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Article

The nexus of polytechnic education expansion, economic growth, and unemployment: A two-decade perspective in Nigeria

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Abstract: This study explores the dynamic relationship between polytechnic expansion, economic growth, and unemployment in Nigeria from 1999 to 2023 using secondary data obtained from the Central Bank of Nigeria and the National Bureau of Statistics. Key macroeconomic variables analyzed include the Number of Polytechnics (NP), Gross Domestic Product (GDP), GDP Growth Rate (GDPGR), and Unemployment Rate (UNER). Descriptive analysis revealed significant growth in polytechnic institutions, alongside persistent unemployment and fluctuating economic performance. The study employed the Augmented Dickey-Fuller (ADF) test to assess stationarity, followed by a cointegration test and the Autoregressive Distributed Lag (ARDL) model to examine both long- and short-run dynamics. The results confirmed a statistically significant long-run equilibrium relationship among the variables, with the ARDL bounds test yielding an F-statistic of 15.84, surpassing the critical upper bound. Notably, the Number of Polytechnics (log_NP) exhibited a strong positive long-term effect on GDP growth (p = 0.0014), reinforcing the role of technical education in economic development. The error correction term (−0.4819, p = 0.0457) was negative and significant, indicating that deviations from the long-run path adjust moderately at a speed of 48.2% annually. Granger causality analysis further showed that polytechnic expansion Granger causes GDP growth, though not GDP directly, implying indirect effects through skill development and labor market productivity. These findings underscore the importance of aligning technical education with industry needs and improving the employability of graduates. The study recommends policy strategies focused on curriculum reform, funding support, and institutional-industry collaboration to fully harness the growth potential of polytechnic education in Nigeria.

Keywords: cointegration; education; GDP growth rate; polytechnic expansion; stationarity; unemployment

1. Introduction

In developing economies, education is widely acknowledged as a cornerstone for economic transformation and inclusive growth. Among the various tiers of education, polytechnic education, a subset of technical and vocational education and training (TVET), has gained renewed prominence for its role in bridging the gap between skill acquisition and economic productivity. Theoretically, the Human Capital Theory [1], posits that investment in education enhances the skills and productivity of individuals, thereby fostering economic growth. In line with this, Endogenous Growth Theory [2] further emphasizes that knowledge, skills, and technological innovation often driven by education are key drivers of sustained economic development. These theoretical underpinnings suggest a strong linkage between the expansion of polytechnic education and macroeconomic indicators such as Gross Domestic Product (GDP) growth and unemployment reduction.

The economic and social context of Nigeria renders this discourse particularly significant. Nigeria, Africa's most populous country, faces persistent structural unemployment, with youth unemployment reaching 53.4% in 2022 [3]. Despite being rich in natural resources, the country grapples with economic instability, high poverty rates, and limited industrial diversification. The mismatch between the labor market demand and the educational output has exacerbated unemployment among graduates. To address these issues, successive Nigerian governments have invested in expanding polytechnic education as a strategic response to unemployment and to stimulate innovation-led growth [4].

Polytechnic education in Nigeria aims to equip students with practical, technical, and entrepreneurial skills that enhance employability and industrial relevance. Historically, technical and vocational education in Nigeria was underprioritized, leading to a shortage of mid-level technical manpower [5]. Drawing parallels, National Board for Technical Education (NBTE) [6], observed a similar neglect in Singapore's colonial education system, which initially impeded post-independence industrial development. Nigeria's renewed focus on polytechnic education mirrors this remedial approach. The NBTE has reported a steady increase in the number of polytechnic institutions, signaling a strategic emphasis on technical education as an economic catalyst [7].

Empirical studies reinforce the developmental potential of polytechnic education. Bukar and Timothy [8] highlighted that graduates from Ramat Polytechnic in Borno State reported improved self-employment and business expansion, attributing this to entrepreneurship training embedded in the curriculum. Realinho et al. [9] demonstrated how educational interventions reduce school dropouts and foster inclusive economic participation. Sadrina et al. [10] emphasized the value of project-based learning in Malaysian polytechnics for enhancing innovation. However, issues of gender disparity remain; Akor et al. [11] documented that socio-cultural constraints continue to hinder female enrollment in technical programs, limiting the potential impact of polytechnic education on overall human capital development.

Despite increasing investments and policy focus, the outcomes remain mixed. Ojo [12] and Adelusi and Adelusi [13] stressed that misalignment between industry needs and curricula, inadequate funding, and poor institutional capacity often undermine the objectives of polytechnic education in Nigeria. These challenges contribute to persistently high Unemployment Rates among graduates of technical institutions, calling into question the effectiveness of polytechnic expansion as a standalone solution.

Previous studies, such as those by Tan [6] and Bukar and Timothy [8], have highlighted issues related to the quality and impact of polytechnic education on economic growth and employment. However, these studies often focus on specific regions or aspects, such as entrepreneurship education or historical and educational factors. For instance, while Tan [6] emphasized historical neglect and slow advancement in construction education in Singapore, Bukar and Timothy [8] explored the role of entrepreneurship education in Northern Nigeria. Realinho et al. [9] provided insights into predicting academic performance and dropout rates using machine learning models but did not specifically address the broader economic impacts of polytechnic education. Additionally, studies like those by Sadrina et al. [10] and Akor et al. [11] examined project-based learning and women's participation in technical education, respectively, but did not comprehensively analyze the nexus between polytechnic expansion, economic growth, and unemployment on a national scale over an extended period.

