



COLLEGE OF BASIC AND APPLIED SCIENCES  
DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCE

ASYMMETRIC INTERPLAY OF INTEREST RATE AND  
INFLATION RATE ON EXCHANGE RATE IN GHANA

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THIS THESIS IS SUBMITTED TO THE SCHOOL OF  
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PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE  
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INTEGRI PROCEDAMUS

# DECLARATION

## Candidate's Declaration

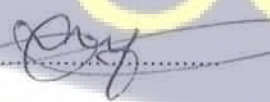

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We hereby certify that this thesis is a first-hand academic research work prepared by the aforementioned candidate and supervised according to the thesis guidelines laid down by the University of Ghana.

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Signature.......... Date..........

Dr. Benedict Mbeah-Baiden  
(Co-Supervisor)

# DEDICATION

This thesis is dedicated to my beloved mother, siblings and loved ones, whose unwavering support and belief in my abilities have been my constant source of motivation. I also dedicate this work to my mentors and educators, whose guidance and wisdom have inspired me to strive for excellence.

To the future generations of researchers, may this work serve as a small contribution to the growing body of knowledge and encourage them to continue exploring the dynamic world of economics and data science.



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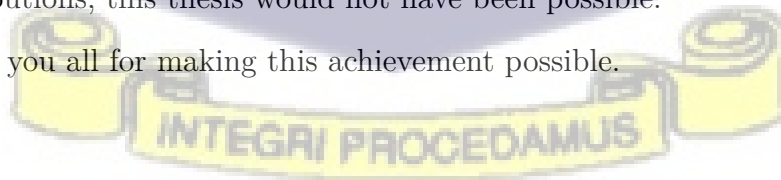
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# ABSTRACT

The relationship between interest rates, inflation, and exchange rates is crucial for macroeconomic stability, yet it often exhibits nonlinear and asymmetric behavior. This study investigates the dynamic interplay among these variables in the Ghanaian economy, employing advanced econometric methodologies, including Threshold Vector Autoregression (TVAR), Vector Error Correction Model (VECM), Impulse Response Function (IRF), and Granger Causality tests. Utilizing monthly data from 2015 to 2024, the research first establishes the presence of cointegration, confirming a long-term equilibrium relationship. The VECM framework is used to analyze short-term adjustments, while the TVAR model captures regime-dependent interactions under varying economic conditions. The results indicate that interest rate changes exert asymmetric effects on exchange rate movements, with inflation playing a more significant role in high-volatility periods. Granger causality tests reveal bidirectional causation between interest rates and inflation, suggesting monetary policy adjustments influence inflation dynamics and vice versa. Additionally, impulse response analysis highlights that exchange rate shocks tend to stabilize over time, whereas inflation-induced shocks cause prolonged currency depreciation. The findings underscore the need for a flexible monetary policy framework that considers regime-dependent dynamics to effectively manage inflation and exchange rate volatility. The study's insights provide policymakers with empirical evidence to design targeted interventions that enhance economic resilience and stability.

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Keywords: Interest Rate, Inflation, Exchange Rate, VECM, TVAR, Granger Causality, Impulse Response Function, Ghana



