic Resilience* (ECORES), is proxied by GDP growth volatility, calculated as the five-quarter rolling standard deviation of real GDP growth rate. This measure captures the economy's capacity

to absorb and adapt to shocks, in line with existing literature on resilience and macroeconomic stability (Briguglio, 2016). Higher volatility indicates weaker resilience, while lower volatility reflects greater macroeconomic stability.

The key independent variable is Green Investment Outcomes (GOUT). Unlike financial flows alone, GOUT reflects the *actual development results* of green finance by measuring progress on three relevant Sustainable Development Goals (SDGs):

1. SDG 7 (Clean Energy) – proxied by renewable energy consumption (% of total final energy use),
2. SDG 12 (Sustainable Consumption and Production) – measured by domestic material consumption per capita,
3. SDG 15 (Life on Land) – proxied by the percentage of forest area relative to total land.

These three indicators were normalised and aggregated using the mean to construct a composite Green Investment Outcome Index, capturing environmental performance attributable to green finance.

Several control variables are included to account for macroeconomic and structural influences on resilience:

1. External Debt (EXDBT): External debt stock as a percentage of GNI, capturing fiscal vulnerability.
2. Inflation (LnINF): Log of the consumer price index, indicating macroeconomic stability.
3. Trade Openness (OPENTR): Trade (exports + imports) as a share of GDP, measuring global economic integration.
4. Institutional Quality (LnINSQ): A composite index based on World Governance Indicators (WGI).
5. Foreign Direct Investment (LnFDI): Net FDI inflows, log-transformed.
6. Labour Force Participation (LnLFORCE): Total labour force size, log-transformed.

To further explore how debt conditions may moderate the green finance–resilience relationship, interaction terms are included, such as:

GOUT × EXDBT, and GOUT × LNINSQ.

Table 1: Description of Variables, Data Sources, and Expected Signs

Variable Name	Description	Measurement/Proxy	Source	Expected Sign
ECORES	Economic Resilience	Five-quarter rolling standard deviation of real GDP growth rate	Computed by Author	Dependent
GOUT	Green Investment Outcomes (composite index)	Average of normalised scores from: 1. Renewable energy consumption (% of final energy use) (SDG 7) 2. Domestic material consumption per capita (SDG 12) 3. Forest area (% of land area) (SDG 15)	UN SDG Database, World Bank Statistical Performance Indicators (SPIs)	–

EXDBT	External Debt	External debt stock (% of GNI)	World Bank (WDI)	+
LnINF	Inflation	Log of Consumer Price Index (CPI)	World Bank (WDI)	+
OPENTR	Trade Openness	Total trade (exports + imports) as % of GDP	World Bank (WDI)	–
LnINSQ	Institutional Quality	Composite of control of corruption, rule of law, and regulatory quality	World Governance Indicators (WGI)	–
LnFDI	Net Foreign Direct Investment	Log of Net FDI inflows	World Bank (WDI)	–
LnLFORCE	Labour Force Participation	Log of total labour force size	World Bank (WDI)	–
GOUT EXDBT ×	Interaction Term: Green Investment Outcomes × External Debt	Multiplicative interaction term	Computed by Author	±
GOUT LnINSQ ×	Interaction Term: Green Investment Outcomes × Institutional Quality	Multiplicative interaction term	Computed by Author	–

Notes: A negative (–) expected sign implies the variable is expected to reduce economic volatility (i.e., improve resilience), a positive (+) sign implies the variable is expected to increase volatility (weaken resilience), while ± implies the direction depends on context or threshold effects.

Model Specification

To examine the relationship between green investment outcomes, external debt, and economic resilience, the study adopts a **Dynamic Panel Autoregressive Distributed Lag (CS-ARDL)** model that accounts for heterogeneity and cross-sectional dependence. The baseline model is specified as:

$$\begin{aligned} \Delta ECORES_{it} = & \alpha_i + \lambda_i (ECORES_{it-1} - \beta_1 EXDBT_{it-1} - \beta_2 GOUT_{it-1} - \beta_3 X_{it-1} - \beta_4 GOUT_{it-1} \times Z_{it-1}) \\ & + \sum_{j=1}^p \gamma_{ij} \Delta ECORES_{it-j} + \sum_{j=1}^q \delta_{it} \Delta EXDBT_{it-j} + \sum_{j=1}^q \delta_{it} \Delta GOUT_{it-j} + \sum_{j=1}^q \theta_{it} \Delta \ln X_{it-j} + \phi Z_t \\ & + \varepsilon_{it} \end{aligned}$$

Where:

1. Δ denotes the first difference operator;
2. λ_i is the adjustment coefficient showing the speed of convergence to the long-run equilibrium;
3. X_{it} : Vector of control variables – inflation, Trade Openness, institutional quality, Foreign Direct Investment, Labour Force Participation,
4. The cointegration term in parentheses represents the long-run relationship;
5. Z_t is the cross-sectional averages of the variables that are included in the CS-ARDL framework to control for unobserved common factors.

