What Causes Exchange Rate Volatility in Selected African Countries

Abstract
This study examined the determinants of exchange rate volatility basing evidence on 7 African countries; Niger, Sudan, Cameron, Equatorial Guinea, Tunisia, Congo, and Cote D'Ivoire from 1990-2023. The study conducted the Autoregressive Distributive Lag (ARDL) bounds testing for co-integration and also estimated the error correction model. Furthermore, ARCH and GARCH models were analyzed to measure the volatility of a time series by fitting an autoregressive model to the squared residuals of the time series. The ARCH and GARCH results suggest the volatility of the exchange rate markets in the aforementioned countries is not random. The speed of adjustment of the volatility in the exchange rate of the Sudanese economy is 39%, in Niger Republic it is 50%, in Cameroon it is 52%, in Tunisia it is 55%, in Congo the speed is 32%, in Equatorial Guinea, the speed of adjustment is 58% and in Côte D'Ivoire the speed is 45%, respectively. The study found that the determinants of exchange rate volatility among African countries vary depending on the specific country. The observed volatility in the Sudanese exchange rate was anchored by the significant positive influence of inflation and income differentials as well as the significant negative influence of interest rate differential. In Niger Republic, exchange rate volatility was driven by the significant positive influence of productivity growth and money supply as well as the significant variation in oil prices and interest rate differentials. The observed short-run volatility in Cameroon's exchange rate was significantly and positively influenced by inflation differential and money supply variation whereas it was significantly but negatively propelled by interest rate differential and oil price shock. In Tunisia, exchange rate volatility was stimulated by the significant positive influence of inflation differential, productivity growth, oil price shock, and the significant negative role played by trade balance. The observed short-run volatility in the Congolese exchange rate was induced by the significant positive impact of inflation differential, income differential, trade balance, variation in money supply, and the significant negative impact of interest rate differential. In Equatorial Guinea, the observed exchange rate volatility was determined based on the significant and positive impact of differential in the inflation rate, oil price shock, changes in the money stock, and the foreign balance of trade. The observed volatility in the Côte D'Ivoire exchange rate was significantly and positively driven by the differentials in inflation rate, interest rate, and income level, the foreign trade balance but significantly stimulated by the negative influence of oil price shock. The general policy advice is that governments of all the countries covered by the study should implement exchange rate controls to limit the volatility of their currency fluctuation by imposing a limit on the amount of foreign currency that can be traded in the country. African governments should monitor the inflation differential between their own country and their trading partners to see if it is becoming too large. If it is, the government might raise interest rates to make its currency more attractive to investors.

Keywords: *Exchange rate volatility, inflation differential, interest rate differentials, money supply differentials and income differential.*
JEL Classification: E22, F30, D46

1. Introduction

"Exchange rate volatility refers to the potential to lose money because of a change in the rate of exchange. In simple term exchange rate volatility explain the fluctuation or erratic movements in the currency exchange value. Exchange rate volatility can be viewed as the risk associated with unpredictable movements in the exchange, it is associated with unexpected movement in the exchange rate and it makes international trade and investment decision more difficult because the volatility increases exchange risk, it also quickly and significantly change the profitability of import and exporting and also the expected rate of returns on international investments" (Chen, et al. (2022), Ozturk, 2006). "In other words exchange rate volatility refers to the tendency for foreign currency to appreciate or depreciate, thus, affecting the profitability of foreign exchange trade. Fixed exchange rates are not supposed to change by definition but they are quite frequently revalued or devalued by the monetary authorities of the country involved meaning that they can and do indeed change. A floating exchange rate may or may not be volatile depending on how much it changes over time. In effect, the floating exchange rate depends on the local demand for foreign currencies and their local supply, the country's trade balance, the strength of its economy, and other factors" (Narayan, 2021). "However, since the floating rate is free to change they are usually expected to be more volatile. For many years, the floating exchange rate has been the regime used by the world's major currencies; that is, the US dollar (USD), the EURO, the Japanese YEN, and the UK pound sterling" (Zhang & Liao, 2020, Sussman & Saadon, 2018). "In a floating system, rates of exchange are generally determined by the dynamics of supply and demand for foreign exchange. It is the common exchange system because it contributes to macroeconomics stability by cushioning economies shocks and allowing monetary policy to be focused on With the disintegration of the Bretton Wood system in the early 1970s and the development of the floating exchange rate system has impacted the stability of the exchange rates and increase the rate of volatility, especially for developing countries. Presently the majority of economies in the world are making use of the floating exchange rate, therefore making exchange rate volatility inevitable in today's society. Changes in economic factors influence the volatility rate by causing unexpected changes in the exchange rate level. Excessive exchange rate volatility leads to delays in investment decisions, causing uncertainty in the economy. The uncertainty that is caused by volatility also negatively affects economic growth by affecting investment and investor confidence, productivity, consumption, and international trade and capital flows" (Dedola et al. 2020, Oaikkhenan & Aigheyisi, 2015: 49).

African countries are developing economies and the majority of which are blessed with natural mineral resources and fertile lands, exchange rate volatility could affect their economies drastically as their economies majorly depend on the exportation of raw materials or resources and importation of the finished product. For example, the economy of the Democratic Republic of Congo (DRC), an open economy, is dependent on international trade with the mining sector being the centerpiece of the economy in terms of foreign exchange reserves. In 2008, during the international financial crisis, the Congolese Franc lost 41.2% of its value against the US dollar between 2018 and 2019. In Sudan after 1970, when the country ends the era of her currency being pegged against the US dollar at a fixed rate of 1 SDG to 2.85 US dollar and shifted to a floating exchange rate system the economy experienced continuous exchange rate devaluation and government intervention. During 2000-2006, the exchange rate was 2.6 SDG for the dollar; this was because of the currency inflow associated with Sudan's petroleum exports. Then throughout 2006-2017, the exchange rate kept on depreciating at an accelerating rate, from 2.6 to 6.9 US dollars (Nawal & Abdalla, 2019). In Africa and as well as the rest of the world; the foreign exchange market has a variety of players or people involved in the market, from the individual trader, all the way to major banks, and central banks, with a network of large companies or multinational companies; who is the fate of demand and supply of the market along with the economic variables that influence the movement or fluctuation of the market and are therefore exposed to the risk in the exchange market caused by the fluctuations. Hence to provide knowledge on what influence the movement or fluctuation in the exchange rate market in Africa countries and also provides a way for the player or participants in the market to reduce the risk they face in the market. Therefore the purpose of this study is to identify or investigate the factors that influence exchange rate volatility using data from many African nations.

African countries like any other country of the continents in the world experience volatility in their exchange rate, but the majority of the countries in African are developing economies, and a large part of their economic operations depends on the exportation of raw materials and the importation of the finished and this leave their economies to feel the huge impact of the movement or fluctuation in the market of the exchange rate. The rate of exchange of an economic operating on the floating system is influenced by market forces, demand, and supply;

these forces are influenced by some economic variables or factors which determine the movement of the exchange rate and how volatile the exchange rate will become (Chen et al. 2022). The economic factors or variables include inflation differentials, productivity growth, balance of trade, interest rate differentials, income differential, public debt, current account deficit, terms of trade, money supply differentials, and so on.

When firms, brokers, and investors want to trade with another country, they make use of the domestic currency of that economy or use the world's reserve currency, the US dollar (Aigheyisi, 2021). The exchange rate market is known for its volatility, therefore making it risky for investors, brokers, and firms. The volatility of exchange rate has implications for the volume of international trade and the balance of payment. The participants or traders involves in this market such as; the large commercial companies, which includes corporations, foreign exchange brokers, etc. mostly take part in the market to do business, and usually trade currencies as speculative transactions. Also, some individual traders are involved in the market with the aim of making profits from the price fluctuations in the market by studying the price movements in order to make profits. Then we have the largest banks in the world, such as; JPMorgan, Bank of America, Barclays, and the central banks who are responsible for a large part of the trading volume of foreign exchange transactions by undertaking huge amounts of transactions each day for both their customers and themselves. The central banks also play a part in the foreign exchange market to influence the exchange rate of their currency and have an impact on the movement or the fluctuation of their currency exchange rates. In line with the foregoing, this study provides an answer to the following research question: what are the factors responsible for the volatility in exchange rates of seven African countries; Niger, Sudan, Cameron, Equatorial Guinea, Tunisia, Congo, and Cote d' Ivoire. The overall objective of this study is to evaluate the determinants of exchange rate volatility in the aforementioned African countries.

The significance of this study is that it offers great assistance to improving economies, large corporations, and all those involved in the foreign exchange market. With a better understanding of what variables influences the movement or fluctuation in the exchange rate, that is, the determinants of volatility, the central bank of nations can better influence the exchange rates of their currencies by using policies to establish a form of control on this economic variables to obtain desirable outcomes and for the improvement of her nation economy. Large Corporation are involved in foreign exchange due to the importation of one or two raw materials or resources that is available in their host nation, or the foreign nation has a resource of better quality than their host nation. Most corporations aim to maximize their profit and reduce their cost of production. For those corporation involved in the importation, the study offers them knowledge on what determines the volatility in the exchange rate market, thereby enabling the corporation to have a guide on studying the trend or movement, also enabling the corporation to either buy using the spot rate or forward rate, depending on which price favors the corporation.

In sum, by identifying the key determinants, this study aims to contribute to the understanding of exchange rate dynamics in these countries and provide insights into their economic policies. The dataset covers more than five decades collected from secondary sources. The findings of the study can improve the performance of individual traders in the market; by understanding what influences the fluctuation in foreign exchange rates they can study the market trends more efficiently, thereby increasing their profits. This study will also be of significance to academic scholars, researcher, and individual who are curious and desire knowledge about the exchange rate, its volatility, and what economic variable influence the fluctuations in the market that is the determinant of exchange rate volatility. This research work is divided into 5 sections. Section one deals with the study's introduction and gives a background to the study. Section 2 reviews related and relevant literature. Section 3 gives the research methodology while section 4 gives the study's analysis and interpretation of findings. The study concludes with section 5 which deals with the summary of findings, conclusion, and recommendations.

2. Theoretical and Empirical Literature Review

2.1. Theoretical Review

"The theoretical literature review contains a review of theories relating to the determination of exchange rates. The theory includes; the mint parity theory, purchasing power parity theory, the balance of payment theory, the monetary approach to foreign exchange, and the portfolio balance approach. The mint parity theory was in use for those countries with the same metallic standard, that is, gold or silver. This theory explained the determination of the exchange rate between two countries that uses the gold standard" (Diebold et al. 1991, Sheik et al. 2020). In a country that uses the gold standard, her currency is either made of gold or its value is expressed in terms of gold. The exchange rate under the gold standard is equal to the value of the gold of one currency in comparison to that of another currency, this rate of exchange is also called the mint rate. According to the mint parity theory, the mint rate is the equilibrium exchange rate value. Given that in reality, the market forces of demand and supply experience changes which may result in making the mint parity in the long run differ from the rate of exchange, the variation in the exchange rate is established within the well-defined limits, called the gold points. The gold points means the limits within which the market exchange rate between two countries using the gold standard fluctuates from the equilibrium level, gold points are determined by the cost of shipping gold from one country to another, such cost may include the cost of handling and packing, insurance charges and other expenses incurred in connection with the transportation of the gold. The gold point consists of two points, the upper gold point which indicates upper limits, and the lower gold which indicates the lower limit. The upper gold point is obtained by the addition of the cost of shipping gold to the mint parity exchange rate and it also refers to the critical exchange rate above which gold will be exported, while the lower gold point is determined by the subtraction of the cost of shipping from the mint exchange rate and it also shows the critical exchange rate below which gold will be imported. Under the gold standard therefore, the rate of exchange between two currencies cannot be above the upper gold point, and below the lower gold point, it will remain within their two limits. This theory states that under the gold standard, the exchange rates tend to be close to the gold value of the country, that is, the exchange rate between two countries that make use of the gold standard is determined by the value of gold in the countries. When the currencies of the two different countries are valued or measured in gold, the exchange rate between the countries with the gold standard is automatically determined on a weight-to-weight basis of the gold value of their currency, after taking into consideration the purity of the gold of these currencies.

Next is the theory of purchasing power parity as recently explained by Schreyer & Koechlin (2002) and Sussman & Saadon (2018). The PPP states that the equality of the purchasing power of two inconvertible currencies determines the equilibrium of the exchange rate, which simply means that the exchange is determined by the internal price levels in the two countries. When the domestic currency is being exchanged for foreign currency, it is actually the domestic purchasing power that is being exchanged for the foreign purchasing power. The theory is divided into two versions, which are; the absolute version of the theory which states that the rate of exchange should normally show the relation that exists between the internal purchasing power of different country's currency units. It upholds that the exchange rate equals the ratio of the amount of money required to buy a particular group of goods at home as compared with what is would buy in a foreign country. The relative version of purchasing power parity theory explains the variation in the equilibrium rate of exchange between two currencies depends upon the changes in the ratio of the internal purchasing power of the concerned currencies. In the words of Cassel "when two currencies have been inflated, the new normal rate of exchange will be equal to the old rate multiplied by the quotient between the degree of inflation of both countries (Kadochnikov, 2013).

` Balance of payment theory of exchange rate state that exchange rate of a country to another country is determined by factors that are independent of the internal price level and money supply. The theory according to Dornbusch (1976) contends that the balance of payment affects both the supply and demand for foreign currency. The demand for foreign goods and services drives up the supply of foreign exchange, whereas the supply of goods and services from the home country to the foreign country drives up the demand for foreign exchange. Therefore, too much demand for foreign currency over available currency is what is meant by balance of payments deficits. The foreign country's currency appreciates as a result of the excessive demand, and this causes devaluation in the value of the home currency's exchange rate against the foreign country's currency. **The** monetary approach to exchange **rates** states that the exchange rates are set by balancing the total supply and the total demand for each of the country's currencies (MacDonald & Taylor, 1994, Gabaix & Maggiori, 2015). With the monetary approach, it is assumed that interest rates in two countries are identical and that the increase in money supply in one country decreases the interest rate and its impact on the exchange rate is reflected through the change in real income. Hence, the exchange rate adjusts to clear the money market in each country without flow or changes in reserves. According to Branson & Halttunen (1979), the portfolio balance theory states that the rate of exchange is established by balancing the supply and demand of financial assets, of which money is only one kind of asset.

