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Research Article

Modelling the Relationship Between Trade Openness, Macroeconomic Variables and Economic Growth in Ghana Using Ardl Models

Ebenezer Ayaaba*, Anuwoje Ida L. Abonongo

Department of Statistics and Actuarial Science, School of Mathematical Sciences, C. K. Tedam University of Technology and Applied Sciences, Navrongo, Ghana

Abstract

This study looked at the interconnections among trade openness, national income (GDP), investment, exchange rate, government spending, financial development and inflation in Ghana employing the autoregressive distributed lag (ARDL) model. The bounds cointegration, as applicable within the ARDL modelling was carried out to check the existence or otherwise of long run relationships among the economic variables while the error correction model (ECM) was also used to capture the short-term relationships among the variables. Unlike known previous studies in Ghana, this study made use of three trade openness proxies including ratio of imports plus exports to GDP (OPEN1), ratio of export to GDP (OPEN2) and the ratio of import to GDP (OPEN3). With GDP growth as endogenous variable, the bound co-integration analysis results showed that there exists co-integration among GDP, openness to trade and the macroeconomic variables included in the study. In this study, the short-run results found that openness to trade and government spending had significant positive effects on Ghana's GDP growth. However, investment, exchange rate and financial development were found to be impacting growth in GDP significantly but negatively. In the long term, trade openness and government spending again had positive influence on GDP growth whiles investment, real effective exchange rate and financial development still impacted GDP growth significantly and negatively at 5 percent significance level. This study recommends among others things that the government of Ghana should reduce trade barriers and streamline regulations in critical sectors to promote GDP growth in Ghana.

Keywords

Trade Openness, GDP Growth, Bounds Cointegration and Macroeconomic Variables

1. Introduction

Economists and policymakers have shown significant interest regarding how openness to trade and the growth of any economy are related. The growth of an economy is believed to be significantly impacted by trade openness, which is the degree of participation of a country in international trade [19, 39, 44]. This study focuses on Ghana, a developing nation that has implemented trade liberalization policies. Historically, Ghana's post-independence trade policies, such as exchange rate controls and import substitution, yielded limited economic growth [11]. In the

*Corresponding author: ayaabaebenezer23@gmail.com (Ebenezer Ayaaba)

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1980s, the Economic Recovery Programs (ERP) supported by the IMF and World Bank aimed to liberalize trade and improve economic performance [11], setting the stage for further investigation as regards how trade openness impacts the growth of the economy.

Classical economic theory posits that trade openness promotes economic expansion by reallocating resources and providing comparative advantages [45]. The success of East Asian countries, often referred to as the "East Asian Miracle," is frequently cited to illustrate the benefits of free trade and export-focused policies [42]. Empirical evidence on how growth is affected by trade openness in Ghana, however, is mixed. Some studies suggest that trade openness and economic growth have a positive relationship [25, 28, 30], while others suggest minimal or no impact on GDP growth [5, 8]. Despite this, global data from the [42] show that global GDP and trade have generally increased together over the past decade, suggesting a complex but potentially positive relationship.

In examining Ghana's economic performance, it is evident that both GDP growth and trade openness have fluctuated over the years. Ghana's average annual GDP growth from 1984 to 2018 was 5.49%, and during that time, trade openness significantly increased [42]. However, the correlation between these two factors remains inconclusive, necessitating further research. Additionally, several macroeconomic variables play crucial roles in driving GDP growth. For instance, investment is believed to be able to enhance productive capacity and foster technological advancement [14]; government spending on infrastructure, education, and health is argued to be stimulating economic activity [13]; inflation impacts consumption, investment, and savings behaviors [17]; the exchange rate influences trade competitiveness and overall economic performance [32]; and financial development is found to be enhancing resource allocation and credit access [23] among others.

This study employed bounds co-integration analysis and the ARDL model to study the connections among economic growth, macroeconomic variables, and trade openness in Ghana. Unlike known previous studies, this study uses three trade openness proxies including total trade to GDP ratio, export to GDP ratio and import to GDP ratio.

2. Literature Review

2.1. Theoretical Literature Review

Three viewpoints may be distinguished in the literature on the relationship between trade openness and economic development: Heckscher-Ohlin trade theory, classical economics, and mercantilism. Mercantilism views trade as a zero-sum game, promoting exports and protecting domestic industries [29, 34]. Classical economists, however, argue that nations should focus on comparative advantage, with trade driving economic growth [22]. The Heckscher-Ohlin theory explains trade patterns based on a country's resource endowments, where nations export goods produced with abundant resources, influencing income distribution. Samuelson in 1948 extended this by introducing factor-price equalization, and Stolper-Samuelson in 1941 showed how tariffs impact factor prices and income distribution.

2.2. Empirical Literature Review

In Ghana, [16] found that openness to trade and quality of institutions positively influenced GDP growth, though their interaction was insignificant, while exchange rates had mixed impacts. [28] found a positive link between growth and trade openness over the long run and [30] highlighted trade openness as the main promoter of GDP growth, with no significant effects from inflation or FDI. In a similar vein, [22] in Cote d'Ivoire discovered that capital formation strengthened the positive relationship between openness to trade and growth. In Nigeria, [33] found openness to trade to be positively impacting growth, though [29] found a negative impact of export trade on GDP growth. Regarding the impact of exchange rate on economic growth, [4] found no significant effect, while [1] found a small positive effect. Studies in Botswana and South Africa [24, 27] confirmed showed positive effects of trade openness on growth, particularly through exports. [41] highlighted the negative impact of openness and quality of institutions on growth in a broader global context. [21, 38] showed that, in the long term, openness to trade and growth have a positive relationship as did [15] in their study of 36 African countries. Conversely, [43] found that trade barriers were positively linked to growth in developing countries. In Kenya, [20] found a negative relationship between openness and growth, while [35] found a positive effects in his study of ECOWAS countries. Finally, studies in Malaysia [25] and Latin America [9] also found a positive impact of trade openness on growth, emphasizing the role of human capital, sound policies, and import-led growth.

3. Methodology

3.1. Data Type and Source

In order to investigate the complex and crucial dynamic relationship between Ghana's GDP growth, openness to trade, and other macroeconomic variables, this study employs a quantitative research design. All data are time series and are sourced from the World Development Indicators (WDI) data base covering the years 1980-2022.

Government expenditure (GSPEND), trade openness investment (INV) proxied by gross fixed capital formation, exchange rate (REER), GDP growth (GROWTH), inflation (CPI), and money supply (M2) as a proxying financial development are the variables included in this study. The use of three openness indicators (proxies), makes this study very innovative. The ratio imports plus exports to GDP is OPEN1, the ratio of export to GDP is OPEN2, and the ratio of import to GDP is OPEN3. These openness proxies were named in accordance with [24] in south Africa.

3.2. Stationarity Test

A key component of time series analysis is the stationarity test. The stationarity test aids in determining the type of process that creates the series as well as the order in which a time series integrates. Finding the right times series model for a given series requires knowing the sequence of integration in order to prevent fitting models that produce erroneous results. For example, a set of time series that are initially not stationary but become so after several differencing can be subjected to co-integration analysis. If the mean, variance, and covariance of a time series are all time invariant, then same series is considered as being weakly/covariance stationary (does not show unit roots).

