Effect of Exchange Rate Volatility and its Transmission Pathways on Economic Growth in Post Exchange Rate Liberalization Ghana

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Abstract

Exchange rate volatility is a major concern for local and foreign investors. Its impact on economic growth has been widely documented in literature. In this paper, we model exchange rate volatility using GARCH (1,1) and analyze its impact on economic growth in Ghana, with a particular focus on the post exchange rate liberalization period, 1990-2019. Additionally, this paper assesses the pathways through which exchange rate volatility affects economic growth. By employing the autoregressive distributed lagged (ARDL) model, we find evidence that exchange rate volatility has a negative impact on economic growth in Ghana. In addition, inflation and interest rates are significant transmission pathways through which exchange rate volatility impact growth in post exchange rate liberalized Ghana. The paper thus suggests the implementation of policies aimed at curbing excessive and rapid fluctuations in the exchange rate. In addition, the Central Bank must embark on more inflation-targeting policies aimed at stabilizing the local currency to attract foreign direct investment.

Keywords: Exchange rate volatility; Economic growth; Post exchange rate liberalization; ARDL; Ghana

JEL Classification Codes: E58, F31, O40,

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1. Introduction

Exchange rates play a key role in the growth of economies across the globe as they affect international trade, foreign direct investment, finance, migration, and macroeconomic stability, among others (Vinh and Duong, 2019). The impact of the exchange rate on indicators of economic performance makes the measurement of exchange rate volatilities and their resulting effects very important to every economy. For decades, Ghana's economy has been highly dependent on the external sector, making it vulnerable to fluctuations in commodity prices due to market uncertainty and other external shocks. The country has persistently been confronted with exchange rate volatilities, making it extremely difficult to predict the growth trend in the country, price stability, and foreign investments (Ajao and Igbekoyi, 2013).

The collapse of the Bretton Woods system exposed many currencies to volatility after a shift from a fixed exchange rate to a floating exchange rate, which has generated a lot of interest among researchers, policymakers, and other practitioners alike. In the early 1980s, Ghana moved away from a fixed exchange rate regime to a flexible regime, as initiated by the international monetary system in 1973 (Bahmani-Oskooee and Arize, 2020). However, the country began to experience currency depreciation on a yearly basis, with an annual average of approximately 8%, which led to its redenomination in 2007. The redenomination, however, did not immune the currency from losing its value, particularly against the three major trading currencies: the US dollar, the British pounds, and the Euro. For example, after the redenomination, Ghana cedi was trading at GH¢0.95 to the US dollar. However, by February 2011, Ghana cedi was selling at 1.54, 2.47, and 2.10 against the dollar, pound, and euro, respectively (Bank of Ghana, 2011). Between 2007 and 2013, the cedi depreciated, on average, by about 15%, 12%, and 14% against the dollar, pounds, and euro, respectively, creating major instability in economic growth. Despite this trend, at the beginning of 2014, cedi assumed an unprecedented move that depreciated substantially against all three trading currencies. The situation invoked public outbursts, and some leading experts likened it to currency crises. According to the 2020 Bank of Ghana annual report, the cedi depreciated by about 21% against the dollar and the pounds and 20% against the euro in the first quarter of 2014. The exchange rate increased from 2.9 in 2013, to 3.71 in 2014. In 2015, the exchange rate increased to 3.79, and then to 4.2 in 2016. It further increased to 4.42, 4.82 and 5.53 in 2017, 2018, and 2019, respectively. In 2020 and 2021, it was 5.76 and 5.73, respectively.

Ghana’s growth rate is uneven when the post-reform period is compared to the earlier period. Ghana’s economic growth rate was retarded in the 1970s and the early 1980s due to political instability. After the 1983 structural adjustment program, the economy responded positively to its negative growth. Moreover, economic growth peaked in the late 2000s as a result of price booms of its main export commodities, such as gold, cocoa, and timber, and the discovery of crude oil. There has been a constant increase in Ghana’s growth rate in recent times since 2016, with a growth rate of 3.45% increasing by 4.70% to 8.14% in 2017, then to 6.26% in 2018, and again 6.48% in 2019. High growth momentum since 2017 consistently placed Ghana among Africa’s 10 fastest-growing economies until the emergence of the Covid-19 pandemic which plunged the entire world into recession.

