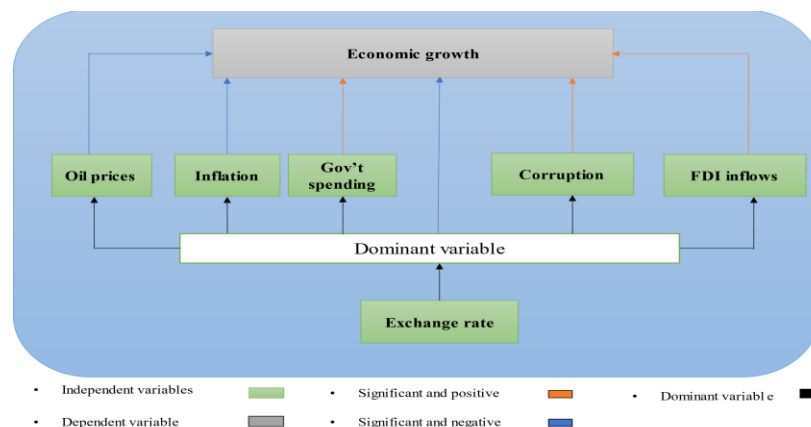# OIL PRICES, EXCHANGE RATE VOLATILITY AND FDI INFLOWS ON THE ECONOMIC GROWTH OF GHANA: WAVELET TECHNIQUE AND ARDL APPROACH

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Graphical Abstract

Abstract

Ghana, like many other developing economies, is intricately connected to global economic trends and fluctuations. This paper investigates the influence of oil prices, exchange rate volatility and FDI inflows on Ghana's economic growth. Moreover, it determines the level of interdependencies and the lead/lag connectedness among the variables. The study utilizes time series data from 1995 to 2022 and applies the Autoregressive Distributed Lag (ARDL) model as well as Wavelet Multiple techniques (Wavelet Multiple Correlation (WMC) and Wavelet Multiple Cross-Correlation (WMCC)). Based on the ARDL model, oil prices and exchange rate volatility adversely impact Ghana's GDP. However, FDI inflows reveal a positive and significant relationship to GDP. Using the Wavelet model, the WMC result demonstrates stronger interdependence among the variables. Finally, the outcome from WMCC indicates that the exchange rate is the dominant variable without any lag that plays a pivotal role in determining the coherence among the economic indicators. Therefore, the study suggests that investment in renewable energy, diversification of export products and markets, enhancement of exchange rate framework, promotion of local content and linkages, and monitoring and evaluation of anti-corruption measures should be encouraged to boost the economy of Ghana.

1. Introduction

The economic stability of every nation is determined by several factors of which crude oil prices, exchange rate volatility and FDI inflows are unarguably major driving forces, particularly in Ghana's GDP. FDI has been an essential driver of global economic growth, precisely in the past few years. Consequently, policymakers and government officials have rigorously implemented a range of incentives and policies to attain more FDI to maximize its impact on indigenous economic growth goals. However, over the past years, high fuel prices, corruption and fluctuations in exchange rates have also become major economic challenges for the emerging nations, specifically Ghana. Meanwhile, developed nations are better equipped to handle the impact of such factors due to their strong domestic economic conditions (Przekota, 2022).

The fluctuations in oil prices can have a significant impact on both welfare and economic growth. During the 1970s and 1980s, the industrialized economies were heavily reliant on oil. This dependence became clear when a series of political incidents in the Middle East led to disruptions in the security of the oil supply. As a result, oil prices were adversely affected worldwide. Since then, there has been a continuous increase in the frequency and severity of oil price shocks (Dadson Awunyo-Vitor, 2018). Ghana is a key player in the African oil industry, producing over 150,841 barrels of crude oil per day in 2021 (Ghana Energy Commission Report, 2022). The Ministry of Energy in Ghana predicts that this production will increase up to 500,000 barrels per day by 2024 due to ongoing developments in offshore resources. However, since the beginning of 2022, the prices of petroleum products in Ghana have significantly risen. This increase has been mainly attributed to the ongoing conflict between Russia and Ukraine, which has had a significant impact on the oil industry.

According to the World Economic Outlook of the International Monetary Fund (2019), variations in the exchange rate generate economic disorder and impact global capital flows in the short and long term. Depreciated currencies can impact the prices of imported goods and services, making them more expensive, and encouraging exports, leading to a reduced trade deficit in economies (Achouak, 2018). On the other hand, a strong currency can reduce the cost of imported products but might decrease the competitiveness of a country's exports (Tankia-Allou, 2021). Ghana redenominated its currency in 2007, pegging 0.93 cedis to USD. Since then, the cedis has been consistently depreciating annually against the dollar.

This paper aims to investigate the impact of oil prices, exchange rate volatility, and FDI inflows on Ghana's economic growth. It seeks to provide empirical evidence and statistical insights into how changes in these variables influence the overall economic performance of Ghana. Moreover, it evaluates the lead/lag connectedness among the variables and provides their level of interdependencies. Previous studies may have individually examined some of the factors such as oil prices, exchange rate volatility, or FDI's impact on Ghana's economic growth. However, the study integrates the analysis of three significant economic factors—FDI, oil prices, corruption and exchange rate volatility—into a single comprehensive investigation. This approach allows for a holistic understanding of how these factors collectively impact economic growth in Ghana, which is novel compared to studies that focus on individual factors in isolation.