3.2.1. Augmented Dickey-Fuller Test

The ADF test checks if a time series is stationary by considering the null hypothesis that the series has a unit root (non-stationarity). The differenced series is estimated via the autoregressive model using a lagged level and lagged difference. The test statistic is assessed against critical values by comparing the coefficient of the lagged differenced series with its standard error. The null hypothesis is rejected, demonstrating stationarity, should the test statistic be greater than the critical value or if the associated probability value is less than the chosen significance level (e.g., 0.05). The test involves estimating the autoregressive (AR) model;

$$\Delta Y_t = \rho Y_{t-1} + \varphi \Delta Y_{t-1} + e_t, \tag{1}$$

where ΔY_t represents the differenced series (i.e., the first difference of the original series Y_t), the coefficient of the variable's lag level is denoted by ρ and e_t is the error term.

The test statistic is also given as;

$$ADF = \frac{\varphi}{SE(\varphi)}, \tag{2}$$

where φ is the coefficient of the lagged differenced series ΔY_{t-1} and the standard error of the coefficient of ΔY_{t-1} is denoted by SE(φ).

3.2.2. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

In the KPSS test, the alternative hypothesis of non-stationarity is compared with the null hypothesis that a time series is stationary around a deterministic trend. The test statistic is calculated by taking the total of squared deviations from the estimated trend and normalizing it by the stationary component's long-run variance. If the test statistic exceeds the critical value or the p-value falls below the selected significance level the null hypothesis is rejected implying non-stationarity of the series.

The KPSS test statistic is given as:

$$KPSS = \frac{1}{T^2} \sum_{t=1}^{T} S_t^2 / \hat{\sigma}^2, \tag{3}$$

where T is the number of time series observations, $\hat{\sigma}^2$ is an estimate of the stationary component's long-run variance, and S_t is the cumulative residuals.

3.2.3. Phillips-Perron (PP) Test

The PP test, like the ADF test, looks for non-stationarity but takes autocorrelation in the error terms into consideration. The differenced series is regressed on its lagged values, and a test statistic is computed using the estimated coefficient and standard error. The null hypothesis of non-stationarity is rejected, indicating stationarity, if the computed test statistic is greater than the critical values. The PP test's corresponding regression equation is provided as

$$\Delta Y_t = \alpha + \beta Y_{t-1} + e_t, \tag{4}$$

where β is the coefficient on the lagged value of the series, α is the intercept term, and ΔY_t is the differenced series. The PP test's equivalent test statistic is given as:

$$t = \frac{\hat{\beta}}{SE(\hat{\beta})}, \tag{5}$$

where t represents the test statistic, $\hat{\beta}$ represents the estimated coefficient, and $SE(\hat{\beta})$ represents the estimated coefficient's standard error.

3.3. Bounds Cointegration

To determine if co-integration exists between time series variables of mixed integration orders (I(0) and I(1)), the ARDL bounds test is used. This test compares the restricted and unrestricted model residuals, selects appropriate lag lengths using criteria such as AIC or SIC, estimates the model, and then uses F-statistics or t-statistics to test the null hypothesis of no cointegration. Critical values, which vary depending on sample size, guide the interpretation: if the test statistic is above the upper bound, cointegration is confirmed; if it is below the lower bound, no cointegration exists. The test statistic associated with the bounds cointegration test is given below:

$$F = \frac{(RSS_0 - RSS_1)/q}{RSS_1/(T-K)}, \tag{6}$$

where RSS_0 is the sum of squares for the residuals from the restricted ARDL model (with no cointegrating relationship), RSS_1 is the sum of squares residuals from the unrestricted ARDL model (with at least one cointegrating relationship), q is the number of restrictions (difference in the number of parameters between the restricted and unrestricted models), T is the total number of observations and K is the total number of parameters estimated in the unrestricted ARDL model.

3.4. The Autoregressive Distributed Lag (ARDL) Model

When time series variables are likely to have different integration orders, particularly I(0) and I(1), the ARDL model is appropriate in examining both their short term and long term dynamics. This study uses this model to determine how openness to trade, GDP growth, investment, exchange rates, government spending, inflation, and financial sector development are related. A key merit of the ARDL model is that it minimizes endogeneity problems. Since each variable can be treated as endogenous, the model avoids residual correlation and ensures a more robust analysis. Furthermore, the ARDL technique effectively distinguishes between endogenous and exogenous variables, assuming a single long run relationship exists between them.

The model's ability to identify cointegrating vectors, even in cases where multiple cointegrating relationships are present, is one of its strengths. Additionally, the ARDL model seamlessly integrates both short-term and long-term dynamics, allowing for a detailed understanding of the data-generating process.

As per [37], the general form of the ARDL model is given as follows:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \cdots + \beta_p Y_{t-p} + \alpha_0 X_t + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \cdots + \alpha_q X_{t-q} + e_t, \quad (7)$$

where Y_t is the dependent variable with $Y_{t-i}, \dots, Y_{t-p}$ as the its lags up to lag order p, β_0 is the model intercept, β_i for $i = 1, 2, \dots, p$ are the coefficients of the p lags of the dependent variable, X_t is the exogenous or independent variable with α_0 as its intercept and α_j for $j = 1, 2, \dots, q$ are the coefficients of the q lags of the independent variable.

3.5. The Error Correction Model (ECM)

Derived from the ARDL model, the Error Correction Model (ECM) maintains the long-term equilibrium while accounting for short-term deviations. The conventional error correction model (ECM) is given in equation (8) below;

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + \sum_{j=0}^{q_1} \gamma_j \Delta X_{1t-j} \sum_{k=0}^{q_2} \sigma_k \Delta X_{2t-k} + \varphi Z_{t-1} + e_t, \quad (8)$$

where ΔY_t represents the differenced values of the endogenous variable, β_0 denotes the constant term of the model, β_i, for $i = 1, 2, \dots, p$ are the short term coefficients of the lagged values of the endogenous variable, γ_j, for $i = 1, 2, \dots, q_1$ are the short term coefficients of the lags of the first exogenous variable X_{1t}, φ is the adjustment parameter, Z_{t-1} is the error correction term and δ_k for $k = 1, 2, \dots, q_2$ are the short term coefficients of the lags of the second independent variable X_{2t}

The ECM is employed in this context to estimate the impact of openness, investment, exchange rates, government spending, inflation, and financial development on GDP growth in Ghana. The model follows the general specification laid out by [26], with additional trade-based indicators included based on the work of [43] to provide a more comprehensive view of trade openness. The ECM is a very crucial tool for comprehending the connection between these variables and GDP growth since it integrates both short-term and long-term dynamics.

3.6. Empirical Models Specification

In this study, the initial empirical model with GROWTH as dependent variable is specified as:

$$GROWTH = \alpha_0 + \gamma T_t + \beta_1 OPENPROXY + \beta_2 INV + \beta_3 REER + \beta_4 GSPEND + \beta_5 CPI + \beta_6 M_2 + e_t, \quad (9)$$

where GROWTH is the GDP growth, OPENPROXY is the proxy of openness under consideration, INV is investment, GSPEND is the government spending, REER is Real effective exchange rate, CPI is inflation and M2 represents the financial sector development proxy. e_t is the model's error term and $\beta_1, \dots, \beta_6$ are the regression coefficients. α_0 and T are the constant and trend terms respectively while γ is the coefficient of the trend term.

The empirical model's ARDL representation for equation (9) is provided by:

$$\Delta GROWTH = \alpha_0 + \gamma T + \sum_{i=1}^{n} \beta_{1i} \Delta GROWTH_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta OPEN_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta INV_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta REER_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta GSPEND_{t-i} \sum_{i=1}^{n} \beta_{6i} \Delta CPI_{t-i} + \sum_{i=1}^{n} \beta_{7i} \Delta M2_{t-i} + \lambda_1 GROWTH_{t-1} + \lambda_2 OPEN_{t-1} + \lambda_3 INV_{t-1} + \lambda_4 REER_{t-1} + \lambda_5 GSPEND_{t-1} + \lambda_6 CPI_{t-1} + \lambda_7 M2_{t-1} + e_t, \quad (10)$$

where $\lambda_1, \dots, \lambda_7$ are the coefficients of the ARDL model in the long-run whiles $\beta_1, \dots, \beta_7$ represent the parameters in the short-run, Δ is the operator for difference, n is the number of lags for both dependent and independent variables.