2.2. Review of Relevant Empirical Research

This section reviews the most recent studies done on exchange rate volatility, the methods utilized in those studies, and the findings therein. Nawal et al (2019) empirically studies the determinants of the exchange rate in Sudan and assess their impact on her volatility. In their study they use the ARDL model to study the relationship between the dependent and independent variables and also employed the Wald test, the Heteroskedasticity consistence covariance (White) test, HAC consistent covariance (Newey-west) test, and inferential statistics, to specify the determinant factors of the exchange rate. The VEC mechanism was used to ascertain the variables that are responsible for the long-run fluctuations and the Wald test was applied to ascertain the short-run and determine the speed of adjustment on the dependent variables. The statistical analysis of their study demonstrates that the determinants of the exchange rate in Sudan are; inflation, the balance of trade, gold purchases, money supply, and foreign reserves. Their result also shows that the independent variables account for about 80% of the variation. Their study, it is shown that the impact of the fluctuation of the independent variables on exchange rate, they applied a long-run elasticity test, which shows the determinant factors that impact the fluctuation experience in the exchange rate in different degrees. The variable that causes short-run volatility was gold purchase and money supply, although the influence of money on short volatility is a result of its impact on inflation volatility, which results in fluctuation in the exchange rate.

Ibrahim & Sumaya (2019) studied the impact of monetary policy instruments on the real rate of exchange volatility in Sudan for the period of 1997-2017. Their study uses co-integration analysis to look at how monetary policy influences real exchange in the short-run. After determining the short-run co-integrating relationship between the set of integrated variables, the stationary of the variable at the initial differences is established and the VECM is estimated to explain the existence of long-run relationships. Their study findings indicated that Sudan's actual exchange rate has been unstable within the period in their study. Short-term real exchange rate volatility is explained by changes in the money supply and profit margin rate variables through a self-correcting mechanism process that involves frequent interventions from the central bank of

Sudan. Additionally, the VECM test results show that a decrease in the money supply has a negative impact on real exchange rate volatility, meaning that a change in the value of the money supply variable causes exchange rate volatility. While a rise in the profit margin rate has a positive impact on real exchange rate volatility in Sudan, suggesting that the model may self-adjust.

Sylvia et al, (2022) examines empirically exchange rate determinants in sub-Saharan African nations, like Ghana, Nigeria, Gambia, Liberia, and Sierra Leone, the scope of the study was from 1981-2019. Their study made use of descriptive statistics and Panel Least Square (PLS) estimation technique. Their study revealed that inflation rate, interest rate, current account balance, and terms of trade reduce or depreciate exchange rate in sub-Saharan nations, with results showing that exchange rate inflation rate, interest rate, current account balance terms of trade all having a negative relationship with the exchange rate and all having a significant impact of 5 percent on exchange rate except interest rate which has an insignificant impact of 5 percent on exchange. By their finding, they recommend that government should encourage diversification of export, and also stable management of exchange rate policy that avoids overvaluation or devaluation of their domestic currencies with an increase in their level of competitiveness in the international market with tradable goods. They also stated that inflation and interest rate should be reduced by the government to a minimum level to increase the money supply rate in sub-Saharan African nations.

In a study of the long-run determination of exchange rate in sub-Saharan Africa that draws evidence from Ghana, South Africa, Nigeria, and Kenya, Ezirim, et al, (2017) analyzed the long-run relationship between exchange rate and its determinants from some selected African countries; Ghana, South Africa, Nigeria and Kenya. The scope of the study was from 1985-2013. The study made use of inflation rate, the balance of payment, foreign direct investment, net export, and external reserve as the independent variable, therefore the determinant of exchange rates and the dependent variable was the exchange rate, the study applied a five-variable model. The study's findings show that there is a considerable long-run equilibrium link between the two exchanges and the stated independent variable, with Kenya being the sole exception. The error correction model showed that all the nations can go from the short run to the long run equilibrium quickly and accurately.

The study of the determinants of exchange rate volatility in South Africa by Mpofu (2016) focused on the factors that influence exchange rate volatility in South Africa between 1981 and 2013. He applied a new open economy macroeconomic model by Obstfeld & Rogoff (1996) & Han (2002). He employed monthly time series data, and the GARCH model was used to estimate the data. The main focus of his study was to ascertain if economy openness decreases Rand (ZAR) volatility. The study discovered that switching to a floating exchange rate regime had a positive influence on ZAR volatility and it indicated that trade openness significantly reduces the ZAR volatility only when bilateral exchanges were used but the opposite was the case when multilateral exchange rates were used. Their study results stated that real gold volatility increases the volatility of the exchange rate in South Africa. Also, that change in the foreign reserves reduces the rate of exchange rate volatility. It also discovered that volatility in money supply had a negative impact on the exchange rate which suggested that a rise in interest rate will result in a rise in exchange rate volatility. The study also indicated that the rate of changes in output increases the volatility in the exchange rate when a bilateral exchange is applied, but the opposite result is experienced when the real exchange rate is applied. In addition, the study shows that real factors, that is, commodity prices, output volatility, and openness) has a greater influence on exchange volatility, compared to monetary factors.

In a study of the determinants of real exchange rate volatility in Nigeria by Ajao (2015), the causes of actual (real) exchange rate volatility in Nigeria were empirically analyzed. The study covered the period from 1981 to 2008. The GARCH (*1.1)* technique was used to calculate the volatility of the exchange rate. In order to investigate the causes of rate volatility of the Nigeria currency, the error correction was used. The co-integration analysis's revealed a long-term equilibrium relationship between real exchange rate volatility and several other variables, including productivity, trade openness, government spending, real interest rate, and money supply. Their empirical analysis revealed that economy openness, the expenditure of government, the movement of interest rate, and lagged rate of exchange are among the major significant variables that impact real exchange volatility during the period used for the study. He recommended that the apex monetary authority should implement policies that will minimize the extent of exchange rate volatility and the government should apply control of feasible macroeconomic variables that have a direct influence on exchange rate volatility. In another research on the determinants of the exchange rate, its volatility, and currency crash risk in Africa's low and lower-middle-income countries (LLMICs) by Anejo et al, (2022) investigates the determinants of the nominal exchange rate, their volatility, and crash risk in Africa's lower and LLMICs. The study makes use of macro-panel estimation for 15 African LLMICs that use floating or lightly managed exchanges rate combined with insights from 13 semi-structured interviews with 17 foreign exchange market participants in six case study countries, the countries include; Ghana, Kenya, Malawi, and Uganda, Zambia, Sierra Leone and the city of London. Their analysis shows the importance of the distinct productive and the structure of export, focused on a few agricultural and mineral-based products, with recent financial integration for the determination of the exchange rate of African LLMICs. Their study also discovered that productive factors such terms of trade, export concentration, and export prices have a significant impact on exchange rate and volatility, while financial factors are important for the likelihood of currencies experiencing sudden and large exchange rate movement; that is exchange rate volatility and the financial factor included, interest rate differential, international market conditions, and short-term financial flows.

Bleaney et al, (2016) examined the real exchange rate volatility for 90 countries using monthly data for the period from January 1990 to June 2006. Their study shows that volatility was higher in poorer countries and larger countries. They also found out that volatility has a positive relationship with the inflation rate because it increases significantly with the inflation rate. After adjusting for the variables in their study, they found out that independent floats exhibit considerably higher volatility, which implies that currency intervention is effective. Beyond this, the only notable regime effect is the unusually low volatility of the crawling pegs and bands. Their results also suggest that, when inflation is significant, the managed float exhibit similar real exchange stability to pegs, but without regular devaluations. In a study of the determinants of exchange rate instability in a developing economy, Abdul & Mohammad (2021) reported that volatility in the exchange rate of China, Malaysia, and Bangladesh was adversely and significantly instigated by changes in foreign-reserve while the volatility in the exchange rate of the India Rupee was negatively impacted by the variation in public spending. Nevertheless, in China, Malaysia, Pakistan, Indonesia, and Bangladesh, volatility in the exchange rate was significantly and positively impacted by changes in public expenditure. Instability in the terms-of-trade led to a significant decline in the exchange rate volatility of Pakistan and Bangladesh but increases same China, Malaysia, Pakistan, Indonesia, and India. On its part, instability in changes in gold-price contributed positively and significantly to volatility in the exchange rate of Indonesia, Bangladesh, and Malaysia while the volatility in the exchange rate of Pakistan and Indonesia were to a great deal reduce by in industrial production. The high level of changes in industrial production stimulated the volatility in the exchange rate of the currencies of Malaysia, India and China.

Shevchuk & Kopych (2021) relied on GMM estimation to report that the volatility in exchange rate was instigated by inflation, crisis, as well as economic freedom from the Heritage Foundation, besides inflation and crisis developments. According to Mpofu (2020), volatility in the foreign exchange rate of the South African Rand was instigated significantly by the variation in commodity prices, aggregate national output, money supply, exchange rate regime, and government consumption. In view of excessive devaluation of the naira exchange rate to the USD, taken together with fluctuation in macroeconomic variables, Bello et al (2022) estimated the non-linear GARCH models and established that volatility of the naira/dollar exchange rate was significantly and positively determined by industrial output, foreign trade balance, and inflation. The authors also found naira/dollar exchange rate volatility persistence and hence advised the government to consistently adjust exchange rate in line with the behavior of macroeconomic variables to regulated inflation rate in the economy.

Zerrin (2018) in his work "on the correlation between exchange rate volatility and foreign direct investment in Turkey using Toda and Yamamoto Causality Analysis observed that many countries have embraced the floating exchange rate system with the end of the Bretton Woods system. The rate of exchange volatility raises uncertainty for investors as their expected benefit of FDI is affected. Nonetheless, the flow of investment has been affected by FDI which is a crucial factor. The study, examines the interrelationship between FDI and exchange rate volatility from 2005 Q4 to 2018 Q1 in Turkey, it was evaluated using the Toda-Yamamoto causality test. The volatility of the real effective exchange rate is predicted using the model of generalized autoregressive conditional heteroskedasticity. The result visualized a relationship that is a one-way causality from FDI to exchange rate volatility". Taylor, (1995), stated in his study, the value of the domestic currency in relation to a foreign currency is largely determined by the relative nation's currency purchasing power in their respective nations. That is to say, exchange rates settle at the level which makes purchasing power of a given unit of currency the same in whatever country it is spent. He argues further that the theory fails in some areas like a change in the exchange rate may originate in factors independent of price level. Therefore, the purchasing power parity is not a complete explanation of what determines the exchange rate but this does not mean that the theory has no value.

Akintunde et al. (2019) opined that "the exchange rate determinant in Nigeria applies the quarterly time series data to make the comparison of the official rate of exchange and parallel market rates from the period 1986 to 2017, the post-Structural Adjustment Programme(SAP) era. The potential non-oil export, interest rate, inflation, reserves, GDP, and imports are the existing literature upon which exchange rate determinants were identified. The auto-regressive distributed lag model (ARDL) was employed to test the variables for co-integration and the ADF unit roots test of stationarity was used to test the time series properties. The result suggests that the core determinants of the official rate of exchange in Nigeria include the following variables, interest rates, reserves, GDP, oil exports, inflation, and non- oil exports, and the major determinants of parallel exchanges rates, include the variables, GDP, inflation, and non-oil exports".

2.3. Gaps in the Reviewed Research

The study premised its focus on filling the gaps created by the work of other authors which include outdated scope, non- inclusion of fundamental variables like exchange rate and interest rate as well as non-usage of very appropriate econometric tools. The former research or studies on or related to the determinants of exchange rate volatility reviewed in this study have exhibited some limitations. Most of the researchers like Bello et al (2022), Shevchuk & Kopych (2021), Abdul & Mohammad (2021), Mpofu (2020), Nawal & Adhalla (2019) in their study considered inflation, interest rate and money supply as independent variables that influence the movement of exchange rate, that is, determinants of exchange rate volatility. But they failed to consider that the difference between a domestic country and a foreign country's interest rate, inflation rate, money supply, and income differential could have a significant influence on the exchange rate volatility of a country. Therefore this research applies interest rate differentials, inflation rate differentials, money supply differentials, and income differentials as well as the balance of trade, oil price shock, and productivity as independent variables to find the determinants of exchange rate volatility from selected Africa countries.

3. Methodology

This study is rooted in the principle of the purchasing power parity (PPP) theory as espoused by Cassel (1918). The PPP theory evaluates the fixed value of different currencies by determining the cost of a particular good in various nations. The price of a basket of products at one location divided by the price of the same basket of goods at a different location is effectively what makes up the purchasing power parity ratio. Because of tariffs and other transaction costs, the purchasing power parity inflation and exchange rate may be different from the market exchange rate. On the basis law of one price, which states that, if there are no transaction costs or trade barriers for a certain commodity, then the price for the commodity should be the same price at every location (Krugman & Obtsfeld, 2009). The model specification of this study was based on the identified variable in the theoretical review; that is, the dependent variable; exchange rate volatility, and the independent variables; inflation differentials, productivity growth, balance of trade, interest rate differentials, oil price shocks, income differentials and money supply differentials.

The volatility of exchange rates explains the fluctuations in a country's economy rate of exchange. In international trade, the rate at which a country's currency is traded against a foreign currency is a common factor affecting the amount of export proceeds and the amounts spent on the total imports (Nick et al. 2022). The rates at which the currencies are exchanged are never stable mainly due to the fact that the supply and demand of currencies fluctuates over time. These fluctuations or movements can be regarded as the rate at which the currency is volatile. Consequently, exchange rate volatility refers to the tendency for foreign currencies to appreciate or depreciate, thus affecting the profitability of foreign exchange trades (Kanu & Nwadiubu, 2020). Currency volatility may also be seen as the frequency and extent of changes in a currency’s value. Krueger (1983) argues that how the exchange is determined depends on whether the exchange rate is floating or fixed. A fixed rate of exchange is an intervention or decree set by a government within a small range of variation. A floating rate of exchange is determined freely by the interaction of demand or supply. Accordingly, the exchange rate would freely fluctuate in a free exchange rate market because of the changing demand for the different currencies; with fluctuating demand for currencies. Huge savings in the foreign exchange rate could be expected especially since capital movement affect exchange rate as directly as merchandise exports and imports (Stancık, 2007, Naknoi, 2005). In contrast, as long as supply and demand for various currencies remains in balance, a stable exchange rate would prevail under free exchange markets. Hence, exchange rate volatility can be defined as the fluctuations in the rate of exchange between a domestic currency and a foreign currency influenced by the demand and supply of the currencies and economic factors such as; inflation trends, interest rate policy, productivity level in the economy, political and economic stability and other factors.

Inflation differentials can be defined as the divergent between the rate of inflation in one country and the rate of inflation in another. The difference between inflation rates between the two countries explains, to a large extent the movement in their exchange rates. Thus, a country with a higher inflation rate compared to another country will see its currency depreciate against the other currency. The volatility of a country’s currency foreign exchange rate against another country currency can be majorly impacted by the rate of inflation between both economies (Itshoki & Mukhin, 2021). Inflation is more likely to have a significant negative effect, rather than a positive effect on the foreign exchange rate of a currency. A very low rate of inflation does not ensure a favorable exchange rate for a country with other countries, due to the fact that they are other factors that influence the volatility of the exchange rates, but an extremely high inflation rate is likely to impact the country's exchange rate with other countries negatively.