By considering oil prices, exchange rate volatility and foreign direct investment (FDI) inflows together, the study offers a comprehensive analysis that accounts for the complex interactions among these variables. It uses advanced econometric techniques such as the Wavelet and Autoregressive Distributed Lag (ARDL) approach to add a layer of sophistication to the analysis. Reviewed studies indicate that Wavelet Multiple Technique is rarely utilized. The study adopts Wavelet Multiple Techniques to ascertain the lead/lag connectedness among the chosen indicators and also determines their correlation and level of interdependencies. This will help policymakers to make adequate forecasts and easily identify the causal relationship among the chosen macroeconomic variables.

This paper seeks to inform policymakers on how to adjust fiscal or monetary policies in response to fluctuations in oil prices or exchange rates and also implement measures to address corruption to enhance investor confidence. Moreover, it will guide investors both domestic and foreign in their investment strategies by highlighting the factors that significantly influence economic growth in Ghana. This will help investors make informed decisions regarding resource allocation, risk management, and investment diversification. Also, it contributes to risk management practices by identifying the vulnerabilities and sensitivities of Ghana's economy to fluctuations in FDI, oil prices, and exchange rates. This information is crucial for businesses, financial institutions, and policymakers to develop strategies for mitigating economic risks and enhancing economic resilience. Furthermore, this paper will enhance economic forecasting models by incorporating the dynamic relationships between FDI, oil prices, exchange rate volatility and

economic growth. Accurate economic forecasts are essential for businesses, investors, and policymakers to make informed decisions and plan for the future effectively.

Lastly, though the study focuses on Ghana, its findings will have a broader implication for understanding the impact of global economic factors on developing economies. The insights from Ghana's experience can be applied to other countries facing similar challenges, making the study globally relevant and contributing to a deeper understanding of economic dynamics in emerging markets.

The introduction being Chapter 1, the remaining of this study is structured as follows: Chapter 2— Literature Review; Chapter 3—Methodology; Chapter 4—Results and Discussion; Chapter 5— Conclusion and Recommendation.

2. Literature Review

2.1. General Empirical Review between FDI, Oil prices and Exchange rate volatility and Economic Growth

There have been varied results and conclusions when it comes to how oil prices, exchange rate volatility and FDI inflows impact economic growth. Some study reports positive, negative and neutral findings. Other studies also show an insignificant interaction, revealing at some point an up-and-down relationship. Table 1 presents a summary of the general existing works of literature studied.

Table 1: *General Empirical Review between FDI,* Oil prices and Exchange rate *and Economic Growth*

Study	Sample	Sample period	Estimation technique(s)	Supporting relationship
(Antwi, 2013)	Ghana	1980-2010	Johansen's multivariate test/Granger causality test	Negative
(Ajayi, 2023)	Nigeria	1985-2020	OLS	Insignificant
(Ayenew, 2022)	22 Sub-Sahara Africa countries	1988-2019	PMG/ARDL model	Positive
(Daramola, 2022)	Nigeria	1975–2021	ARDL	Positive
(Evans, 2021)	Ghana	1995–2019	ARDL	Positive

(Larry, 2019)	Ghana	1993 – 2016	ARDL	Positive
(Majumder, 2023)	29 developing countries	1991-2019	LSDV estimation	Negative
(Nsofor, 2017)	Nigeria	1985-2016	OLS	Negative
(Okwu, 2020)	30 leading economies	1997-2017	Panel data technique	Positive
(Owusu Agyemang, 2021)	Ghana	1980-2012	ARDL	Positive
(Samuel, 2021)	Ghana	1980-2018	GARCH and ARDL	Positive
(Yakubu, 2020)	Ghana	1985-2016	ARDL	Positive
Oil prices and Economic growth				
(Dadson Awunyo-Vitor, 2018)	Ghana	1970-2012	Granger causality test	Negative
(Deyshappriya, Rukshan, & Padmakanthi, 2023)	38 OECD countries	2000-2020	Generalized Method of Moment (GMM)	Mixed relationship
(Przekota, 2022)	Poland	2000-2020	VAR model	Neutral
(Liaqat, Ashraf, Nisar, & Khursheed, 2022)	Pakistan	1972-2022	ARDL	Negative
(Abdelsalam, 2020)	MENA countries	1970-2018	Panel quantile regression, FE, RE, GMM	Negative
(Gershon, 2019)	Oil importing African countries	1980-2015	VAR model, Granger causality test	Mixed relationship
(Akinsola & Odhiambo, 2020)	7 Low -income oil importing African countries	1990-2018	Panel ARDL	Negative

Exchange rate and Economic development				
(Tankia-Allou, 2021)	Ghana	1980-2018	VAR and OLS	Negative
(Morina, 2020)	Central and Eastern European nations	2002-2018	Fixed effect	Negative
(Wenjia Deng, 2023)	Developed and developing countries	50 years sample	Fixed effect	Positive
(Mwinlaaru, 2017)	Ghana	1984-2014	OLS	Negative
(Barguellil, 2018)	45 developing economies	1985-2015	GMM	Negative

PMG- Pooled Mean Group; ARDL – Auto regression distributed lag model; VAR- Vector Autoregression model; OLS- Ordinary Least Square; GARCH- Generalized Autoregressive conditional heteroskedasticity; LSDV- Least Square Dummy Variable; FMOLS – Fully Modified Ordinary Least Square; GMM – Generalized Methods of Moments.