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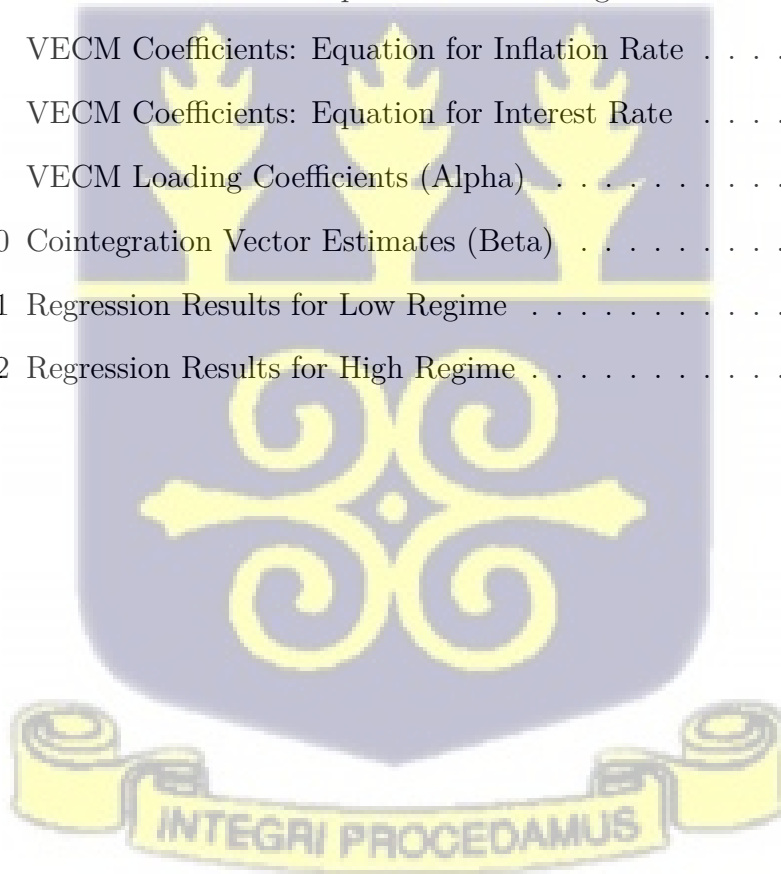
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# LIST OF ABBREVIATION

<b>Exc<sub>Rate</sub></b> .....	Exchange Rate
<b>Int<sub>Rate</sub></b> .....	Interest Rate
<b>Inf<sub>Rate</sub></b> .....	Inflation Rate
<b>VECM</b> .....	Vector Error Correction Model
<b>TVAR</b> .....	Threshold Variance Autocorrelation
<b>IRF</b> .....	Impulse Response Function
<b>IMF</b> .....	International Monetary Fund
<b>SAP</b> .....	Structural Adjustment Programs
<b>CPI</b> .....	Consumer Price Index
<b>GDP</b> .....	Gross Domestic Product
<b>ASEAN</b> .....	Association of Southeast Asian Nations
<b>SVAR</b> .....	Structural Vector Autoregression
<b>FCVAR</b> .....	Fractional Cointegration Vector Autoregression
<b>NARDL</b> .....	Nonlinear Autoregressive Distributed Lag
<b>MPR</b> .....	Monetary Policy Rate
<b>GIRFs</b> .....	General Impulse Response Functions

# CHAPTER 1

## BACKGROUND OF THE STUDY

### 1.1 Introduction

The complex interplay between interest rates and exchange rates is of significant importance in the financial sector of Ghana, as it influences economic activities, shapes investment decisions, and informs policy strategies. This chapter introduces the study by detailing the background, problem statement, research objectives, questions, rationale, and overall structure.

### 1.2 Background Context of Inflation, Interest, and Exchange Rate

Economic variables such as interest rates, inflation rates, and exchange rates are fundamental indicators of financial stability, policy effectiveness, and overall economic health. Their historical evolution reflects the complex interplay of monetary policies, market dynamics, geopolitical events, and structural changes in economies worldwide, particularly in Africa and Ghana.

Interest rates, representing the cost of borrowing or the return on savings, have

shaped investment decisions, fiscal management, and economic growth. The progression of interest rate from fixed systems during the gold standard era to the dynamic frameworks of modern monetary policies reveals a critical aspect of global financial development. Similarly, inflation rates, which track the general increase in prices over time, highlight how economies respond to supply shocks, demand pressures, and policy interventions. Meanwhile, exchange rates, which determine the relative value of currencies, have been central to international trade, cross-border investments, and economic globalization.

In the African context, these variables have been profoundly influenced by colonial legacies, post-independence reforms, and external economic shocks, such as oil price volatility and global financial crises. For Ghana, the historical trajectory of interest rates, inflation rates, and exchange rates underscores the challenges and progress associated with economic transitions, structural adjustments, and policy reforms aimed at fostering stability and growth.