6. ε_{it} is the white noise error term.

7. $GOUT_{it-1} \times Z_{it-1}$: Interaction terms between green investment outcomes and key moderators such as institutional quality and external debt.

The Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) model is employed in this study due to its robustness in handling common econometric challenges in macro-panel data. It effectively addresses cross-sectional dependence, a key concern in Africa where countries often face shared external shocks such as global commodity price fluctuations or regional policy spillovers, by incorporating cross-sectional averages to capture unobserved common factors. The model also allows for heterogeneous short-run dynamics across countries while assuming homogeneous long-run relationships, capturing diverse short-term responses while estimating a unified long-term effect. Moreover, CS-ARDL is suitable for panels with mixed integration orders ($I(0)$ and $I(1)$), making it ideal for datasets where stationarity varies across variables. These features make CS-ARDL a robust and flexible framework for analysing the dynamic link between green investment outcomes and economic resilience in Africa.

PRESENTATION AND DISCUSSION OF RESULTS

Descriptive Statistics

Table 2: Descriptive Statistics

	GDPGR	GOUT	EXTD	FDI	INF	LFORCE	LNINSQ	OPENTR
Mean	4.767	0.815	32.33	5.55E+11	9.457	2.33E+07	-0.385	54.08
Median	4.570	0.803	28.82	1.56E+11	7.372	2.07E+07	-0.093	52.63
Maximum	15.03	1.000	148.2	9.89E+12	44.36	7.33E+07	1.241	122.4
Minimum	-7.178	0.669	2.322	-7.40E+11	-0.692	7.64E+06	-2.269	0.000
Std. Dev.	3.307	0.084	22.06	1.67E+12	7.826	1.50E+07	1.285	20.03
Skewness	-0.052	0.538	1.605	4.407	1.676	1.345	-0.859	0.637
Kurtosis	4.583	2.354	7.313	21.77	6.872	4.137	4.314	3.593
Jarque-Bera	100.6	63.00	1156	17194	1049	341.0	187.0	79.02
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	960	960	960	960	960	960	960	960

Source: Author's Computation using E-Views 13 Version.

The panel descriptive statistics in Table 2 presents the statistics for key variables used in this study which are GDP growth (GDPGR), green investment outcomes (GOUT), external debt (EXTD), foreign direct investment (FDI), inflation (INF), labour force participation (LFORCE), institutional quality (LNINSQ), and trade openness (OPENTR) based on quarterly panel data covering 960 observations across selected African economies from 2004Q1 to 2023Q4. On average, GDP growth was 4.8 percent, with peaks of 15.0 percent and contractions of -7.2 percent, underscoring the cyclical vulnerabilities and external shocks that frequently characterize African growth trajectories (UNECA, 2020). Green investment outcomes, proxied by a composite sustainability index, averaged 0.81, remaining relatively stable but below the maximum value, suggesting gradual progress toward green development goals. This is consistent with recent evidence that while African economies have expanded renewable energy use and forest conservation, progress remains uneven and constrained by weak institutional capacity (Attah et al., 2025; Opeyemi et al., 2019).

External debt, measured as a share of gross national income (GNI), averaged 32.3 percent but exhibited significant volatility, ranging from 2.3 percent to 148.2 percent, reflecting recurrent debt accumulation and

restructuring episodes in the region (Zajontz, 2022). Similarly, foreign direct investment flows were highly erratic, with sharp outflows and surges that resulted in a skewed distribution, aligning with earlier findings that FDI in Africa is highly sensitive to global commodity cycles and domestic policy uncertainty (Zang et al., 2023; Ogbonna et al., 2022; Asiedu, 2006). Inflation averaged 9.5 percent, with extreme spikes above 40 percent, further evidencing macroeconomic instability, a pattern well-documented in studies on Africa's susceptibility to both fiscal and supply-side shocks (Leininger et al., 2021; Mangeni, 2024). Labour force participation, averaging 23.4 million, grew steadily over time, though the distribution was skewed toward earlier years with smaller pools, reflecting demographic expansion consistent with Africa's youth-driven population structure (ILO, 2021). Institutional quality, expressed in logarithmic form, had a negative mean (−0.39), pointing to persistent governance weaknesses, although some periods recorded improvements. This echoes the findings of Acemoglu and Robinson (2012), who argue that weak institutions are central to Africa's growth fragility.