The impact of exchange rate volatility on economic growth has generated much discussion among policymakers, researchers, and investors because of its impact on economies across the globe. Despite extensive research, country-specific studies such as Ghana remain limited. Some of the limited studies include that of Alagidede and Ibrahim (2017). Notwithstanding, it is observed that the existing studies utilized data that covered episodes of fixed/pegged regimes, wholesale auction systems, and managed-floating regimes. These exchange rate

regimes represent different exchange rate policies implemented in Ghana in the past, with potentially different impacts on growth and other economic outcomes. Hence, the exclusive focus on the post exchange liberalization period allows us to analyze the isolated effect of volatility of the present floating exchange rate regime on economic growth in Ghana. Furthermore, there is a lacuna in prior studies of Ghana with respect to the transmission mechanisms through which exchange rate volatility affects economic growth. Therefore, this paper makes contribution to literature in the following ways. To begin with, it assesses the volatility of Ghana's exchange rate since its liberalization. Second, it assesses the impact of exchange rate volatility on economic growth in Ghana in post exchange rate liberalization. Third, it seeks to provide evidence on whether inflation and interest rates serve as transmission mechanisms through which exchange rate volatility affects economic growth in post liberalized Ghana.

The following shows the order for the remainder of this paper. Section 2 reviews the empirical literature on exchange rate volatility and economic growth. Section 3 presents the data description, methodology, and estimation techniques. The results and findings are presented and discussed in Section 4, and Section 5 concludes the paper with policy implications.

2. Literature Review

The purchasing power parity (PPP) theory postulates that changes in the exchange rate between two countries are due to changes in the relative prices or rates of inflation in the two economies. This is premised on the law of one price, which states that in a competitive market, identical products sold in different countries must be sold at the same price when their price is expressed in terms of the same currency, free transportation cost, and barriers to trade. Though widely applied, PPP theory has been criticized based on strong hypotheses and assumptions; hence, it is not being practiced. On the other hand, the interest rate parity (IRP) theory is an asset approach for determining the exchange rate. It is based on exchange rates being used not only to compare the prices of goods and services across countries, but also to compare the return on foreign currency-denominated assets (e.g., stocks and bonds) to the return on domestic assets. This theory suggests a strong relationship between interest rates and currency value movements. This suggests that future exchange rates will depend on the differences in interest rates between the two countries. The interest rate parity condition implies that given the foreign exchange market equilibrium, the expected return on domestic assets will equal the exchange rate-adjusted expected return on foreign currency assets.

Exchange rate fluctuations affect economic growth in two ways: investment and international trade. In the area of investment, theoretical studies by Nucci and Pozzolo (2010), Campa and Goldberg (1999), and Harchaoui et al. (2005), with only slight variances in their constructions, employed distinct dynamic optimization problems with a typical adjustment-cost model of a company that runs in an imperfect undefined environment. The results of these hypothetical studies can be categorized into three (3) groups. First, the exchange rate affects investment through domestic and export sales. The prices of goods sold in the local market are lower than those of foreign goods because of the depreciation of the economy's currency. Second, investments react to the exchange rate because of the price of the inputs imported into the country. Imported goods become very expensive and adversely affect investment decisions. Third, the exchange rate has been shown to impact investment by the prices of imported investments through adjustment costs. Therefore, investors refuse to invest in countries with unstable exchange rates. Depreciation increases the price of the investment, leading to a higher cost of adjustment and lower investments.

Again, by analyzing the linkage between international trade and high exchange rate volatility, Bahmani-Oskooee and Arize (2020) asserted that less foreign trade and lower costs are higher for risk-averse traders when exchange rate volatility is high, thus affecting the economic growth of a country. Other studies have argued that this assertion is founded on a restrictive assumption concerning the form of the utility function since the effect becomes uncertain when these limitations are eased. For instance, De Grauwe (1988) finds that an increase in the uncertainty of the exchange rate has both income and substitution effects. The income effect shifts resources into the export sector when the utility of export income declines because of an increase in exchange rate risk. However, the substitution effect shifts resources from relatively risky export activities to less risky ones. Thus, if the income effect dominates the substitution effect, exchange rate volatility can positively impact export activities and, to some extent, economic growth.