Understanding the historical context of these economic indicators provides a foundation for analyzing their current dynamics, interrelationships, and implications for Ghana's financial and economic development. This exploration not only informs macroeconomic strategies but also supports the design of robust policies to address contemporary challenges in monetary management and trade competitiveness.

### **1.3 The Dynamic Interplay of Inflation, Interest and Exchange Rates**

The intricate relationship between inflation, interest rates, and exchange rate volatility is pivotal in macroeconomic discourse, especially for emerging economies like Ghana. These variables collectively shape the nation's economic stability, directly influencing sectors such as trade, investment, and economic growth trajectories. Inflation, captured through shifts in the Consumer Price Index

(CPI), represents the pervasive increase in price levels, while interest rates serve as indicators of borrowing costs and savings returns. Exchange rate volatility, characterized by the Ghanaian cedi's unpredictable fluctuations against major global currencies, creates challenges for international trade and investment planning. A thorough understanding of how inflation and interest rates contribute to exchange rate volatility is vital for developing robust monetary and fiscal strategies to ensure economic resilience.

In advanced economies, inflation often arises from demand-pull factors where high consumer spending outpaces production capabilities, or cost-push factors such as rising energy prices (Moynihan, 2023). Price levels are often tracked using tools like the Consumer Price Index (CPI), which captures fluctuations in the cost of a selected group of goods and services over time.

Interest rates, reflecting the cost of borrowing and the return on savings or investments, play a significant role in shaping economic performance, influencing capital movement, and affecting exchange rate behavior. On a global scale, interest rate decisions by major monetary authorities such as the US Federal Reserve, the European Central Bank and the Bank of Japan exert substantial influence on international capital flows (Kallianiotis, 2017). Higher interest rates in advanced economies often attract foreign capital seeking higher returns, strengthening their currencies while creating depreciation pressures on emerging market currencies. Conversely, low interest rates can encourage risk-taking and capital flows into emerging markets, but they also increase global liquidity, impacting exchange rate stability.

In Africa, inflation trends often result from a combination of external shocks and domestic vulnerabilities. Many African economies, including Ghana, rely heavily on imported goods and are thus susceptible to exchange rate pass-through effects, where depreciation of local currencies directly increases the cost of imports. Furthermore, structural challenges such as inefficient agricultural production and weak supply chains exacerbate inflationary pressures.

On the other hand, interest rates are influenced by domestic economic conditions, external financial pressures, and the need to attract foreign investment (Muchiri, 2017). High interest rates in African countries may attract international capital but often at the cost of higher borrowing costs for domestic businesses and governments. This dynamic can constrain economic growth while supporting currency stability. Conversely, lower interest rates may spur domestic economic activity but risk inflation and currency depreciation. Exchange rate volatility in Africa is often tied to the interplay of interest rate adjustments and external shocks, such as fluctuations in commodity prices or global financial market trends. In Ghana, inflation has historically been influenced by a mix of domestic fiscal policies, monetary conditions, and external factors. The reliance on imported goods, coupled with exchange rate volatility, often amplifies inflationary pressures (Garcia et al., 2011). Increases in global oil prices or disruptions in food supply chains directly affect the CPI. Ghana's central bank closely monitors inflation trends to set monetary policy, aiming to maintain price stability and foster economic growth. Thus, inflation in Ghana is not only a reflection of domestic economic conditions but also a barometer of external economic influences and policy responses.

Also, interest rates significantly influence economic performance, capital flows, and the exchange rate. The Bank of Ghana adjusts the policy rate to control inflation, manage liquidity, and stabilize the exchange rate (Allor, 2020). High interest rates in Ghana can attract foreign investment into government securities, strengthening the cedi, but may also increase the cost of borrowing for businesses and households, slowing economic growth.

Lower interest rates aim to boost economic activity but can lead to capital outflows and exchange rate pressures if inflation is not effectively managed. The interaction between interest rates and exchange rates is critical in Ghana's open economy, where external factors like global oil prices and foreign investment trends further compound the challenges of achieving monetary and exchange rate

stability (Mordi, 2006).