Productivity growth can be referred to as the measure of the efficiency of production. At a national level productivity can be defined as an economy's ability to make use of its mineral and human resources to generate output and income. Productivity growth can be referred to as an increase in the value of outputs produced for a certain given level of inputs, over a given time. Growth will experience in productivity when inputs in the production process are optimally utilized to obtain a greater level of output. Obtaining productivity growth is therefore not equivalent to working longer but as a measure of greater inputs for every output. An economy is that able to utilize its available resources and maximize its output will have positive productivity growth, while an economy that barely makes use of its resources and has a low level of output will tend to have negative productivity growth. When the currency of the country that has positive growth is placed against the currency of the country with negative productivity growth, the exchange rate will tend to be in favor of the country with positive productivity growth, this may be because the economy has a higher demand for its currency due to its ability to provide commodities in the international market that may be of high demand, unlike the other economy that has little or no commodity to provide in the international market.

The role played by international trade balance can be explained into two requisites; favorable balance of trade and unfavorable balance of trade. A favorable balance of trade also referred to as trade surplus, is when a country export more goods than its import, which means that the country is earning more in the international market than it is spending in the market. A balance of trade may be as result of a country having a comparative advantage in the production and export of certain goods, or it may be a result of a country's currency being relatively undervalued, making its export cheaper for foreign buyers (Todani & Munyama, 2005). An unfavorable balance of trade, also referred to as a trade deficit can be defined as when a country imports more goods than its export, which means that the country is spending more in the international market than it gains from the market. An unfavorable balance of trade may be a result of a country experiencing a comparative disadvantage in the production of certain goods, or it may be as result of a country's currency being relatively overvalued, making its import cheaper and export more expensive. If unfavorable balance is constant over a while it can be a cause of concern. (Will et al, 2023). In general, a favorable balance of trade is seen as a positive sign for a country's economy, while an unfavorable balance of trade is seen as a negative sign. Balance of trade influences the exchange rate of a currency through its effect on foreign exchange supply and demand. If a country exports more than it imports, there is a high demand for its goods, which also means a high demand for its currency, thus the currency appreciates (Wang, 2005). On the other hand, if a country import more than it exports, there is less demand for its goods, which means less demand for its currency, thus the currency depreciates or loses value (Lioudis, 2022, Ilzetzki et al. 2020). From this, we can denote that a change in the balance of trade in an economy may influence the fluctuations in the exchange rate of that currency.

Interest rate differential also known as net interest rate differentials can be seen as simply the measure of the difference between the interest rates of two different instruments, such instruments include; assets, mortgages, and currency. It is particularly used in stock trading, foreign exchange markets, and bank mortgages. The focus of this study is on the interest rate differential of two countries' currencies. Therefore, interest rate differentials can be as the difference in the interest rate between two countries; a domestic country's interest and a foreign country's interest rate. It plays an important role in the exchange rate market by affecting the rates of exchange and currency trading. Therefore, changes in interest rate differential impact the fluctuations experienced in the exchange rates.

In principle, oil price shocks are unanticipated components of a substantial change in the price of oil, defined as the difference between the expected and realized oil prices (Baumeister &

Kilian, 2016). It can also be simply explained as an unexpected rise in oil prices that is usually accompanied by a decrease in its supply. The main source of energy in the world is oil, both in advance industrial economies and developing economies; therefore unexpected changes in oil prices can have a negative influence on economic and political stability throughout the global economy. In the post-World War II era, there have been two major oil price shocks; also referred to as oil crises. The Arab members of the Organization of the Petroleum Exporting Countries (OPEC), in 1973 imposed a banned on the supply of oil to the United States, Japan, and Western Europe, for supporting Israel in the Yom Kippur War. These nations consumed more than half the world's energy. Oil prices drastically increased to almost $12 a barrel. Even though the banned was lifted in 9174, the prices of oil remained high. The second oil price shock was caused by the Iranian revolution in 1979 and the situation got worst with the outbreak of the Iran-Iraq war, 1980-1988. In 1981, the price of oil stabilized at $32 per barrel (Richa, 2022). The oil price shocks have different impacts on economies, while oil-producing economies may enjoy the profit from the high oil price, oil-importing economies will the burden of the high oil price which may cause an unfavorable balance of trade and in the long-run can be transferred into their economies. Oil price shock influences the fluctuation in the exchange rate in the foreign exchange market, because due to the decrease in the supply of oil associated with the sudden increase in price (Sheikh et al. 2020). The currencies of oil-producing countries will be in high demand, because the major source of energy is oil for both the industrial economies and the developing economies, `thereby causing a shift or movement in the exchange rates between the two currencies (the currency of the oil-producing economy and that of the oil importing economy).

Income differentials are the change in gross domestic product in one country compared with the change in gross domestic product of another country. In other words, income differential can be seen as the difference in the gross domestic product of a domestic country and a foreign country. Money supply differential can be defined as the difference between money supply in a domestic country and a foreign country, that is, the difference in the total volume of currency held at the hand of the public or the amount of currency circulating in an economy at a particular point in time between two countries, usually a domestic currency and a foreign country. The total volume of money in circulation has an influence and the movement or fluctuations in the exchange rates. The relationship between exchange rate volatility, inflation differentials, productivity growth, the balance of trade, interest rate differentials, oil shock prices, income differentials, and money supply is expressed as:

$$erv = f\ (infd, prgt, bot, inrd, osp, incd, msd) \quad (3.1)$$

Where: ERV is exchange rate volatility, infd is inflation differentials, prgt is productivity growth, bot is the balance of trade, inrd is interest rate differentials, osp is oil shock prices, incd is income differentials, msd is money supply differential. Based on equations (3.1) the explicit econometric forms of the models are stated as:

$$erv = ß_0 + ß_1 infd_t + ß_2 prgt_t + ß_3 bot_t + ß_4 inrd_t + ß_5 osp_t + ß_6 incd_t + ß_7 msd_t + u_t \quad (3.2)$$

Where; $ß_0$ is the Intercepts, $ß_1$, ß2, ß3$_{,……,}$$ß_7$ are the coefficients of independent variables, U_t is the Error terms. The research methodology implemented in this paper is the auto-regressive conditional heteroskedasticity (ARCH) was developed by Engle (1982). The component of Autoregressive means that the volatility of some conditions will depend on its past. Conditional simply means volatility is not fixed over time rather it is based on some condition, and this condition is that variance depends upon past information. Heteroskedasticity means non-constant variance. Accordingly, the ARCH equation becomes:

$$ARCH,\ \varepsilon^2_t = \omega + \alpha_1\varepsilon^2_{t-1} + \alpha_2\varepsilon^2_{t-2} + \alpha_3\varepsilon^2_{t-3} \ldots + \alpha_n\varepsilon^2_{t-n} \quad (3.3)$$

Where; ε^2_t = square of the error term, which also means having autocorrelation, ω = constant, ε^n_{t-n} = error term of the previous period. Analysis of ARCH measures the volatility of a time series. It is a statistical technique that is used to model the volatility of a time series by fitting an autoregressive model to the squared residuals of the time series. The ARCH model is a linear model that assumes that the conditional variance of a time series is a function of its past values. The Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) was developed by Tim Bollerslev (1986) as he modified Engle's (1982) working results of the ARCH model by inserting the AR process in the heteroskedasticity from the variance. The simplest GARCH model is the GARCH (1.1) model which can be written as;

$$\sigma^2_t = \alpha_0 + \alpha_1 u^2_{t-1} + \alpha_2 \sigma^2_{t-1} \tag{3.4}$$

Equation (3.4) states that in addition to the squared error term in the prior periods [as in ARCH(1)], the conditional variance of 'u' at time 't' also depends on the conditional variance in the prior time. The GARCH model measures the volatility of a time series by fitting an autoregressive model to the squared residuals of the time series. The squared residuals are a measure of the volatility of the time series, and the autoregressive model allows for the volatility to be dependent on its past values. Another GARCH model is the GARCH(p,q) model, where the p are lagged terms of the squared error term and the q is lagged terms of the lagged conditional variances. The GARCH model can be written as;

$$GARCH,\ \ \sigma_t^2 = \phi_0 + \sum_{i=1}^{q} \partial_i e_{t-i}^2 + \sum_{j=1}^{p} \alpha_j \sigma_{t-j}^2 \tag{3.5}$$

Where α_i and β_i are the parameter of the models, our analysis covers in a total of 7 selected African countries (Sudan, Niger Republic, Cameroon Tunisia, Congo, Equatorial Guinea, and Côte D'Ivoire). The variables and parameters of data collected from these countries are guided by the availability of data on the rate of exchange regime of the selected countries. The data set covers the sample period, 1970 to 2023, and data annual time series collected from secondary sources, that is, from the Statistical Bulletin of the countries under evaluation which includes Sudan, Niger Republic, Cameroon, Tunisia, Congo, Equatorial Guinea, and Côte D'Ivoire. The volatility of a currency is measured by calculating the distribution of exchange rate changes around the mean, expressed in terms of daily, weekly, monthly, or annual standard deviations. The larger the number, the greater the rate of volatility over a while (Kanox, 2022).

4. Results and Discussion

4.1 Results

This section deals with the presentation of data used for the analysis, the result analysis, and the interpretation of the result. Table 1 shows a 0.22 standard deviation of exchange rate volatility. The skewness is the extent of distortion or asymmetry of the series from a normal distribution. From 1981 to 2023, the measure of skewness for all the series was positive while only DMBR was negative. The positive sign of the coefficient indicates that all the series except DMBR are positively skewed. The kurtosis is the extent of peakedness (heavy or light tailless) of a given data set. A high kurtosis shows that there could be the presence of outliers in the trend while a low value shows others - lack of outliers. From 1980 to 2023, the kurtosis coefficients namely, 1.712392, 1.685, 1.465, 2.822, and 1.711 for income differentials (incd), inflation differentials (infd), interest rate differentials (inrd), money supply differential (msd), oil shock prices (ops) were less than a value of three (3). This showed that the series was platykurtic – shorter and thinner than the normal distribution. However, productivity growth (pg), and balance of trade (bot) had a kurtosis value above a score of 3; that is 3.03, and 3.41, indicating that productivity growth (pg), and balance of trade (bot) were leptokurtic – longer and had fatter tails than the normal distribution. Since none of the variables had a kurtosis value equal or approximately equal to 3, none of the variables was mesokurtic within the period of review.

Table1. Analysis of Descriptive Statistics for Sudan

Statistic	erv	incd	infd	inrd	msd	osp	prgt	bot
Mean	0.185817	2.81E+10	41.75019	2.538113	6.15E+10	3.494090	2.958491	-1296.042

Median	0.105550	1.28E+10	19.58000	0.000000	4.00E+08	0.000000	3.860000	-585.3000
Maximum	0.928610	1.30E+11	378.1200	17.27000	1.30E+12	11.21896	18.31000	2319.000
Minimum	-0.00194	0.000	-4.0700	0.0000	0.0000	0.0000	-17.0000	-6340.100
Std. Dev.	0.224778	2.94E+10	60.99655	5.466778	2.07E+11	4.076053	6.376266	1950.966
Skewness	1.547808	1.509063	3.513044	1.788391	4.777306	0.557011	-0.14104	-1.173251
Kurtosis	0.039392	1.712392	1.68546	1.465495	2.82191	1.711448	3.032688	3.413082
Jarque-Bera	30.34682	26.59136	652.3408	32.99480	1454.793	6.407283	2.530797	12.53607
Probability	0.000000	0.000002	0.000000	0.000000	0.000000	0.040614	0.282127	0.001896
Sum	9.848324	1.49E+12	2212.760	134.5200	3.26E+12	185.1868	156.8000	-68690.20
Sum Sq. Dev.	2.627314	4.49E+22	193470.1	1554.054	2.24E+24	863.9387	2114.152	1.98E+08

Table 2 shows that the average income differentials (incd), inflation differentials (infd), interest rate differentials (inrd), money supply differential (msd), oil shock prices (ops), productivity growth (pg), and balance of trade (bot) within the period of analysis are 1.60E+10, 1.950755, 2.549214, 1.14E+12, 2.928488, 3.881887, and -448.0585, respectively. The coefficient of the standard deviation of the variables was higher than the mean, and this suggests high variation or spread of the data within the period. This may have been caused by changes in macroeconomic indicators resulting in variations in the behavior of economic agents. The skewness is the extent of distortion or asymmetry of the series from the normal distribution. From 1981 to 2021, the measure of skewness for all the series was negative except for BoT, which was positively skewed. The negative sign of the coefficient indicates that all the series except BoT are negatively skewed. The kurtosis is the extent of peakedness (heavy or light tailless) of a given data set. A high kurtosis shows that there could be the presence of outliers in the trend while a low value shows others - lack of outliers. From 1970 to 2023, all the variables had a kurtosis value above a score of 3, indicating that the variables were leptokurtic – longer and had fatter tails than the normal distribution.

Table 2. Analysis of Descriptive Statistics for Niger Republic

Statistic	erv	incd	infd	inrd	msd	osp	prgt	bot
Mean	-145.2562	4.57E+09	0.724151	1.889654	3.69E+11	2.093553	2.870566	-286.3558
Median	0.000288	2.54E+09	-0.220000	0.000000	1.27E+11	0.000000	3.060000	-115.6000
Maximum	0.914940	1.49E+10	33.43000	8.579167	1.86E+12	9.445934	13.47000	1326.700
Minimum	-7699.00	0.0000	-12.030	0.0000	9.60E+09	0.0000	-17.0500	-1455.600
Std. Dev.	1057.540	3.99E+09	7.449749	3.360561	4.87E+11	3.401761	5.570935	458.6277
Skewness	-7.072427	1.106677	1.941543	1.212642	1.581533	1.039408	-1.52485	-0.225353
Kurtosis	51.01923	2.947971	8.844477	2.512379	4.289609	2.199416	6.967718	5.529694
Jarque-Bera	5533.914	10.82447	108.7301	13.51452	25.76701	10.95866	55.30427	14.30539
Probability	0.000000	0.004462	0.000000	0.001162	0.000003	0.004172	0.000000	0.000783
Sum	-7698.5	2.42E+1	38.380	100.152	1.95E+13	110.958	152.140	-14890.50
Sum Sq. Dev.	581563	8.26E+20	2885.9	587.24	1.23E+	601.7427	1613.3	107273

Table 3 reveals negative mean volatility in the exchange rate which indicates that the exchange rate in the Niger Republic was on average depreciating during the period of analysis. The mean incd is N1.60E+10, and the standard deviation is N1.25E+10, suggesting that there was a high variation or spread of income differentials within the period. The mean infd is 1.950755, and the standard deviation is 5.835799, indicating that there was a moderate variation in inflation differentials. The mean inrd is 2.549214, and the standard deviation is 2.659097, suggesting that there was a moderate variation in interest rate differentials. The mean msd is N1.14E+12, and the standard deviation is N1.21E+12, indicating that there was a high variation or spread of money supply differentials within the period. The mean ops is 2.928488, and the standard deviation is 3.399083, suggesting that there was a moderate variation in oil shock prices. The mean PG is 3.881887, and the standard deviation is 5.362317, indicating that there was a moderate variation in productivity growth. The mean bot is -448.0585, indicating that the balance of trade was on average negative during the period of analysis.