2.2. Gaps and Contributions

The literature reviewed on the influence of oil prices, exchange rate and FDI inflows is inconclusive. Some study reports positive, negative, and neutral findings and an insignificant interaction. This necessitates further research in the area to contribute to the existing literature and reach a more definitive conclusion on the subject. Moreover, reviewed studies have individually evaluated the effect of oil prices, exchange rate volatility and FDI inflows on economic development. However, the study integrates the analysis of three significant economic factors—FDI, Oil prices and Exchange rate volatility—into a single comprehensive investigation. This approach allows for a comprehensive understanding of how these factors collectively impact economic growth in Ghana. Finally, it further determines the lead/lag connectedness and level of interdependencies among the selected economic indicators.

2.3. Study hypothesis

Table 2. Indicates the generated hypothesis for the study. This paper seeks to investigate the integrated influence of oil prices, exchange rate volatility, corruption levels, and FDI inflows on Ghana's economic growth.
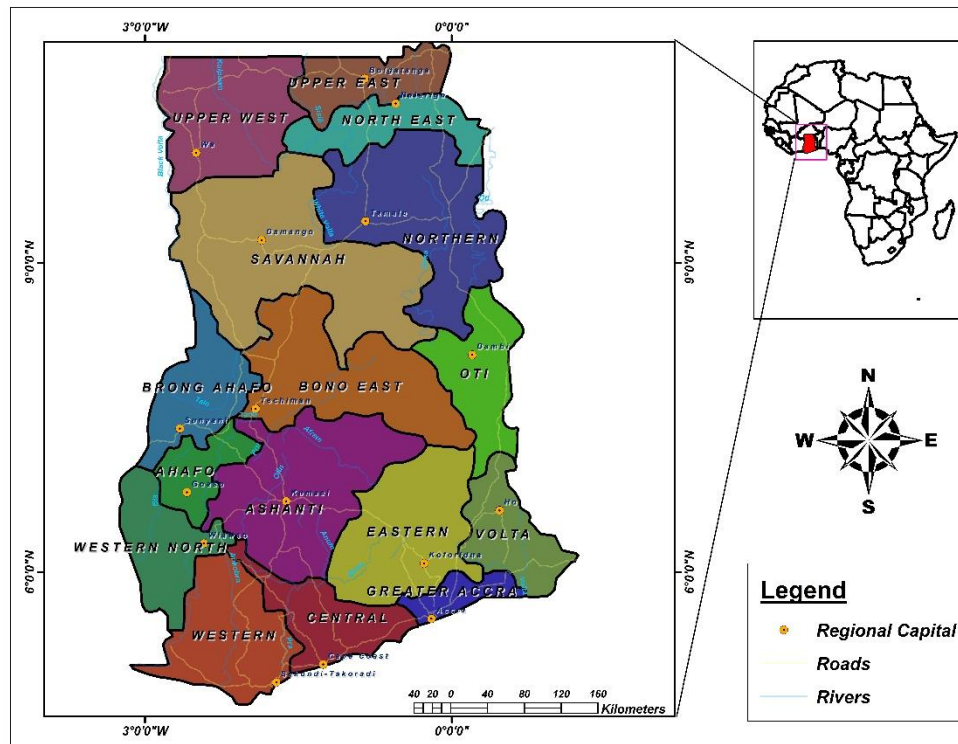
Table 2: *Study Hypothesis*

NO.	HYPOTHESIS
H1	A significant negative correlation between oil prices and GDP in Ghana.
H2	A significant negative influence of exchange rate fluctuations on Ghana's GDP.
H3	A significant positive impact between FDI and GDP in Ghana.

3. Methodology

3.1. Study Area

This paper centers on Ghana, situated in West Africa. It consists of 16 administrative regions. A geographical representation of Ghana is shown in Figure 1.

Figure 1: Study Area

(Source: Author's Construct)

3.2. Data Source

The study uses secondary and quantitative data for its time series analysis from 1995 to 2022 to explain how oil prices, exchange rate volatility and FDI inflows influence Ghana's GDP. It further identifies the lead/lag connectedness and the level of interdependencies among the chosen economic indicators. As shown in Table 3, GDP is used as the dependent variable. Oil prices, exchange rate and FDI inflows are utilized as the main explanatory variables to help in the estimation of the research's objectives. Other control variables used are Inflation and Government spending.
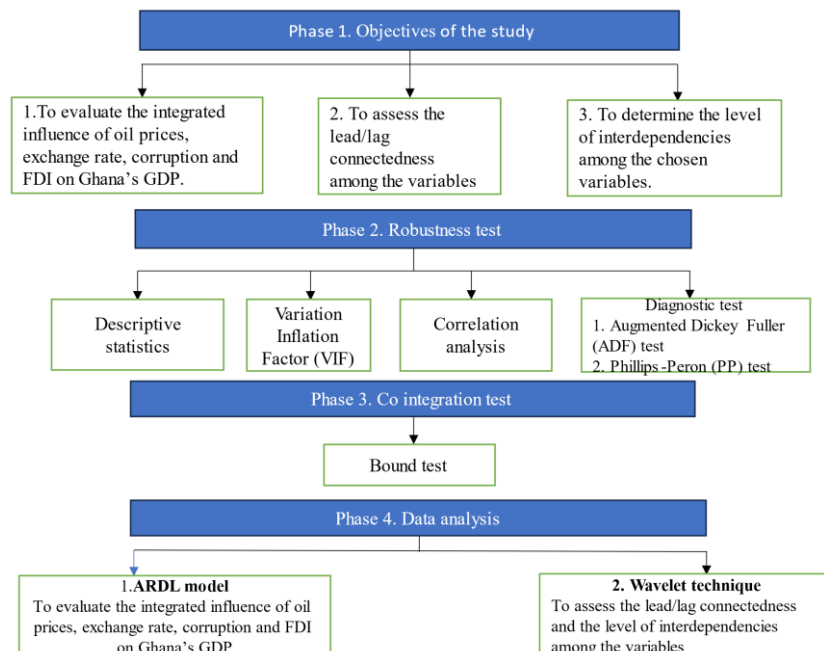
Table 3: Variable Description