Using the parameters in equation (10) above, the employed ARDL model is now used for the testing of cointegrating long run connections among the variables. The hypotheses for the cointegration test (i.e, the bounds test) are given as:

H_0: There is no long-run relationship (cointegration) among the variables

H_1: There is long-run relationship (cointegration) among the variables

The decision of cointegration or otherwise is then made following steps described in cointegration analysis section above.

The ECM for the study is given subsequently after the cointegration test on the λ parameters as follows:

$$\Delta GROWTH = \alpha_0 + \gamma T + \sum_{i=1}^{n} \alpha_{1i} \Delta GROWTH_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \Delta OPEN_{t-i} + \sum_{i=1}^{n} \alpha_{3i} \Delta INV_{t-i} + \sum_{i=1}^{n} \alpha_{4i} \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_{5i} \Delta GSPEND_{t-i} \sum_{i=1}^{n} \alpha_{6i} \Delta CPI_{t-i} + \sum_{i=1}^{n} \alpha_{7i} \Delta M2_{t-i} + \varphi ECT + e_t, \quad (11)$$

where endogenous and exogenous variables have same definitions as in equation (9) and (10), $\alpha_1, \ldots, \alpha_7$ are the coefficients for the short-run, φ is the coefficient for the error correction term (that is, the coefficient of ECT). This coefficient (φ) must be negative a value, less than a unit and also be significant statistically. The higher this value, the faster the speed of adjustment.

3.7. Model Selection

This study used the Schwarz Bayesian Information Criterion (SBIC) to select the best ARDL model. It is one of many statistical tools used for choosing models. By including a penalty term for the number of parameters, goodness-of-fit and model complexity are balanced. This criterion is especially useful when comparing models with different numbers of predictors. SBIC is derived from Bayesian probability principles but can be applied broadly to models estimated via maximum likelihood. In practice, the model with the lowest SBIC value is generally preferred, as it is considered more parsimonious and less likely to overfit the data. The penalty term increases with the number of parameters, encouraging simpler models. The SBIC is widely employed in disciplines like econometrics, machine learning, and statistics as a tool for model selection. It provides a fine balance between model complexity and explanatory power, leading to more robust and generalizable predictions. Unlike other criteria like the Akaike Information Criterion (AIC), SBIC imposes a stronger penalty for additional parameters, making it more conservative. The SBIC is presented mathematically as seen below;

$$SBIC = \text{In}\left|\widehat{\sum_u(p)}\right| + \frac{\text{In(T)}}{T} pK^2, \quad (12)$$

where T is the size of observations in the data, p *is* the order of lags, K represents the number of parameters in the model and $\sum_u(p) = T^{-1} \sum_{t=1}^{T} \hat{u}_t \hat{u}'_t$ represents the covariance matrix for the model's residuals with no degrees of freedom corrected.

3.8. Model Diagnostics

For model diagnostics, the Breusch-Godfrey, ARCH-LM and CUSUM tests are used.

3.8.1. Breusch-Godfrey Test

This study employs the Breusch-Godfrey test, also known as the LM test for serial correlation, to identify autocorrelation in regression models' residuals, which is a breach of the assumption of independent errors. Autocorrelation in residuals can result in bias coefficient estimates and lead to incorrect inferences. Developed by Trevor Breusch and Leslie Godfrey in 1978, this test is widely used in econometrics and time series analysis. It employs an auxiliary regression to check for serial correlation in residuals, ensuring reliable regression analysis by diagnosing autocorrelation. The auxiliary regression takes the form as seen below:

$$e_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_p y_{t-p} + \gamma_1 \hat{e}_{t-1} + \gamma_2 \hat{e}_{t-2} + \ldots + \gamma_q \hat{e}_{t-q} + \varepsilon_t, \quad (13)$$

where e_t is the residuals obtained from the original regression model, y_{t-i} is the lagged values of the endogenous variable with p representing the highest lag order of the endogenous or dependent variable,

$\hat{e}_{t-i}$ is the lagged values of the residuals with q being highest lag order, $\beta_0, \ldots, \beta_p$ are the coefficients associated with the lags of the dependent variable, $\gamma_1, \ldots, \gamma_q$ are the coefficients associated with the lags of the residuals and ε_t denotes the error term of the regression.

The test statistic used in the Breusch-Godfrey test is the Lagrange Multiplier (LM) statistic which is computed based on the coefficients estimated from the auxiliary regression. The LM statistic is formulated as:

$$Q = T(T+2) \sum_{i=1}^{q} \left(\frac{\hat{\gamma}_i^2}{n-1}\right) \quad (14)$$

where Q is the test statistic, T represent the size of the sample, q is the largest number of lags considered for the residuals, γ_i are the predicted coefficients of the lagged residuals in the auxiliary regression.

The hypothesis for the test is given as:

H_0: There is no serial correlation in the residuals up to lag q

H_1: There is serial correlation in the residuals up to lag q

The decision rule is to reject H_0 and conclude that there is serial correlation in the residuals of the model if the $p-$ value $< \alpha$ or if $Q > \chi^2(q)$, where α is the chosen significance level (e.g., 5% or 1%) and q is the number of lagged residuals captured in the auxiliary regression.

3.8.2. ARCH-LM

Conditional heteroskedasticity in time series model errors, where residual variance varies over time depending on historical values, is detected by the test referred as the ARCH-LM test. Regression analysis is used to calculate the test, using lagged squared residuals as the exogenous variables and squared residuals as the endogemous variable. The test statistic (LM) is determined as:

$$LM = T(R^2) \tag{15}$$

where T represents the number of observations, R^2 denotes the coefficient of determination from a regression of squared residuals on their lagged values, and LM is the test statistic. The LM statistic is compared to a chi-squared distribution with degrees of freedom determined by the number of lagged residuals. If the LM statistic exceeds the critical chi-squared value or if the p-value is below the chosen significance level, the null hypothesis of no conditional heteroskedasticity is rejected, indicating the presence of ARCH effects.

3.8.3. Parameter Stability Tests

To investigate any structural changes or shifts in the parameters of a time series model, the cumulative sum test (CUSUM test) is used. It is useful for assessing the stability of the model over time and identifying if the relationship between the variables of the study has experienced any significant or major changes. Time series analysis and quality control both frequently employ this test. For a series of data points $x_1, x_2, x_3 \ldots, x_n$ with a reference value *m*, the CUSUM test statistic formula is as follows;

$$S_t = \sum_{i=1}^{t} (x_i - m), \tag{16}$$

where S_t is the CUSUM test statistic at time *t*, x_i the observed value at time *i* and *m* is the reference or expected value.

The idea behind the cumulative sum of squares test is to monitor the cumulative sum of deviations from the reference value. If there is a significant shift or change in the process, the CUSUM statistic will show a noticeable trend away from zero. The magnitude and direction of the trend can provide information about the nature of the change (e.g., whether it's an increase or decrease).

Hypothesis:

H_0: The model's parameters are consistent over time; there are no structural changes.

H_1: The model's parameters have experienced significant changes at some point in time.