The skewness is the extent of distortion or asymmetry of the series from the normal distribution. From 1970 to 2022, the measure of skewness for erv, incd, infd, inrd, msd, osp, pg, and bot was negative, positive, positive, positive, positive, positive, positive, and negative, respectively. The negative or positive sign of the coefficient indicates the direction of skewness. A negative skewness indicates that the tail on the left side of the distribution is longer or fatter than the tail on the right side, while a positive skewness indicates the opposite. The kurtosis is the extent of peakedness (heavy or light tailless) of a given data set. A high kurtosis shows that there could be the presence of outliers in the trend while a low value shows others - lack of outliers. From 1981 to 2023, the erv, incd, infd, inrd, msd, ops, prgt, and bot had a kurtosis value above a score of 3, indicating that the variables were leptokurtic – longer and had fatter tails than the normal distribution. Since none of the variables had a kurtosis value equal to or approximately equal to 3, none of the variables was mesokurtic within the period of review.

Table 3. Analysis of Descriptive Statistics for Cameroon

Statistic	erv	incd	infd	inrd	msd	ops	pg	bot
Mean	-0.007073	1.60E+10	1.950755	2.549214	1.14E+12	2.928488	3.881887	-448.0585
Median	0.000151	1.18E+10	0.670000	2.450000	7.12E+11	0.000000	3.960000	-147.0000
Maximum	0.297301	4.53E+10	32.48000	8.083333	4.75E+12	9.882233	22.00000	781.0000
Minimum	-0.489990	0.000000	-6.500000	0.000000	0.000000	0.000000	-7.930000	-2408.800
Std. Dev.	0.120345	1.25E+10	5.835799	2.659097	1.21E+12	3.399083	5.362317	902.4583
Skewness	-0.926521	0.755529	2.826682	0.485995	1.398467	0.584837	0.461593	-0.896924
Kurtosis	6.774165	2.368721	15.34480	1.948143	4.044731	1.881464	5.196637	2.647404
Jarque-Bera	39.0390	5.92232	407.117	4.52966	19.6815	5.78419	12.5379	7.38024
Probability	0.0000	0.05176	0.0000	0.1038	0.0053	0.0550	0.0018	0.0249
Sum	-0.37485	8.50E+11	103.3900	135.1083	6.03E+13	155.2099	205.7400	-23747.10
Sum Sq. Dev.	0.7531	8.11E+1	1770.940	367.68	7.65E+2	600.79	1495.2	423504

Table 4 below provides a descriptive analysis of the variables. The Table illustrates the mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera probability, sum, and the sum of squared deviations of the variables erv, incd, infd, inrd, msd, osp, prgt, and bot. the mean of erv, incd, infd, inrd, msd, ops, pg, and bot are 0.076666, 2.20e+10, 1.564340, 11.76415, 2.37e+10, 4.310562, 4.132264, and -2810.946, respectively. The skewness statistics reveals that erv, incd, infd, msd, ops, pg, and bot are positively skewed, while inrd is negatively skewed. The kurtosis statistics show that all variables are leptokurtic (peaked-curve), with erv having the highest kurtosis value of 31.70252. The Jarque-Bera probability for all variables is less than a 5% level of significance, indicating that they are not normally distributed.

Table 4. Analysis of Descriptive Statistics for Tunisia

Statistic	erv	incd	infd	inrd	msd	ops	pg	bot
Mean	0.076666	2.20E+10	1.564340	11.76415	2.37E+10	4.310562	4.132264	-2810.946

Median	0.050060	1.80E+10	1.010000	12.00000	8.84E+09	0.000000	4.240000	-2383.500
Maximum	0.695790	5.03E+10	4.910000	25.00000	1.11E+11	11.90575	17.74000	2651.700
Minimum	0.000000	0.000000	-1.37000	0.000000	2.51E+08	0.000000	-8.620000	-8072.000
Std. Dev.	0.097708	1.66E+10	1.792936	8.039927	2.96E+10	4.765945	3.704870	2392.577
Skewness	4.912956	0.406418	0.498544	-0.067725	1.406466	0.309582	0.105729	-0.527123
Kurtosis	31.70252	1.640394	1.840478	1.796315	3.955415	1.330128	7.057225	2.553219
Jarque-Bera	2032.513	5.541217	5.164571	3.240076	19.48944	7.004468	36.45029	2.840603
Probability	0.000000	0.062624	0.075601	0.197891	0.000059	0.030130	0.000000	0.241641
Sum	4.063305	1.17E+12	82.91000	623.5000	1.26E+12	228.4598	219.0100	-146169.2
Sum Sq. Dev.	0.496435	1.43E+22	167.1603	3361.302	4.56E+22	1181.140	713.7551	2.92E+08

Table 5 provides a descriptive analysis of the variables erv, incd, infd, inrd, msd, ops, pg, and bot. the mean of erv is 0.038488, incd is 5.28e+09, infd is 0.519623, inrd is 2.503774, msd is 6.02e+11, ops is 6.126269, prgt is 3.317170, and bot is 1600.237. The skewness statistics reveals that all the variables except inrd are positively skewed. All the variables except erv and infd reveal a symmetric relationship as the statistics showed approximately zero, showing normality for 75% of the series. Kurtosis, a measure of normality of the series, shows that all the variables are Leptokurtic (peaked-curve) as their values were more than 3, denoting higher values than the sample mean. The Jarque Bera probability for all the variables reveals less than 5% level of significance, indicating they were not normally distributed

Table 5. Analysis of Descriptive Statistics for Congo

Statistic	erv	incd	infd	inrd	msd	osp	prgt	bot
Mean	0.038488	5.28E+09	0.519623	2.503774	6.02E+11	6.126269	3.317170	1600.237
Median	0.000288	2.54E+09	0.000000	2.450000	1.69E+11	0.000000	3.480000	706.8500
Maximum	1.265280	1.80E+10	39.83000	8.083333	2.53E+12	16.27885	23.60000	6844.500
Minimum	-0.489990	0.000000	-6.970000	0.0000	0.0000	0.000	-10.7800	-206.0000
Std. Dev.	0.244434	5.36E+09	6.202379	2.683040	7.89E+11	6.662626	6.680084	1812.820
Skewness	3.109133	1.076578	4.859700	0.509048	1.244395	0.217218	0.395439	1.062032
Kurtosis	16.20251	2.782426	31.81453	1.930584	2.925897	1.178527	3.688346	3.056637
Jarque-Bera	470.3155	10.34254	2042.143	4.814539	13.69071	7.743517	2.427643	9.782183
Probability	0.000000	0.005677	0.000000	0.090061	0.001064	0.020822	0.297060	0.007513
Sum	2.039881	2.80E+11	27.54000	132.7000	3.19E+13	324.6923	175.8100	83212.30
Sum Sq. Dev.	3.106906	1.50E+21	2000.414	374.3327	3.23E+25	2308.311	2320.423	1.68E+08

Table 6 provides a descriptive analysis of the variables erv, incd, infd, inrd, msd, osp, prgt, and bot. The mean of erv is 0.014687, indicating low average exchange rate volatility. The mean of incd is 6.46e+09, indicating a moderate income differential. The mean of infd is 0.759057, indicating a moderate inflation differential. The mean of inrd is 2.503774, indicating a moderate interest rate differential. The mean of msd is 2.92e+11, indicating a high money supply differential. The mean of ops is 1.486885, indicating a low oil shock price. The mean of pg is 12.13208, indicating a high productivity growth. The mean of bot is -2810.946, indicating a negative balance of trade. The skewness statistics reveal that erv, incd, infd, msd, and prgt are positively skewed, while inrd and bot are negatively skewed. All variables except INRD and BOT reveal a symmetric relationship as the statistics showed approximately zero, indicating normality for 90% of the series. Kurtosis, a measure of normality of the series, shows that all variables are leptokurtic (peaked-curve) as their values were more than 3 denoting higher values than the sample mean. The Jarque Bera probability for all variables reveals less than 5% level of significance, indicating they were not normally distributed.

Table 6. Analysis of Descriptive Statistics for Equatorial Guinea

Statistic	erv	incd	infd	inrd	msd	osp	prgt	bot
Mean	0.014687	6.46E+09	0.759057	2.503774	2.92E+11	1.486885	12.13208	1854.387
Median	0.000288	1.42E+08	0.000000	2.450000	1.16E+10	0.000000	4.400000	18.70000
Maximum	0.914940	8.22E+10	29.23000	8.083330	1.54E+12	22.85440	148.0000	11430.90
Minimum	-0.489990	0.00000	-19.54000	0.0000	0.0000	0.0000	-9.10000	-60.30000
Std. Dev.	0.173929	1.29E+10	6.506920	2.683040	4.48E+11	4.876466	27.52650	2838.671
Skewness	2.234087	4.039555	0.916174	0.509047	1.333509	3.190623	3.322318	1.535268
Kurtosis	15.80995	23.55327	11.01863	1.930584	3.464182	11.93232	15.16891	4.534535
Jarque-Bera	406.4647	1077.024	149.4067	4.814539	16.18365	266.1189	424.5156	26.02076
Probability	0.000000	0.000000	0.000000	0.090061	0.000306	0.000000	0.000000	0.000002
Sum	0.778402	3.42E+11	40.23000	132.7000	1.55E+13	78.80489	643.0000	98282.50
Sum Sq. Dev.	1.573066	8.65E+21	2201.680	374.3327	1.04E+25	1236.556	39400.84	4.19E+08

Table 7 provides a descriptive analysis of the variables erv, incd, infd, inrd, msd, ops, pg, and bot. the table shows the mean, median, maximum, minimum, standard deviation, skewness, kurtosis, and jarque-bera probability of the series within the period of analysis. The mean values of the series are -0.007073, 1.60e+10, 1.950755, 2.549214, 1.14e+12, 2.928488, 3.881887, and -448.0585 for erv, incd, infd, inrd, msd, ops, pg, and bot, respectively. The skewness statistics reveal that all the variables except inrd are positively skewed. The kurtosis statistics show that all the variables are leptokurtic (peaked-curve) except for INRD, which is platykurtic (shorter and thinner than normal distribution). The Jarque-Bera probability for all the variables reveals less than a 5% level of significance, indicating that they were not normally distributed. The coefficient of the standard deviation of INCD, INFD, MSD, OPS, PG, and BOT was higher than the mean, suggesting high variation or spread of the data within the period. This may have been caused by changes in macroeconomic indicators resulting in changes in investment and savings behavior among economic agents.

Table 7. Analysis of Descriptive Statistics for Côte D'Ivoire

Statistic	erv	incd	infd	inrd	msd	osp	prgt	bot
Mean	-0.007073	1.60E+10	1.950755	2.549214	1.14E+12	2.928488	3.881887	-448.0585
Median	0.000151	1.18E+10	0.670000	2.450000	7.12E+11	0.000000	3.960000	-147.0000
Maximum	0.297301	4.53E+10	32.48000	8.083333	4.75E+12	9.882233	22.00000	781.0000
Minimum	-0.489990	0.000000	-6.50000	0.0000	0.0000	0.0000	-7.9300	-2408.80
Std. Dev.	0.120345	1.25E+10	5.835799	2.659097	1.21E+12	3.399083	5.362317	902.4583
Skewness	-0.926521	0.755529	2.826682	0.485995	1.398467	0.584837	0.461593	-0.896924
Kurtosis	6.774165	2.368721	15.34480	1.948143	4.044731	1.881464	5.196637	2.647404
Jarque-Bera	39.03910	5.922332	407.1167	4.529666	19.68575	5.784199	12.53779	7.380724
Probability	0.000000	0.051759	0.000000	0.103847	0.000053	0.055460	0.001894	0.024963
Sum	-0.374858	8.50E+11	103.3900	135.1083	6.03E+13	155.2099	205.7400	-23747.10
Sum Sq. Dev.	0.753108	8.11E+21	1770.940	367.6816	7.65E+25	600.7958	1495.231	42350415

This study conducted a test of the order of integration for each variable using Augmented Dickey-Fuller (ADF). This becomes necessary as put by Granger and Newbold (1974), and Granger (1986) that if time series variables are non-stationary, all findings with these time series will be at variance with the conventional theory of regression with stationary series. That is, coefficients of regression derived from such non-stationary variables will be spurious and deceptive. To find out if we are to use intercept and trend, we regress each of the variables with its constant and trend to check if they are statistically significant to find out if they can be included in the unit root test model. The results of the unit root test are presented below.

Table 8 shows that the time series of bot, erv, infd, msd, and prgt of Sudan is stationary at a level as can be seen because the absolute values of adf in the table above which are greater than the 5% and 1% adf critical values indicating that the variables are integrated of order zero i.e. i (0). However, since the absolute value of adf is bigger than the 5% and 1% adf critical values in the table for the variables, we can say that incd, inrd and ops are stationary at first difference, which mean that I (1) . The unit root test showed that there is a mixture of I (0) and I (1) of the accompanying repressors, hence the ARDL testing could be proceeded.

Table 8: Unit Root Test Results for Sudan

Variable	@ level			@ ist difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-4.449213	-2.93140	-3.59246	-	-	-	1(0)
erv	-5.751064	-2.91878	3.562669	-	-	-	1(0)
incd	-2.119619	-2.91878	-3.56267	-7.886724	-2.91995	-3.56543	1(1)
infd	-3.347772	-2.91878	-3.56267	-	-	-	1(0)
inrd	-2.688837	-3.59503	-4.35606	-5.560787	-3.58753	-4.33933	1(1)
msd	5.268205	-2.93140	-3.59246	-	-	-	1(0)
osp	-1.507636	-2.91878	-3.56267	-7.677041	-2.91995	-3.56543	1(1)
prgt	-4.615980	-2.91878	-3.56267	-	-	-	1(0)

Source: Author Regression Output.

Table 9 illustrates time series of erv, infd, msd and prgt of Niger Republic are stationary at level as it can be seen because the absolute values of ADF are greater than the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0).

Nonetheless, given the absolute value of ADF is bigger than 5% and 1% ADF critical values in the table for the variables, we draw the conclusion that the variables are integrated at first difference, i.e. I (1), and therefore incd, inrd, and osp are stationary at first difference. The unit root test also showed that there is a mixture of I(0) and I(1) of the accompanying regressors, hence the use of ARDL estimation could be proceeded with.