The motivation for this study stems from the pressing need to deepen our understanding of how the expansion of polytechnic education in Nigeria has influenced economic growth and unemployment dynamics over the past two decades. In line with national development priorities, polytechnics in Nigeria have been established to produce mid-level technical manpower in areas such as mechanical engineering, civil engineering, electrical/electronic engineering, computer science, science laboratory technology, building technology, environmental health, business administration, agricultural technology, and mass communication. These technical and vocational skills are essential for industrial development, innovation, self-employment, and the growth of small and medium enterprises (SMEs) [5,7].

Over the years, the level and quality of skill production have witnessed fluctuations. While the Number of Polytechnics and enrollments has increased significantly, especially with the addition of more private institutions, this expansion has not always translated into proportional improvements in skill quality or labor market readiness. Several factors account for this, including inconsistent curriculum review, underfunding, inadequate infrastructure, and limited industry-academic partnerships. Moreover, graduate employability surveys (e.g., [14]) have identified gaps in practical competence, especially in emerging areas like digital technologies, automation, and renewable energy, pointing to a mismatch between training outputs and labor market needs.

The objectives of this study are to examine historical trends in the Number of Polytechnics (NP), Gross Domestic Product (GDP), GDP Growth Rate (GDPGR), and Unemployment Rate (UNER) in Nigeria from 1999 to 2023; assess the stationarity of the variables (NP, GDP, GDPGR, and UNER) to validate the reliability of the time-series analysis; evaluate the strength and stability of correlations among NP, GDP, and UNER with GDPGR, and determine the presence and nature of long-run cointegration between polytechnic expansion (NP), economic size (GDP), and unemployment (UNER), and how they influence GDPGR.

The results of this study are expected to benefit the Ministry of Education, the NBTE, the Ministry of Labor and Employment, and economic planning agencies such as the National Economic Council and the National Planning Commission. These institutions are directly responsible for formulating and implementing education, labor, and economic policies. Insights from this research can guide targeted investments in technical education, curriculum realignment, and institutional reforms to enhance the contribution of polytechnics to national development. Also, the findings are relevant for development partners, donor agencies, and private-sector employers seeking evidence-based approaches to strengthening Nigeria's workforce and reducing structural unemployment.

2. Methods

2.1. Method of data collection

In this research, secondary data has been used. Secondary data was collected from the Central Bank of Nigeria Statistical Bulletin 2023 and the National Bureau of Statistics Bulletin 2023. The variables considered include the NP, GDP, GDPGR, and UNER from 1999 to 2023.

The period 1999–2023 was adopted for this study due to its historical and policy relevance in Nigeria's socio-economic and educational landscape. First, 1999 marks the beginning of Nigeria's Fourth Republic and the return to democratic governance, which brought renewed focus on human capital development, including significant reforms and investments in education, particularly technical and vocational education. During this period, there was a deliberate push by successive governments to expand access to polytechnic education as a strategy to reduce youth unemployment and improve national productivity. Additionally, this 25-year window captures multiple economic cycle periods of growth, recession, and recovery, thereby providing a robust temporal frame to examine the dynamic relationships between polytechnic expansion, economic growth, and unemployment. Importantly, comprehensive and reliable data on polytechnic numbers, GDP, unemployment, and growth rates also became more consistently available from 1999 onward through national databases and reports, ensuring empirical accuracy and consistency in the analysis. This time frame is thus both policy-informative and data-driven, making it suitable for capturing long-run trends and meaningful conclusions.

2.2. Method of data analysis

A large number of macroeconomic variables often exhibit non-stationarity in real-world scenarios. When the mean and variance of a time series dataset remain unchanged throughout the observed period, the dataset is considered stationary. This is an important statistical characteristic. If a time series exhibits particular characteristics, it is deemed stationary. However, if a time series' variance and mean change over time and its covariance between two time periods depends on the specific interval between them rather than on the absolute time, then it is said to be non-stationary. The fact that the dataset's properties are changing over time makes it practically non-stationary.

Several statistical methods are used to thoroughly evaluate a time series dataset's stationarity. Additionally, the Augmented Dickey-Fuller (ADF) test is a commonly used instrument for this purpose. There are numerous tests available for determining stationarity, including the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, the Phillips-Perron test, and modified variants of the Phillips-Perron test. In this study, the stationarity of the data collected for analysis will be evaluated using the ADF test. The purpose of this test is to investigate the null hypothesis, which claims that the unit root of the time series data indicates non-stationarity. Using the ADF test on the dataset, the study's goal is to ascertain whether the significant variables stay constant over the allotted time. Examining stationarity is essential to ensuring the caliber and reliability of subsequent time series analyses and to providing a solid foundation for the in-depth study of the relationship between polytechnic education expansion, economic growth and unemployment in Nigeria.

2.2.1. The augmented dickey-fuller (ADF) test

In time series analysis, the ADF test is a crucial instrument for identifying the presence of a unit root when analyzing economic variables across time. A unit root indicates non-stationarity [15], which means that the variance and mean of the time series data are not constant across the observed period. The Augmented Dickey-Fuller statistic, denoted as:

$$\Delta y_t = \rho \Delta y_{(t-1)} + \partial + \varepsilon_t \quad (1)$$

where Δy_t represents the first difference of the time series variable, ρ symbolizes the coefficient on the lagged first difference, ∂ is the intercept term, and ε_t is the white noise error term.

The null hypothesis (H_0) of the ADF test states that there is a unit root, which would imply non-stationarity. The greater the null hypothesis is rejected at a particular confidence level, the more negative the Augmented Dickey-Fuller statistic is. This is by the maxim that a larger negative statistic suggests a stronger argument disputing the existence of a unit root. The Augmented Dickey-Fuller test with an intercept term is used in the conventional method. If the test statistic falls below the critical values of a selected significance level, the null hypothesis (H_0: No unit root) must be rejected. After calculating the initial difference and creating a stationary time series, the process is repeated if the null hypothesis is not rejected. The order of integration, or the number of unit roots, can be inferred from the amount of differencing required to reject the null hypothesis. This procedure guarantees a strong assessment of stationarity, enabling later analyses to be built upon a stable base of dependable and stationary time series data.