4. Results and Discussion

4.1. Descriptive Analysis for Variables

Table 1. *Summary Statistics for the study variables.*

	Variable								
Statistic	**GROWTH**	**INV**	**REER**	**GSPEND**	**M2**	**CPI**	**OPEN1**	**OPEN2**	**OPEN3**
Mean	4.480	17.736	273.857	9.723	23.422	26.387	63.034	26.671	36.364
Std. Dev.	3.547	6.852	555.656	2.316	6.543	24.642	27.067	11.391	16.123
Ex Kurtosis	2.904	-0.857	14.410	-0.496	-1.095	7.299	-0.384	-0.608	-0.383
C.V.	0.792	0.386	2.029	0.238	0.279	0.934	0.429	0.427	0.443
Skewness	-0.854	-0.28	3.936	0.482	-0.219	2.609	-0.330	-0.335	-0.240
Minimum	-6.924	3.750	68.182	5.861	11.305	4.865	6.320	3.338	2.982
Maximum	14.047	29.002	3053.589	15.308	34.108	122.870	116.050	48.802	67.246

The descriptives for the variables under investigation are shown in Table 1. GDP growth is leptokurtic (excess kurtosis of 2.904), left-skewed (skewness value of -0.854), and averages 4.48% each year, indicating a propensity for lower extreme values.

Investment in fixed capital averages about 17.74% of GDP, left-skewed (skewness value of -0.280) and platykurtic distributed (excess kurtosis of -0.857).

The exchange rate (REER) has a mean of 273.86. Its distribution is heavily right-skewed (skewness value of 3.936) and leptokurtic (excess kurtosis of 14.410), indicating many extreme values. Government spending averages 9.72% of GDP, with moderate variability (standard deviation of 2.316), and is right-skewed (skewness value of 0.482) and platykurtic (excess kurtosis of -0.496).

Money supply (M2) is left-skewed (skewness value of -0.219) and slightly platykurtic distributed (excess kurtosis of -1.095). Inflation (CPI), averages 26.39%. The distribution is right-skewed (skewness value of 2.609) and leptokurtic (excess kurtosis of 7.299), reflecting a concentration of higher values and many extremes.

Trade openness is measured using three proxies: OPEN1 (sum of imports and exports to GDP), OPEN2 (exports to GDP), and OPEN3 (imports to GDP). OPEN1 averages 63.03% is left-skewed (skewness value of -0.335) and platykurtic (excess kurtosis of -0.384). OPEN2 averages 26.67% with less variability (standard deviation of 11.391) and shows a similar distribution. OPEN3 has a mean of 36.36%, left-skewed (skewness value of -0.240) and platykurtic in nature (excess kurtosis of -0.383).

4.2. Unit Root Test Results

The unit root test results for the ADF, PP, and KPSS tests are shown in Tables 2 and 3. The purpose of these three tests is to give a more thorough evaluation of the variables' order of integration.

The null hypothesis of unit roots could not be rejected since, as Table 2 demonstrates, the ADF and PP tests yielded insignificant data at the 5% significance level (p-values all greater than 0.05) for all nine series in their original form. According to Table 3, the KPSS test demonstrated significant statistics at the 5% significant level, confirming the series' non-stationarity and rejecting the null hypothesis of stationarity. As a result, first differencing was carried out. Tables 2 and 3 show that all nine series became stationary at the first difference level at the 5% significant level (test statistic for KPSS less than the 5% critical value, p-values for ADF and PP for all variables less than 0.05).

Table 2. ADF and PP Unit Root Tests for original and First Differenced data.

ADF Unit Root Test					PP Unit Root test			
Variable	Constant only		With trend		Constant only		With trend	
	Test statistic	P-value	Test statistic	P-value	Test statistic	P-value	Test statistic	P-value
GROWTH	-2.943	0.175	-3.537	0.538	-2.933	0.056	-3.521	0.066
1st differenced GROWTH	-2.946	0.011**	-3.540	0.035**	-2.935	<0.001**	-3.524	<0.001**
INV	-2.943	0.163	-3.537	0.665	-2.933	0.212	-3.521	0.636
1st differenced INV	-2.946	0.027**	-3.540	0.037**	-2.935	<0.001**	-3.524	0.001**
REER	-110.918	1.000	-3.376	0.068	-2.711	0.072	-3.364	0.056
1st differenced REER	-7.966	<0.001**	-9.789	<0.001**	-9.579	<0.001**	-10.147	<0.001**
GSPEND	-0.748	0.833	-1.741	0.733	-2.853	0.081	-2.880	0.169
1st differenced GSPEND	-5.454	<0.001**	-6.011	<0.001**	-7.871	<0.001**	-8.199	<0.001**
M2	-2.933	0.638	-3.521	0.348	-2.933	0.698	-3.521	0.298
1st differenced M2	-2.935	<0.001**	-3.524	<0.001**	-2.935	<0.001**	-3.524	<0.001**
CPI	-2.943	0.129	-3.537	0.147	-2.933	0.176	-3.521	0.072
1st differenced CPI	-2.946	0.001**	-3.540	0.002**	-2.935	0.001**	-3.524	<0.001**
OPEN1	-2.301	0.172	-1.347	0.876	-1.835	0.363	-1.560	0.808
1st differenced OPEN1	-3.232	0.018**	-3.790	0.017**	-6.513	<0.001**	-6.870	<0.001**

ADF Unit Root Test					PP Unit Root test			
Variable	Constant only		With trend		Constant only		With trend	
	Test statistic	P-value	Test statistic	P-value	Test statistic	P-value	Test statistic	P-value
OPEN2	-1.831	0.361	-2.047	0.559	-1.732	0.415	-2.023	0.589
1st differenced OPEN2	-3.609	0.006**	-3.794	0.017**	-6.909	<0.001**	-7.039	<0.001**
OPEN3	-2.293	0.174	-1.052	0.935	-1.865	0.349	-1.329	0.880
1st differenced OPEN3	-2.707	0.033**	-3.489	0.041**	-6.663	<0.001**	-7.320	<0.001**

Note: ** implies significance of variable at 5% significance level

Table 3. KPSS Test results for Original and First Differenced Data.

KPSS Unit Root test				
Variable	Constant only		With trend	
	Test statistic	5% critical	Test statistic	5% critical
GROWTH	0.589	0.463	0.171	0.146
1st differenced GROWTH	0.129	0.463**	0.071	0.146**
INV	0.482	0.463	0.168	0.146
1st differenced INV	0.193	0.463**	0.052	0.146**
REER	0.491	0.472	0.153	0.146
1st differenced REER	0.073	0.472**	0.066	0.146**
GSPEND	0.497	0.472	0.173	0.146
1st differenced GSPEND	0.105	0.472	0.084	0.146**
M2	0.616	0.463	0.177	0.146
1st differenced M2	0.091	0.463**	0.093	0.146**
CPI	0.619	0.463	0.162	0.146
1st differenced CPI	0.114	0.463**	0.079	0.146**
OPEN1	0.473	0.472	0.191	0.146
1st differenced OPEN1	0.201	0.472**	0.069	0.146**
OPEN2	0.543	0.472	0.168	0.146
1st differenced OPEN2	0.120	0.472**	0.065	0.146**
OPEN3	0.518	0.472	0.201	0.146
1st differenced OPEN3	0.268	0.472**	0.073	0.146**

