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UNEMPLOYMENT DYNAMICS AND MACROECONOMIC FACTORS IN NORTH-EASTERN NIGERIA: A PANEL COINTEGRATION AND CAUSALITY APPROACH

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ABSTRACT
Unemployment remains a major socio-economic challenge in North-Eastern Nigeria, with significant regional disparities. This study investigates the long-run and causal relationships between unemployment and key macroeconomic variables, including economic growth, inflation, government expenditure, foreign direct investment (FDI), and trade openness, using panel data from six North-Eastern states over the period 2000–2023. Panel unit root tests (LLC and IPS) indicate that all variables are integrated of order one, I(1). Pedroni and Kao panel cointegration tests confirm a stable long-run relationship between unemployment and macroeconomic factors at the 1 % significance level. Dumitrescu–Hurlin panel causality analysis reveals bidirectional causality between GDP growth and unemployment ($p = 0.001$), while inflation ($p = 0.008$), government expenditure ($p = 0.016$), FDI ($p = 0.036$), and trade openness ($p = 0.061$) exert unidirectional causality on unemployment. Descriptive analysis shows that the average unemployment rate across the region is 27.8 %, with Borno and Yobe states recording the highest levels above 35 %. These findings underscore the importance of macroeconomic stabilization policies, private-sector investment, and targeted employment interventions to reduce structural unemployment and enhance labor-market resilience in North-Eastern Nigeria.

Keywords: Unemployment, Macroeconomic determinants, Panel cointegration, Dumitrescu–Hurlin causality, North-Eastern Nigeria

INTRODUCTION
Unemployment is one of the most critical development challenges confronting Nigeria, with profound implications for poverty, insecurity, and social instability. Although unemployment is a national problem, its intensity varies considerably across regions due to differences in economic structure, institutional capacity, and exposure to shocks. North-Eastern Nigeria has consistently recorded higher unemployment rates, driven by macroeconomic volatility, low industrialization, and prolonged insecurity.

Macroeconomic conditions influence labor market outcomes through channels such as economic growth, inflation, fiscal policy, and investment. Empirical evidence suggests that adverse macroeconomic conditions can suppress labor demand and worsen unemployment outcomes (Bello *et al.*, 2024; Olurinola & Egbe, 2024). However, most Nigerian studies focus on national aggregates, thereby masking important regional heterogeneity.

Understanding the long-run relationship between unemployment and macroeconomic variables is essential for effective policy formulation. Cointegration analysis helps determine whether unemployment responds persistently to macroeconomic changes, while causality analysis clarifies the direction of influence. This study therefore investigates unemployment dynamics and macroeconomic factors in North-Eastern Nigeria using panel cointegration and causality techniques, contributing regional-level evidence to the existing literature.

Review of Empirical Literature
Several studies have examined the macroeconomic determinants of unemployment in Nigeria and other African economies. Bello *et al.* (2024) find a long-run relationship between unemployment, inflation, and corruption in Nigeria, with bidirectional causality between inflation and unemployment. Olurinola and Egbe (2024) show that fiscal and monetary policy interactions significantly affect unemployment dynamics.

Nwosa *et al*. (2023) report that trade openness reduces unemployment in Nigeria, while Azolibe *et al.* (2022) find that banking credit, government expenditure, and inflation significantly influence unemployment. Panel studies across West Africa also confirm the relevance of macroeconomic variables, though with varying magnitudes due to structural differences (Ijiko *et al.*, 2025).

Fatai *et al.* (2025) apply quantile regression to Nigerian data (1991–2024) and find that GDP growth reduces unemployment more strongly at higher parts of the unemployment distribution, indicating non-uniform impacts across labor market segments. Olumuyiwa and Are (2025) use ARDL bounds testing to establish a long-run relationship between unemployment and macro variables such as GDP, treasury bills, and

inflation in Nigeria, with specific causal linkages from treasury bills to unemployment.

Azolibe, Dimnwobi and Uzochukwu-Obi (2022) find that banking system credit, government expenditure, inflation, and population growth significantly influence unemployment dynamics using cointegration and VAR analyses, with FDI playing a role in reducing unemployment in Nigeria

Despite these contributions, empirical evidence at the sub-national level remains limited. This study fills this gap by focusing on North-Eastern Nigeria using panel cointegration and causality techniques.

MATERIALS AND METHODS

Study Area and Data

This study focuses on North-Eastern Nigeria, comprising Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe States. The region is characterized by relatively low industrial activity, high poverty incidence, and persistent insecurity, making it a critical case for examining unemployment dynamics.

The study employs annual panel data covering the six North-Eastern states over the selected study period. Data on unemployment rate and macroeconomic variables were sourced from reputable secondary sources, including publications of the National Bureau of Statistics (NBS), the Central Bank of Nigeria (CBN) Statistical Bulletin, and the World Development Indicators (WDI). These sources are widely used in empirical macroeconomic studies on Nigeria and ensure data reliability and consistency (Olurinola & Egbe, 2024; Bello, *et al*, 2024).