Variable	Description	Unit	Time span	Sources
GDP	Gross Domestic Product (current)	USD	1995-2022	World Development Indicator (WDI)
COP	Brent crude oil price	USD/Barrel	1995-2022	UNCTAD, database
EXG	Official exchange rate	LCU per USD, period average	1995-2022	World Development Indicator (WDI)
FDI	Foreign Direct Investment Inflows (BOP, current)	USD	1995-2022	World Development Indicator (WDI)
CPI	Corruption Perception Index	Percentage	1997-2022	Transparency International Database
INF	Inflation, consumer price	Annual Percentage	1995-2022	World Development Indicator (WDI)
GOVS	General final government expenditure	USD	1995-2022	World Development Indicator (WDI)

3.3. Research Framework

As shown in Figure 2, the paper seeks to ascertain the complex relation of oil prices, corruption, exchange rate and FDI inflows on Ghana's GDP. Moreover, it focuses on determining the lead/lag connectedness and the level of interrelations among the employed economic indicators. To achieve this, descriptive statistics, correlation analysis, Variation inflation factor and diagnostic tests are conducted to examine the fluctuations, multicollinearity and robustness among the variables. A bound test is run to evaluate the cointegration among the chosen indicators. Finally, the ARDL model is chosen to evaluate the relationships among the variables and the Wavelet technique is employed to determine the lead/lag connectedness and the level of reliance among the employed indicators.

Figure 2: Research Framework

3.4. Data Normalization

The data for the study may materialize as sporadic. As a result of the wider range of figures with different variables, they are normalized to maintain a standardized format. Normalizing the data will eliminate the immeasurable differences in the numerical association among the variables and authorize various types of variables to be evaluated within a particular interval. n represents the number of samples first selected and m number of selected variables. The data are normalized using Eqn. (1) and (2). Eqn. (1) is utilized if the selected variable negatively influences the dependent variable; else Eqn. (2) is used below:

$$X_{it} = (x_{it} - min(x_t)) \div (max(x_t) - min(x_t)), i = 1, 2, 3, \ldots n; \ t = 1, 2, 3, \ldots m$$

$$X_{it} = (x_{it} - min(x_t)) \div (max(x_t) - min(x_t)), i = 1, 2, 3, \ldots n; \ t = 1, 2, 3, \ldots m$$

Where, X_{it} and x_{it} implies the normalized and original figures for a variable with n representing all the years; $max(x_t)$ and $min(x_t)$ indicates the maximum and minimum figures for each variable with n in all the years.

3.5. ARDL Modeling Approach

The study discusses different approaches and models used to analyze research, focusing on the OLS-based multiple linear regression and the residual-based Engle-Granger method. However, due to limited data availability for emerging economies like Ghana, the study suggests the use of the ARDL model. This model is preferred because it is flexible and can analyze variables that are unified at both I(0) and I(1). Moreover, it can capture the interrelation among the variables in time series by taking adequate lags. Furthermore, it allows for the identification of an error correction term (ECT) using a simple linear transformation. Equation (3) represents the model used to assess how oil prices, corruption, FDI inflows and exchange rates influence Ghana's economy.

$$GDP_{it} = B_i + \theta_1 COP_{it} + \theta_2 EXG_{it} + \theta_3 FDI_{it} + \theta_4 CPI_{it} + \theta_5 INF_{it} + \theta_6 GOVS_{it} + \theta_7 TOP_{it} + \varepsilon t \quad (3)$$

3.6. Wavelet Multiple Technique

The study employs the Wavelet Multiple Technique encompassing Wavelet Multiple Correlation (WMC) and Wavelet Multiple Cross-Correlation (WMCC). This study adopts this method to identify the correlation between two or more possibly related variables, and examines the level of interdependencies between GDP (dependent variable) and other economic variables from the short and long-term time periods. It also assesses the dominant indicator at a particular wavelet period to serve as either a leading (initial variable to react to unexpected events) or lagging (the last indicator to react to unexpected events following the other indicators) (E. Boateng et al. 2022).

The WMC denoted as $\Omega X(\lambda_j)$ is recounted as the multiscale symmetry determined through Xt as indicated. The root squared R^2 of the regression attained by integrating $w_{ijt}, i = 1, 2, \ldots, n$ variables in a straight way for which R^2 is the greatest attained at each scale λ_j. Empirical studies reveal that no auxiliary regressions should run as the R^2 consents with the regression variable z_i on a set of predictors $\{z_k, k \neq i\}$ indicated as $R_i^2 = 1 - \rho^{-ii}$, and $\rho^{ii} = $ the ith diagonal feature of the correlation matrix P that is complete and inverse. Therefore, WMC is shown in Equation (4) as

$$\Omega X(\lambda j) = \left(1 - \frac{1}{max\ diagP\ _j^{-1}}\right)^{1/2} \tag{4}$$

Where Pj is the correlation matrix of W_{jt} in the form (n x n)

By permitting a lag τ at each scale λ_j between observed and adapted numbers, the WMCC can be derived as

$$\Omega X, \tau(\lambda_j) = Corr(w_{ijt}, \widehat{w}_{ijt+\tau}) = \frac{Cov(w_{ijt}, \widehat{w}_{ijt+\tau})}{Var(w_{ijt})Var(\widehat{w}_{ijt+\tau})} \tag{5}$$

Where for n = 2, WMC and WMCC align with conventional wavelet correlation and cross-correlation.