2.2.2. Cointegration test

One of the fundamental concepts of time series analysis is cointegration, which studies stationary linear combinations of integrated variables. Given that it suggests the existence of a long-term equilibrium and a shared stochastic trend for the variables under study, this scientific approach is extremely important. When the dynamics of the short- and long-term relationships between variables are determined by a cointegration study, long-term forecasts are more accurate.

The two widely accepted techniques for carrying out cointegration analysis are the Engle-Granger technique and the Johansen-Juselius methodology. When the variables of interest have the same order of integration, these methods become significant.

The Engle-Granger technique was developed by Engle and Granger [16] and is especially useful when the variables show distinct orders of integration. Regression analysis is required once the variables have been differenced into stationary series to build a cointegrating connection. On the other hand, the current study examined the long-term correlations among variables using the Autoregressive Distributed Lag (ARDL) approach. The variables were integrated into two orders, I(1) and I(0), which validate this decision. The ARDL approach, which is a reliable tool for cointegration analysis and can handle variables with different orders of integration, was made famous by Narayan [17].

The ARDL model can be expressed mathematically as follows:

$$\Delta y_t = \alpha + \beta_1 \Delta y_{t-1} + \beta_2 \Delta x_{t-1} + \cdots + \beta_k \Delta x_{t-k} + \varepsilon_t \quad (2)$$

where Δy_t and Δx_t represent the first differences of the variables under consideration, α is the intercept term, $\beta_1, \beta_2, \cdots, \beta_k$, are the coefficients, and ε_t is the white noise error term.

Utilizing the ARDL methodology, the research guarantees an exhaustive investigation of the enduring associations among variables, providing a sturdy basis for well-informed evaluations and projections.

2.2.3. The autoregressive distributed lag (ARDL) cointegration approach

It is important to ensure that the errors match the characteristics of white noise while estimating the ARDL model. A selection criterion, such as the Schwarz Bayesian Criterion, Akaike Information Criterion (AIC), or Final Prediction Error, is used to determine the optimal lag duration (p). These conditions aid in improving the model's accuracy by selecting a lag time that minimizes bias or information loss.

White noise is a time-series sequence with independently distributed random variables with a constant mean and variance. For the ARDL model to be reliable, the errors must exhibit white noise characteristics.

After determining the proper lag length (p), the ARDL model is developed and calculated. The ARDL $(m, n; p)$ model with p exogenous variables can be represented in the following generalized form:

$$\Delta y_t = \alpha + \beta_1 \Delta y_{t-1} + \beta_2 \Delta x_{t-1} + \cdots + \beta_m \Delta y_{t-m} + \gamma_1 \Delta x_{1,t-1} + \gamma_2 \Delta x_{2,t-1} + \cdots + \gamma_n \Delta x_{n,t-n} + \varepsilon_t \quad (3)$$

where Δy_t and Δx_t denote the first differences of the dependent and exogenous variables, respectively. The model includes lagged terms for both the dependent and exogenous variables (m and n lag lengths, respectively). The coefficients, $\alpha, \beta_1, \beta_2, \cdots, \beta_m, \gamma_1, \gamma_{2,\cdots,}\gamma_{n,}$ capture the impact of past values on the current changes, and ε_t represents the white noise error term.

The study ensures a dependable and precise representation of the long-term interactions between variables within the framework of polytechnic education expansion, economic growth, and unemployment in Nigeria by implementing the generalized ARDL model and precise lag length selection criteria.

3. Result and discussion

3.1. Result

The result presented in **Table 1** shows that between 1999 and 2023, Nigeria experienced notable trends in polytechnic expansion, economic growth, and unemployment. The NP averaged 103.4, ranging from 35 to 146, with a standard deviation of 32.71, indicating moderate variability and substantial growth over the period. The data showed a negative skewness (−0.32) and kurtosis (−0.92), suggesting a stable expansion with fewer outliers.

Table 1. Descriptive statistics of the number of polytechnics (NP), gross domestic product (GDP), GDP growth rate (GDPGR), and unemployment rate (UNER) from 1999–2023.

Variable	Mean	StDev	Minimum	Median	Maximum	Skewness	Kurtosis
NP	103.4	32.71	35.00	105.00	146.00	−0.32	−0.92
UNER (%)	4.25	0.74	3.70	3.84	6.00	1.49	0.92
GDP ($) B	324.60	160.70	59.40	375.80	574.20	−0.45	−1.15
GDPGR (%)	4.86	3.67	−1.79	5.31	15.33	0.51	1.64

Source: Researchers Analysis (2024).

The Unemployment Rate (UNER) averaged 4.25%, with low variability (SD = 0.74%), though skewness (1.49) suggested occasional spikes, reaching up to 6.00%. GDP averaged $324.60 billion, showing steady growth (SD = $160.70 billion), while the GDP Growth Rate averaged 4.86% (SD = 3.67%), with occasional high-growth years. These trends highlight the interplay between education expansion and economic outcomes, underscoring the need for integrated policies to enhance labor market relevance and reduce unemployment.

Table 2. Normality test of the number of polytechnics (NP), gross domestic product (GDP), GDP growth rate (GDPGR), and unemployment rate (UNER).