Bailliu *et al.* (2003) empirically investigated whether exchange rate policy matters for economic growth. Using panel data from 60 countries and the generalized method of moments (GMM) estimation technique, they found that exchange rate regimes characterized by a monetary policy anchor, whether pegged, intermediate, or flexible, exert a positive influence on economic growth. Using GMM estimation technique, Schnabl (2008) finds a robust negative relationship between exchange rate volatility and growth for 41 small open economies at the European Monetary Union (EMU) periphery. International trade, international capital flows, and macroeconomic stability have been identified as important transmission channels from exchange rate stability to increased growth. Similarly, Vieira *et al*. (2013) revealed that real exchange rate volatility had a negative impact on economic growth using GMM in 82 developed and developing countries from 1970 to 2009. Barguellil et al. (2018) also used GMM for 45 developing and emerging countries from 1985 to 2015, and revealed that not only did exchange rate volatility affects economic growth negatively, but the impact depends on existing exchange rate regime and financial openness. Furthermore, the authors ascertained that volatility is more harmful when countries adopt flexible exchange rate regimes and financial openness. In Ghana, Alagidede and Ibrahim (2017) also revealed that exchange rate volatility is harmful to economic growth; however, it is only up to a point as the growth-enhancing effect can also come from innovation and more efficient resource allocation. Similarly, Ahiabor and Amoah (2019) established that real effective exchange rate volatility has a negative effect on economic growth in Ghana, using the Fully Modified Ordinary Least Squares (FMOLS) estimation technique from 1980 to 2015. Adjei (2019) also reported that exchange rate volatility exerts a negative effect on economic growth in both the short and long run from 1983 to 2010. Using the fixed effects estimation technique, Morina et al. (2020) revealed that exchange rate volatility has a significant negative effect on economic growth among 14 Central and Eastern European countries (CEE) from 2002 to 2018.

3. Methodology

3.1 Model Specification

The Solow model is a neoclassical growth model owing to its continuous substitutability of the factors of production, and each of the factors of production is faced with diminishing returns. Solow divided output growth into three components, labor, capital, and total factor productivity, using the Cobb-Douglas production function for the growth equation, as shown in equation (1).

$$Y = f\ (A, L, K) \qquad (1)$$

where *A* denotes total factor productivity, *L* is the labor force, and *K* is the capital stock. factor productivity represents the part that is not accounted for by capital and labor. It is assumed to be endogenously determined by economic-, institutional-, and country-specific factors. From

the Cobb-Douglas production function specified by Solow in equation (2), the total factor productivity is assumed to be the level of technology.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \qquad (2)$$

The output growth model is specified by including exchange rate volatility as a variable for the other explanatory variables. GDPG is the dependent variable, with independent variables, such investment, gross capital formation, and government expenditure. The estimable model is given by Equation (3):

$$lnGDPG_t = \beta_0 + \beta_1 lnGDPG_{t-1} + \beta_2 lnERV_t + \beta_3 lnGCF_t + \beta_4 lnFDI_t + \beta_4 lnGE_t + \varepsilon_t \quad (3)$$

where GDPG is the growth of gross domestic product, ERV is exchange rate volatility, GCF is gross capital formation, FDI is foreign direct investment and GE is government expenditure. The variables are transformed using natural logarithms. Hence, the coefficients represent the elasticities.

After examining the effect of exchange rate volatility on economic growth, transmission channels are considered using an interaction term. The variables considered for the transmission mechanisms in this paper are inflation and interest rates, as shown in Equation (4). We modified equation (3) with the interaction term (*ERV*W*), where *W* represents inflation and the interest rate. The other variables have been explained previously.

$$lnGDPG_t = \beta_0 + \beta_1 lnGDPG_{t-1} + \beta_2 lnERV_t + \beta_3 lnGCF_t + \beta_4 lnFDI_t + \beta_4 lnGE_t + \beta_5 (ERV * W) + \varepsilon_t \quad (4)$$

3.2 Measuring Volatility

In this paper, exchange rate volatility was measured using the nominal exchange rate, crude oil price, and interest rate. Several methods have been used to measure volatility including standard deviation, realized volatility, and GARCH models (Chen and Hsu, 2012). However, in this paper, the Generalized Autoregressive Conditional Heteroskedasticity, GARCH (1,1) model is used to measure exchange rate volatility as has been used in the literature to measure volatility (Barguellil et. al, 2018; Alagidede and Ibrahim, 2017; Mpofu, 2016). It is also considered as a standard approach for volatility modelling because it better explains the volatility of a certain series. Under GARCH models, the two conditions necessary for the modelling–heteroscedasticity and the ARCH effect–must be present. The GARCH (1,1) model is specified in equation (5) and (6). Equation (6) represents the GARCH, which captures the square of the lag of the residual and a lag of the GARCH, whereas equation (5) captures the square root of the GARCH, crude oil price, and interest rate, which measures oil price volatility.