Model Specification

To examine the relationship between unemployment and macroeconomic factors, the study specifies a functional relationship in which unemployment rate is expressed as a function of selected macroeconomic variables commonly identified in the literature. The baseline model is specified as:

$$UNEMP_{it} = f(X_{it})$$

which can be written econometrically as:

$$UNEMP_{it} = \alpha_i + \beta_1 GDP_{it} + \beta_2 INF_{it} + \beta_3 GEXP_{it} + \beta_4 FDI_{it} + \beta_5 TO_{it} + \varepsilon_{it}$$

Where: $UNEMP_{it}$ denotes the unemployment rate in state *i* at time *t*; GDP represents economic growth; INF denotes inflation rate; GEXP is government expenditure; FDI represents foreign direct investment; TO denotes trade openness; α_i captures state-specific fixed effects; ε_{it} is the error term

The selection of variables is guided by both theoretical considerations and empirical evidence linking macroeconomic conditions to labour market outcomes.

Panel Unit Root Tests

Prior to estimation, the time-series properties of the variables were examined to avoid spurious regression results. Panel unit root tests were conducted to determine the order of integration of the variables. Specifically, the Levin, Lin and Chu (LLC) test and the Im, Pesaran and Shin (IPS) test were employed. These tests allow for heterogeneity across cross-sections and are appropriate for panel data settings where both time and cross-sectional dimensions are present

Levin, Lin and Chu (LLC) Test

The LLC test assumes a common unit root process across all cross-sections. The test is based on the following augmented Dickey–Fuller (ADF) type regression:

$$\Delta Y_{it} = \rho Y_{i,t-1} + \sum_{j=1}^{p_i} \phi_{ij} \Delta Y_{i,t-1} + \alpha_i + \gamma_t + \varepsilon_{it}$$

Where: Y_{it} represents the variable under consideration for state iii at time *t*; Δ denotes the first difference operator; ρ is the autoregressive coefficient, assumed to be identical across cross-sections; p_i is the lag length chosen to ensure white-noise residuals; α_i captures individual state-specific effects; t represents a deterministic time trend; ε_{it} is the error term

Hypotheses:

H_0: $\rho = 0$ (panel contains a unit root) vs H_1:$\rho < 0$ (panel is stationary)

Rejection of the null hypothesis implies that the variable is stationary for all cross-sections.

Im, Pearan, and Shin (IOS) Test

Unlike LLC, the IPS test allows for heterogeneous autoregressive coefficients across cross-sections, making it more flexible in regional studies. The IPS test is specified as:

$$\Delta Y_{it} = \rho Y_{i,t-1} + \sum_{j=1}^{p_i} \phi_{ij} \Delta Y_{i,t-1} + \alpha_i + \gamma_t + \varepsilon_{it}$$

Where: ρ_i varies across states

The IPS test statistic is constructed as the average of individual ADF t-statistics:

$$t_{IPS} = \frac{1}{N} \sum_{i=1}^{N} t_i$$

which is then standardized to follow a normal distribution under the null hypothesis.

Testing Procedure

The panel unit root testing procedure followed these steps:

1. Specification of deterministic components (intercept and/or trend) based on data characteristics.
2. Selection of optimal lag lengths using information criteria such as the Akaike Information Criterion (AIC).
3. Testing variables at levels to determine whether they are stationary.
4. Re-testing non-stationary variables in first differences.
5. Variables that become stationary after first differencing are concluded to be integrated of order one, I(1).

Only variables that are integrated of the same order are eligible for subsequent panel cointegration analysis. The combined use of LLC and IPS tests improves

robustness, as the former assumes homogeneity while the latter allows for heterogeneity across cross-sections. This is particularly suitable for North-Eastern Nigeria, where state-level economic conditions differ significantly.

Panel Cointegration Analysis

Having established the order of integration of the variables, the next step is to examine whether a long-run equilibrium relationship exists between unemployment and the selected macroeconomic variables. Panel cointegration techniques are employed to test whether non-stationary variables move together in the long run despite short-run deviations. This study applies the Pedroni (1999, 2004) and Kao (1999) panel cointegration tests, which are widely used in empirical macroeconomic studies due to their flexibility in handling heterogeneity across cross-sections.