Variable	Anderson-Darling (A-D) Statistic (*p*-value)	Log transformation Anderson-Darling (A-D) Statistic
NP	0.37 (0.39)	0.63 (0.09)
UNER (%)	3.10 (< 0.005)	0.73 (0.05)
GDP ($) B	0.86 (0.02)	0.79 (0.05)
GDPGR (%)	0.38 (0.37)	0.46 (0.06)

The normality test results in **Table 2** reveal that the original distributions of several variables deviate significantly from normality, as indicated by low p-values in the Anderson-Darling (A-D) test. For instance, the UNER (A-D: 3.10, $p < 0.005$) exhibits significant non-normality. Similarly, GDP shows slight non-normality (A-D: 0.86, $p = 0.02$). However, log transformation improves the normality of these variables, as evidenced by their transformed A-D statistics and p-values approaching significance thresholds. For example, the log-transformed UNER (A-D: 0.73, $p = 0.05$) and GDP (A-D: 0.79, $p = 0.05$) demonstrate near-normal distributions. Variables like the NP and GDPGR already exhibit approximate normality in their original form, with A-D statistics of 0.37 ($p = 0.39$) and 0.38 ($p = 0.37$), respectively, but log transformation further enhances their distributions. These results suggest that log transformation is an effective method for mitigating non-normality, facilitating the application of parametric statistical techniques to these data.

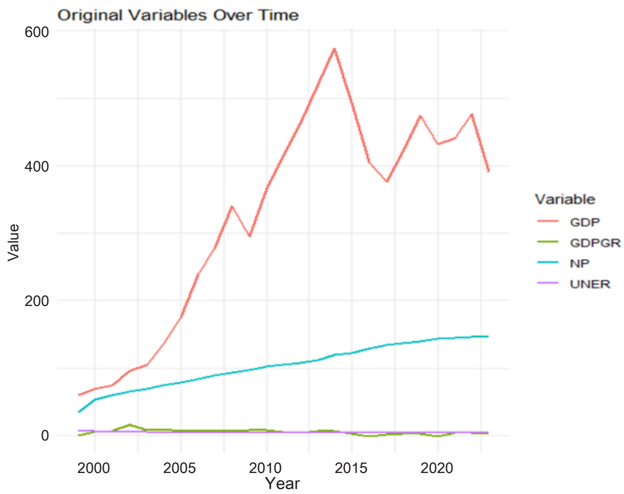

Figure 1. Trends of GDP, GDP growth rate, number of polytechnics, and unemployment rate in Nigeria (1999–2023).

Figure 1 shows the temporal dynamics of key macroeconomic and educational indicators in Nigeria from 1999 to 2023. The red line representing GDP shows a strong upward trend until around 2014, followed by noticeable fluctuations and a mild decline after 2016, reflecting Nigeria's economic instability likely driven by oil price shocks and other macroeconomic disruptions. The Number of Polytechnics (NP), in cyan, shows a steady linear increase, indicating sustained efforts by the Nigerian government to expand technical and vocational education infrastructure. However, the GDP Growth Rate (GDPGR), shown in green, exhibits high volatility, with sharp peaks and troughs suggesting periods of rapid expansion followed by economic contractions. The relatively flat purple line representing the Unemployment Rate (UNER) implies only marginal variation over the period, despite the expansion in polytechnics, hinting that the increase in educational institutions alone may not be sufficient to significantly lower unemployment. These observations underline the importance of not only expanding access to education but also ensuring curriculum relevance and economic alignment to improve employment outcomes and economic resilience.

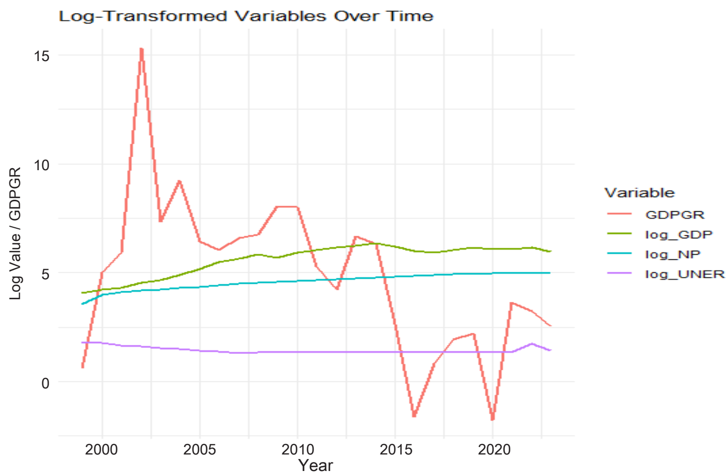

Figure 2. Log-transformed trends of polytechnic expansion, economic indicators, and growth rate in Nigeria (1999–2023).

Figure 2 illustrates the log-transformed trajectories of key variables: log(GDP), log(NP), log(UNER), and the untransformed GDP Growth Rate (GDPGR) to stabilize variance and better assess long-term relationships. The log(GDP) and log(NP) curves demonstrate steady upward movements, reflecting consistent growth in national output and expansion in polytechnic institutions. This visual suggests a potential alignment between infrastructure development in education and economic capacity. In contrast, log(UNER) shows a relatively flat and slightly declining trend, indicating minimal change in unemployment despite these expansions. The GDPGR line, remaining untransformed due to its already bounded nature, exhibits high volatility with sharp peaks and troughs, underscoring persistent macroeconomic instability. These contrasting patterns imply that while investment in polytechnics and economic expansion have progressed, they may not have sufficiently translated into reduced unemployment or stable economic growth, highlighting the need for policies that bridge education with employability and economic resilience.

3.1.1. Testing the variables for stationarity

A stationary process is one whose statistical properties, such as mean, variance, and autocorrelation, remain constant over time. To assess stationarity in this study, the ADF test was employed.