Exchange rate volatility poses challenges to international trade and investment planning. In both advanced and emerging markets, understanding how inflation and interest rates interact with exchange rate dynamics is crucial for designing effective monetary and fiscal policies to mitigate economic uncertainties.

The value of the Ghana cedi (GHS) relative to major foreign currencies such as the US dollar (USD), has experienced volatility due to various economic factors. These fluctuations are influenced by both domestic and international elements. Historically, Ghana has faced challenges with the depreciation of its currency, particularly during periods of high inflation and economic instability, leading to significant depreciation against major currencies during crises (Ayiah-Mensah et al., 2023).

Moreover, external factors including global economic conditions, fluctuations in key commodity prices like gold and oil (which are significant to Ghana's exports), and evolving patterns in international trade also affect the value of the cedi. (Nuhu and Bukari, 2021). A thorough understanding of the complex interactions between interest rates, inflation as well as the exchange rate is crucial for policymakers, financial institutions, investors, and businesses operating in the country. Despite this, the precise mechanisms linking interest rates and the exchange rate remain poorly understood.

## 1.4 Problem Statement

In today's highly interconnected global financial system, arbitrage mechanisms are essential in aligning returns on comparable assets across countries. Real interest rates, acting as key indicators of return on savings, heavily impact decisions regarding deferred consumption. These choices influence both the level of savings and the broader processes of capital formation and economic growth internationally, (Obstfeld and Rogoff, 1996).

Unlike many other economies, the Ghana economic system is integrated into

the global market where key macroeconomic indicators including the inflation rate, interest rate and exchange rate, are crucial to shaping macroeconomic stability, influencing market trends and the accumulation of capital, which together contribute to economic stability and growth. (Sena et al., 2021).

Exchange rate volatility remains a critical challenge for Ghana's economic stability, affecting trade, inflation, and monetary policy effectiveness. The dynamic interplay between interest rates, inflation rates, and exchange rates has significant implications for financial markets, investment decisions, and overall economic performance. However, traditional econometric models often fail to capture the nonlinear dependencies and regime-specific effects influencing exchange rate fluctuations.

Existing studies have established that interest rates and inflation exert both short-term and long-term influences on exchange rates, yet there remains a lack of consensus on the strength and direction of these relationships across different economic conditions. Moreover, while Granger causality tests and vector error correction models (VECM) provide insight into causal linkages and long-term equilibrium, they do not adequately capture threshold effects and asymmetric responses observed in real-world data.

To address these gaps, this study employs an advanced econometric modeling approach that incorporates threshold vector autoregression (TVAR) and the impulse response function (IRF). This approach allows for a comprehensive assessment of linear and non-linear dependencies, regime shifts, and predictive accuracy in modeling exchange rate movements.

By exploring the detailed interactions and dependencies between these macroeconomic variables, this research aims to provide valuable information that can contribute to strengthening stability and resilience within the financial and economic landscape of Ghana.

## 1.5 Objectives of the Study

The main objective of this study is to capture and model the non-linear relationships between inflation, interest rates and the exchange rates. This process includes examining complex relationships and interdependencies through the use of advanced econometric and statistical modeling methods.

The study specifically seeks to:

1. Analyze the historical trends of inflation, interest rates, and exchange rate volatility in Ghana.
2. Investigate the causal relationships between inflation, interest rates, and exchange rate volatility.
3. Investigate the long-short term dynamics of exchange rate, interest rate and inflation rate of Ghana
4. To analyze the extent to which shocks in interest rates and inflation rates explain variations in the exchange rate using Forecast Error Variance Decomposition (FEVD).
5. Investigate the dynamic effects of changes in interest rates and inflation rates on exchange rate movements through Impulse Response Functions (IRF).
6. Assess the magnitude of the impact of inflation and interest rates on exchange rate volatility using threshold variance autocorrelation model.
7. To provide policy recommendations based on the findings.