Trade openness averaged 54.1 percent of GDP, reflecting moderate integration into global markets, but its variability highlights exposure to external demand shocks and commodity price cycles (Chowdhury, 2025; Hassan, 2024). Importantly, the Jarque–Bera statistics strongly rejected normality across all variables, suggesting the presence of structural breaks, extreme values, and nonlinear dynamics. These distributional properties reinforce the methodological necessity of employing robust dynamic panel estimators to capture persistence, heterogeneity, and volatility in assessing the interplay between green investment, external debt, and economic resilience in Africa.

Cross- Sectional Dependence Test

Table 3: Cross-Sectional Dependence Test Result

Variable	CD	(p-value)	CDw	(p-value)	CDw+	(p-value)	CD*	(p-value)
Economic Resilience	23.87	(0.000)	-0.40	(0.686)	201.00	(0.000)	5.58	(0.000)
Green Investment Outcome	49.58	(0.000)	-1.85	(0.064)	402.59	(0.000)	3.09	(0.002)
Inflation Rate (LnINF)	10.61	(0.000)	-2.56	(0.010)	146.91	(0.000)	-3.49	(0.000)
Trade Openness (OPENTR)	27.17	(0.000)	-4.94	(0.000)	295.89	(0.000)	-0.04	(0.969)
Institutional Quality	0.13	(0.893)	-4.85	(0.000)	118.23	(0.000)	4.41	(0.000)
External Debt (EXDBT)	26.76	(0.000)	-3.85	(0.000)	293.37	(0.000)	3.47	(0.001)
FDI (LnFDI)	4.22	(0.000)	-1.14	(0.253)	131.97	(0.000)	13.22	(0.000)
Labour Force (LnLFORCE)	68.35	(0.000)	-3.78	(0.000)	551.46	(0.000)	0.88	(0.378)
CD: Pesaran (2015, 2021) CDw: Juodis & Reese (2021) CDw+: Power-enhanced CDw from Fan et al. (2015) CD*: Pesaran & Xie (2021) with 4 principal components								

Source: Author's Computation using Stata 17 Version.

Cross-sectional dependence (CSD) in panel data can bias and undermine the efficiency of parameter estimates, making it essential to test for interdependencies across countries. Using the xtcd2 framework, this study applies

four CSD tests [CD (Pesaran, 2015, 2021), CDw (Juodis & Reese, 2021), CDw+ (Fan et al., 2015), and CD* (Pesaran & Xie, 2021)] to distinguish between weak and strong dependence. Results reveal strong and statistically significant CSD across most variables, including Economic Resilience (ECORES), Green Investment Outcomes (GOUT), Inflation (LnINF), Trade Openness (OPENTR), External Debt (EXDBT), and FDI (LnFDI), particularly under the CD and CDw+ tests (e.g., ECORES: CD = 23.87, CDw+ = 201.00; GOUT: CD = 49.58, CDw+ = 402.59; $p < 0.01$).

Although CDw results are insignificant for some variables (e.g., ECORES and LnFDI), the power-enhanced CDw+ and CD* tests consistently confirm strong interdependencies. For example, EXDBT shows high dependence (CD = 26.76; CDw+ = 293.37; $p = 0.000$), reflecting shared debt exposures across African economies. Mixed results for institutional quality (LNINSQ) highlight potential variation in governance structures or measurement complexity. Overall, the presence of significant CSD justifies the use of second-generation estimators like CS-ARDL or CCEMG, which account for unobserved common factors and yield more reliable inference in macro-panel contexts.