Table 3. Result of augmented dickey-fuller unit root test for the variables.

Variables	Level		1st Difference		2nd Difference		Order of integration
	No Trend	With Trend	No Trend	With Trend	No Trend	With Trend	
NP	−6.0078	−9.1665	-	-	-	-	I(0)
UNER (%)	−2.7125	−0.3345	−6.3466	−9.3031	-	-	I(1)
GDP ($) B	−3.1072	−0.4608	−2.8599	−4.1676	-	-	I(1)
GDPGR (%)	−3.0382	−5.0275	-	-	-	-	I(0)
Critical values							
5%	−2.9919	−3.6122	−2.9981	−3.6220	-	-	

The results, shown in **Table 3**, indicate that while some variables are stationary at level (I(0)), others become stationary only after first differencing (I(1)). Specifically, the NP and GDPGR are stationary at level, whereas the UNER and GDP are non-stationary at level but stationary after first differencing. This finding implies that regression analysis using undifferentiated non-stationary variables may lead to spurious results. The presence of mixed integration orders justifies the use of the ARDL model, which is robust in handling both I(0) and I(1) variables, enabling simultaneous estimation of short-run and long-run dynamics. The bounds-testing approach within ARDL provides a robust framework for testing Cointegration, even in small samples.

3.1.2. Co-integration test of the macroeconomic variables

Table 3 presents the results of the differencing procedure, revealing that while some variables were stationary at level (I(0)), others became stationary only after the first differencing (I(1)). This step was crucial to prevent spurious regression and enhance the reliability of subsequent analyses. Differencing aligns with best practices in time series analysis, as it addresses non-stationarity in the original data, ensuring its suitability for further examination. This approach is particularly relevant when assessing Cointegration, which determines whether variables share a long-term relationship. Given the mixed order of integration (I(0) and I(1)) observed in this study, the ARDL method is the most appropriate analytical framework. ARDL is effective in evaluating both short- and long-term relationships among variables with varying integration orders. Its lag selection process, guided by information criteria, ensures an optimal lag structure that accurately captures the dynamics between variables. Following this, **Table 4** presents the results of the cointegration trace test for variables such as NP, GDP, and GDPGR, which will determine the presence of sustained relationships among them.

Table 4. Result of test for the existence of level relationship amongst the variables in the ARDL.

Number of regressors	Value of statistic $K = 3$
Computed F-statistic	15.84
5% critical value	
Lower bound value	2.87
Upper bound value	4.00

The critical bound values were extracted from [18].

Table 4 presents the results of the bounds test for cointegration within the ARDL framework, which evaluates the existence of a level relationship among the variables. The computed F statistic is 15.84, which exceeds the upper bound critical value of 4.00 at the 5% significance level. According to Pesaran et al. [18], this result confirms rejecting the null hypothesis of no cointegration, establishing a long-run relationship among the variables. Hence, there exists a statistically significant long-run relationship among the variables in the ARDL model. This means that polytechnic expansion and other macroeconomic indicators have a long-run equilibrium association with GDP growth in Nigeria. The result underscores the suitability of the ARDL model for further analysis, as it demonstrates that the variables maintain a stable and statistically significant long-term equilibrium relationship despite their mixed integration orders (I(0) and I(1)). This finding is pivotal for exploring the dynamics of the relationships among the variables in subsequent analyses.

Table 5 presents the results of optimal lag length combinations for the Autoregressive Distributed Lag (ARDL) model based on the AIC. The combinations vary across the number of lags included for each variable: GDPGR (dependent variable), log-transformed Number of Polytechnics (log_NP), log-transformed GDP (log_GDP), and log-transformed Unemployment Rate (log_UNER). The first row in the table, with 3 lags for all variables, yields the lowest AIC value (72.62833), indicating the best model fit among the alternatives. This implies that the model with lag order ARDL(3,3,3,3) is optimal for analyzing the long-run and short-run dynamics between polytechnic expansion, GDP, unemployment, and economic growth. Subsequent models with higher AIC values are progressively less suitable for capturing these relationships.

Table 5. Optimal lag length selection results for the ARDL model using Akaike information criterion (AIC).

	GDPGR	log_NP	log_GDP	log_UNER	AIC
1	3	3	3	3	72.62833
2	2	3	1	2	100.8641
3	1	3	0	0	100.953
4	2	3	1	3	101.7082
5	2	3	0	2	102.0419
6	2	3	2	2	102.6244
7	1	2	0	0	108.141
8	1	2	0	1	108.7884
9	2	2	2	2	109.6378
10	1	2	1	1	110.6517
11	1	1	1	1	117.0627

Table 6. Estimated long-run coefficients.

Variable	Estimate	Std. Error	*t* value	Pr(>|*t*|)
(Intercept)	−82.2261	23.5278	−3.4950	0.0030
L(GDPGR, 1)	1.2008	0.2621	4.5820	0.0003
L(log(NP), 1)	28.1219	7.2627	3.8720	0.0014
L(log(GDP), 1)	−7.5355	3.3597	−2.2430	0.0394
L(log(UNER), 1)	−9.9056	8.2044	−1.2070	0.2448
d_log_NP	45.0277	11.7810	3.8220	0.0015
d_log_GDP	3.7064	5.0100	0.7400	0.4701
d_log_UNER	2.5802	6.7909	0.3800	0.7090

Source: Authors Analysis (2024).

The result in **Table 6** presents the estimated long-run and short-run coefficients from the ARDL model examining the relationship between economic growth (GDPGR) and its predictors: the Number of Polytechnics (log_NP), GDP (log_GDP), and Unemployment Rate (log_UNER).