4. Results and Discussions
4.1 Descriptive statistics and Correlation analysis

In preparation to conduct the diagnostic test, a thorough descriptive analysis is run to examine the fluctuations among the selected variables. A time span of data set from 1995 to 2022 is used for the analysis. The descriptive analysis focuses on standard deviations, means, skewness, and kurtosis with 28 observations (see Table 4). The values of the standard deviation ranging from 0.264 to 0.376 indicate that the employed data points are relatively close to the mean. Moreover, the selected variables exhibit both positive and negative skewness, indicating that a considerable portion of their distributions is skewed to the left and right of the standard curve, respectively. Kurtosis values of the employed variables are both lesser and higher than 3, which implies that they both exhibit a platykurtic and leptokurtic distribution respectively. Furthermore, the correlation analysis in Table 4 shows a strong correlation among most of the variables. However, few correlations among the variables reveal a weaker relationship.

Table 4: Descriptive Statistics

VARIABLE	MEAN	STANDARD DEV.	SKEWNESS	KURTOSIS
GDP	0.381	0.349	0.351	1.588
COP	0.555	0.321	-0.319	1.885
EXG	0.747	0.264	-1.178	3.483
FDI	0.424	0.376	0.046	1.287
CPI	0.617	0.321	-0.253	1.868
INF	0.738	0.248	-1.484	4.397
GOVS	0.396	0.337	0.260	1.480
OBSERVATION	28			

(Source: Estimated from STATA MP 17)

Table 5: Correlation Analysis of Selected Variables

	GDP	COP	EXG	CPI	FDI	INF	GOVS
GDP	1.000						
COP	-0.617	1.000					
EXG	-0.906	0.400	1.000				
CPI	-0.819	0.686	0.666	1.000			
FDI	0.820	-0.731	-0.583	-0.836	1.000		
INF	0.447	-0.443	-0.2784	-0.441	0.516	1.000	

GOVS	0.953	-0.721	-0.795	-0.827	0.849	0.489	1.000

(Source: Estimated from STATA MP 17)

4.2 Variation Inflation factor (VIF)

To evaluate the presence of multicollinearity in the regression model, the VIF is conducted. Table 6 shows that the VIF values for the chosen variables are less than 10% implying that the variables are without multicollinearity.

Table 6: Variation Inflation factor (VIF)

Variable	VIF	1/VIF
GOVS	9.00	0.1112
FDI	5.25	0.1903
CPI	4.23	0.2366
EXG	3.64	0.2744
COP	2.76	0.3629
INF	1.42	0.7062
Mean VIF	4.38	

4.3 Diagnostic Test
4.3.1 Unit Root Test

From Table 7, both the PP and ADF tests reveal that INF is stationary at level. This implies that their approximate p-values for z(t) are lower than 5%. It further suggests that Inflation is integrated with I(0). Moreover, the PP and ADF tests also indicate that GDP, COP, CPI, EXG, FDI and GOVS are not stationary at the level. However, they are stationary at 1st difference for both the ADF and PP tests. They are significant at both 1% and 5% at the level of confidence. This becomes appropriate to utilize the bounds test.

Table 7: Unit Root Test

	LEVEL		LAG	1ST DIFFERENCE	
	ADF	PP		ADF	PP
GDP	0.9794	0.9774		0.0005	0.0000
COP	0.4722	0.5473		0.0013	0.0007
EXG	1.0000	1.0000		0. 0008	0. 0000

CPI	0.6664	0.5622		0.0113	0.0000
FDI	0. 6930	0.6211	1	0.0464	0.0000
INF	0.0004	0.0004		0.0000	0.0000
GOVS	0. 8360	0.7793		0.0026	0.0000

(Source: Estimated from STATA MP 17)

4.4. Co integration Test Results

The bounds test is an essential tool for assessing variables of distinct orders of correlation and for determining long- and short-term coefficients simultaneously. It is derived through the F-statistic test. A higher F-statistic than the I(1) bound indicates the presence of interrelation in the equation, while a lower F-statistic than the I(0) bounds demonstrate no co-integration.

Table 8: ARDL Bounds Test

	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_01	L_01
k_6	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43
	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_01	L_01
k_6	-2.57	-4.04	-2.86	-4.38	-3.13	-4.66	-3.43	-4.99

H0: no levels relationship   F = 24.290
t = -5.945
Critical Values (0.1-0.01), F-statistic, Case 3

(Source: Estimated from STATA MP 17)

From Table 8, the computed F-statistic can be verified as 24.290. This is above the I(1) bounds at all the significant levels revealing an existence of co-integration. Moreover, the bounds test shows

a long-term correlation among the chosen indicators. An ARDL model is utilized to evaluate the long-run correlation among the variables. The chosen models are ARDL (2,0,2,1,1,2,2) for GDP_{it} and its covariates in the model. Table 9 demonstrates the derived co-efficient of the long-run model.