$$ERV = \beta 0 * \sqrt{H} + \beta 1 * OP + \beta 2 * IR \qquad (5)$$

$$H_t = \beta 0 + \beta 1 * e_{t-1}^2 + \beta 2 * H_{t-1} \qquad (6)$$

where ERV represents exchange rate volatility, OP denotes crude oil price, IR captures interest rate, β represents coefficients, H_t denotes GARCH, H_{t-1} is the lag of GARCH, and e is the residual. Exchange rate volatility was used as a variable in the main empirical model for the analysis.

3.3 Estimation Strategy

The autoregressive distributed lag (ARDL) model was adopted as the estimation technique. The ARDL model contains the lagged values of the dependent variable, and the current and lagged values of the regressors as explanatory variables. Unlike a VAR model, which is strictly

for endogenous variables, the model uses a combination of endogenous and exogenous variables. The use of the ARDL model for estimation is appropriate if the variables are integrated in different orders. The ARDL (p, q) error correction model comes with the difference operator for the dependent variable, as specified in equation (7), and that of the transmission mechanism is shown in equation (8).

$$\Delta lnGDPG_t = \alpha + \sum_{i=1}^{p} \beta_{1i} \Delta\, lnGDPG_{t-i} + \sum_{j=1}^{q} \beta_{2j} \Delta\, lnERV_{t-j} + \sum_{k=1}^{q} \beta_{3m} \Delta\, lnGCF_{t-m} + \sum_{l=1}^{q} \beta_{4l} \Delta\, lnFDI_{t-l} + \sum_{m=1}^{q} \beta_{5k} \Delta\, lnGE_{t-k} + \lambda ECT_{t-1} + \varepsilon_t \quad (7)$$

$$\Delta lnGDPG_t = \alpha + \sum_{i=1}^{p} \beta_{1i} \Delta\, lnGDPG_{t-i} + \sum_{j=1}^{q} \beta_{2j} \Delta\, lnERV_{t-j} + \sum_{k=1}^{q} \beta_{3m} \Delta\, lnGCF_{t-m} + \sum_{l=1}^{q} \beta_{4l} \Delta\, lnFDI_{t-l} + \sum_{m=1}^{q} \beta_{5k} \Delta\, lnGE_{t-k} + \sum_{n=1}^{q} \alpha_{1n} \Delta\, (lnERV * W)_{t-n} + \lambda ECT_{t-1} + \varepsilon_t \quad (8)$$

where λECT_{t-1} is the error correction term (ECT), which gives the long-run information in the model; $\beta's$ denote the short-run coefficients; p and q captures the lag lengths; α_i also denotes the interaction coefficient; W represents the inflation and interest rate; and $(ERV * W)$ represents the interaction term between exchange rate volatility and inflation or interest rate.

To ensure the suitability of the estimation technique, the study used the Breusch-Godfrey LM test to test for serial correlation, and the White test was used to test for heteroskedasticity. The Jarque-Bera normality test was used to test for normality. For stability, the Cumulative Sum of Recursive Residuals (CUSUM) graph proposed by Pesaran and Pesaran (1997) is used to check for stability.

3.4 Data Source and Variable Description

Annual time series data spanning 1990 to 2019 were employed for this paper with data sourced from the World Development Indicators (WDI). The start year of the data used is based on the post-exchange rate liberation period, which commenced in 1990. GDP growth is the annual percentage growth rate of GDP at market prices based on a constant local currency. This paper uses the value of the local currency (Ghana Cedi) against the United States Dollar (US) is used as a proxy for the exchange rate. Furthermore, net FDI inflow is used as a measure of foreign direct investment. Investment is proxied by gross capital formation, which measures gross net investment by enterprises, government, and households within the domestic economy for a given period of time. Government expenditure refers to all government consumption, investments, and transfer payments including intermediate consumption, gross capital formation, employee compensation, and other taxes on production and payables. To measure exchange rate volatility, this paper used the crude oil price, interest rate, and nominal exchange rate. Crude oil price data were sourced from the U.S Energy Information Administration (EIA). Hassan et al. (2017) support the evidence that oil prices and interest rates influence a country's exchange rate. Interest rate is the lending interest rate.