In the long-run component, L(GDPGR, 1) has a positive and significant coefficient (1.2008, $p = 0.0003$), indicating strong persistence in GDP growth—past growth influences current growth positively; L(log(NP), 1) is positively significant (28.1219, $p = 0.0014$), suggesting that expansion in polytechnics contributes significantly to long-run economic growth, likely through increased technical skill development and job creation; L(log(GDP), 1) is negative and statistically significant (−7.5355, $p = 0.0394$), which is counterintuitive. This may reflect diminishing returns to output over time or structural inefficiencies in translating GDP growth to economic benefits; and L(log(UNER), 1) is negative but not statistically significant (−9.9056, $p = 0.2448$), implying that while higher unemployment tends to reduce economic growth, the effect is not robust in the long run within this model.

In the short-run component (differenced variables), d_log_NP is positive and significant (45.0277, $p = 0.0015$), reinforcing that short-term increases in polytechnic institutions stimulate economic activity, and d_log_GDP and d_log_UNER are both insignificant, suggesting a limited immediate impact of short-run changes in GDP and unemployment on current growth dynamics.

These findings reinforce the critical role of polytechnic expansion in promoting economic growth in both the short and long run. The results provide empirical support for government policies focused on expanding technical and vocational education. Conversely, the negative long-run impact of GDP may suggest structural issues in translating macroeconomic growth into widespread development. The results also imply that reducing unemployment, while theoretically beneficial, must be coupled with education and productivity-enhancing policies to yield significant growth outcomes.

The estimated long-run cointegration equation from the ARDL model (based on **Table 6**) expresses the long-run equilibrium relationship between GDP Growth Rate (GDPGR) and the log-transformed explanatory variables: Number of Polytechnics (NP), Gross Domestic Product (GDP), and Unemployment Rate (UNER). The general form is:

$$GDPGR_t = -82.2261 + 28.1219 \cdot log(NP)_t - 7.5355 \cdot log(GDP)_t - 9.9056 \cdot log(UNER)_t + \varepsilon_t \quad (4)$$

This cointegration equation in Equation (4) affirms that polytechnic expansion plays a positive role in fostering long-term economic growth in Nigeria, reinforcing the importance of technical education investment for sustainable development.

$$\text{Cointeq} = \text{LOG\_GDP} - (0.1177*\text{LOG\_GDPGR} + 50.0646*\text{LOG\_NP} - 30.5175*\text{LOG\_NFP} + 7.7420*\text{LOG\_NSP} - 36.4520*\text{LOG\_NPP} + 8.2229*\text{LOG\_UNER}) \quad (5)$$

Table 7. Error correction representation of the selected ARDL model.

Variable	Coefficient	Std. Error	*t*-Statistic	*p*-Value
D(GDPGR_1)	−0.6004	0.1	−6.00	0.000
D(log_NP)	−98.6803	10.5	−9.40	0.000
D(log_NP_1)	5.1116	2.3	2.22	0.038
D(log_GDP)	−4.2288	1.8	−2.35	0.028
D(log_GDP_1)	7.839	2.1	3.73	0.002
D(log_UNER)	8.8272	3.2	2.76	0.012
D(log_UNER_1)	0.7064	1.9	0.37	0.715
ECT(−1)	−0.4819	0.2039	−2.36	0.0457

Source: Authors Analysis (2024).

Table 7 presents the short-run dynamics and the speed of adjustment from disequilibrium to long-run equilibrium based on the selected ARDL model. The error correction term (ECT) captures the rate at which deviations from the long-run equilibrium are corrected in subsequent periods. $ECT(-1) = -0.4819$ and is statistically significant ($p = 0.0457$); this implies that 48.2% of the disequilibrium from the previous year's deviation from long-run equilibrium is corrected in the current year. The negative and significant coefficient confirms the existence of a valid long-run relationship (cointegration) among the variables. The system converges back to equilibrium relatively quickly, within about two years.

Short-run dynamics found that $D(GDPGR\_1)$ is negative and highly significant ($\beta = -0.6004$, $p < 0.001$), indicating strong autoregressive behavior in previous growth negatively affects current growth, possibly due to correction for overshooting. *D(log_NP)* is negative and highly significant ($\beta = -98.6803$, $p < 0.001$), suggesting that an immediate increase in polytechnic institutions may temporarily disrupt GDP growth, likely due to adjustment costs or delayed productivity impacts. $D(log\_NP\_1)$ is positive and significant ($\beta = 5.1116$, $p = 0.038$), indicating that the positive impact of polytechnic expansion materializes with a lag. $D(log\_GDP)$ is negative and significant ($\beta = -4.2288$, p = 0.028), while its lag, $D(log\_GDP\_1)$, is positive and highly significant ($\beta = 7.839$, $p = 0.002$), suggesting an oscillating effect of GDP on growth, possibly due to cyclical investment-output responses. While $D(log\_UNER)$ is positive and significant ($\beta = 8.8272$, $p = 0.012$), which is somewhat counterintuitive, possibly indicating that in the short term, efforts to reduce unemployment may not immediately translate to growth. $D(log\_UNER\_1)$ is insignificant ($p = 0.715$), implying limited lasting short-term influence.

The Error Correction Model (ECM) equation is expressed as:

$$\Delta GDPGR_t = -0.6004\Delta GDPGR_{t-1} - 98.6803\Delta log(NP)_t + 5.1116\Delta log(NP)_{t-1} - 4.2288\Delta log(GDP)_{t-1} + 7.8390\Delta log(GDP)_{t-1} + 8.8272\Delta log(UNER)_{t-1} + 0.7064\Delta log(UNER)_{t-1} - 0.4819 \cdot ECT_{t-1} + \varepsilon_{t-1} \quad (6)$$

Based on the result, the study infers that the presence of a significant and negative ECT confirms a stable cointegration relationship among economic growth, polytechnic expansion, unemployment, and GDP, suggesting these variables move together in the long run. The findings imply that while the short-run effects of polytechnic expansion might be volatile or delayed, long-term impacts are growth-enhancing. Thus, policy strategies should be consistent and sustained, recognizing that the benefits of polytechnic investment manifest over time. The results also highlight the importance of macroeconomic coordination, as GDP and unemployment show complex, lagged impacts on growth.