Note: ** implies significance of variable at 5% significance level

4.3. Lag Order Selection (With Growth as Dependent Variable)

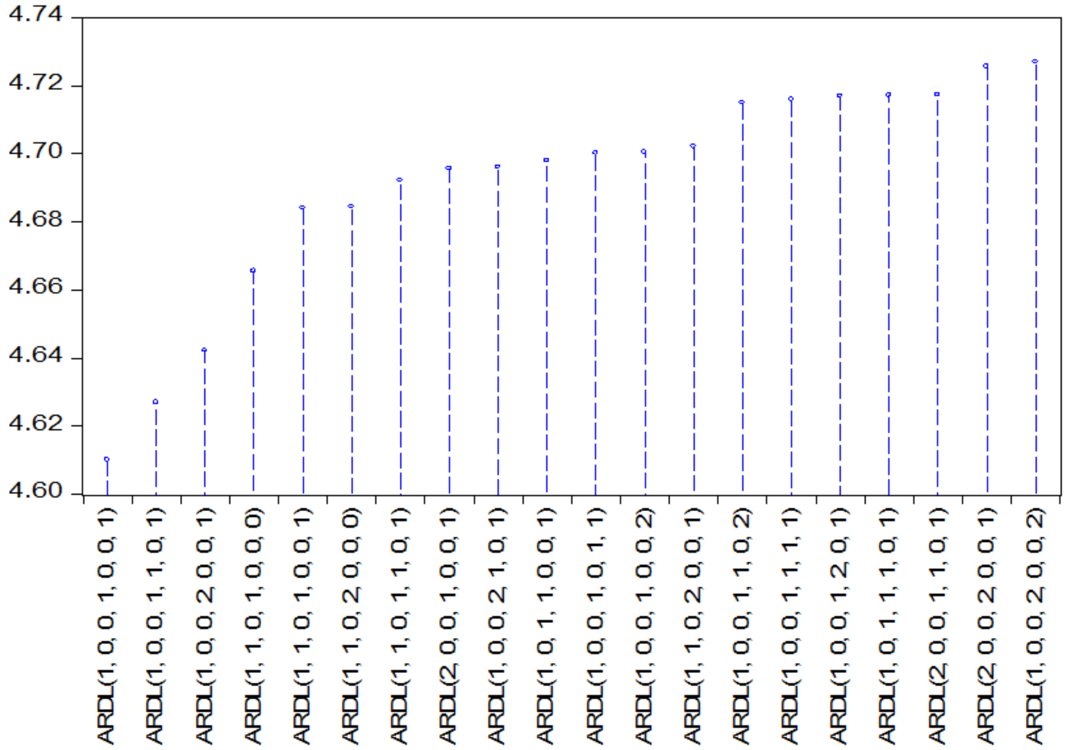


Figure 1. *SBIC of the Top Models with OPEN1 (GROWTH is dependent).*

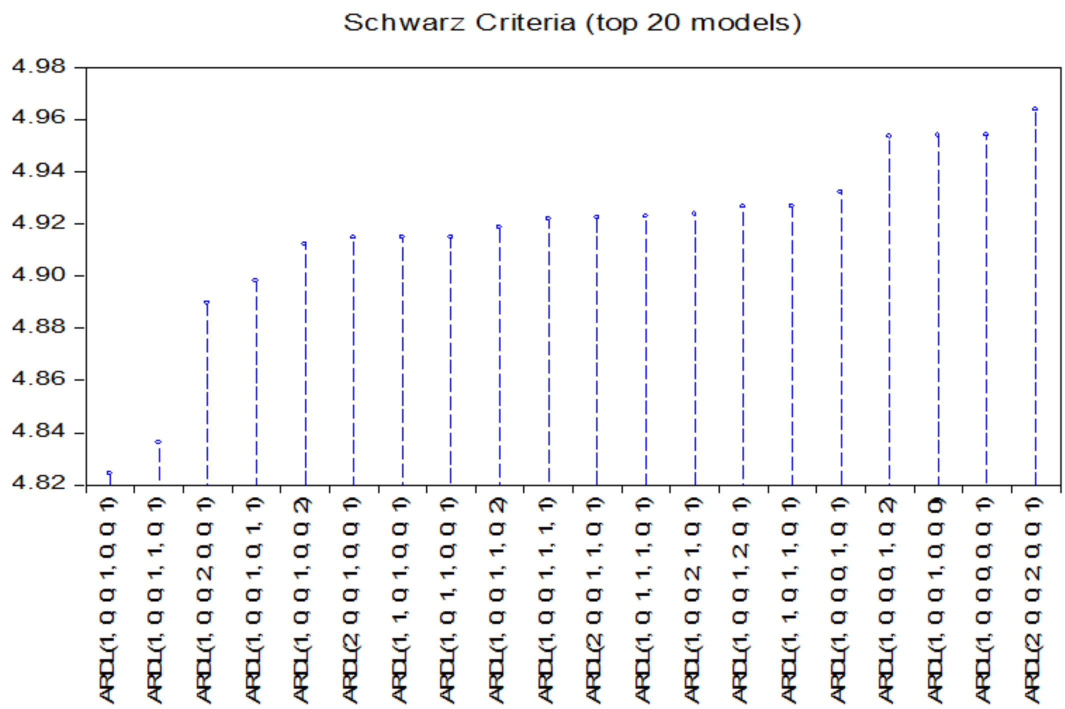


Figure 2. *SBIC of the Top Models with OPEN2 (GROWTH is dependent).*

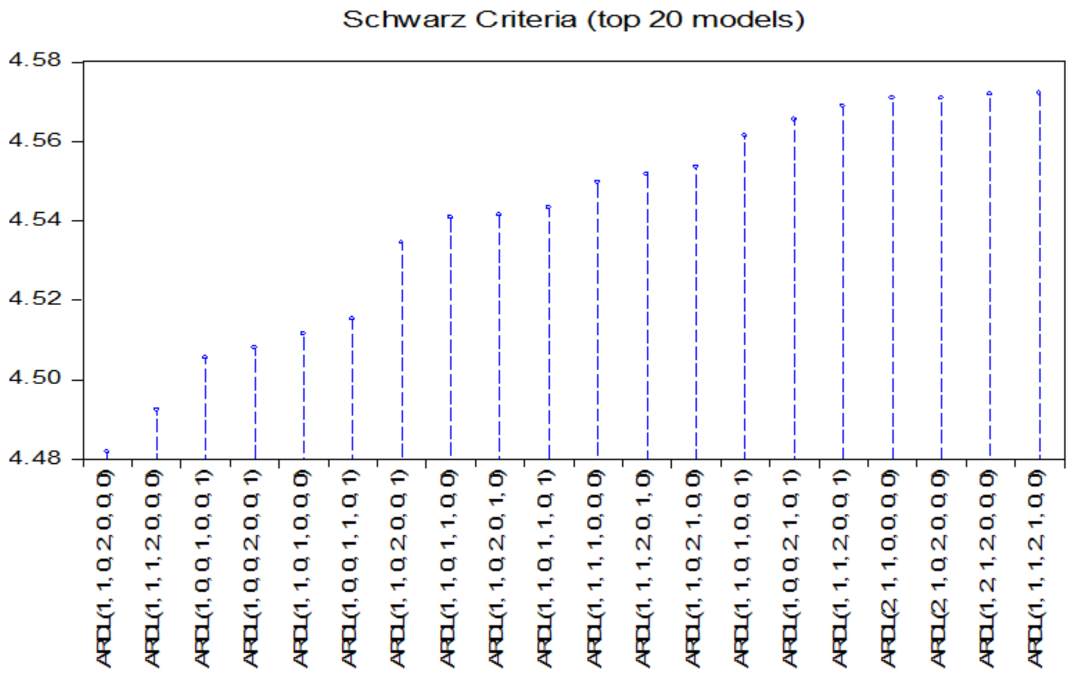


Figure 3. *SBIC of the Top Models with OPEN3 (GROWTH is dependent).*

The SBIC automatic lag selection method was used to choose the best lag order for the dependent and the independent variables to aid in achieving proper and acceptable ARDL modelling.