## 1.6 Research Questions and Hypotheses

- **Research Hypotheses**

1. **Hypotheses for the Granger Causality Test (Exchange Rate, Inflation Rate, and Interest Rate)**

(a) Inflation Rate and Interest Rate

- Null Hypothesis ( $H_0$ ): The interest rate does not Granger-cause the inflation rate.
- Alternative Hypothesis ( $H_1$ ): The interest rate Granger-causes the inflation rate.
- Null Hypothesis ( $H_0$ ): The inflation rate does not Granger-cause the interest rate.
- Alternative Hypothesis ( $H_1$ ): The inflation rate Granger-causes the interest rate.

(b) Exchange Rate and Inflation Rate

- Null Hypothesis ( $H_0$ ): The inflation rate does not Granger-cause the exchange rate.
- Alternative Hypothesis ( $H_1$ ): The inflation rate Granger-causes the exchange rate.
- Null Hypothesis ( $H_0$ ): The exchange rate does not Granger-cause the inflation rate.
- Alternative Hypothesis ( $H_1$ ): The exchange rate Granger-causes the inflation rate.

(c) Exchange Rate and Interest Rate

- Null Hypothesis ( $H_0$ ): The interest rate does not Granger-cause the exchange rate.
- Alternative Hypothesis ( $H_1$ ): The interest rate Granger-causes the exchange rate.
- Null Hypothesis ( $H_0$ ): The exchange rate does not Granger-cause the interest rate.
- Alternative Hypothesis ( $H_1$ ): The exchange rate Granger-

causes the interest rate.

## 2. Hypothesis of Cointegration

The number of cointegrating relationships among the variables (Exchange Rate, Inflation Rate, and Interest Rate) is  $r$ , where  $r$  is the hypothesized rank:

–  $H_0 : r = 0$ : There is no cointegration among Exchange Rate, Inflation Rate, and Interest Rate (no long-term equilibrium relationship exists).

–  $H_1 : r > 0$ : There is at least one cointegrating relationship among Exchange Rate, Inflation Rate, and Interest Rate.

–  $H_0 : r \leq 1$ : There is at most one cointegrating relationship among the variables.

–  $H_1 : r > 1$ : There are at least two cointegrating relationships among the variables.

–  $H_0 : r \leq 2$ : There are at most two cointegrating relationships among the variables.

–  $H_1 : r > 2$ : There are three cointegrating relationships among the variables.

## 3. Hypothesis for the Threshold Vector Autoregression (TVAR) Analysis

The Threshold Vector Autoregression (TVAR) model will be used to assess how the relationships between interest rates, inflation, and exchange rates changes under different economic regimes. The hypotheses for this analysis are formulated as follows:

### (a) Null Hypothesis ( $H_0$ )

–  $H_{01}$ : There is no significant difference in the effect of interest rates on exchange rates between the high-interest-rate and low-interest-rate regimes.

- $H_{0_2}$ : Inflation does not have a regime-dependent impact on exchange rate fluctuations.
- $H_{0_3}$ : The response of exchange rates to monetary policy shocks (interest rate changes) remains the same regardless of the economic regime.

(b) **Alternative Hypothesis ( $H_1$ )**

- $H_{1_1}$ : The effect of interest rates on exchange rates differs significantly between the high-interest-rate and low-interest-rate regimes.
- $H_{1_2}$ : Inflation has a regime-dependent impact on exchange rate fluctuations, indicating structural changes in monetary transmission mechanisms.
- $H_{1_3}$ : Exchange rates respond asymmetrically to monetary policy shocks depending on whether the economy is in a high or low-interest-rate regime.

• **Research Questions**

1. What are the historical patterns and trends in inflation, interest rates, and exchange rate volatility in Ghana?
2. What are the causal relationships between inflation, interest rates, and exchange rate volatility in Ghana?
3. How do exchange rates, interest rates, and inflation interact in the short and long run?
4. To what extent do shocks in interest rates and inflation rates explain variations in the exchange rate, as measured by Forecast Error Variance Decomposition (FEVD)?
5. How does the exchange rate dynamically respond to changes in interest rates and inflation rates, as captured by Impulse Response Functions (IRF)?