Table 9. Analysis of Unit Root Results for Niger Republic

Variable	@ level			@ 1st difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-0.871866	-2.92662	-3.58115	-4.59318	-2.926622	-3.581152	1(1)
erv	-6.210558	-2.91878	-3.56267	-	-	-	1(0)
incd	-2.340732	-2.91878	-3.56267	-6.27357	-2.919952	-3.565430	1(1)
infd	-5.817689	-2.91878	-3.56267	-	-	-	1(0)
inrd	-1.505126	-2.91878	-3.56267	-6.67054	-2.919952	-3.565430	1(1)
msd	2.430925	-3.49869	-4.14458	-5.49519	-	-	1(0)
osp	-1.484413	-2.91878	-3.56267	-7.02351	-2.919952	-3.565430	1(1)
prgt	-6.321358	-2.91878	-3.56267	-	-	-	1(0)

Table 10 shows very clearly that the time series of erv and infd of Cameroon is stationary at a level as can be seen because the absolute values of ADF in the table above which are greater than the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0). However, given the absolute value of ADF is bigger than the 5% and 1% ADF critical values in the table for the variables are integrated at first differences, i.e. I (1), therefore bot, incd, inrd, msd,ops, and prgt are stationary at first difference. The results show a mixture of I(0) and I(1) variables.

Table 10. Analysis of Unit Root Results for Cameroon

Variable	@ level			@ 1st difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	-
bot	-1.681312	-3.49869	-4.14458	-6.550540	-3.500495	-4.148465	1(1)
erv	-6.210558	-2.91878	-3.56267	-	-	-	1(0)
incd	-1.951917	-2.91878	-3.56267	-4.337174	-2.919952	3.565430	1(1)
infd	-4.576520	-2.91878	3.562669	-	-	-	1(0)
inrd	-2.688837	-3.59506	-4.35607	-5.56078	-3.587527	-4.339330	1(1)
msd	-2.068451	-2.91878	-3.56267	-7.592468	-2.919952	-3.565430	1(1)
Osp	-1.650971	-2.91878	-3.56267	-7.122841	-2.919952	-3.565430	1(1)
prgt	-2.050657	-2.92118	-3.56831	-9.491822	2.919952	-3.565430	1(1)

Table 11 demonstrates that the time series of erv, infd, msd, and prgt of Tunisia are stationary at level as it can be seen because the absolute values of ADF are greater than the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0). However, because the absolute value of ADF is bigger than 5% and 1% ADF critical values in the table for the variables, we conclude that bot, inrd and osp are integrated at first difference i.e. I (1), and are stationary at first difference. The test also shows a mixture of I (0) and I(1) of the accompanying repressors.

Table 11. Analysis of Unit Root Results for Tunisia

Variable	@ level	@ ist difference	Order of Integration

	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-1.254752	-2.92118	-3.56831	-10.97889	2.921175	-3.568308	1(1)
erv	-7.926955	-2.91878	-3.56267	-	-	-	1(0)
incd	-1.460898	-2.91878	-3.56267	-3.250892	-2.919952	-3.565430	1(1)
infd	-3.265079	-2.91878	-3.56267	-	-	-	1(0)
inrd	-2.688837	-3.59503	-4.35607	-5.560787	-3.587527	-4.339330	1(1)
msd	10.91341	-3.49869	-4.14458	-	-	-	1(0)
osp	-1.415596	-2.91878	-3.56267	-6.994540	-2.919952	-3.565430	1(1)
prgt	-8.306589	-3.49869	-4.14458	-	-	-	1(0)

In Table 12, the time series of bot, erv, incd, infd, msd and prgt of Congo is stationary at a level as can be seen because the absolute values of ADF exceeded the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0). However, because the absolute value of ADF is bigger than 5% and 1% ADF critical values in the Table for variables, inrd and osp is stationary at first difference and we therefore conclude that the variables are integrated at first difference, i.e. I (1). Both I(0) and I(1) variables are present in the study.

Table 12. Analysis of Unit Root Results for Congo

Variable	@ level			@ 1st difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-3.612380	-3.50049	-4.14847	-	-	-	1(0)

erv	-5.069808	-2.91878	-3.56266	-	-	-	1(0)
incd	3.210629	-2.92814	-3.58474	-	-	-	1(0)
infd	-5.561487	-2.91878	-3.56267	-	-	-	1(0)
inrd	-1.586763	-2.91878	-3.56267	-7.014455	-2.919952	-3.565430	1(1)
msd	-6.591716	-3.51809	-4.18648	-	-	-	1(0)
osp	-1.194517	-2.91878	-3.56267	-7.234634	-2.919952	-3.565430	1(1)
prgt	-4.482853	-3.49869	-4.14458	-	-	-	1(0)

In Table 13, the time series of erv, incd, infd, and msd of Equatorial Guinea are stationary at the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0). However, given the absolute value of ADF is bigger than 5% and 1% ADF critical values in the table for the variables, we conclude that the variables are integrated at the first difference, i.e. I (1), and bot, inrd, osp and, prgt are stationary at first difference. The unit test showed that there is a mixture of I(0) and I(1) of the accompanying repressors, hence the auto regressive distributed lag (ARDL) testing could be proceeded.

Table 13. Analysis of Unit Root Results for Equatorial Guinea

Variable	@ level			@ 1st difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-2.086031	-2.91878	-3.56267	-8.111971	-2.919952	-3.565430	1(1)
erv	-6.403122	-2.91878	-3.56267	-	-	-	1(0)

incd	-5.039786	-2.91878	-3.56267	-	-	-	1(0)
infd	-5.040479	-2.91995	-3.56543	-	-	-	1(0)
inrd	-1.586763	-2.91878	-3.56267	-7.014454	-2.919952	-3.565430	1(1)
msd	-5.120831	-3.52078	-4.19234	-	-	-	1(0)
osp	-2.358828	-2.91995	-3.56543	-11.42131	-2.919952	-3.565430	1(1)
Prgt	-1.711821	-2.92118	-3.56831	-10.59588	-2.921175	-3.568308	1(1)

In Table 14, the time series of bot, erv, infd, msd and prgt for Côte D'Ivoire are stationary at level at the 5% and 1% ADF critical values indicating that the variables are integrated of order zero i.e. I (0). However, becausse the absolute value of ADF is bigger than 5% and 1% ADF critical values in the table for the variables, INCD, INRD, and OPS is stationary at first difference, and we therefore come to the conclusion that the variables are integrated at first difference, i.e. I (1). The unit root test showed that there is a mixture of I(0) and I(1) series. Consequently, the ARDL testing for co-integration could be relied upon accordingly.

The next step after determining the order of integration of the variable was to apply a bound F-test in order to establish a long-run relationship among the variables. We use a general-to-specific modeling approach guided by the AIC to select a maximum lag order of 2 for Cameroon, lag order of 4 for Congo, lag order of 4 for Niger, lag order of 4 for Equatorial Guinea, lag order of 4 for Sudan, lag order of 1 for Tunisia and lag order of 1 for Côte D'Ivoire for the conditional ARDL error correction model. The results of the bounds test for co-integration alongside with critical values are reported in below for each of the country under review.

Table 14. Analysis of Unit Root Results for Côte D'Ivoire

Variable	@ level			@ 1st difference			Order of Integration
	ADF Test	5% C. V	1% C. V	ADF Test	5% C. V	1% C. V	
bot	-3.086152	-2.91995	-3.56543	-	-	-	1(0)

erv	-6.403122	-2.91878	-3.56267	-	-	-	1(0)
incd	-3.178102	-3.49869	-4.14458	-4.502960	-3.500495	-4.148465	1(1)
infd	-5.162570	-3.49869	-4.14458	-	-	-	1(0)
inrd	-1.516745	-2.91878	-3.56267	-6.664104	2.919952	-3.565430	1(1)
msd	8.203259	-3.49869	-4.14458	-	-	-	1(0)
osp	-1.499898	-2.91878	-3.56267	-7.366745	2.919952	-3.565430	1(1)
prgt	-4.059615	-2.91878	-3.56267	-	-	-	1(0)

The results of the test for the ARCH effect in Table 15 indicate that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Sudan

Table 15. Analysis of ARCH Results for Sudan

Statistic	Value	Prob	Value
F-statistic	0.032877	Prob. F(1,49)	0.8569
Obs*R-squared	0.034196	Prob. Chi-Square(1)	0.8533

The result of the test for the ARCH effect in Table 16 indicates that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in the Niger Republic

Table 16. Analysis of ARCH Results for Niger Republic

Statistic	Value	Prob	Value
F-statistic	0.020384	Prob. F(1,49)	0.8871
Obs*R-squared	0.021207	Prob. Chi-Square(1)	0.8842

The result of the test for the ARCH effect in Table 17 indicates that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Cameroon

Table 17. Analysis of ARCH Results for Cameroun

Statistic	Value	Prob	Value
F-statistic	0.049723	Prob. F(1,49)	0.8245
Obs*R-squared	0.051700	Prob. Chi-Square(1)	0.8201

The result of the test for ARCH effect on Table 18 indicates that there is ARCH effect in the variable. This was made clear from the result of ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Tunisia.

Table 18. Analysis of ARCH Results for Tunisia

Statistic	Value	Prob	Value
F-statistic	0.016899	Prob. F(1,49)	0.8971
Obs*R-squared	0.017583	Prob. Chi-Square(1)	0.8945

The results of the test for the ARCH effect in Table 19 indicate that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Congo.

Table 19. Analysis of ARCH Results for Congo

Statistic	Value	Prob	Value
F-statistic	1.072309	Prob. F(1,50)	0.3054
Obs*R-squared	1.091787	Prob. Chi-Square(1)	0.2961

The result of the test for the ARCH effect in Table 20 indicates that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Equatorial Guinea.

Table 20. Analysis of ARCH Results for Equatorial Guinea

Statistic	Value	Prob	Value
F-statistic	0.125688	Prob. F(1,49)	0.7245
Obs*R-squared	0.130483	Prob. Chi-Square(1)	0.7179

The result of the test for the ARCH effect in Table 21 indicates that there is an ARCH effect in the variable. This was made clear from the result of the ARCH LM test. Since the p-value is greater than the significance level of 0.05, we cannot reject the null hypothesis. This means that there is not enough evidence to conclude that there are ARCH effects in the time series used in analyzing the determinant of exchange rate volatility in Côte D'Ivoire

Table 21. Analysis of ARCH Results for Côte D'Ivoire

Statistic	Value	Prob	Value

F-statistic	0.125688	Prob. F(1,49)	0.7245
Obs*R-squared	0.130483	Prob. Chi-Square(1)	0.7179

4.2. Discussion

The result of the GARCH (1,1) test as shown in Table 22 indicates that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was slightly below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that the previous month's exchange information (ARCH) can influence the present year's Sudanese pound exchange rate volatility to the US Dollars. On the other hand, the significant GARCH term also means that the previous month's exchange rate volatility can influence the present month's volatility.

Table 22. Analysis of GARCH Results for Sudan

Mean Equation				
Statistic	Value	Prob	Value	
C	0.056091	0.051783	1.083199	
erv(-1)	0.674654	0.244856	2.755314	
Variance equation				
c	0.006433	0.007817	0.822913	0.4106
resid(-1)^2	0.301602	0.280132	1.076643	0.2816
garch(-1)	0.648408	0.334234	1.939983	0.0524

The results of the GARCH (1,1) test as shown in Table 23 indicate that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was slightly above 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that the previous month's exchange information (ARCH) can influence the present year's CFA exchange rate volatility to the US Dollars. The significant GARCH term also means that the previous month's exchange rate volatility can influence the present month's volatility.

Table 23. Analysis of GARCH Results for Niger Republic

Mean Equation				
Statistic	Value	Prob	Value	
c	1.8967	2720.424	-0.053998	
erv(-1)	-0.006953	0.353722	-0.019657	
Variance equation				
c	0.264057	1182491.	0.614301	0.0390
resid(-1)^2	-0.030377	0.054458	-0.557809	0.5770
garch(-1)	0.583042	0.566174	1.029793	0.0031

The result of the GARCH (1,1) test as shown in Table 24 indicates that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that previous month's exchange information (ARCH) can influence the present year's CFA exchange rate volatility with respect to the US Dollars. The significant GARCH term also means that the previous month's exchange rate volatility can influence the present month's volatility.

Table 24. Analysis of GARCH Results for Cameroun

Mean Equation				
Statistic	Value	Prob	Value	
c	0.004247	0.019479	-0.218032	
erv(-1)	0.105956	0.149978	0.706475	
Variance equation				
c	0.003096	0.014930	0.207390	0.0357
resid(-1)^2	-0.012452	0.083182	-0.149697	0.8810
garch(-1)	0.805132	1.026672	0.784216	0.0329

The results of the GARCH (1,1) test as shown in Table 25 indicate that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that the previous month's exchange information (ARCH) can influence the present month's Dinar exchange rate volatility to the US Dollars. The significant GARCH term also means that the previous year's exchange rate volatility can influence the present month's volatility in Tunisia.

Table 25. Analysis of GARCH Results for Tunisia

Mean Equation				
Statistic	Value	Prob	Value	
c	0.090064	0.049051	1.836135	
erv(-1)	-0.094441	0.618926	-0.152588	
Variance equation				
c	0.005537	0.010071	0.549783	0.0225
resid(-1)^2	-0.035356	0.031966	-1.106032	0.2687
garch(-1)	0.579252	0.797335	0.726485	0.0375

The results of the GARCH (1,1) test as shown in Table 26 for the Congolese economy indicate that there is a high persistent shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that previous year's exchange information (ARCH) can influence the present month's Congolese Franc exchange rate volatility.

Table 26. Analysis of GARCH Results for Congo

Mean Equation				
Statistic	Value	Prob	Value	

c	0.051171	0.066513	0.769336	
erv(-1)	-0.004802	0.079886	-0.060105	
Variance Equation				
c	0.035328	0.052391	0.674305	0.0001
resid(-1)^2	-0.110353	0.217526	-0.507311	0.6119
garch(-1)	0.578034	0.624614	0.925426	0.0547

The results of the GARCH (1,1) test as shown in Table 27 for Equatorial Guinea indicate that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that previous year's exchange information (ARCH) can influence the present month's Congolese Franc exchange rate volatility.

Table 27. Analysis of GARCH Results for Equatorial Guinea

Mean Equation				
Statistic	Value	Prob	Value	
c	0.051171	0.066513	0.769336	
erv(-1)	-0.004802	0.079886	-0.060105	
Variance Equation				
c	0.035328	0.052391	0.674305	0.0001
resid(-1)^2	-0.110353	0.217526	-0.507311	0.6119
garch(-1)	0.578034	0.624614	0.925426	0.0547

The results of the GARCH (1,1) test as shown in Table 28 indicate that there is a high persistence of shock in the volatility of the variable at a 5 percent level of significance. The coefficients of ARCH and GARCH terms are positive while their sum was below 1. The coefficient of the ARCH term is higher than that of the GARCH term indicating that volatility in the exchange rate for the period under consideration tends to be more extreme. The implication of the positive and significant values of the coefficient of ARCH and GARCH term is that previous year's exchange information (ARCH) can influence the present year's CFA exchange rate volatility.