Panel Unit Root Test

Table 4: Panel Unit Root Test Result

CADF Test					
Variable	Level		1 st Difference		Order of integration
	Z[t-bar]	p-value	Z[t-bar]	p-value	
Economic Resilience (ECORES)	-7.984	0.000	-	-	I(0)
Green Investment Outcome (GOUT)	-0.348	0.364	-16.280	0.000	I(1)
Inflation Rate (LnINF)	-3.137	0.001	-	-	I(0)
Trade Openness (OPENTR)	-1.024	0.153	-16.295	0.000	I(1)
Institutional Quality	-5.269	0.000	-	-	I(0)
External Debt (EXDBT)	-1.015	0.155	-16.377	0.000	I(1)
FDI (LnFDI)	-4.168	0.000	-	-	I(0)
Labour Force (LnLFORCE)	0.169	0.567	-16.319	0.000	I(1)
Critical Values	10%	5%	1%		
	-2.660	-2.750	-2.920		

Source: Author's Computation using Stata 17.

Note: variables are all in linear log transformation except those in rate or percentages.

Table 4 reports the results of the Cross-sectionally Augmented Dickey-Fuller (CADF) panel unit root test, which accounts for cross-sectional dependence. The findings reveal a mixed order of integration among the variables. Economic Resilience, Inflation (LnINF), Institutional Quality, and FDI (LnFDI) are stationary at levels (I(0)), as indicated by significant Z[t-bar] values and p-values below 0.01, for instance, ECORES (-7.984 , $p = 0.000$) and LNINSQ (-5.269 , $p = 0.000$). In contrast, Green Investment Outcome (GOUT), Trade Openness (OPENTR), External Debt (EXDBT), and Labour Force (LnLFORCE) are non-stationary at levels but become stationary after first differencing, confirming their integration at order one (I(1)). This combination of I(0) and I(1) variables supports the use of panel ARDL techniques, which allow for mixed integration without risking spurious regressions especially since no variable is integrated of order two.

Panel Cointegration Test

Table 5: Cointegration Test Result

Statistic	Value	Z-value	P-value	Interpretation
Gt	-3.703	-5.124	0.000	Significant: Reject the null of no cointegration.
Ga	-22.009	-4.640	0.000	Significant: Reject the null of no cointegration.
Pt	-12.279	-4.714	0.000	Strongly significant: Cointegration exists.
Pa	-19.722	-5.092	0.000	Strongly significant: Cointegration exists.

Source: Author's computation using Stata 17 Version

Table 5 presents the Westerlund (2007) cointegration test results, assessing long-run equilibrium among the panel variables. All four statistics, Gt and Ga (group level) and Pt and Pa (panel level), reject the null hypothesis of no cointegration at the 1% level. For example, Gt is -3.703 ($Z = -5.124$, $p = 0.000$), and Pt is -12.279 ($Z = -4.714$, $p = 0.000$), confirming a stable long-run relationship both within countries and across the panel. These findings validate the suitability of ARDL frameworks for modelling the short- and long-run dynamics of economic resilience and green investment outcomes.

Dynamic Panel Autoregressive Distributed Lag (DARDL) Test

Table 6: Dynamic Panel Autoregressive Distributed Lag (DARDL) Estimation Results

Dependent Variable: Economic Resilience (ECORES)					
Variable	Coefficient	Std. Error	z-Statistic	P-value	95% Confidence Interval
Short-Run Coefficients					
D_GOUT (Green Investment Shock)	4.5503	1.3345	3.41	0.001	1.9313 to 7.1692
D_LnINF (Inflation)	-0.1062	0.0578	-1.84	0.066	-0.2196 to 0.0072
D_OPENTR (Trade Openness)	0.0083	0.0041	2.01	0.045	0.0002 to 0.0164
D_LNINSQ (Institutional Quality)	0.4646	0.2877	1.62	0.107	-0.0999 to 1.0291
D_EXDBT (External Debt)	-0.0979	0.0288	-3.40	0.001	-0.1544 to -0.0414
D_LnFDI (Foreign Direct Investment)	0.0263	0.0097	2.71	0.007	0.0072 to 0.0454
D_LnLFORCE (Labour Force)	-1.6017	1.0842	-1.48	0.140	-3.7294 to 0.5260
D_GOUT_LNINSQ	-0.5858	0.3538	-1.66	0.098	-1.2802 to 0.1087
D_GOUT_EXDBT	0.1213	0.0331	3.66	0.000	0.0563 to 0.1862
Adjustment Term					
L1_ECORES	-0.1525	0.0175	-8.72	0.000	-0.1868 to -0.1182
Long-Run Coefficients					
L1_GOUT	-0.0945	0.4645	-0.20	0.839	-1.0061 to 0.8171