6. How do inflation and interest rates impact exchange rate volatility under different economic regimes?

## 1.7 Significance of the Study

This research aims to enhance the academic discourse on macroeconomic policy in Ghana by exploring the underlying factors driving exchange rate volatility. It offers actionable insights for policymakers, financial institutions, and investors seeking to manage the risks tied to currency fluctuations. Additionally, the outcomes of this study will provide a foundation for future inquiries into the interplay between major macroeconomic variables in emerging market economies.

Below are considerable significance that this work would bring to light

### 1. **Economic Relevance**

Interest and exchange rates play a central role in shaping economic dynamics and influencing trends in financial markets. Gaining a holistic understanding of their impact on lending costs, investment behavior, inflation, external trade, and overall economic health is vital for formulating sound economic strategies.

### 2. **Implications for Policy**

Shifts in interest and exchange rates directly affect monetary policy decisions. Understanding their mutual influence is essential for assessing the effectiveness of such policy tools.

### 3. **Guidance for Investment Strategies**

Interest and exchange rate movements are key considerations for both local and foreign investors. These fluctuations affect capital mobility, currency valuation, and the risk profile of investments. Insight into their relationship can aid in developing robust investment plans and mitigating exposure to currency risk.

#### 4. Market Stability and Risk Mitigation

Financial institutions and businesses in Ghana are vulnerable to the instability caused by interest and exchange rate changes. A deeper understanding of how these variables interact is crucial for managing financial risks and promoting overall market stability.

#### 5. Addressing Knowledge Gaps

Current studies often overlook the intricate causal links among inflation, interest rates, and exchange rate movements. This research addresses that gap by examining their interconnected dynamics in detail.

#### 6. Responding to Economic Pressures

Ghana continues to grapple with inflationary pressures, external trade deficits, and currency instability. Investigating how interest and exchange rates interact can offer strategic insights for tackling these persistent macroeconomic challenges.

### 1.8 Limitation and Scope of the study

This research focuses on analyzing key macroeconomic indicators in Ghana, including the inflation rate, interest rate and exchange rate spanning from 2000 to the first quarter of 2023. The study also examines the exchange rate and its interaction with these interest rates during the same time frame.

Although expanding the analysis to include additional economic indicators, such as the balance of payments, would provide valuable insights, the study is limited by time constraints and the availability of resources.

Additionally, extending the analysis to encompass more economic variables would significantly increase the complexity of understanding the relationships between them.

## 1.9 Structure of the Study

This study is organized into five chapters, with each chapter addressing specific aspects of the research framework, in accordance with ethical standards for thesis work.

1. **Chapter One:** Provides an introduction to the topic, including the background, problem statement, research objectives, and questions. It also outlines the scope and limitations of the study, along with the rationale for the research. By the end of this chapter, readers will gain an understanding of the importance of exploring the complex relationship between interest rates, inflation and exchange rate in Ghana.
2. **Chapter Two:** Presents a review of relevant literature, summarizing key studies in the field, including their methodologies, analyses, discussions, and conclusions. This chapter aims to highlight the complexities and nuances of using Vector Error Correction Models (VECM) in similar research.
3. **Chapter Three:** Details the research methodology adopted to answer the research questions posed in Chapter One.
4. **Chapter Four:** Discusses the findings from the data analysis, where the methodology outlined in the previous chapter is applied. It provides detailed interpretations of the results obtained from the various machine learning algorithms applied.
5. **Chapter Five:** Presents the final discussion, based on the findings in Chapter Four, and offers conclusions and recommendations based on the analysis.

## CHAPTER 2

# LITERATURE REVIEW

### 2.1 Introduction

The dynamic interplay between inflation rates, interest rates and exchange rates is a critical area of study in financial economics particularly for emerging markets like Ghana. Understanding this relationship is essential for policy makers, investors and researchers, as it influences monetary policy, investment strategies, and economic stability.

Volatility in interest rates can significantly impact exchange rates and the overall economic environment and can create considerable uncertainty in financial markets. Grasping these impacts is essential for sound policy-making and strategic financial planning.