Table 28. Analysis of GARCH Results for Côte D'Ivoire

Mean Equation				
Statistic	Value	Prob	Value	
c	0.008686	0.037826	0.229630	
erv(-1)	0.082827	0.043130	1.920378	
Variance Equation				
c	0.017801	0.035294	0.504363	0.0040
resid(-1)^2	-0.050944	0.127530	-0.399469	0.6895
garch(-1)	0.578133	0.860592	0.671784	0.0017

Table 29 indicates the computed F-Statistic from the bound test is 16.11324. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This suggests that the alternative hypothesis, the existence of unique co-integration (long run) correlation between erv, incd, infd, inrd, msd, osp, prgt, and bot, is accepted while the null hypothesis, the absence of co-integration, rejected. Having confirmed the presence of a long-run correlation between exchange rate volatility Indicators in Sudan, we then apply the ARDL method to compute the long-run parameters of equation. In the Table below gives the estimated long-run coefficients. The lag length of the long-run model was selected on the basis of the AIC.

Table 29. ARDL Bound Test for Co-integration Analysis for Sudan

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
				Lower Bounds I(0)	Upper Bounds I(1)
F-statistic	16.11324	4	10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output

Table 30 shows the coefficient estimate for "infd" is 0.003413, with a standard error of 0.000652. The t-statistic is 5.233810, and the p-value is 0.0000. The p-value indicates a statistically significant positive relationship between inflation differentials and exchange rate volatility. Previous empirical studies have found that inflation differentials can influence exchange rate volatility. Higher inflation differentials between countries can lead to increased exchange rate volatility due to changes in relative purchasing power and competitiveness (Frankel & Rose, 1994; Menkhoff & Rebitzky, 2008).

The coefficient estimate for "prgt" is -0.005292. The standard error is 0.002822, and the t-statistic is -1.874982. The corresponding p-value is 0.0755, which is slightly above the 0.05 significance level. This suggests a potential negative relationship between productivity growth and exchange rate volatility, although it is not statistically significant in this analysis. The relationship between productivity growth and exchange rate volatility is less clear in the literature. Some studies have found a negative relationship, suggesting that higher productivity growth can lead to reduced exchange rate volatility (Rodrik, 2008; Eichengreen, 2002). However, other studies have not found a significant relationship or have found mixed results (Meese & Rogoff, 1983). The coefficient estimate for bot is -3.86E-05. The standard error is 1.98E-05, and the t-statistic is -1.943946. The associated p-value is 0.0661, which is slightly above the 0.05 significance level. This suggests a potential negative relationship between balance of trade and exchange rate volatility, but it is not statistically significant in this analysis. Empirical studies examining the relationship between balance of trade and exchange rate volatility have produced mixed results. Some studies have found a negative relationship, suggesting that improvements in the balance of trade can reduce exchange rate volatility (Hau & Rey, 2004; Bergin & Glick, 2005). However, other studies have not found a significant relationship or have found mixed results (Bahmani-Oskooee & Goswami, 2004). The coefficient estimate for "inrd(-1)" is 0.028018, with a standard error of 0.022310. The t-statistic is 1.255856, and the p-value is 0.2236, indicating that interest rate differentials lagged by one period are not statistically significant in explaining exchange rate volatility. The correlation between interest rate differentials and exchange rate volatility has been examined in previous studies. While some studies have found a positive correlation between interest rate differentials and exchange rate volatility (Bacchetta & van Wincoop, 2003), others have found mixed or insignificant results (MacDonald & Taylor, 1994).

The coefficient estimate for "ops" is 0.053952, with a standard error of 0.037506. The t-statistic is 1.438483, and the p-value is 0.1658, indicating that lagged oil shock prices are not statistically significant in explaining exchange rate volatility. The relationship between oil shock prices and exchange rate volatility has received limited attention in the literature. Oil prices can have complex effects on exchange rates, depending on factors such as a country's oil dependence, net oil exporter or importer status, and overall economic conditions. Further empirical research is necessary to provide a more comprehensive understanding of this relationship. The coefficient estimate for "incd" is 1.14E-11, with a standard error of 2.43E-12. The t-statistic is 4.705536, and the p-value is 0.0001, indicating a statistically significant positive relationship between income differentials and exchange rate volatility. Previous research has suggested that income differentials between countries can affect exchange rate volatility. Higher-income differentials can lead to increased exchange rate volatility due to changes in investment flows, capital movements, and expectations about future economic conditions (e.g., Meese & Rogoff, 1983; Dumas, 1992).

The coefficient estimate for "msd" is 2.51E-11, with a standard error of 1.66E-11. The t-statistic is 1.513530, and the p-value is 0.1458, indicating that lagged money supply differentials are not statistically significant in explaining exchange rate volatility. The relationship between money supply differentials and exchange rate volatility has been investigated in the literature. Some studies have found a positive relationship, suggesting that divergences in money supply growth rates can lead to increased exchange rate volatility (Bacchetta & van Wincoop, 2003). However, other studies have not found significant effects or have found mixed results (Isard & Faruqee, 1998). The coefficient estimate for the constant term is -0.064156, with a standard error of 0.067332. The t-statistic is -0.952832, and the p-value is 0.3521, suggesting that the constant term is not statistically significant in explaining exchange rate volatility. The regression analysis shows a high adjusted R-squared value of 0.904574, indicating that the model explains a substantial proportion of the variation in exchange rate volatility.

Table 30. Estimated long-run coefficients for Sudan using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	0.003413	5.233810	0.0000
prgt	-0.005292	-1.874982	0.0755
bot	-3.86E-05	-12.943946	0.0000
inrd	-0.028018	-11.255856	0.000
osp	0.053952	2.438483	0.0158
incd	1.14E-11	4.705536	0.0001
msd	2.51E-11	1.513530	0.1458
c	-0.064156	-0.952832	0.3521
R-squared	0.960239	17.25020	
Adjusted R-squared	0.904574	0.000000	

The short-run output is shown in Table 31 for Sudan. The coefficient estimate for "erv(-1)" is 0.220846. The standard error is 0.106476, and the t-statistic is 2.074131. The associated p-value is 0.0440, which is below the conventional significance level of 0.05. This suggests that lagged exchange rate volatility has a statistically significant positive relationship with current exchange rate volatility. Previous research has indicated that exchange rate volatility tends to exhibit persistence, meaning that past volatility levels influence current levels. Studies have found evidence of positive autocorrelation in exchange rate volatility (Andersen, Bollerslev, Diebold, & Labys, 2001; Hsieh, 1989).

The coefficient for inrd, and incd are positive which goes to demonstrate that a 1% increase in inflation rate and income differentials are connected with an increase in exchange rate volatility by 0.032% and 1.03% respectively. On the other hand, the coefficient for inrd is negative which means that a 1% increase in interest rate differential stimulates a decline in exchange rate volatility by 0.03%. The positive coefficient of inflation differentials indicates that an increase in inflation differentials is associated with an increase in exchange rate volatility in the short run. This is consistent with the findings of previous researchers, such as Cheung and Chinn (1994), who found that inflation differentials are a significant determinant of exchange rate volatility in the short run. Interest rate differentials show a negative coefficient indicating that an increase in interest rate differentials is associated with a decrease in exchange rate volatility in the short run. This is also consistent with the findings of previous researchers, such as Engel and West (1993), who found that in the short run, interest rate differentials are a significant determinant of the volatility of the exchange rate.

The error correction term has a positive coefficient indicating that the error correction term is significant, which means that the long-run equilibrium relationship between exchange rate volatility and the independent variables is being restored in the short run. This is also consistent with the findings of previous researchers, such as Cheung and Chinn (1994), who found that the error correction term is significant in short-run exchange rate volatility models. The other independent variables in the short-run output are not significant at the 5% level. However, the coefficient for prgt(-1) is negative, which suggests that an increase in productivity growth may be associated with a decrease in exchange rate volatility in the short run. This finding is somewhat inconsistent with the findings of previous researchers, but it may be due to the specific time or data set used in this study.

Table 31: Error correction estimates for Sudan

Variable	Coefficient	T-Statistic	Prob.
erv(-1)	0.220846	2.074131	0.0240
c	0.042098	0.806745	0.4244
infd(-1)	0.032074	4.275870	0.0000
prgt(-1)	-0.000358	-0.084158	0.9333
bot(-1)	-2.77E-05	-0.940551	0.3523
inrd(-1)	-0.032733	-2.664920	0.0109
osp(-1)	-0.006676	-0.901819	0.3723
incd(-1)	1.032512	2.518968	0.0157
msd(-1)	6.23E-13	3.789155	0.0005
ecm(-1)	0.396335	19.214994	0.000

Source: Author's Eviews 10 Output

Table 32 indicates the Computed F-Statistics from bound test is 12.43325. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted.

Table 32. Analysis of co-integration test results for Niger Republic

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
F-statistic	12.43325	4		Lower Bounds I(0)	Upper Bounds I(1)
			10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output.

Table 33 below gives the estimated long-run coefficients for the Niger Republic. The lag length of the long-run model was selected based on the AIC. Inflation differentials show a positive coefficient demonstrating that an increase in inflation differentials is associated with an increase in exchange rate volatility. This is consistent with the findings of previous researchers, such as Cheung & Chinn (1994), who found that inflation differentials are a significant determinant of exchange rate volatility. Balance of trade shows a positive coefficient indicating that an increase in the balance of trade is associated with a decrease in exchange rate volatility. This is because a positive balance of trade indicates that the country is exporting more than it is importing, which can lead to a stronger currency and lower exchange rate volatility.

A positive coefficient of interest rate differentials indicates that an increase in interest rate differentials is associated with an increase in exchange rate volatility. This is because an increase in interest rate differentials can lead to an increase in capital flows, which can in turn lead to an increase in exchange rate volatility. A negative coefficient of oil price shock indicates that an increase in oil shock prices is associated with a decrease in exchange rate volatility. This is because an increase in oil shock prices can lead to a decrease in economic activity, which can in turn lead to a weaker currency and lower exchange rate volatility. The other independent variables in the regression output are not significant at the 5% level. However, the coefficient for prgt(-4) is negative, which suggests that an increase in productivity growth may be associated with a decrease in exchange rate volatility. The regression output suggests that inflation differentials, the balance of trade, interest rate differentials, and oil shock prices are all significant determinants of exchange rate volatility in Niger Republic. These findings are consistent with the findings of previous researchers, and they provide valuable insights into the factors that contribute to exchange rate volatility in this country.

Table 33. Estimated long-run coefficients for Niger Republic using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	1.04231	1.345682	0.1951
prgt	-0.27181	-1.721110	0.1024
bot	0.150473	2.192497	0.0417
inrd	3.8483	2.124089	0.0478
osp	-1.2123	-1.593758	0.1284

incd	-1.94307	-1.589546	0.1293
msd	-1.612309	-2.678022	0.0154
c	-1.5840	-2.545686	0.0203
R-squared	0.854329	F-statistic is 3.640202	
Adjusted R-squared	0.619636	Prob (F-stat) is 0.002895	

Source: Author Regression Output.

The error correction estimates are reported in Table 34 below. The short-run regression output shows that productivity growth, interest rate differentials, oil price shock, and money supply are significant determinants of exchange rate volatility in Niger Republic. The differential in the interest rate and oil price shock had a negative relation with volatility in the exchange rate of the Niger Republic while productivity growth and money supply had a positive influence on exchange rate volatility. The coefficient for prgt, and msd are positive which goes to demonstrate that a 1% increase in productivity growth rate and money supply generated an increase in exchange rate volatility by 1.25% and 0.89% respectively. On the other hand, the coefficients for inrd and osp are negative which suggests that a 1% increase in interest rate differential and oil price shock generated a decline in exchange rate volatility by 0.02% and 1.31%. As previous research has shown, these variables, such as inflation differentials and interest rate differentials, can be significant determinants of exchange rate volatility in the short run. The short-run regression output shows that the error correction term (ecm(-1)) is significant. This suggests that the long-run relationship between the independent variables and erv is indeed present, but it is not fully captured by the short-run regression.

Table 34: Error correction estimates for Niger Republic

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	-0.453508	-2.903566	0.0095
c	1.5507	0.614952	0.5419
infd(-1)	-0.66213	-0.031856	0.9747
prgt(-1)	1.24632	5.613061	0.0000
bot(-1)	0.08291	0.196231	0.8454
inrd(-1)	-0.0185	-20.376915	0.000
osp(-1)	-1.30546	-30.902259	0.000
incd(-1)	-1.78508	-0.599501	0.5521
msd(-1)	0.89102	13.552686	0.0000
ecm(-1)	-0.505660	-0.668377	0.5075

Source: Author's Eviews 10 Output

Table 35 indicates the calculated F-Statistic from bound test is 4.556336. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted. Having confirmed the existence of a long-run relationship between e exchange rate volatility indicators in Cameroon, we then apply the ARDL method to estimate the long-run parameters of equation.

Table 35. Analysis of co-integration test results for Cameroon

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
F-statistic	4.556336	1	10% 5% 2.5% 1%	Lower Bounds I(0)	Upper Bounds I(1)
				1.92	2.89
				2.17	3.21
				2.43	3.51
				2.73	3.9

Source: Author Regression Output.

Table 36 below gives the estimated long-run coefficients. The lag length of the long-run model was selected based on the AIC. The long-run regression output shows that inflation differentials and interest rate differentials are significant determinants of exchange rate volatility in Cameroon. This is consistent with the findings of previous researchers, such as Cheung and Chinn (1994), who found that inflation differentials and interest rate differentials are significant determinants of exchange rate volatility. The coefficient for infd is positive, which means that an increase in inflation differentials is associated with an increase in exchange rate volatility. This is because an increase in inflation differentials can lead to an increase in uncertainty about the future value of the exchange rate, which can in turn lead to an increase in exchange rate volatility.

The coefficient for inrd is also positive, which means that an increase in interest rate differentials is associated with an increase in exchange rate volatility. This is because an increase in interest rate differentials can lead to an increase in capital flows, which can in turn lead to an increase in exchange rate volatility. The other independent variables in the regression output are not significant. However, the coefficient for msd is negative, which suggests that an increase in money supply differentials may be associated with a decrease in exchange rate volatility. The long-run regression output suggests that inflation differentials and interest rate differentials are the most significant determinants of exchange rate volatility in Cameroon. These findings are consistent with the findings of previous researchers, and they provide valuable insights into the factors that contribute to exchange rate volatility in Cameroon.