Figure 3 illustrates the comparative performance of the ARDL model in tracking Nigeria's GDP Growth Rate over time. The actual GDP growth (blue line) closely mirrors the fitted values from the model (green line), suggesting that the model effectively captures the dynamics of economic growth across the observed period. The residuals (red dashed line), representing the difference between actual and fitted values, fluctuate around zero and remain relatively small, indicating that the model's prediction errors are minimal and randomly distributed—an important sign of model adequacy and the absence of systematic bias. The consistency between the actual and fitted curves implies the ARDL model is suitable for explaining short- and long-run influences of polytechnic expansion, GDP, and the Unemployment Rate on economic growth. These results reinforce the model's validity for policy simulation and forecasting within the Nigerian macroeconomic context.

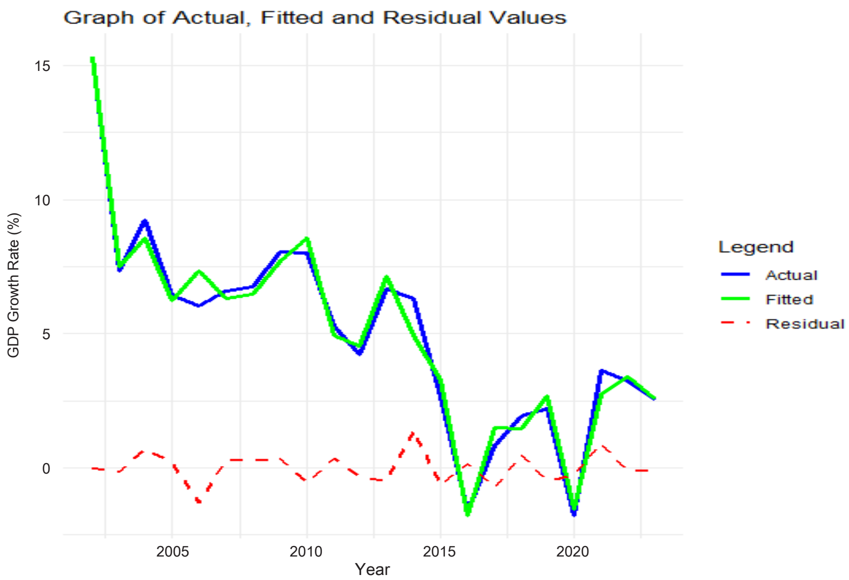

Figure 3. Graph of the actual, fitted, and residual.

The recursive CUSUM test plot in **Figure 4** assesses the structural stability of the estimated model parameters over time. The black line represents the cumulative sum of residuals, while the red lines denote the 5% significance boundaries. Since the CUSUM line remains within the upper and lower bounds throughout the sample period, the null hypothesis of parameter stability cannot be rejected. This indicates that the regression coefficients are stable over time, and there is no structural break in the underlying model. Consequently, the ARDL model used in the analysis is robust and reliable for policy inference and forecasting within the study period. This finding strengthens the validity of conclusions drawn from the model about the long-run and short-run impacts of polytechnic expansion and macroeconomic variables on Nigeria's economic growth.

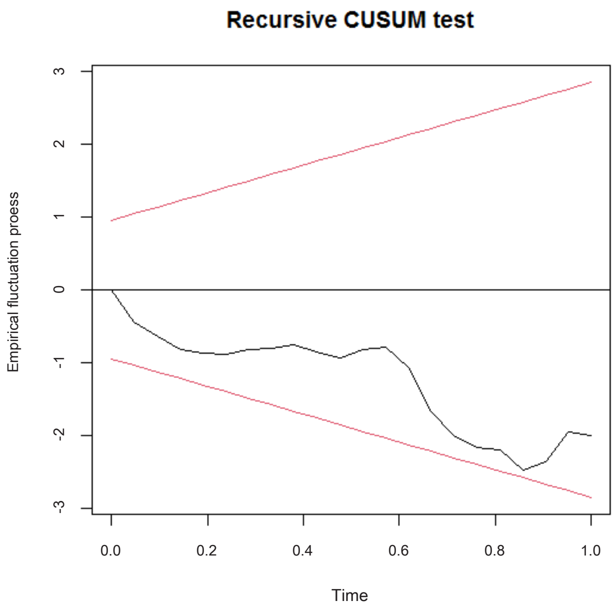

Figure 4. Recursive CUSUM test for stability of model parameters.

The Granger causality results in **Table 8** reveal several important dynamics. Notably, the Number of Polytechnics (NP) significantly Granger causes the GDPGR with a p-value of 0.0019, suggesting that past values of polytechnic expansion help predict future economic growth. This supports the argument that technical and vocational education contributes meaningfully to Nigeria's economic performance. Additionally, the UNER Granger causes both GDP and GDPGR, indicating that fluctuations in unemployment can forecast macroeconomic outcomes, likely due to labor market effects on productivity and output. However, there is no evidence that NP Granger causes GDP directly or that GDPGR Granger causes GDP, suggesting that the relationship between education expansion and output growth is more indirect, possibly mediated by labor dynamics or skills deployment. These findings underscore the strategic importance of education policy, particularly polytechnic education, as a tool for driving growth and reducing unemployment in Nigeria.