4.5 ARDL Analysis for the Model
4.5.1. Discussion of Long Run Results

Due to the long-run correlation in the model, an ARDL model is conducted to assess the interrelation among the economic indicators. The outcome of Table 9 shows that oil price fluctuations (COP) have a substantial adverse effect on GDP. This is appropriate at a 10% level of confidence. This agrees with the evidence of (Dadson Awunyo-Vitor, 2018). It signifies that an increase in oil prices will generate a 6.30% decrease in Ghana's economy. Exchange rate volatility (EXG) also shows an adverse influence on GDP at a 1% significant level. This confirms the outcome of (Tankia-Allou, 2021) implying that a depreciation in the domestic currency against the foreign exchange rate leads to a decline in the economy. The outcome shows that a depreciation through a rise in the foreign exchange rate will result in a reduction of 68.9% in the GDP of Ghana. However, FDI inflows in Ghana also show a significant beneficial impact on Ghana's GDP. This indicates that a unit increment in FDI inflows will reveal a 13.1% rise in Ghana's GDP.

Inflation on the other hand reveals a negative relation with GDP. This reveals that as prices of goods and services increase, GDP declines, thus a percentage increment in inflation will result in a decrease of about 3.1 % in GDP. Corruption using the CPI index shows a significant positive interrelation with GDP. It is significant at 10%. This result contradicts with existing literature (Awadzie, 2021). However, the study asserts that factors such as informal economic activity, a temporal boost in investment and market failure in Ghana can influence corruption to impact GDP positively though it is generally recognized as a negative indicator. Government spending is significantly positive to GDP in the current year. It is appropriate at a 1% level of confidence. The result denotes that as government spending rises, Ghana's economy also boosts, thus a percentage rise in Government spending reveals a 70.3% increase in GDP.

Table 9: Long-Run Relationship using the ARDL Model

D.GDP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]

ADJ						
GDP						
L1.	-1.1383	0.191	-5.94	0.000***	-1.571	-0.705
LR						
COP	-0.0630	0.046	-1.93	0.085*	-0.166	-0.403
EXG	-0.689	0.063	-10.92	0.000***	-0.832	-0.546
FDI	0.131	0.034	3.81	0.004**	0.053	0.209
CPI	0.109	0.058	1.86	0.095*	0.023	0.240
INF	-0.031	0.050	-0.61	0.555	-0.143	0.082
GOVS	0.703	0.083	8.45	0.000***	0.515	0.891
SR						
GDP						
LD.	0.1237	0.177	0.70	0.502	-0.276	0.523
EXG						
D1.	1.3648	0.222	6.15	0.000***	0.863	1.867
LD	1.1666	0.604	1.93	0.086**	-2.00	2.533
FDI						
D1.	-0.039	0.041	-0.95	0.365	-0.131	0.053
CPI						
D1.	-0.069	0.048	-1.42	0.190	-0.178	0.041
INF						
D1.	0.028	0.035	0.81	0.438	-0.051	0.108
LD	0.013	0.029	0.43	0.678	-0.054	0.079
GOVS						
D1.	-0.670	0.093	-7.23	0.000***	-0.880	-0.461
LD.	-0.587	0.073	-8.02	0.000***	-0.752	-0.421
_cons	0.734	0.155	2.81	0.001***	0.384	1.084

ARDL (2,0,2,1,1,2,2) regression
Number of obs.   =   26
R-squared   = 0.9704
Adj R-squared   = 0.9178
Log likelihood = 75.281501
Root MSE   = 0.0227
*, **, *** means significant at 10%, 5%, and 1%, respectively

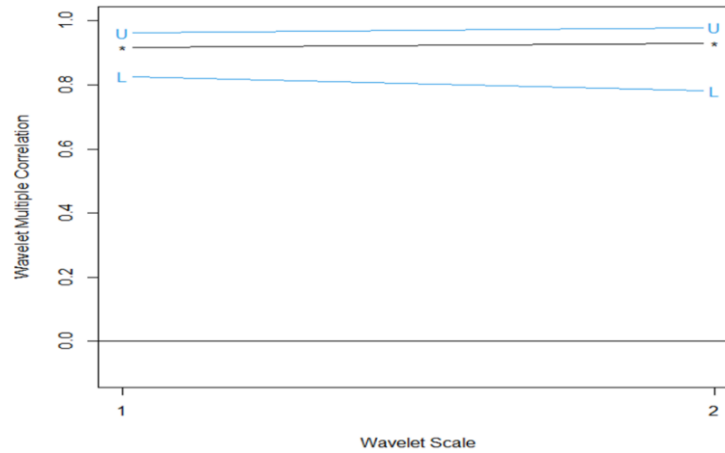*(Source: Estimated from STATA MP 17)*

4.6. Discussion of Wavelet Multiple Techniques

4.6.1 Wavelet Multiple Correlation (WMC)

Figure 3 depicts the WMC of the variables analyzed in the study. It encompasses the complete sample period from 1995 to 2022. The U and L values denote the upper and lower limits at a 95% confidence level. These results are statistically supported by the outcome in Table 10. The findings, obtained through the frequency localization of the Maximal Overlap Discrete Wavelet Transform

(MODWT), illustrate the level of the correlation between the variables analyzed across short-to-long-term periods. While the outcomes do not indicate a leading or lagging variable, they do demonstrate wider interrelations between all the studied variables across different time scales.