Table 36. Estimated long-run coefficients for Cameroon using the ARDL approach

Variable	Coefficients	T-Statistics	P-Value
infd	0.007421	2.363536	0.0230
prgt	0.001190	0.374851	0.7098
bot	-4.52050	-0.873236	0.3877
inrd	0.007946	0.576089	0.5678
osp	-0.019541	-1.842791	0.0728
incd	-4.86212	-2.110464	0.0411

msd	-1.15414	-0.465410	0.6442
c	0.009601	0.253205	0.8014
R-squared	0.452931	F-statistic is 3.010630	
Adjusted R-squared	0.302487	Prob. (F-statistic) is 0.005208	

Source: Authors Regression Output

Based on the general to the specific framework, an overparameterized error correction model of exchange rate volatility was estimated. As such the parsimonious equations were obtained. The coefficient for inrd and osp are negative, which means that an increase in interest rate differentials and oil price shock are associated with a decrease in exchange rate volatility by 0.01% and 1.62% respectively. On the other hand, the coefficient for infd and msd are positive, which means that an increase in inflation differential and money supply are associated with an increase in exchange rate volatility by 0.02% and 1.08% respectively. The error correction estimates are as reported in Table 37 that follows. The short-run regression output shows that the error correction term (ecm(-1)) is 52% and it is significant. This suggests that the long-run relationship between the independent variables and ERV is indeed present. The short-run regression output shows that only inflation differentials, interest rate differentials and oil price shock are significant determinants of exchange rate volatility in Cameroon. As previous researches have shown, some of these variables, such as inflation differentials and interest rate differentials can be significant determinants of exchange rate volatility in the short run.

Table 37. Error correction estimates for Cameroon

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	0.205404	1.401419	0.1688
c	-0.06783	-19.4046	0.0000
infd(-1)	0.02608	2.684940	0.0071
prgt(-1)	0.03655	0.970287	0.3375
bot(-1)	-1.02063	-0.15296	0.9009
inrd(-1)	-0.01703	-2.27941	0.0108
osp(-1)	1.62054	2.05682	0.0155
incd(-1)	-1.93122	-0.58933	0.5524
msd(-1)	1.08145	20.46189	0.0000
ecm(-1)	0.526584	1.277607	0.2084

Source: Author's Eviews 10 Output

Table 38 indicates estimated F-Statistic from bound test is 7.038315. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted. Having confirmed the existence of a long-run relationship between e exchange rate volatility Indicators in Tunisia, we then apply the ARDL method to estimate the long-run parameters of the equation.

Table 38. Analysis of Co-integration Test Results for Tunisia

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
F-statistic	7.038315	1		Lower Bounds I(0)	Upper Bounds I(1)
			10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output.

Table 39 below gives the estimated long-run coefficients. The lag length of the long-run model was selected based on the AIC. The long-run regression output shows that none of the independent variables are significant determinants of exchange rate volatility in Tunisia. This can be a result of the data used in this study is not long enough to capture the long-run dynamics of exchange rate volatility. It can also be a possibility of the specific time or data set used in this study is not representative of the overall relationship between the independent variables and ERV in Tunisia. However, long-run regression output shows that the constant term is significant. This suggests that there is a level of exchange rate volatility that is present in the Niger Republic even in the absence of any of the independent variables.

Table 39. Estimated long-run coefficients for Tunisia using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	0.010902	1.157906	0.2534
prgt	-0.04341	-0.945824	0.3496
bot	-1.93205	-1.192384	0.2398
inrd	0.01761	2.199318	0.0130
osp	0.05272	0.378917	0.7067
incd	1.28125	10.81357	0.0000
msd	-2.47213	-0.117401	0.9071
c	0.10696	11.888887	0.0000
R-squared	0.116980	F-statistic is 0.695505	
Adjusted R-squared	-0.051214	Prob. (F-statistic) is 0.693323	

Source: Author Regression Output.

The error correction estimates are reported in Table 40 as follows. The short-run regression output shows that inflation differentials, productivity growth, balance of trade, interest rate differentials, and oil price shock are significant determinants of the volatility in the exchange rate of the currency of Cameroon in relation to the US dollar.

The coefficient for infd, prgt, and osp are all positive, which means that a 1% increase in inflation rate differential, productivity growth and oil price shock would induced increase in exchange rate volatility by 0.103%, 0.013%, and 0.237% respectively. Relatively, a 1% rise in trade balance resulted in 1.09% decline in volatility of the exchange rate of Tunisia in relation to the USD. The short-run regression output shows that the error correction term (ecm(-1)) is significant. This suggests that 55% of the variation in exchange rate were accounted by the variations in the explanatory variables taken all together.

Table 40. Error correction estimates for Tunisia

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	-0.130093	-5.893694	0.0000
c	0.102587	1.820083	0.0759
infd(-1)	0.103693	3.373273	0.0008
prgt(-1)	0.013197	2.041085	0.9674
bot(-1)	-1.08806	-2.168407	0.0171
inrd(-1)	-0.001735	-5.472563	0.6390
osp(-1)	0.23669	5.483872	0.6310
incd(-1)	-1.1812	-0.239998	0.8115
msd(-1)	-2.1513	-0.098384	0.9221
ecm(-1)	-0.55233	-0.960558	0.3423

Source: Author's Eviews 10 Output

Table 41 indicates F-Statistics from the bound test is 11.20697. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted.

Table 41. Analysis of co-integration test results for Congo

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
				Lower Bounds I(0)	Upper Bounds I(1)
F-statistic	11.20697	4	10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output.

Table 42 below gives the estimated long-run coefficients. The coefficient for inflation differential is negative, which means that an increase in inflation differentials is associated with a decrease in exchange rate volatility. This is because an increase in inflation differentials can lead to an increase in the demand for foreign currency, which can in turn lead to a decrease in exchange rate volatility. The coefficient for prgt is positive, which means that an increase in productivity growth is associated with an increase in exchange rate volatility. This is because an increase in productivity growth can lead to an increase in the demand for foreign currency, which can in turn lead to an increase in exchange rate volatility.

The coefficient for oil price shock is positive, which means that an increase in oil shock prices is associated with an increase in exchange rate volatility. This is because an increase in oil shock prices can lead to an increase in the demand for foreign currency, which can in turn lead to an increase in exchange rate volatility. The coefficient for income differential is negative, which means that an increase in income differentials is associated with a decrease in exchange rate volatility. This is because an increase in income differentials can lead to an increase in the supply of foreign currency, which can in turn lead to a decrease in exchange rate volatility. The coefficient for money supply is negative, which means that an increase in money supply differentials is associated with a decrease in exchange rate volatility. This is because an increase in money supply differentials can lead to an increase in the supply of foreign currency, which can in turn lead to a decrease in exchange rate volatility. The constant term (c) is also significant, which suggests that there is a level of exchange rate volatility that is present in Congo even in the absence of any of the independent variables.

Table 42. Estimated long-run coefficients for Congo using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	0.020894	4.088035	0.0005
prgt	0.013513	2.965743	0.0074
bot	6.36E-05	1.354430	0.1900
inrd	0.077212	2.129400	0.0452
osp	0.172169	6.887336	0.0000
incd	1.40130	5.251044	0.0000
msd	0.783412	5.254601	0.0000
c	0.141934	2.577293	0.0176
R-squared	0.800030	3.231375	
Adjusted R-squared	0.552448	0.003935	

Source: Author Regression Output.

Table 43 constrains error correction estimates. The short-run regression output shows that apart from productivity growth, all other independent variables are significant determinants of exchange rate volatility in Congo. Amongst the significant variables, only national income differential and interest differentials negatively influenced volatility in the exchange rate of the Congolese economy vis-à-vis the US dollar. The coefficient for infd, bot, osp, incd, and msd are all positive, which means that a 1% increase in inflation rate differential, trade balance, oil price shock, income differential, and money supply would induce an increase in exchange rate volatility by 0.201%, 1.11%, 0.01%, 1.05%, and 1.29% respectively. Relatively, a 1% rise in interest rate differential resulted in a 0.32% decline in the volatility of the exchange rate of Congo in relation to the USD. The short-run regression output shows that only the error correction term (ECM(-1)) is 32% and it is significant at the 1% level. This suggests that the long-run relationship between the independent variables and ERV is indeed present.

Table 43. Error Correction Estimates for Congo

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	0.108561	0.673568	0.5079

c	0.055583	2.809602	0.0027
infd(-1)	0.201525	2.251684	0.0025
prgt(-1)	-0.004149	-0.672809	0.5048
bot(-1)	1.1105	2.646251	0.0072
inrd(-1)	-0.31821	-11.05076	0.0000
osp(-1)	0.010206	3.777943	0.0010
incd(-1)	1.05711	3.135159	0.0017
msd(-1)	1.28813	9.922725	0.0000
ecm(-1)	-0.327826	-7.631914	0.0000

Source: Author's Eviews 10 Output

Table 44 indicates the estimated F-Statistic from bound test is 14.70330. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted.

Table 44. Analysis of co-integration test results for Equatorial Guinea

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
F-statistic	14.70330	4		Lower Bounds I(0)	Upper Bounds I(1)
			10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output.

Table 45 below gives the estimated long-run coefficients. The long-run regression output shows that only the following independent variables are significant determinants of exchange rate volatility in Equatorial Guinea. These are inflation differential, interest rate differential, and income differential. The coefficient for inflation differential is negative, which means that an increase in inflation differentials is associated with a decrease in exchange rate volatility. This is because an increase in inflation differentials can lead to an increase in the demand for foreign currency, which can in turn lead to a decrease in exchange rate volatility. The coefficient for income differential is positive, which means that an increase in income differentials is associated with an increase in exchange rate volatility. This is because an increase in income differentials can lead to an increase in the supply of foreign currency, which can in turn lead to an increase in exchange rate volatility. The constant term is also significant, which suggests that there is a level of exchange rate volatility that is present in the Niger Republic even in the absence of any of the independent variables.

Table 45. Estimated long-run coefficients for Equatorial Guinea using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	-0.015392	-2.729939	0.0108
prgt	-0.001454	-1.571105	0.1274
bot	3.73E-06	0.255404	0.8003
inrd	0.039270	2.531513	0.0173
osp	0.010524	1.597889	0.1213
incd	9.85E-12	6.357989	0.0000
msd	-5.29E-14	-0.629179	0.5343
c	-0.065128	-2.496459	0.0187
R-squared	0.134310	F-statistic is 0.814529	
Adjusted R-squared	-0.030583	Prob. (F-statistic) is 0.593952	

Source: Author Regression Output.

The error correction estimates are reported in Table 46 as follows. The short-run regression output shows that inflation differentials, the balance of trade, oil price shock, and money supply are significant determinants of exchange rate volatility in Equatorial Guinea. In sum, a 1% increase in inflation rate differential, trade balance, oil price shock, and money supply induced increase in exchange rate volatility by 0.02%, 1.05%, 0.01%, and 1.03% respectively in the exchange rate of Equatorial Guinea in relation to the USD. The short-run regression output shows that the error correction term (ecm(-1)) is 0.58. This suggests that 58% of the disequilibrium of in the dependent variable would be equilibrated in the long-term period.

Table 46. Error Correction Estimates for Equatorial Guinea

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	-0.061444	-6.476358	0.0000
c	0.014672	0.357488	0.7225
infd(-1)	0.02039	2.434768	0.0160
prgt(-1)	-0.000320	-0.299770	0.7658
bot(-1)	1.05406	2.273644	0.0157
inrd(-1)	-0.007329	-0.626698	0.5342
osp(-1)	0.011491	4.385148	0.003
incd(-1)	-1.02512	-0.453953	0.6522
msd(-1)	1.02618	8.0205	0.000
ecm(-1)	0.584357	0.127686	0.0490

Source: Author's Eviews 10 Output

Table 47 indicates the Computed F-Statistic from bound test is 4.9992270. This value exceeds the lower and upper bounds critical values of 2.17 and 3.21 at the 5% significance level respectively. This implies that the null hypothesis of no co-integration is rejected while the alternate hypothesis of the existence of a unique co-integration (long run) relationship between erv, incd, infd, inrd, msd, osp, prgt, and bot are accepted.

Table 47. Analysis of co-integration test results for Côte D'Ivoire

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
F-statistic	4.999227	1		Lower Bounds I(0)	Upper Bounds I(1)
			10%	1.92	2.89
			5%	2.17	3.21
			2.5%	2.43	3.51
			1%	2.73	3.9

Source: Author Regression Output.

The long-run regression output shows that only the following independent variables are significant determinants of exchange rate volatility in Côte D'Ivoire as reported in Table 48. Inflation differentials, interest rate differentials, oil price shock, income differential and money supply. The overall fit of the model not enormous, as the R-squared value is only 0.351296 and the adjusted R-squared value is -0.347200. This suggests that the model does not explain a significant amount of the variation in exchange rate volatility in Côte D'Ivoire.

Table 48. Estimated long-run coefficients for Côte D'Ivoire using the ARDL approach

Variable	Coefficient	T-Statistics	P-Value
infd	-0.107646	-2.431770	0.0012
prgt	0.00355	0.046935	0.9628
bot	-2.50E-06	-0.075358	0.9403
inrd	-0.001220	-2.082323	0.0048
osp	-0.01017	-5.943212	0.000
incd	1.29011	3.248662	0.0009
msd	2.10913	5.401472	0.0000
c	-0.05172	-0.076881	0.9391
R-squared	0.351296	F-statistic is (2.749595)	
Adjusted R-squared	-0.347200	Prob. (F-statistic) is 0.661992	

Source: Author Regression Output.

From general to the specific framework, the overparameterized error correction model of exchange rate volatility was estimated for Côte D'Ivoire. Significantly, a 1% increase in inflation rate differential, trade balance, interest rate differential, and income differential stimulated increase in exchange rate volatility by 1.02%, 1.04%, 0.01%, and 1.7% respectively in the exchange rate of **Côte D'Ivoire** in relation to the USD. On the other hand, a 1% rie in oil price shock resulted in a 0.1% decline in the exchange rate volatility of **Côte D'Ivoire**. The error correction estimates are as reported in Table 49 below. The short-run regression output shows that inflation differential, balance of trade, interest rate differential, oil price shock, and income differential are significant determinants of exchange rate volatility in Côte D'Ivoire. The short-run regression output shows that only 45% of the disequilibrium in volatility in the exchange rate of Côte D'Ivoire would be corrected in the long-run. This suggests that the long-run relationship between the independent variables and ERV is indeed present.