Table 8. Summary of granger causality test results (1999–2023).

Hypothesis Tested (Does X Granger-cause Y?)	F-Statistic	*p*-Value	Decision at 5% Level
NP → GDP	0.4566	0.6406	No Granger causality
GDPGR → GDP	0.0815	0.9221	No Granger causality
UNER → GDP	4.4884	0.0262	Yes, Granger causality exists
UNER → GDPGR	4.3398	0.0290	Yes, Granger causality exists
UNER → NP	1.7166	0.2078	No Granger causality
NP → GDPGR	9.014	0.0019	Yes, Granger causality exists

3.2. Discussion of findings

The results of the study affirm the long-held assumption in policy and academic circles that polytechnic education plays a pivotal role in influencing economic growth. The descriptive statistics revealed that from 1999 to 2023, the Number of Polytechnics in Nigeria increased substantially, reflecting government efforts to expand technical and vocational education. However, this expansion occurred alongside relatively stagnant unemployment levels, highlighting a persistent disconnect between education output and labor market absorption, an issue echoed in the studies by Ojo [12] and Adelusi and Adelusi [13], who criticized misalignment between curricula and industry needs.

The stationarity and cointegration analysis justified the use of the ARDL model, which revealed a significant long-run relationship between polytechnic expansion (log_NP) and GDP Growth Rate (GDPGR). Specifically, the positive and statistically significant coefficient of log_NP suggests that increasing the Number of Polytechnics contributes positively to economic growth in the long run. This aligns with Bukar and Timothy [8] findings on the economic empowerment of polytechnic graduates through entrepreneurship education. The short-run dynamics, however, reveal some complexities. The immediate negative impact of changes in log_NP on GDPGR suggests that the benefits of expansion are not instantaneous, possibly due to adjustment costs or implementation lags, as observed by Tan [6] in the Singaporean context. Interestingly, the lagged positive effect confirms that such investments pay off over time, reinforcing the value of long-term policy consistency.

The presence of a significant and negative error correction term in the ARDL model implies a stable long-run equilibrium exists between GDP growth and the predictors. This validates the structural stability of the model, as further confirmed by the CUSUM test, and provides policymakers with confidence in the robustness of these findings for use in long-term planning.

Granger causality tests further deepen the understanding of these linkages. The Number of Polytechnics Granger causes GDP growth but not GDP directly, suggesting that the influence of polytechnic expansion on output growth is mediated, likely through skill development and labor productivity an interpretation consistent with the work of Realinho et al. [9] and Sadrina et al. [10]. Unemployment also Granger causes GDP and GDPGR, implying that changes in labor market conditions have predictive power over economic performance. These findings reinforce the importance of labor market-responsive education systems, especially technical and vocational training.

Despite the increasing Number of Polytechnics and growing GDP, the limited reduction in Unemployment Rates observed suggests challenges with the absorptive capacity of the labor market. This is consistent with Akor et al. [11], who pointed to structural barriers such as gender disparities and poor female representation in technical fields. Moreover, as Realinho et al. [9] noted, dropout rates and completion challenges may further dilute the intended benefits of education expansion, calling for improved program delivery and support systems.

In summary, the study confirms that polytechnic education is a vital engine for economic growth in Nigeria, but its full potential can only be realized when expansion is matched by policies that enhance quality, relevance, and employability. To this end, institutions such as the NBTE, the Ministry of Education, and the Ministry of Labor and Employment should leverage these findings to refine strategic interventions that integrate curriculum reform, industry collaboration, and targeted funding mechanisms. Long-term investments in technical education must go beyond infrastructure expansion to include pedagogical innovations and gender-sensitive programming that broaden access and deepen impact across the economy.

4. Conclusion

This study examined the nexus between polytechnic expansion, economic growth, and unemployment in Nigeria from 1999 to 2023. The findings of the study reveal that while the Number of Polytechnics grew steadily over the study period, unemployment levels remained relatively stagnant. Through the ARDL framework, a statistically significant long-run relationship was established between polytechnic expansion and GDP growth, highlighting the positive impact of technical and vocational education on economic performance. However, short-run effects were mixed; initial expansions appeared to temporarily dampen growth before generating positive outcomes in subsequent periods. Granger causality tests further confirmed that polytechnic expansion predicts GDP growth, although the effect is indirect, likely operating through improved labor productivity and entrepreneurship development.

Despite these positive associations, the limited reduction in unemployment underscores persistent challenges in aligning educational output with labor market demands. These findings indicate that simply increasing the Number of Polytechnics is not sufficient to achieve inclusive economic growth; rather, targeted policy actions are needed to improve curriculum relevance, enhance institutional quality, and strengthen industry linkages.

Based on the findings of the study, the following recommendations were made:

i. The National Board for Technical Education and the Ministry of Education should collaborate with industry stakeholders to align polytechnic curricula with current labor market needs and emerging industries, including digital technology, green jobs, and manufacturing.

ii. Programs that integrate entrepreneurship, internships, and project-based learning into polytechnic education should be scaled up to foster practical skills and enhance job readiness.

iii. Federal and state governments should provide sustained financial support to polytechnics, particularly for infrastructure, instructional resources, and faculty development, ensuring equitable growth across regions.

iv. A national database tracking graduate outcomes, skills utilization, and employer feedback should be institutionalized to guide continuous policy refinement and ensure that polytechnic expansion translates into measurable economic benefits.

In conclusion, polytechnic education holds significant potential for advancing Nigeria's development goals. Realizing this potential requires a shift from expansion-focused policies to a more integrated and demand-driven technical education strategy that empowers graduates, enhances productivity, and sustainably reduces unemployment.

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