4. Results and Discussion

4.1 Estimation of Exchange rate volatility

The GARCH (1,1) model was used to measure exchange rate volatility. Two conditions are necessary for GARCH modelling: heteroscedasticity and ARCH effect. White's test rejected

the null hypothesis of homoscedasticity. The LM test (measuring the ARCH effect) also indicated rejection of the null hypothesis of no ARCH effect. Table 1 presents the results of the ARCH model. Table 2 shows the results of the GARCH (1,1) model used to measure the volatility in the exchange rate. The coefficients of the ARCH and GARCH models are statistically significant at the 1% and 5% significance levels, respectively, and the predicted variance measuring the exchange rate volatility is shown in Figure 1.

Table 1: Results of ARCH model

	Variables	**Coefficients**
ER	Interest rate	0.0154***
		(0.0035)
	Oil price	0.0261***
		(0.0011)
	Constant	-0.8263***
		(0.5911)
ARCH	ARCH (L1)	2.9333***
		(0.9205)
	Constant	0.0007
		(0.0175)

*** denotes statistical significance level at 1%. The standard errors are in parentheses.

Table 2: Results of GARCH (1, 1) model

	Variables	**Coefficients**
ER	Interest rate	0.0158***
		(0.0038)
	Oil price	0.0258***
		(0.0007)
	Constant	-0.8396***
		(0.9085)
ARCH	ARCH (L1)	3.5597***
		(1.2239)
	GARCH (L1)	-0.0125**
		(0.0103)
	Constant	0.0009
		(0.0080)

***, ** denotes statistical significance level at 1% and 5%. The standard errors are in parentheses.

Figure 1 shows Ghana's exchange rate volatility from 1990 to 2019. Exchange rate volatility was relatively high from 1990 to 2000 and around 2015, with the highest being around 1995. Exchange rate volatility was relatively low after 2000–2012, when it started to rise again. After 2015, the volatility declined until 2019.

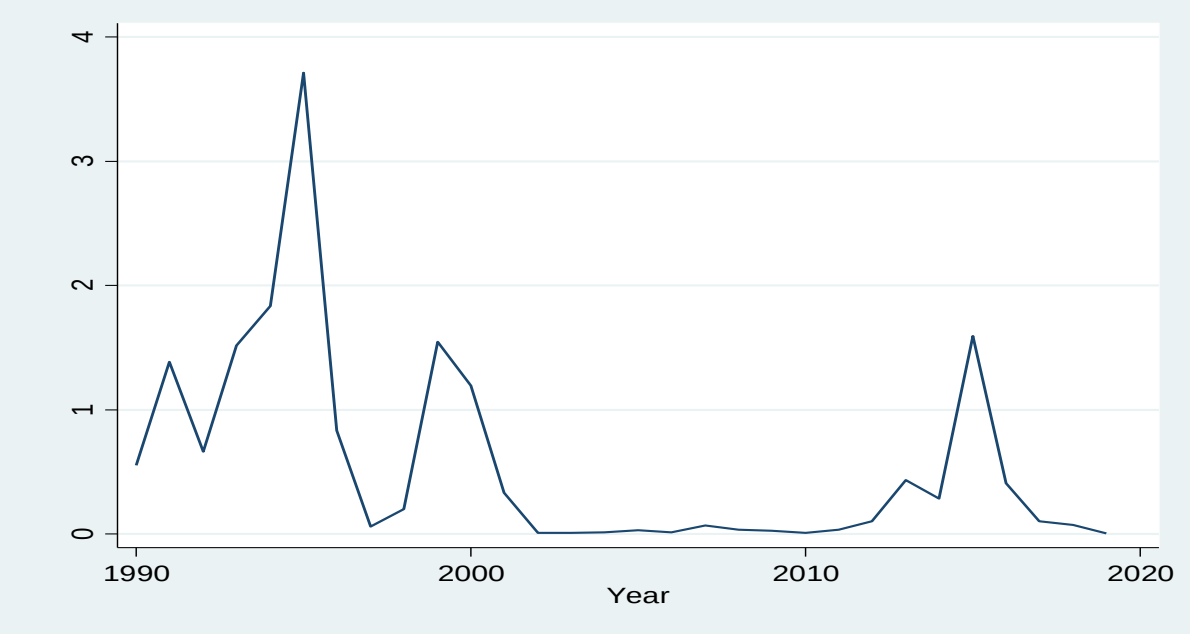

Figure 1: Exchange rate volatility estimated from GARCH (1,1)

4.2 Descriptive Statistics

Table 3 presents the summary statistics for the variables employed.