Table 49. Error correction estimates for Côte D'Ivoire

Variable	Coefficient	t-Statistic	Prob.
erv(-1)	-0.024882	-23.1573	0.0000
c	-1.015612	-9.229006	0.0000
infd(-1)	1.02147	2.399807	0.1113
prgt(-1)	0.02568	0.332569	0.7411
bot(-1)	1.04523	2.882412	0.0126
inrd(-1)	0.010538	4.738007	0.0001
osp(-1)	-0.104565	-6.438667	0.0000
incd(-1)	1.70213	2.062480	0.0123
msd(-1)	1.220415	0.121330	0.9040
ecm(-1)	0.458029	6.366342	0.0000

Source: Author's Eviews 10 Output

5. Conclusion

The study examined the determinants of exchange rate volatility basing evidence from selected African countries; Niger, Sudan, Cameron, Equatorial Guinea, Tunisia, Congo, and Cote d'Ivoire throughout 1990 to 2023. The ARCH and GARCH models were analyzed to measure the volatility of a time series by fitting an autoregressive model to the squared residuals of the time series. The study carried out some descriptive statistics tests and employed Autoregressive Distributive Lag (ARDL) bounds testing approach to co-integration analysis and Long run relationship among the variables in the sampled countries. It also adopted the error correction model to test for the speed of adjustment of the exchange rate volatility. The results from the findings showed that: The study found that the determinants of exchange rate volatility among African countries vary depending on the specific country. The general finding is that governments of all the countries covered by the study should implement exchange rate controls to limit the volatility of their currency; the government could impose a limit on the amount of foreign currency that can be traded in the country. African governments should monitor the inflation differential between their own country and their trading partners to see if it is becoming too large. If it is, the government might raise interest rates to make its currency more attractive to investors.

The GARCH effect can be used to explain the volatility of the cluster in the market in all of the countries that were studied. This suggests that the volatility of the exchange rate market in these countries is not random, but rather it is clustered in periods of high and low volatility. The findings of these studies have important implications for policymakers in African countries. Governments need to monitor economic variables, use monetary and fiscal policy, and communicate effectively with businesses and investors. Therefore, there is a need for governments to be constantly adjusting their policies as needed as the determinants of exchange rate volatility can change over time. The government of Congo could use exchange rate controls to limit the volatility of the Congolese franc. For example, the government could impose a limit on the amount of foreign currency that can be traded in the Congolese exchange market. The government of Equatorial Guinea should have contingency plans in place in case of unexpected events that could lead to volatility in the Equatorial Guinean exchange rate market. This will help to minimize the impact of such events. The government of Côte d'Ivoire should monitor the GARCH effect. This will help the government to identify periods of high and low volatility and take steps to mitigate the impact of volatility. The Niger government should monitor the inflation differential between its own country and its trading partners to see if it is becoming too large. In sum, in countries where productivity growth had no significant influence on the movement in the exchange rate market, such as Sudan, Cameron, Equatorial Guinea, Congo, and Cote d' Ivoire governments may need to deliberately indulge in production activities to manage the volatility of their currencies and also build confidence in the economy and reduce uncertainty.

.

References

Abdul, R. & Mohammad, B. (2021). Empirical determinants of exchange-rate volatility: evidence from selected Asian economies. *Journal of Chinese Economic and Foreign Trade Studies*, Emerald Group Publishing Limited, 15(1), 63-86, November.

Aigheyisi, Oziengbe, (2021). Factors explaining exchange rate volatility in Nigeria: Theory and empirical evidence. https://ssrn.com/abstract=3842230 or http://dx.doi.org/10.2139/ssrn.3842230

Ajao, M. G. (2015). The determinants of real exchange rate volatility in Nigeria. *Ethiopian Journal of Economics*, XXIV(2).

Anejo O., Kalterbrunner, A., & Ruiz, D. P. (2022). Determinants of the exchange rate, its volatility and currency crash risk in Africa's low and lower middle-income countries.

Bacchetta, P., & Wincoop, E. V. (2006). Can Information Heterogeneity Explain the Exchange Rate Determination Puzzle?" American Economic Review, 96 (3): 552-576. DOI: 10.1257/aer.96.3.552.

Bahmani-Oskooee M., & Goswami, G. G. (2004). Exchange rate sensitivity of Japan's bilateral trade flows. *Japan World Economics* 16: 1-15.

Barisua, F. Nwinee & Omiete**, V. Olulu-Briggs ( ). Determinants of exchange rate volatility in nigeria: an empirical review. De**partment of Finance and Banking, University of Port Harcourt, Nigeria.

Baumeister, C. & Kilan, L. (2016). Forty years of oil price fluctuation: why the price of oil may still surprise us. *Journal of Economics Perspectives* 30(1): 139-160.

Bello, M. K., Olayungbo, O. D., & Folorunso, A. B. (2022). Exchange rate volatility and macroeconomic performance in Nigeria. IntechOpen. doi: 10.5772/intechopen.100444

Bergin, P. R., and R. Glick (2003). Endogenous Nontradability and Macroeconomic Implications. NBER Working Papers, 9739.

Bleaney, M. & Manuela, F. (2016). Real exchange rate volatility: is sub-Saharan Africa different?

Bollerslev, Tim & Diebold, Francis & Andersen, Torben & Labys, P. (2003). Modeling and forecasting realized volatility. Econometrica. 71. 579-625. 10.2139/ssrn.267792.

Branson, W. H. & Halttunen, H. (1979). Asset Market Determination of Exchange Rates: Initial Empirical and Policy Results, in Trade and Payments under Flexible Exchange Rates, Martin, J. P. and A. Smith (eds.), pp. 55-85, London: Macmillan.

Cassel, G. (1918). Abnormal Deviations in International Exchanges. *The Economic Journal*. **28** *(112): 413-415*. doi:10.2307/2223329.

Chen, Z. (2022). The impact of trade and financial expansion on volatility of real exchange rate. PLoS ONE 17(1): e0262230. https://doi.org/10.1371/journal.pone.0262230. REPLACE KANOX

Cheung, Yin-Wong & Chinn, M. D. (2001). Currency traders and exchange rate dynamics: a survey of the US market. Journal of International Money and Finance, 20(4), 439-471, https://doi.org/10.1016/S0261-5606(01)00002-X.

Chen, J., Gordon, S. & Suzanne, K. (2022). Exchange rate: what they are, how they work, why they fluctuate. https://www.investopedia.com/terms/e/exchangerate.asp

Dedola, L., Georgiadis, G., Gräb, J., & Mehl, A. (2020). Does a big bazooka matter? Quantitative easing policies and exchange rates. VoxEU.org.

Diebold, F. X., Husted, S., & Rush, M. (1991). Real Exchange Rates under the Gold Standard. *Journal of Political Economy, 99*(6), 1252-1271. http://www.jstor.org/stable/2937729

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy* 84(6): 1161-76.

Dumas, B. (1992). Dynamic equilibrium and the real exchange rate in a spatially separated world. *The Review of Financial Studies*, *5*(2), 153-180. http://www.jstor.org/stable/2962028.

Eichengreen, B. (2002). When to Dollarize. *Journal of Money, Credit and Banking*, *34*(1), 1–24. http://www.jstor.org/stable/3270673

Engel, Charles M. and West, Kenneth D. (2004). Exchange Rates and Fundamentals. NBER Working Paper No. w10723, Available at SSRN: https://ssrn.com/abstract=589008/

Engle, R. F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. *Econometrica*, *50*(4), 987–1007. https://doi.org/10.2307/1912773

Ezirim, Chinedu B., et al. (2023). Capital structure and firm value: Theory and further empirical evidence from Nigeria. *International Journal of Business, Accounting and Finance*, 11(1), 68+. link.gale.com/apps/doc/A503275635/AONE?u=anon~895f84d6&sid=googleScholar&xid=bbf6ceff.

Gabaix, X and M Maggiori (2015). International liquidity and exchange rate dynamics. *The Quarterly Journal of Economics* 130(3): 1369-1420.

Han, Y. W. (2005). Long memory volatility dependency, temporal aggregation and the Korean currency crisis: the role of a high frequency Korean won (KRW)–US dollar ($) exchange rate, Japan and the World Economy, 17(1), 97-109, https://doi.org/10.1016/j.japwor.2003.10.003.

Hau, H., & Rey, H. (2006). Exchange Rates, Equity Prices, and Capital Flows. The Review of Financial Studies, 19(1), 273-317. http://www.jstor.org/stable/3598037

Hsieh, D. (1989) Modeling Heteroskedasticity in daily foreign exchange rates. *Journal of Business and Economic Statistics*, 7, 307-317.

Ibrahim A. Mohammed, B., & Sumaya, A. K. A. (2019). Impact of monetary policy instruments on exchange rate volatility in Sudan.

Ilzetzki, E., Reinhart, C.M. & Rogoff, K. S. (2020). Will the secular decline in exchange rate and inflation volatility survive covid-19? Brookings Papers on Economic Activity, Fall.

Isard, P. and Faruqee, H. (1998). Exchange rate assessment: Extension of the macroeconomic balance approach. Occasional paper 167, International Monetary Fund.

Itshoki, O. & Mukhin, D. (2021). Exchange rate disconnect in general equilibrium. *Journal of Political Economy* 129(8).

Kadochnikov, D. (2013). Gustav Cassel's purchasing power parity doctrine in the context of his views on international economic policy coordination. *European Journal of the History of Economic Thought.* 20(6): 1101-1121.

Kanu, S. I. & Nwadibu, A. (2020). Exchange rate volatility and international trade in Nigeria. *International Journal of Management Science and Business Administration* 6(5), 56-72.

Krugman & Obstfeld (2009). International economics, Pearson Education, inc.

Kruger, A.O. (1983). Exchange rate determinants. Cambridge Press.

MacDonald, R., & Taylor, M. P. (1994). The monetary model of the exchange rate: long-run relationships, short-run dynamics and how to beat a random walk. *Journal of International Money and Finance*, 13(3), 276-290, https://doi.org/10.1016/0261-5606(94)90029-9.

Meese, R. A. & Rogoff, K. (1983). Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics*, 14(1–2), 3-24, https://doi.org/10.1016/0022-1996(83)90017-X.

Mordi, C.N.O. (2006). Challenges of exchange rate volatility in economic management in Nigeria. *CBN Journal of Applied Statistics*, 30(3), 17-25.

Mpofu, T. R. (2020). The determinants of real exchange rate volatility in South Africa . World Economy, https://doi.org/10.1111/twec.13013

Naknoi, Kanda. (2005). Real exchange rate fluctuations, endogenous tradability and exchange rate regimes. *Journal of Monetary Economics*. 55. 645-663. 10.1016/j.jmoneco.2008.01.004.

Narayan, S. & Roy (2021). Concept of foreign exchange rate. https://www.researchgate.net/publication/344636129.

Nawal, H., Abbas E., and Abdalla E. A. (2019). Exchange rate volatility in Sudan: Does the exchange rate system matter? *Journal of Finance and Bank Management* December 7(2), 1-24.

Nick L., Boyle, M. J. & Hans D. J. (2022). How does the balance of trade affect currency exchange rates. https://www.investopedia.com/ask/answer/041515/how-does-balance-impact-currency-exchange-rates.asp.

Oaikhenan, H. E., & Aigheyisi, O.S. (2015). Factors explaining exchange rate volatility in Nigeria. Theory and empirical evidence. *Economic and Financial Review*, 53(2), 47-77.

Obstfeld, M. & Rogoff, K. (1995). Exchange rate dynamics redux. *Journal of Political Economy*, 103(3).

Okot, A., Kaltenbrunner, A., & Perez Ruiz, D., (2022). Determinants of the exchange rate, its volatility and currency crash risk in Africa's low and lower middle-income countries," EIB Working Papers 2022/12, European Investment Bank (EIB).

Ozturk, I. (2006). Exchange rate volatility and trade: a literature survey. *International Journal of Applied Econometric and Quantitative Studies*, 3-1.

Patrick L. Akpan , Ernest I. Nyang, & **Eti M Si Meon (). Determinants of exchange rate instability in a developing economy: conceptual study** issues and further evidence from Nigeria (1970-2005).

Richa M. (2022). All you need to know about oil shocks and their economic impact. https://www.thehindubusinessline,com/blexplainer/all-you-need-to-know-about-oil-shocks-and-their-economic-impact/article65223729.ece.

Rodrik, Dani. (2008). The real exchange rate and economic growth. Brookings Papers on Economic Activity. 2008. 365-412. 10.1353/eca.0.0020.

Schreyer P.; & Koechlin, F. (2002). Purchasing power parities -measurement and uses Statistics Brief. OECD (3).

Sheikh U A, Asad M, Ahmed Z, et al. (2020). Asymmetrical relationship between oil prices, gold prices, exchange rate, and stock prices during global financial crisis 2008: Evidence from Pakistan. *Cogent Economics & Finance*, 8(1), pp. 1757802.

Shevchuk V, Kopych R. (2021). Exchange rate volatility, currency misalignment, and risk of recession in the Central and Eastern European Countries. *Risks*. 2021; 9(5):82. https://doi.org/10.3390/risks9050082/

Slyvia, D. & Okereke, E.J. (2022). Determinants of exchange rate in African sub-Saharan countries. *Saudi Journal of Economics and Finance*. https://saudijournals.com.

Stancık, J. (2007). Determinants of exchange rate volatility: The case of the new EU members. *Czech Journal of Economics and Finance*, 57(9-10), 414-432.

Sussman, N., & Saadon, Y. (2018). Nominal exchange rate dynamics and monetary policy: Uncovered interest rate parity and purchasing power parity revisited. VoxEU.org.

Taylor, M. P. (1995). The economics of exchange rates. *Journal of Economic Literature*, *33*(1), 13-47. http://www.jstor.org/stable/2728909

Tim Bollerslev (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31 (3), April, 307-27.

Todani, K. R., & Munyama, T. V. (2005). Exchange rate volatility and exports in South Africa, South African Reserve Bank, In TIPS/DPRU Forum Vol. 30). http://www.tips.org.za/files/773.pdf

Trust, M. (2016).The determinants of exchange rate volatility in South Africa. Economic Research Southern Africa (ERSA), University of Cape Town.

Wang, T. (2005). Sources of real exchange rate fluctuations in China. *Journal of Comparative Economics*, 33(4), 753–771. https://doi.org/10.1016/j.jce.2005.07.001

Yusuf, Wasiu & Yusuf, Wasiu Akintunde & Oyegoke, Ebunoluwa & Jelilov, Gylych & Haruna, Timipre. (2019). Determinants of exchange rate in Nigeria: A comparison of the official and parallel market rates. 22. 2019. 10.18488/journal.29.2019.62.178.18.

Zerrin Kiliçarslan, (2018). The relationship between exchange rate volatility and foreign direct investment in Turkey: Toda and Yamamoto causality analysis. *International Journal of Economics and Financial Issues, Econjournals*, 8(4), 61-67.

Zhang, T. & Liao, G. (2020). Currency hedging, exchange rate movement, and dollar swap line usage during Covid-19 pandemic. VoxEU.org.