Figure 3: WMC among Selected Variables

(Source: Estimated from R)

Table 10: *Wavelet Multiple Correlations (WMC)*

Scale	WMC 'lower'	Correlation	WMC 'upper'
1	0.8347	0.9222	0.9643
2	0.8846	0.9652	0.9898

The WMC results (table 10 and Figure 3) for the sample convey a relatively higher level of correlation among the chosen variables in both short and long periods. Scale 1 demonstrates strong correlations among the variables with lower and upper bounds of 0.8347 and 0.9643, respectively, and an average correlation of 0.9222. This indicates a very high degree of coherence at shorter periods. This implies that there is a consistently strong relationship among all the economic variables. The coherence is high, meaning changes in one variable are highly correlated with changes in the others. This might suggest that at shorter periods (or higher frequencies), the economic variables move together closely.

Moreover, scale 2 indicates even stronger correlations, with lower and upper bounds of 0.8846 and 0.9898, respectively, and an average correlation of 0.9652. This reveals highly synchronized over longer periods among the variables. This suggests that over longer periods (or lower frequencies), the variables exhibit an even more synchronized relationship. This might imply

that fundamental economic trends are closely linked and move together over longer time horizons. The high coherence at both scales indicates that economic policies affecting one variable are likely to have strong and immediate impacts on others. Therefore, it is prudent for policymakers to be aware of these tight interconnections.
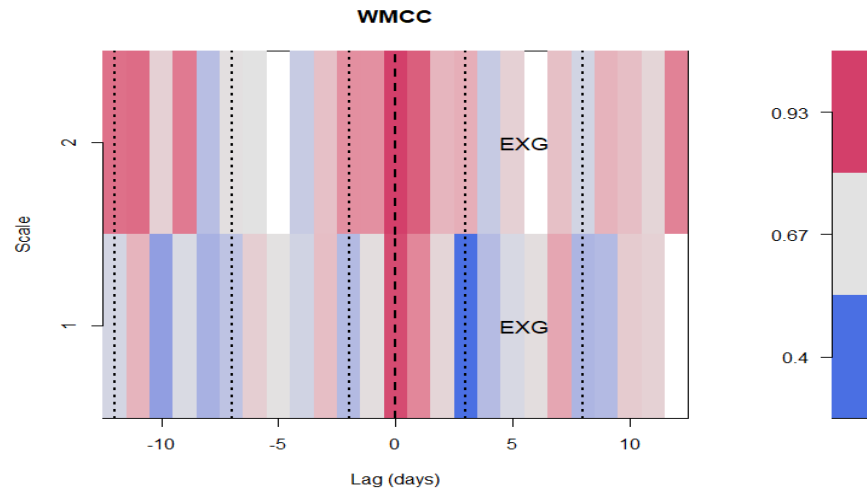
4.6.2. Wavelet Multiple Cross-Correlation (WMCC)

The WMCC introduced in Table 11 and Figure 4 reveals two wavelet scales. Localizations at positive lag signify a lagging variable whiles negative lag communicates a leading variable at their specific scales. The zero-lag of localization reveals there is neither lead nor lag. At each wavelet scale, localization unequivocally demonstrates the highest values in the linear integration of all variables. These are depicted by dashed lines within the dotted lines at all lags. When a variable is displayed on a scale, it indicates that the variable is most likely to lead or lag behind all the other variables at that scale. This means that, at that scale, it has the topmost value in the linear integration of all the variables at their particular scales.

The significance of WMCC is that it specifies the level of interconnection among the variables, and provides the most predominant variable at a particular wavelet scale to serve as either a leading (the premiere variable to react to unexpected occurrence) or lagging (the last variable to react to unexpected event following the other indicators) (Boateng, 2022).

From Figure 4, the result reveals that the exchange rate is the pivotal and predominant driver of the relationship among the variables without any lag. This suggests that the exchange rate plays a crucial role in determining the coherence among the economic indicators at both short and long periods. It also indicates that changes in exchange rate volatility have an immediate impact on the coherence with other economic indicators such as GDP, oil price fluctuations, FDI, corruption, inflation, and government spending.

Figure 4: WMCC among Chosen Variables.

WMCC

(Source: Estimated from R)

Table 11: WMCC among Chosen Variables

Scale	Localizations	Time Lag (days)	Leading/Lagging variables
1	0.9222	0	EXG
2	0.9652	0	EXG

4.7. Hypothesis Testing

To test the hypothesis in Table 2, this paper's analysis reveals that based on the ARDL approach, oil prices and exchange rate volatility have adverse relations to economic growth. This indicates that H1 and H2 are accepted respectively. However, corruption and FDI inflows show a positive relation to GDP which also implies that H3 is rejected while H4 is accepted.

5. Conclusions and Policy Implications

5.1. Conclusion

The core objective of this research is to ascertain the integrated influence of oil prices, exchange rate volatility and FDI inflows on economic growth in Ghana. Furthermore, it evaluates the lead/lag connectedness among the variables and provides their level of interdependencies. Analyses are performed through the Wavelet multiple techniques (WMC, WMCC) and ARDL approach. To measure the variations and degree of correlation among the variables, descriptive statistics and correlation analyses are conducted. VIF is also employed to determine the presence of multicollinearity in the regression model. The result indicates that the employed variables are without multicollinearity. Moreover, a diagnostic test is conducted using PP and ADF tests to allay

spurious results in the regression analysis. Outcomes from both tests convey that Inflation is stationary at a level while the remaining indicators are correlated at I(1) and I(2) respectively. This confirmed the appropriate use of bounds test to verify the co-integration of the employed economic indicators.