L1_LnINF	-0.0150	0.0222	-0.68	0.497	-0.0585 to 0.0285
L1_OPENTR	0.0023	0.0012	1.86	0.064	-0.0001 to 0.0047
L1_LNINSQ	-0.2666	0.1670	-1.60	0.111	-0.5944 to 0.0611
L1_EXDBT	-0.0193	0.0107	-1.80	0.072	-0.0404 to 0.0018
L1_LnFDI	0.0031	0.0039	0.80	0.423	-0.0045 to 0.0107
L1_LnLFORCE	0.0116	0.0468	0.25	0.804	-0.0803 to 0.1035
L1_GOUT_LNINSQ	0.3444	0.2048	1.68	0.093	-0.0575 to 0.7463
L1_GOUT_EXDBT	0.0240	0.0127	1.90	0.058	-0.0009 to 0.0488
Constant C	-0.1593	1.0427	-0.15	0.879	-2.2056 to 1.8869

Source: Author's Computation using Stata 17 Version

The Dynamic ARDL (DARDL) model in Table 6 investigates the relationship between green investment outcomes (GOUT) and economic resilience (ECORES) in selected African countries, accounting for macroeconomic and institutional factors such as external debt, trade openness, institutional quality, and their interaction with green investment. The results provide compelling evidence for both the short-run and long-run dynamics shaping resilience in the region.

The short-run coefficient of GOUT (4.55, $p = 0.001$) is positive and highly significant, indicating that positive shocks to green investment outcomes immediately enhance economic resilience. This finding aligns with expectations under the Sustainable Development Goals (SDG 7, SDG 12, and SDG 15), where green investments in clean energy, sustainable land use, and consumption efficiency contribute directly to adaptive capacity, environmental health, and economic stability. It suggests that countries that expand their green investment portfolios (especially through projects with visible environmental returns) can experience near-term gains in resilience. Interestingly, the lagged level of GOUT is insignificant (-0.0945 , $p = 0.839$), implying that the long-run accumulation effect of green investment is weak or uneven across countries. This may reflect implementation lags, project inefficiencies, or a lack of institutional mechanisms to convert green finance flows into sustained resilience dividends. This interpretation is further supported by the interaction effects.

The interaction between green investment and institutional quality ($D_GOUT_LNINSQ = -0.586$, $p = 0.098$; $L1_GOUT_LNINSQ = 0.344$, $p = 0.093$) exhibits a nonlinear and time-dependent effect. In the short run, strong institutions may actually dampen the immediate impact of green investments, possibly due to regulatory delays, bureaucratic inertia, or slow disbursement processes. However, in the long run, improved institutional quality becomes an enabler, gradually enhancing the effectiveness of green investment. This dynamic supports the theory that institutions matter, but their benefits may only manifest over time as systems mature and policy coherence improves.

One of the most critical findings is the role of external debt. The direct effect of external debt ($D_EXDBT = -0.098$, $p = 0.001$) is significantly negative, suggesting that high debt burdens constrain resilience-building efforts, possibly through reduced fiscal space, higher interest obligations, and limited capacity to respond to shocks. However, the interaction term $GOUT \times EXDBT$ ($D_GOUT_EXDBT = 0.121$, $p = 0.000$) reverses this narrative, indicating that green investments can partially offset the harmful effects of external debt. This may occur when green projects are financed through concessional climate finance, blended finance instruments, or green bonds, which reduce the macro-fiscal burden and channel resources toward productivity-enhancing sectors. It shows that not all debt is bad, its impact depends on the nature of investments it supports.

Other control variables behave as expected. Trade openness ($D_OPENTR = 0.0083$, $p = 0.045$) positively affects resilience, as more open economies can leverage global capital, technology, and market access for adaptive development. FDI inflows ($D_LnFDI = 0.026$, $p = 0.007$) are also beneficial in the short run, suggesting that international capital plays a role in building climate-smart infrastructure and capabilities. However, labour force participation ($D_LnLFORCE = -1.60$, $p = 0.140$) has an insignificant negative coefficient, hinting at possible

structural rigidities or underemployment challenges in the labour market, which could dilute the resilience payoff from a growing workforce.