Relative to this study, the ARDL model in its general form is given as ARDL (p, q_1, q_2, q_3, q_4, q_5, q_6), where p represents the length of the lags of GROWTH which is the endogenous variable and q_1, q_2, q_3, q_4, q_5 and q_6 are number of lags of the openness proxy, INV, REER, GSPEND, CPI and M2 respectively.

Figure 1, 2 and 3 are the plots displaying the top 20 models each when the three different trade openness proxies were considered in the modelling one at a time. On the y-axis of the plots are the SBIC values whiles the x-axis captures the ARDL models.

In Figure 1, when the first proxy of trade openness (OPEN1) was considered, the ARDL (1, 0, 0, 1, 0, 0, 1) was selected since it had the least SBIC value. Also, in Figure 2 when the second trade openness proxy (OPEN2) was considered, the ARDL (1, 0, 0, 1, 0, 0, 1) was selected. Finally, when the third proxy of trade openness (OPEN3) was considered, the ARDL (1, 1, 0, 2, 0, 0, 0) was selected because it had the least SBIC value among the rest. These three ARDL models will subsequently be referred to as Model 1, Model 2 and Model 3 respectively.

4.4. Bounds Cointegration Test Results (with GDP GROWTH as Dependent Variable)

The results of the bounds cointegration tests is shown in Table 4. The bounds cointegration test's null hypothesis asserts that a long-term relationship between the variables under consideration does not exist, while the alternative argues that there is a relationship between the variables. Based on Table 4, the study concludes that, at the 5% significance level, there is a substantial long-term relationship (cointegration) between the variables and GDP GROWTH. This conclusion is drawn from the fact that, at the 5% level of significance, the F-test statistics for Models 1 (4.7976), 2 (4.6108), and 3 (5.8484) all exceed or surpass the upper bound critical value of 4, leading to the rejection of H_0 (that there is no cointegration) and the acceptance of H_1 (that there is cointegration).

Table 4. *ARDL Bounds Test Results (GROWTH is dependent).*

Model	Dependent Variable	Function	F-Statistic
Model 1	GROWTH	F (GROWTH| OPEN1, INV, REER, GSPEND, CPI, M2)	4.7976***
Model 2	GROWTH	F (GROWTH| OPEN2, INV, REER, GSPEND, CPI, M2)	4.6108**
Model 3	GROWTH	F (GROWTH| OPEN3, INV, REER, GSPEND, CPI, M2)	5.8484***
Critical Value Bound of the F-statistics: Intercept and Trend			

Model	Dependent Variable		Function			F-Statistic
	1%		5%		10%	
	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
	3.6	4.9	2.87	4	2.53	3.59

*** indicates statistical significance at 5%.

4.5. Long-run and Short-run ARDL Results (With GROWTH as Dependent Variable)

Since co-integration exist, the study goes on to estimate the coefficients for both long and short terms for the Models that were selected using the SBIC. As indicated in the lag order selection section above, the selected Models were ARDL (1, 0, 0, 1, 0, 0, 1) for Model 1(model with OPEN 1), ARDL (1, 0, 0, 1, 0, 0, 1) for Model 2 (model with OPEN 2), and ARDL (1, 1, 0, 2, 0, 0, 0) for Model 3 (model with OPEN 3).

Across all models, trade openness substantially increases GDP growth in Ghana, based on the long-term results shown in Table 5 (coefficients of 0.1104, 0.1797, and 0.2331 for Models 1, 2, and 3, respectively). This suggests that for models with OPEN 1, OPEN 2, and OPEN 3, respectively, a 1% increase in openness to trade results in GDP growth gains of roughly 0.11 percent, 0.18 percent, and 0.23 percent.

These results are consistent with economic theory, which holds that trade increases efficiency, capital accumulation, and the supply of limited resources, all of which support economic expansion. The positive impact of openness to trade on Ghana's GDP growth validates previous research by [25, 28, 30]. It does, however, contradict studies by [20, 36] which discovered a negative relationship between openness and growth in Kenya and Ghana respectively.

Investment (INV) had coefficients of approximately -0.4033, -0.3474, and -0.4159 for Models 1, 2, and 3, respectively, showing a negative and significant impact on GDP growth. Accordingly, for models with OPEN 1, 2, and 3, a unit percentage increase in investment leads to a fall in GDP growth by roughly 0.40 percent, 0.35 percent, and 0.42 percent, respectively. This inverse relationship is surprising, as investment is typically expected to enhance economic efficiency and growth. This result agrees with those of [15, 31] in South Africa and sub-Saharan Africa respectively, but contradicts the findings of [7, 11, 18] in Ghana. The negative impact of investment on GDP growth in Ghana could be due to inefficiencies, misallocations, external shocks, or investments directed toward low-productivity sectors.

In all models, the real exchange rate (REER) significantly reduces GDP growth; for every unit percentage increase in REER, GDP growth decreases by 0.002 percent. This negligible impact indicates that an appreciating Ghanaian cedi makes exports more expensive and less competitive internationally, reducing export revenues and economic growth. Additionally, cheaper imports can harm domestic industries, increase competition, and potentially lead to job losses and lower industrial output. This finding is consistent with studies by [3] but deviates from [6].

Government expenditure (GSPEND) positively influences GDP growth in Models 1 and 2 at a 5 percent significance level and in Model 3 at a 10 percent level. Specifically, a unit percentage rise in GSPEND results in increase GDP growth by about 0.63 percent, 0.69 percent, and 0.42 percent in Models 1, 2, and 3, respectively base on OPEN 1, 2 and 3. This finding aligns with studies by [10, 40] but contradicts findings by [36] in Ghana and [24] in South Africa.

GDP growth is positively impacted by inflation, albeit at 5 percent significance level, this effect is insignificant. This result is consistent with that of [33]. In Models 1 and 3, the money supply (M2) significantly reduces GDP growth; a unit percentage rise in M2 results in decline in GDP growth by 0.31 and 0.43 percent, respectively, indicating a less developed financial sector in Ghana. This outcome is in line with Botswana's [2].

The short run estimates indicate that openness to trade significantly and positively influences growth in GDP across all models, with coefficients of approximately 0.11, 0.18, and 0.16 for Models 1, 2, and 3, respectively. Investment negatively affects GDP growth in the short run, with coefficients of -0.40, -0.33, and -0.51 for Models 1, 2, and 3, respectively.

Similar to the long run results, REER negatively influences GDP growth in the short run at a 5% level of significance. At the same significance level, government spending positively affects short-term GDP growth, leading to increases of 0.63%, 0.66%, and 0.83% in Models 1, 2, and 3, respectively. While inflation negatively impacts GDP growth, its effect is not statistically significant in either the short or long term. Meanwhile, M2 has a significant negative influence on short-term GDP growth, resulting in declines of 0.62%, 0.50%, and 0.62% in Models 1, 2, and 3, respectively.

For Models 1, 2, and 3, the error correction term (ECT) coefficients are -0.9530, -0.9015, and -0.9815 correspondingly; all of these values are significant at the 5% level. With high adjustment coefficients of 95%, 90%, and 98% for Models 1, 2, and 3, respectively, this shows that any variation that deviates from the long-run equilibrium relationship owing to shocks will be brought back to equilibrium. This implies a quick and easy adjustment to equilibrium.