Exchange rate is mostly affected by bilateral trade activities and balance of payment. However, addressing these factor and other domestic indicators such as Interest rate and Inflation rate in the financial domain will help mitigate the impact of pressures exerted on exchange rate dimensionally.

Multivariate time series approach has proven to be efficient in identifying complex relationships, patterns and interactions present in time series data. This literature review aims to identify relationship, capturing the complex, non-linear dynamics inherent in financial time series data of the Ghanaian economic landscape,

## 2.2 Inflation Rate

Inflation, defined as the rate at which the general level of prices for goods and services rises, eroding purchasing power, has been a recurring economic phenomenon throughout history (Salim, 2019). Its causes and impacts have varied across regions and time periods, influenced by economic policies, societal structures, and external shocks. Understanding the historical trajectory of inflation provides critical insights into its dynamics and implications for monetary policy.

Globally, inflation has existed since the advent of money as a medium of exchange. In ancient Roman times, currency devaluation, which reduced the precious metal content in coins, led to inflationary episodes. During the Middle Ages, the influx of gold and silver from the Americas during the Age of Exploration caused "price revolutions," with prolonged inflation across Western economies (Mattick, 2024). The 19th century marked a period of relative stability in inflation rates, aided by technological advancements from the Industrial Revolution and the adoption of the Gold Standard, which linked currencies to gold and maintained monetary discipline (Bernholz, 2015).

The 20th century, however, saw significant inflationary disruptions. During World Wars I and II, governments printed money to finance military expenditures, leading to hyperinflation in several countries, notably Germany during the Weimar Republic (Schularick and Taylor, 2012). 1930's were characterized by deflation as global economies contracted (Burdekin and Siklos, 2004). Inflation rose during reconstruction after World War II, and the oil price shocks of the 1970's introduced stagflation, combining high inflation and unemployment (Heine and Herr, 2024). From the 1980's onward, many countries adopted inflation-targeting policies and granted independence to central banks, achieving relatively low and stable inflation rates.

Inflation in Africa reflects the continent's unique economic history, shaped by colonial legacies, post-independence economic strategies, and vulnerability to

global economic shocks. During the colonial era, inflation was generally low as colonial administrations maintained strict monetary controls and integrated African economies into global trade as suppliers of raw materials (DeLancey, 2001). However, post-independence efforts to industrialize and urbanize in the 1950's-1980's led to fiscal deficits and inflationary pressures (Sarkar, 2019). The 1970's oil price shocks further exacerbated inflation across resource-importing African economies. In the 1980's and 1990's, structural adjustment programs (SAPs), implemented under the guidance of the International Monetary Fund (IMF) and the World Bank aimed to stabilize economies through monetary tightening and subsidy removal. While these measures temporarily spiked inflation, they were necessary to curb hyperinflation in some cases (Githua, 2013). Recent inflation trends in Africa are highly varied. For instance, Zimbabwe experienced hyperinflation in the 2000's due to excessive money printing and economic mismanagement (McIndoe-Calder, 2018). Across the continent, global factors such as the COVID-19 pandemic, supply chain disruptions, and the Russia-Ukraine war have contributed to rising inflation in recent years.

Ghana's inflation history mirrors the broader African experience but is also shaped by its unique economic trajectory. In the pre-independence era, under British colonial rule, Ghana (then Gold Coast) experienced relatively low inflation due to the fixed exchange rate system and conservative monetary policies (LARMIN JR, 2022). During Post-independence, the government pursued ambitious industrialization programs, while these efforts were transformative, they led to fiscal deficits and inflationary pressures (Osei et al., 2020). The oil shocks of the 1970's significantly impacted Ghana, causing inflation to surge and eroding real incomes. During the structural adjustment period in the 1980's and 1990's, Ghana implemented reforms under the IMF and World Bank to stabilize its economy. These included currency devaluation, fiscal consolidation, and monetary policy tightening. While these measures reduced hyperinflation, they also introduced short-term economic hardship (Konadu-Agyemang, 2018).