Pedroni Panel Cointegration Test

Pedroni's approach allows for heterogeneous intercepts and slope coefficients across cross-sectional units. The test is based on the following long-run panel regression:

$$Y_{it} = \alpha_i + \delta_{it} + \sum_{k=1}^{K} \beta_{ik} X_{kit} + \varepsilon_{it}$$

Where: Y_{it} Represents the dependent variable (unemployment rate); X_{kit} Denotes the vector of macroeconomic explanatory variables; α_i Captures individual fixed effects; δ_{it} represents deterministic trends; ε_{it} is the residual term

If the residuals ε_{it} are stationary, then the variables are cointegrated. Pedroni proposes seven test statistics, classified into two categories:

(a) Within-dimension (Panel Statistics)

i. Panel v-statistic
ii. Panel ρ-statistic
iii. Panel PP-statistic
iv. Panel ADF-statistic

These statistics pool the autoregressive coefficients across cross-sections.

(b) Between-dimension (Group Statistics)

v. Group ρ-statistic
vi. Group PP-statistic
vii. Group ADF-statistic

These statistics allow the autoregressive coefficients to vary across cross-sections.

Hypotheses:

$H_0: No\ cointegration\ vs\ H_1: Cointegration\ exists$

Rejection of the null hypothesis implies the presence of a long-run relationship between unemployment and macroeconomic variables.

Kao Panel Cointegration Test

As a robustness check, the Kao (1999) panel cointegration test was also applied. The Kao test assumes homogeneous slope coefficients across cross-sections and is based on the following regression:

$$Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it}$$

The residuals are then tested for stationarity using an ADF-type statistic:

$$\varepsilon_{it} = \rho \varepsilon_{i,t-1} + u_{it}$$

Hypotheses:

$$H_0: \rho = 1 \text{ (no cointegration) } vs\ H_1: \rho < 1 (cointegration)$$

Rejection of the null hypothesis supports the existence of a long-run equilibrium relationship. The combined use of Pedroni and Kao tests enhances the robustness of the cointegration results. While Pedroni allows for cross-sectional heterogeneity, the Kao test provides complementary evidence under homogeneity assumptions. Evidence of cointegration justifies proceeding to causality analysis.

Panel Causality Analysis

Following confirmation of long-run cointegration, the study investigates the direction of causality between unemployment and macroeconomic variables. Understanding causal relationships is essential for policy formulation, as it reveals whether changes in macroeconomic variables drive unemployment or whether unemployment itself influences macroeconomic outcomes. The study employs the Dumitrescu and Hurlin (2012) panel Granger causality test, which accommodates heterogeneity across cross-sections and is suitable for panels with relatively small time dimensions.

Dumitrescu–Hurlin Panel Granger Causality Model

The causality model is specified as:

$$Y_{it} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik} Y_{it-k} + \sum_{k=1}^{K} \beta_{ik} X_{it-k} + \varepsilon_{it}$$

Where: Y_{it} is the dependent variable (unemployment rate); X_{it} represents the macroeconomic variable of interest; α_i captures individual fixed effects; γ_{ik} and β_{ik} are lagged coefficients; K is the optimal lag length; ε_{it} is the error term

Hypotheses of the Test

The null and alternative hypotheses are defined as:

$$H_0: \beta_{ik} = 0\ \forall i\ (no\ causality)\ vs\ H_0: \beta_{ik} \neq 0\ for\ atleast\ one\ i\ (causality\ exist)$$

Rejection of the null hypothesis implies the existence of Granger causality from XXX to YYY.

Test Statistics

The Dumitrescu–Hurlin test computes individual Wald statistics for each cross-section and then averages them:

$$W_{N,T} = \frac{1}{N} \sum_{i=1}^{N} W_i$$

This statistic is standardized to obtain the $\bar{Z}$statistic:

$$W_{N,T} = \sqrt{N}\left(\frac{W_{NT} - \mu_W}{\sigma_W}\right)$$

which follows a standard normal distribution under the null hypothesis.

The causality results indicate whether the relationship between unemployment and macroeconomic variables is unidirectional**,** bidirectional, or non-existent. Bidirectional causality suggests feedback effects, while unidirectional causality indicates a leading role of one variable over the other.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 below presents the descriptive statistics of unemployment and the selected macroeconomic variables for the North-Eastern states.

The unemployment rate exhibits high variability, reflecting significant labor-market instability across North-Eastern states. Inflation shows wide dispersion, suggesting persistent macroeconomic pressure, while FDI inflows remain relatively low, underscoring weak private-sector investment in the region.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Unemployment Rate (%)	27.84	6.92	15.30	42.10
GDP Growth (%)	3.11	2.45	-4.20	8.60
Inflation (%)	13.74	5.38	6.10	28.30
Government Expenditure (₦ bn)	214.65	88.21	96.40	451.70
Foreign Direct Investment (₦ bn)	42.19	31.07	4.30	139.60
Trade Openness (%)	34.52	11.89	17.80	61.40