Table 5. *ARDL estimation Results with GROWTH as Dependent Variable.*

Long-Run Results (Model 1)					
Equations	**Variables**	**Coefficient**	**S. E**	**T-Statistic**	**P-Value**
GROWTH	OPEN1	0.1104	0.0287	3.8469	0.0006**
	INV	-0.4033	0.0743	-5.4299	<0.0001**
	REER	-0.0018	0.0011	-1.7151	0.0963*
	GSPEND	0.6289	0.182	3.4558	0.0016**
	CPI	-0.0208	0.0171	-1.2117	0.2348
	M2	-0.3076	0.1177	-2.6126	0.0137**
	C	3.0628	2.2586	1.3561	0.1849
	TREND	0.1828	0.0568	3.218	0.0030**
Short-Run Results (Model 1)					
ΔGROWTH	ΔOPEN1	0.1106	0.0283	3.9140	0.0005**
	ΔINV	-0.4040	0.0768	-5.2628	<0.0001**
	ΔREER	-0.0042	0.0010	-4.2872	0.0002**
	ΔGSPEND	0.6300	0.1846	3.4133	0.0018**
	ΔCPI	-0.0208	0.0177	-1.1759	0.2486
	ΔM2	-0.6228	0.1392	-4.4749	0.0001**
	ΔTREND	0.1831	0.0572	3.2014	0.0032**
	ECT (-1)	-0.9530	0.1334	-7.1411	<0.0001**
Long-Run Results (Model 2)					
GROWTH	OPEN2	0.1796	0.0706	2.5432	0.0162**
	INV	-0.3474	0.0807	-4.3041	0.0002**
	REER	-0.0021	0.0012	-1.7409	0.0916*
	GSPEND	0.6865	0.2131	3.2218	0.0030**
	CPI	-0.0216	0.0203	-1.0646	0.2953
	M2	-0.1699	0.1226	-1.3855	0.1758
	C	1.6213	2.6147	0.6201	0.5397
	TREND	0.1345	0.0636	2.1142	0.0426**
Short-Run Results (Model 2)					
ΔGROWTH	ΔOPEN2	0.1717	0.0673	2.5495	0.0160**
	ΔINV	-0.3320	0.0801	-4.1468	0.0002**
	ΔREER	-0.0045	0.0011	-4.1680	0.0002**
	ΔGSPEND	0.6561	0.2057	3.1897	0.0033**
	ΔCPI	-0.0207	0.0200	-1.0322	0.3100
	ΔM2	-0.5001	0.1479	-3.3822	0.0020**
	ΔTREND	0.1286	0.0612	2.1022	0.0438**
	ECT (-1)	-0.9015	0.1456	-6.5635	<0.0001**

Long-Run Results (Model 1)					
Equations	**Variables**	**Coefficient**	**S. E**	**T-Statistic**	**P-Value**
Long-Run Results (Model 3)					
GROWTH	OPEN3	0.2331	0.0541	4.3054	0.0002**
	INV	-0.4159	0.0771	-5.3959	<0.0001**
	REER	-0.002	0.0011	-1.8148	0.0799*
	GSPEND	0.4182	0.2301	1.8174	0.0795*
	CPI	-0.0046	0.0172	-0.2647	0.7931
	M2	-0.4276	0.1416	-3.02	0.0052**
	C	5.5022	2.4202	2.2734	0.0306**
	TREND	0.2202	0.0675	3.2602	0.0028**
Short-Run Results (Model 3)					
ΔGROWTH	ΔOPEN3	0.1629	0.0549	2.9697	0.0059**
	ΔINV	-0.5066	0.0784	-6.4613	<0.0001**
	ΔREER	-0.0036	0.0009	-4.0258	0.0004**
	ΔREER (-1)	-0.0013	0.0007	-1.9248	0.0641*
	ΔGSPEND	0.8308	0.1788	4.6471	0.0001**
	ΔCPI	-0.0114	0.0202	-0.5631	0.5777
	ΔM2	-0.6226	0.1288	-4.8344	<0.0001**
	ΔTREND	0.3468	0.0594	5.8377	<0.0001**
	ECT (-1)	-0.9815	0.1251	-7.8428	<0.0001**

** and * indicates significance at 5% and 10% significance levels respectively.

Table 6*. Test for Significance of the Models.*

Equation	$R^2_{adjusted}$	DW	F-Statistic	*P*-value
Model 1	0.768	2.136	14.607	<0.0001***
Model 2	0.714	1.938	11.236	<0.0001***
Model 3	0.778	1.917	13.758	<0.0001***

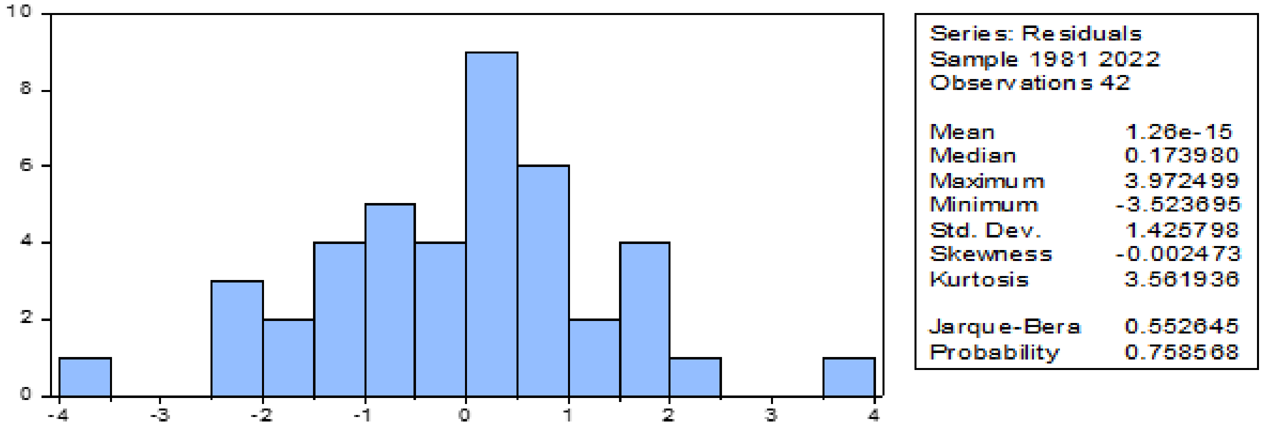
*** means statistically Significant at 1% significance level

Table 6 contains additional information about the three ARDL models for measuring the impact of openness to trade and other macro-economic variables on GDP growth in Ghana. From same table, the fitted models are all significant at 5 since the probability values associated with the *F*-statistics are less than 0.05. Additionally, according to the Adjusted R-Squared statistics, OPEN1 and the other macroeconomic variables account for about 77% of the total variations in GDP growth, OPEN2 and the other variables account for roughly 71%, and the third trade-based trade openness proxy (OPEN3) accounts for roughly 78% of the growth changes. This demonstrates the quality of the fitted models. For Models 1, 2, and 3, the corresponding Durbin-Watson (DW) statistics are 2.266, 2.059, and 2.450. Even though not an exhaustive test for serial correlation, these DW statistics demonstrate that the models' residuals are free from first order autocorrelation.