The outcome of the analysis confirms a long-term interrelation. Therefore, an ARDL model is employed to evaluate the long-term correlation. The results of the ARDL model denote a significant association between the independent variables and GDP at a 1%, 5% and 10% confidence level. Oil price fluctuations, exchange rate volatility and inflation demonstrate an adverse impact on the economic growth of Ghana. However, Corruption using the CPI index, FDI inflows and Government Spending reveal a positive and significant relationship to GDP in Ghana.

Though corruption is generally seen as detrimental to economic development, there are certain conditions under which corruption might have a positive impact on GDP. These conditions are usually seen in the context of specific economic environments, particularly in developing countries. These include informal economies where a significant portion of the economic activity is informal or outside the formal regulatory framework, corruption can facilitate these informal activities. This can result in increased economic transactions and higher GDP. Moreover, a temporary boost in investment can also play a role, in some cases, corruption can attract short-term investment by providing firms with easier access to contracts and resources. Investors might be willing to engage in corrupt practices to gain access to lucrative markets or resources, temporarily boosting GDP. Finally, in situations where market failures or government failures impede economic activity, corruption might help to bypass these impediments. For example, if there are significant barriers to entry in certain industries due to monopolistic practices or restrictive regulations, corruption might allow new entrants to participate in the market, thus increasing competition and economic output. These can be the conditions the corruption in Ghana has a positive interrelation with GDP.

Using the Wavelet technique, WMC and WMCC are used, and the WMC results demonstrate a relatively higher level of correlation between GDP and independence variables. The degree of interdependency reaches a peak of approximately 0.9652 for the wavelet multiple correlations, 0.8846 for the lower panel and 0.9898 for the upper panel. This shows a perpetual increase in the multiple correlations over the periods and therefore confirms that economic policies affecting one variable are likely to have strong and immediate impacts on others.

Lastly, the outcome from WMCC reveals that the exchange rate is a significant driver and dominant variable that influences the relationship among the variables without any lag. This connotes that the exchange rate has a significant influence in assessing the coherence among the economic indicators, which implies that changes in the exchange rate will have an immediate and strong impact on the other variables.

5.2. Policy Implication

This study gives the following recommendations based on the conclusive results; Firstly, as a result of the adverse effect of oil price fluctuations on economic development in the analysis, stakeholders and policymakers in Ghana should promote the development and adoption of renewable energy sources to reduce Ghana's dependence on fossil fuels, including oil. Investments in solar, wind, hydroelectric, electric vehicles, battery storage and biomass energy can contribute to energy security, reduce environmental pollution, and create new opportunities for economic growth and job creation.

Secondly, the government and policymakers of Ghana can reduce their reliance on oil by diversifying its economy. This includes investing in sectors such as agriculture, manufacturing, tourism, and services. This will help cushion the economy from the volatility of oil prices and create a more resilient economic base. Also, diversification policies can be strengthened by implementing incentives to support the growth of non-oil sectors. This may include granting small and medium-sized enterprises (SMEs) financial support, fostering innovation and technology adoption, improving infrastructure connectivity, and facilitating trade and investment in non-oil sectors.

Moreover, the paper concludes that the exchange rate significantly affects economic growth. In this regard, policymakers in Ghana can develop and implement a robust exchange rate management framework that incorporates market-based mechanisms, transparent exchange rate policies, and communication strategies to enhance market confidence and reduce speculative activities that contribute to volatility. It is also imperative that the government diversify its export markets and products to reduce its vulnerability to external shocks and currency fluctuations. By expanding export opportunities across different regions and sectors, Ghana can mitigate the negative impact of exchange rate volatility on its trade balance and economic growth.

Additionally, to adequately reduce corruption in Ghana, there should be continuous monitoring and evaluation of the impact of anti-corruption measures on economic growth. Data-

driven approaches should be used to assess the effectiveness of interventions and make evidence-based decisions to combat corruption and promote sustainable economic development. Government and policymakers should also strengthen anti-corruption measures to reduce corruption levels. This includes enhancing transparency, accountability, and enforcement of laws and regulations. This will create a more conducive environment for sustainable economic growth.

Furthermore, Ghana can expand the positive impact of FDI inflows on its economy when FDI projects are encouraged to incorporate local content requirements and promote linkages with domestic suppliers, industries, and services. This can create spillover effects, stimulate local economic development, and enhance the positive impact of FDI on the broader economy. Policymakers should also maintain regulatory stability, transparency, and predictability to build investor confidence and attract sustained FDI inflows. This will protect investors' rights, and intellectual property, and ensure fair competition to create a conducive investment climate.

Finally, in regard to the exchange rate being the dominant and pivotal variable in the WMCC analysis, governments and policymakers should consider its immediate effect on the broader economic environment. For instance, stabilizing exchange rates could have significant and immediate benefits for the economy. It has the ripple effect to influence other significant variables such as oil price fluctuations, corruption FDI inflows, inflation and government spending. Therefore, policymakers should focus more on the strategies to manage exchange rate volatility to achieve more stable and coherent economic outcomes.

5.3 Limitations of the Study

This research has some limitations. The main challenge we faced was the unavailability of data. We needed secondary data from 1980, but it was not accessible. While some variables have data from 1980, others do not, leading to a reduction in the study's sample size. However, we still present the study's findings due to the predictive ability of the ARDL and Wavelet model. For future studies, researchers should seek data samples that extend beyond the period specified in this work, if available. Moreover, other factors such as interest rate, gross savings, trade openness and population can be used as control variables to measure economic growth, therefore the selected variables cannot be regarded as the sole determinant of economic growth.

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