Finally, the error correction term ($L1_ECORES = -0.153$, $p = 0.000$) is negative and highly significant, confirming the presence of a long-run equilibrium. The speed of adjustment (15.3%) is moderate, indicating that shocks to the resilience path are corrected over time, but not immediately, which reinforces the need for sustained investment and policy continuity.

Table 7: Diagnostics Results

Statistic	Value
Number of Observations	944
F-statistic	13.84
Prob > F	0.000
R-squared	0.2216
Adjusted R-squared	0.2056
Root MSE	0.5243

Source: Author's Computation using Stata 17 Version

The summary statistics of the regression model provide useful insights into the overall performance and explanatory power of the estimated dynamic panel DARDL model. The model is based on 944 observations, which is sufficient for robust panel estimation and inference. The F-statistic value of 13.84 and its corresponding p-value of 0.000 indicate that the overall model is statistically significant at the 1% level. This means that, collectively, the explanatory variables included in the model significantly explain variations in the dependent variable (economic resilience) across the countries and time periods under study. The R-squared value of 0.2216 suggests that approximately 22.16% of the variation in economic resilience is explained by the model's independent variables. While this may appear modest, it is acceptable in macroeconomic and panel studies where country-specific heterogeneity, structural breaks, and measurement issues often result in relatively lower R-squared values. Furthermore, the adjusted R-squared, which accounts for the number of predictors relative to sample size, is slightly lower at 0.2056, but still reinforces the model's explanatory validity.

Lastly, the Root Mean Squared Error (Root MSE) of 0.5243 represents the standard deviation of the model's residuals. This relatively low value indicates that the model's predicted values are, on average, close to the actual observed values of economic resilience, reinforcing the model's overall goodness-of-fit. In summary, the regression model is statistically significant, appropriately specified, and demonstrates a reasonable degree of explanatory power within the context of a complex macroeconomic panel dataset.

CONCLUSION AND RECOMMENDATION

This study examined the dynamic relationship between green investment outcomes and economic resilience across selected African economies, using a Dynamic Autoregressive Distributed Lag (DARDL) framework. The findings reveal that positive shocks to green investment significantly enhance economic resilience in the short run. This suggests that environmentally focused initiatives, such as investments aligned with Sustainable Development Goals (SDG 7 on clean energy, SDG 12 on responsible consumption, and SDG 15 on life on land), can quickly strengthen a country's adaptive and absorptive capacities against economic and ecological shocks. However, the long-run effect of green investment outcomes appears muted, indicating that while green finance can yield immediate resilience gains, its sustained impact may be hampered by institutional inefficiencies, delayed implementation, or weak policy integration.

The results further highlight the complex role of institutional quality and external debt in shaping these dynamics.

While stronger institutions may initially delay the realisation of green investment impacts, likely due to bureaucratic hurdles or slow regulatory processing over time, they emerge as critical enablers of sustainable outcomes. Similarly, external debt exhibits a significantly negative direct effect on resilience, reflecting its burden on macroeconomic stability. However, the interaction term between green investment and external debt is both positive and statistically significant, underscoring that when external borrowing is effectively channelled into green and productive sectors, it can mitigate the harmful effects of debt and contribute meaningfully to resilience. Other complementary factors, such as trade openness and foreign direct investment, also show positive effects on economic resilience, pointing to the importance of global economic integration and cross-border capital flows in supporting climate-aligned development. The error correction term confirms the existence of a long-run equilibrium relationship, with the system adjusting moderately back to balance after short-run deviations.

Based on these findings, it is recommended that African governments prioritise scaling up targeted green investments that deliver both environmental and resilience benefits. Policymakers should ensure that these investments are strategically selected, efficiently executed, and supported by a robust monitoring framework. Strengthening institutional quality through governance reforms, policy coherence, and capacity building will be essential to convert short-term green finance inflows into long-term resilience dividends. Furthermore, external borrowing strategies must be aligned with sustainability goals; public debt should increasingly be used to fund projects that enhance climate resilience and environmental sustainability rather than consumption or recurrent expenditure.

Finally, there is a need to promote foreign direct investment and trade policies that favour the green economy. This includes removing barriers to the import of clean technologies, creating incentives for green-sector investors, and deepening regional cooperation on climate-related infrastructure. In sum, green investment offers a pathway to build economic resilience in Africa, but this potential can only be fully realised through prudent debt management, institutional strengthening, and strategic international engagement.

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