Table 3: Summary Statistics

Variables	Mean	Std Dev	Min	Max
Inflation (INFL)	19.218	12.064	7.126	59.462
GDP growth (GDPG)	5.475	2.411	2.178	14.047
Exchange rate volatility (ERV)	5.342	12.008	0.007	41.035
Foreign direct investment (FDI)	3.975	2.845	0.251	9.517
Gross capital formation (GCF)	5.585	5.861	8.212	1.773
Government Expenditure (GE)	10.649	2.019	7.069	15.308

Inflation had a mean of 19.218%, indicating that inflation was relatively high during the study period. The GDP growth averaged 5.478%, while exchange rate volatility had a mean of 5.342%. Foreign direct investment was relatively low, with a mean of 3.975%. Gross capital formation and government expenditure have mean values of 5.585 and 10.649, respectively.

4.3 Unit root results

The results of the Augmented Dickey Fuller (ADF) test for unit roots are presented in Table 4. The stationarity test results show non-stationarity for GDP growth, gross capital formation, and interest rate at their levels, albeit stationary at their first difference. Inflation, foreign direct investment, government expenditure, and exchange rate volatility are stationary at their levels. Thus, the variables were integrated of mixed orders (zero and one).

Table 4: Results of Augmented Dickey-fuller unit root test

	Level	First Difference
Variables	**Statistics**	**Statistics**
Inflation (INFL)	-3.811**	-5.838***
GDP growth (GDPG)	-3.063	-6.229***
Exchange rate volatility (ERV)	-3.648**	-8.199***
Foreign Direct Investment (FDI)	-3.597**	-4.481***
Gross capital formation (GCF)	-2.289	-5.526***
Interest rate (IR)	-2.337	-5.405***
Government Expenditure (GE)	-3.847**	-6.094***

The null hypothesis states that variables have unit roots.
***, ** denotes rejection of the null hypothesis at 1% and 5% significance level

4.3 Cointegration results

Table 5 shows there exist cointegration among the variables because the F-Statistic is greater than the upper bound critical values at 5% and 10%. This implies a rejection of the null hypothesis of no cointegration. Therefore, there exists a long-run relationship among the variables.

Table 5: ARDL Bound Test for Cointegration Results

Critical values of F-statistic				
	95%		90%	
F-Statistic	Lower Bound	Upper Bounds	Lower Bound	Upper Bounds
7.879	2.86	4.01	2.45	3.52

F_{GDP} (GDPG| ERV, FDI, GCF, GE)

4.4 Long-run Results

Table 6 displays the results for the long-run impact of exchange rate volatility (ERV) on GDP growth.

Table 6: Long Run Estimation Results

Dependent variable: *lnGDPG*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnERV	-0.0174	0.0028	-6.25	0.000***
lnFDI	0.0528	0.0266	1.99	0.087**
lnGCF	0.2662	0.0308	8.65	0.000***
lnGE	-0.3282	0.1106	-2.97	0.021**

Note: *** and ** denote statistical significance at the 1% and 5% level, respectively.
All regressions include a constant, although not displayed