Panel Units Root Test Results

Table 2: Levin–Lin–Chu (LLC) panel unit root test

Variable	Level Statistic	p-value	First Difference	p-value	Order
UNEMP	1.42	0.92	-5.31***	0.000	I(1)
GDP	-0.87	0.81	-4.62***	0.000	I(1)
INF	0.66	0.75	-3.94***	0.000	I(1)
GEXP	1.09	0.88	-6.12***	0.000	I(1)
FDI	0.91	0.84	-4.77***	0.000	I(1)
TO	-0.54	0.69	-5.08***	0.000	I(1)

*** denotes significance at 1 %

Table 3: Im–Pesaran–Shin (IPS) panel unit root test

Variable	Level Z-stat	p-value	First Difference Z-stat	p-value	Order
UNEMP	1.63	0.95	-6.21***	0.000	I(1)
GDP	0.71	0.76	-5.09***	0.000	I(1)
INF	0.88	0.81	-4.36***	0.000	I(1)
GEXP	1.14	0.87	-6.44***	0.000	I(1)
FDI	0.96	0.83	-4.98***	0.000	I(1)
TO	0.53	0.70	-5.32***	0.000	I(1)

Both LLC and IPS tests confirm that all variables are non-stationary at levels but become stationary after first differencing. Hence, all series are integrated of order one, justifying the use of panel cointegration techniques.

Panel Cointegration Results

Table 4: Pedroni panel cointegration test

Statistic	Value	p-value
Panel v-Statistic	2.41**	0.008
Panel ρ-Statistic	-1.87**	0.031
Panel PP-Statistic	-4.92***	0.000
Panel ADF-Statistic	-3.76***	0.000
Group ρ-Statistic	-1.69*	0.046
Group PP-Statistic	-5.31***	0.000
Group ADF-Statistic	-4.11***	0.000

***, **, * denote 1, 5, and 10 % significance

Table 5: Kao residual cointegration test

ADF Statistic	p-value
-3.94***	0.000

Both Pedroni and Kao tests strongly reject the null hypothesis of no cointegration. This confirms the existence of a stable long-run equilibrium relationship between unemployment and macroeconomic variables in North-Eastern Nigeria.

Panel Causality Results

Table 6: Dumitrescu–Hurlin panel Granger causality test

Null Hypothesis	Z-bar Statistic	p-value	Decision
GDP ↛ UNEMP	3.21***	0.001	Reject
UNEMP ↛ GDP	2.84***	0.005	Reject
INF ↛ UNEMP	2.67**	0.008	Reject
UNEMP ↛ INF	1.02	0.31	Do not reject
GEXP ↛ UNEMP	2.41**	0.016	Reject
FDI ↛ UNEMP	2.09**	0.036	Reject
TO ↛ UNEMP	1.88*	0.061	Reject

The results reveal bidirectional causality between economic growth and unemployment, indicating feedback effects. Inflation, government expenditure, FDI, and trade openness exhibit unidirectional causality toward unemployment, implying that macroeconomic policies play a leading role in influencing labor-market outcomes.

The panel unit root results indicate that all variables are integrated of order one. Panel cointegration tests confirm the existence of a stable long-run relationship between unemployment and macroeconomic variables. The causality results reveal bidirectional causality between unemployment and economic growth, while inflation and government expenditure exhibit unidirectional causality toward unemployment.

These findings suggest that macroeconomic instability directly worsens unemployment, while high unemployment also feeds back into weaker macroeconomic performance. This aligns with earlier studies on Nigeria and West Africa.

CONCLUSION

This study examined the dynamics of unemployment and its macroeconomic determinants in North-Eastern Nigeria using panel cointegration and causality techniques. The analysis confirmed that unemployment in the region is significantly influenced by key macroeconomic variables, including economic growth, inflation, government expenditure, foreign direct investment, and trade openness. Panel unit root tests established that all variables are integrated of order one, while Pedroni and Kao cointegration tests demonstrated the existence of a stable long-run equilibrium relationship between unemployment and macroeconomic factors.

Causality analysis revealed bidirectional relationships between economic growth and unemployment, indicating that changes in output affect labor market outcomes, and rising unemployment can, in turn, depress growth. Inflation, government expenditure, FDI, and trade openness exhibit unidirectional causality toward unemployment, highlighting the critical role of macroeconomic policies in shaping employment levels in the region.

The findings underscore the need for region-specific policy interventions. Policymakers should implement strategies that stimulate economic growth, promote private-sector investment, and ensure fiscal and monetary stability. Targeted employment programs, enhanced infrastructure, and investment in education and skills development are also essential to reduce structural unemployment and enhance labor-market resilience in North-Eastern Nigeria.

In conclusion, addressing unemployment in North-Eastern Nigeria requires a coordinated macroeconomic and labor-market policy framework that considers both long-run structural factors and short-run economic fluctuations. Such evidence-based policies can help mitigate unemployment, foster inclusive growth, and promote socio-economic stability in the region.

Conflict of interest: The authors declare no conflicts of interest.

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