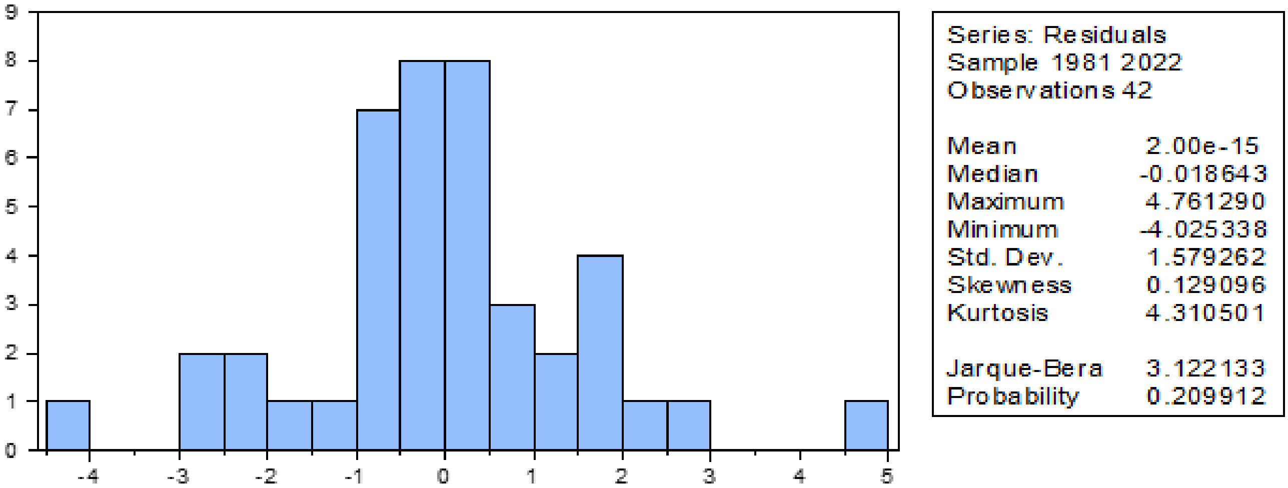
4.6. Models Diagnostics

Table 7 shows the results for other diagnostic tests on the models. These tests include the ARCH-LM, Breusch-Godfrey and Jarque-Bera tests for heteroscedasticity, higher order autocorrelation and normality tests respectively. The results show that for all the models, the p-values exceed 0.05 for all the tests thus we do not reject the null hypothesis for each of the tests. In other words, the residuals of all the models are homoscedastic and free from higher order autocorrelation.

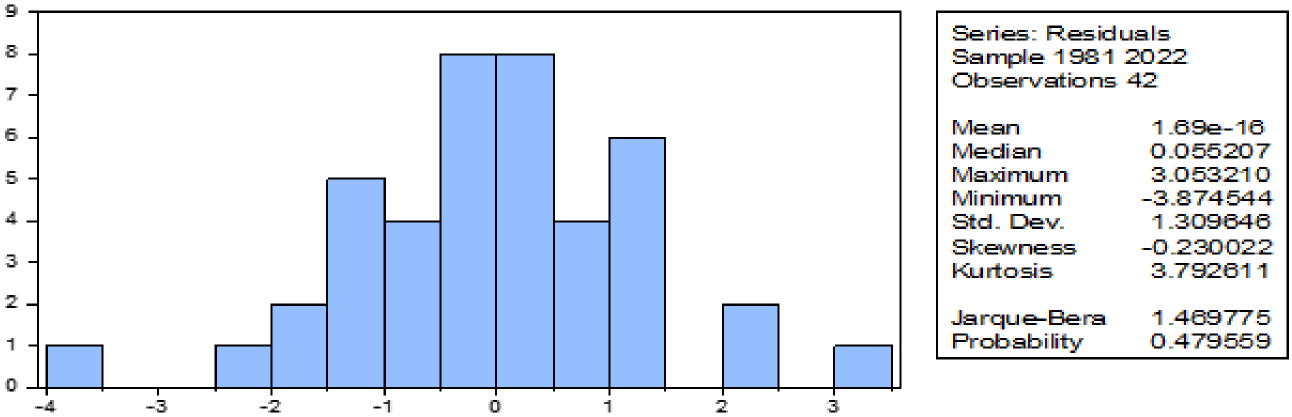
The Jarque-Bera normality test result captured in Figure 4 also shows that the errors for each model are distributed normally since an insignificant Jarque-Bera test statistic is obtained.



Normality Plot for Model 1



Normality Plot for Model 2



Normality Plot for Model 3

Figure 4. *Normality Plots for Model 1, 2 and 3.*

Figure 5. CUSUM and CUSUMSQ Plots for Model 1, 2 and 3.

Table 7. Diagnostics tests Results.

Diagnostics for Models			
Test Statistic	**Model/Equation**	**F/Jarque Bera statistic**	**P-Value**
	Model 1	0.293	0.7482
Serial Correlation Test	Model 2	0.4505	0.6417
	Model 3	0.0248	0.9755
ARCH-LM Test	Model 1	1.6067	0.2125

Diagnostics for Models			
Test Statistic	**Model/Equation**	**F/Jarque Bera statistic**	**P-Value**
	Model 2	0.8637	0.3584
	Model 3	0.3208	0.5744
	Model 1	0.5526	0.7586
Jarque-Bera Normality test	Model 2	3.1221	0.2099
	Model 3	1.4698	0.4796

A study proposes that employing CUSUM and CUSUMSQ plots, a stability diagnostic checks for the models' parameters can be done [37]. These plots for the models are presented in Figure 5. The tests involve testing the null hypothesis that the vector of coefficients for each model remains constant over time, against the alternative that vector varies [12]. As proposed by [12], the null hypothesis is not rejected if the plots stay under the 5 percent critical bound. Figure 5's plots demonstrate that, all of the models' parameters are stable over time because the null hypothesis of stability is not rejected.

5. Conclusions and Recommendations

Employing yearly time series data from 1980 to 2022, this study examines the connections between Ghana's openness to trade, GDP growth, investment, real effective exchange rate, government spending, inflation, and financial development. Three trade openness proxies are used in this study. The Autoregressive Distributed Lag (ARDL) modelling approach was used. The study concludes that after first differencing, all the macroeconomic time series did not contain unit roots. Considering growth in GDP as the dependent variable, the bounds cointegration test shows that a long-term equilibrium relationship between the variables exist in all the three models when the three different proxies of trade openness were considered.

The findings validate the critical role of international trade in Ghana's economic growth by demonstrating that openness to trade has a strong long and short-term effect on GDP growth. While the REER has a small negative effect on GDP growth, investment has a great inverse effect on GDP growth. Also, GDP growth is found to be positively impacted by government spending, while inflation has a slight but positive impact on the growth of Ghana's GDP. On average, financial sector development in Ghana is found to have a negative impact on GDP growth. The models were validated using post-ARDL modelling tests including normality, serial correlation, heteroskedasticity, and model stability tests.

The study's conclusions lead to the following recommendations. First, to support Ghana's trade-driven growth, the government should lower trade barriers and streamline regulations in critical sectors to promote international trade. Again, as the export-to-GDP ratio directly influences GDP growth, the Ghana Export Promotion Authority should take steps aimed at diversifying the country's exports to ensure sustained economic prosperity.

Abbreviations

ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
ARCH-LM	Autoregressive Conditional Heteroskedasticity-lagrange Multiplier
ARDL	Autoregressive Distributed Lag
BIC	Bayesian Information Criterion
CPI	Consumer Price Index
CUSUM	Cumulative Sum
CUSUMSQ	Cumulative Sum of Squares
CV	Coefficient of Variation
ERP	Economic Recovery Program
ECOWAS	Economic Community Oof West African States
ECM	Error Correction Model
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GMM	Generalized Methods of Moments
GSPEND	Government Spending
IMF	International Monetary Fund
INV	Investment
LM	Lagrange Multiplier
NATREX	Natural Real Exchange Rate
OLS	Ordinary Least Squares
KPSS	Kwiatkowski-Phillips-Schimdt-Shin
OPEN	Openness
PACF	Partial Autocorrelation Function
PP	Phillips Perron
REER	Real Effective Exchange Rate
SAP	Structural Adjustment Program
VECM	Vector Error Correction Model
VAR	Vector Autoregression
WDI	World Development Indicators

Conflicts of Interest

The authors declare no conflicts of interest.

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