As Table 6 shows, the long-run results indicate that exchange rate volatility has a negative and significant impact on GDP growth. A percentage increase in exchange rate volatility negatively affects Ghana's economic growth by 1.74% at the 1% significance level. This finding is consistent with theory in the sense that high exchange rate volatility may cause a reduction in trade volumes, which may negatively affect profit-seeking economic agents. This, in turn, influences them to charge higher prices for goods and services to avoid exposure to currency risk (Alagidede and Ibrahim, 2017). Again, this leads to higher import costs and higher prices of goods and services in the country. Higher prices reduce consumption, leading to a fall in total demand and thus deteriorating economic growth. According to Kandil and Mirzaie (2008), exchange rate volatility determines aggregate demand through imports, exports, and domestic currency demand, affecting the economy. This result supports the theoretical studies of Obstfeld and Rogoff (1998), which revealed that exchange rate volatility causes a domestic country to be costly through direct and indirect impacts that worsen the economy. The direct effect is where households are uncomfortable with exchange rate movements because of the challenges of consumption smoothing. An indirect effect occurs when firms set higher prices as a risk premium plan. This estimation result is also in line with the findings of Morina et al. (2020); Barguellil et al. (2018), and Alagidede and Ibrahim (2017). Regarding the covariates, FDI and gross capital formation exert a positive and significant effect on Ghana's economic growth. However, government expenditures have a significant negative effect on economic growth.

4.5 Short-run results

The short-run results and the error correction term (ECT) are displayed in Table 7. The coefficient of ECT is negative (-0.1224) and statistically significant, as required. The ECT measures the speed of adjustment for any short-run deviation. The short-run result indicates that exchange rate volatility has a negative effect on GDP growth, with a 1% increase in exchange rate volatility resulting in a 7.2% decrease in GDP growth. This indicates that exchange rate volatility has a negative impact on economic growth in both the long and short run. The study further indicates that FDI and gross capital formation have negative and significant effects on economic growth in Ghana in the short run. However, government expenditure positively affects Ghana's economic growth.

Table 7: Short run results and the error correction model

Dependent variable = $\Delta lnGDPG$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta lnERV$	-0.0720	0.0161	-4.47	0.003***
$\Delta lnFDI$	-0.3271	0.1219	-2.68	0.031**
$\Delta lnGCF$	-1.0373	0.3079	-3.37	0.012**
$\Delta lnGE$	1.4117	0.3586	3.94	0.006***
ECT	-0.1224	0.1102	-1.11	0.001***

Note: *** and ** denote statistical significance at the 1% and 5% level, respectively.
All regressions include a constant, although not displayed

4.6 Transmission channels

The pathways through which exchange rate volatility affects economic growth were explored by interacting the exchange rate volatility variable with pathway variables. In this paper,

inflation and interest rate pathways were explored. The statistical significance level of an interaction term indicates whether a pathway exists or not. The long- and short-run results of the pathways for the two models are presented in Tables 8 and 9, respectively. Model 1 represents the inflation pathway, whereas Model 2 represents the interest rate pathway.

Table 8. Long run results of transmission pathways

Variable	Dependent Variable: *lnGDPG*	
	Model 1	Model 2
lnERV	0.1302***	0.0706**
	(0.0218)	(0.0256)
lnFDI	-0.0212	0.4585***
	(0.0518)	(0.0675
lnGCF	0.5754***	-0.2494**
	(0.0787)	(0.0911)
lnGE	0.1885***	0.3403
	(0.0787)	(0.2223)
*ln(ERV*INF)*	-0.0202***	
	(0.0023)	
*ln(ERV*IR)*		-0.0002*
		(0.0001)

Model 1 in Table 8, which specifies the interaction between exchange rate volatility and inflation, reveals a negative (-0.0202) and significant long-run impact on economic growth. Thus, inflation is one of the pathways through which exchange rate volatility affects economic growth. This is plausible because a high exchange rate increases general price levels, which leads to a fall in demand for goods and services and a firm's profits. In other words, higher prices increase the cost of living as consumers reduce consumption, leading to a fall in total demand and discouraging investment decisions and activities by producers. In exploring the interest rate channel in the long run, Model 2 in Table 8 specifies the interaction between exchange rate volatility and the interest rate. The results reveal that the interest rate also serves a transmission pathway, with a negative (-0.0002) and significant impact on economic growth in the long run. This is also plausible because higher exchange rate volatility is associated with a higher interest rate, which, in turn, decreases investment to reduce GDP growth.

Models 1 and 2 in Table 9 display the short-run transmission channels for inflation and interest rates, respectively. With a positive and significant interaction term between exchange rate volatility and inflation, the findings reveal that the interest rate is a transmission pathway in the short run, albeit with a positive impact on economic growth. The findings also reveal that interest rate is not a significant transmission pathway in the short run given an insignificant interaction term.

Table 9: Short run results of transmission pathways

Variable	Dependent Variable: *lnGDPG*	
	Model 1	Model 2
Δ*lnERV*	-1.1900*** (0.1863)	-0.1687*** (0.0443)
Δ*lnFDI*	-0.3106 (0.1862)	-0.5804*** (0.1497)
Δ*lnGCF*	2.2028* (0.7613)	1.8597*** (0.4292)
Δ*lnGE*	-3.5989** (0.6247)	-1.0951* (0.4977)
Δ*ln(ERV*INF)*	0.0291** (0.0049)	
Δ*ln(ERV*IR)*		-0.0011 (0.0006)
ECT	-0.0765* (0.0184)	-0.0543*** (0.0112)

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
All regressions include a constant, although not displayed

4.7 Diagnostics tests

To ascertain the reliability and robustness of the estimates, there is a need to check for diagnostics arising from the estimations. The diagnostic test results on equation (3) for serial correlation, heteroskedasticity, normality and stability are presented in Table 10 and Figure 2. Given the p-values, there is evidence of no serial correlation or heteroskedasticity among the variables. In addition, the residuals are normally distributed. The CUSUM graph also confirmed the stability of the variables during the study period.

Table 10: Test for autocorrelation and heteroskedasticity

Test	**P- value**
Autocorrelation (Breusch-Godfrey LM test)	0.1195
Heteroskedasticity (White's test)	0.4076
Normality (Jarque-Bera normality test)	0.7835

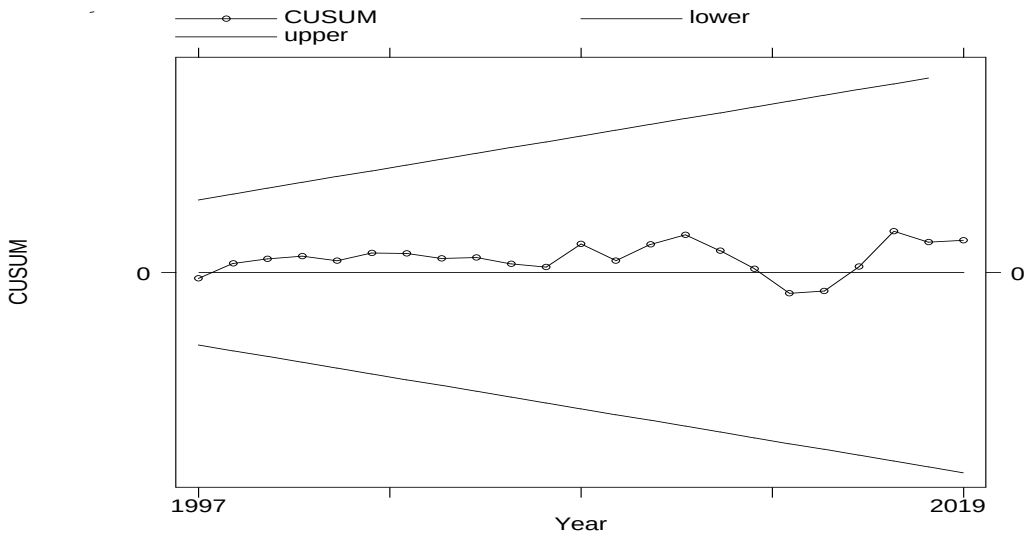

Figure 2: CUSUM graph for stability

5. Conclusion and policy implication

This paper examines the effect of exchange rate volatility on economic growth, as well as the transmission mechanisms through which exchange rate volatility affects economic growth in Ghana from 1990 to 2019. The findings indicate that exchange rate volatility deteriorates economic growth in Ghana in both the long and short run. Inflation and interest rates are the transmission channels through which exchange rate volatility affects economic growth in Ghana. These findings have important policy implications. This paper recommends that policymakers must embark on policies that stabilize the exchange rate. This may be done through policies that aim to encourage the consumption of locally produced goods and services, restrict the importation of goods that could easily be produced domestically, process and export finished and semi-finished products, and attract foreign direct investment, among others. Additionally, inflation-targeting policies adopted by the Bank of Ghana (BoG) must be sustained. Furthermore, the Central Bank should pursue tight fiscal and monetary policies such as controlling money supply to stabilize interest rates and inflation to help improve economic growth when there is high exchange rate volatility because price stability may lead to a stable interest rate for economic growth.

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