In the 21st century, Ghana's inflation rates have fluctuated due to exchange rate volatility, energy crises, and fiscal imbalances (LARMIN JR, 2022). From 2010 onward, improved monetary policies helped moderate inflation, though challenges such as debt sustainability and external shocks persist. Recent inflation spikes in 2022-2023 were attributed to global factors, including the aftermath of the COVID-19 pandemic, disruption of option of supply chains, and currency depreciation.

## 2.3 Interest Rate

Interest rates, representing the cost of borrowing or the return on investment according to Bean and FCIA (2017), are crucial economic variables that influence monetary policy, economic growth, and financial stability. Their historical evolution reflects changes in economic systems, market dynamics, and policy frameworks across different regions.

Interest rates have a long and varied history, shaped by economic philosophies, market structures, and geopolitical events. The concept of interest originated in ancient economies such as Mesopotamia, Egypt, and Greece, where interest was charged on loans, often tied to agricultural cycles (Ustaoğlu and Sağın, 2020). Religious and moral codes, like those in ancient Judaism and early Christianity, at times prohibited or regulated interest, viewing it as usury. In medieval Europe, the Catholic Church's stance against usury suppressed formal interest-based lending. However, informal credit markets flourished, and the prohibition of interest waned with the rise of commerce and trade during the Renaissance.

The establishment of central banks, such as the Bank of England in 1694, institutionalized interest rate policies (Marcussen, 2013). The Industrial Revolution saw relatively low interest rates in many parts of Europe, supporting capital investment and economic growth. Interest rate policies became central to macroeconomic management. Post-World War II reconstruction saw governments using low rates to stimulate investment. During the 1970's, oil price shocks and

stagflation led to sharp increases in interest rates globally. 1980's witnessed high interest rates, particularly in the U.S, under restrictive monetary policies aimed at curbing inflation (Mankiw, 2001). Central banks have increasingly adopted inflation targeting as a guiding principle for interest rate decisions. The global financial crisis of 2008 and the COVID-19 pandemic resulted in historically low interest rates in many economies to stimulate demand and recovery.

In Africa, the evolution of interest rates reflects colonial legacies, post-independence economic policies, and responses to global economic trends. Under colonial rule, Interest rates were centrally controlled and tailored to support the interests of colonial powers, often neglecting the credit needs of local populations (Gardner, 2012). After independence, many African governments established state-owned banks to drive economic development. Interest rates were often kept artificially low to encourage industrialization and agricultural expansion. However, these policies frequently led to inefficiencies, misallocation of credit, and suppressed private sector growth. Additionally, the oil price shocks of the 1970's prompted several African nations to adopt restrictive monetary policies, raising interest rates to stabilize inflation.

In response to fiscal crises, the IMF and World Bank introduced structural adjustment programs (SAPs) in Africa (Saeed, 2024). These reforms included liberalizing interest rates to reflect market conditions. While this improved efficiency in financial markets, it also led to higher borrowing costs, affecting investment and consumption. Interest rates in Africa remain highly variable, influenced by domestic fiscal policies, global economic conditions, and currency stability. Countries with stable economies, like Botswana, maintain relatively low and stable rates (Lewin, 2011). Nations with fiscal and inflationary challenges, like Zimbabwe, experience volatile and high interest rates (Mashakada, 2013).

Ghana's interest rate history is closely tied to its colonial legacy, post-independence economic policies, and ongoing efforts to achieve macroeconomic stability. During British colonial rule, Ghana's financial system was tightly

controlled, with interest rates set to facilitate the export of cash crops like cocoa. The banking sector served colonial interests, providing limited access to credit for local businesses and individuals.

Following independence in 1957, Ghana pursued ambitious industrialization and infrastructure development programs (Sackeyfio-Lenoch, 2016). Interest rates were kept low to encourage borrowing for these initiatives, but this often led to inflation and financial imbalances. The 1970's oil crises and fiscal mismanagement exacerbated Ghana's economic woes, resulting in rising inflation and real interest rate volatility.

Under structural adjustment programs, Ghana liberalized its financial sector, allowing market forces to determine interest rates. This led to more realistic rates, improving credit allocation efficiency but increasing borrowing costs for businesses and individuals.

Interest rates in Ghana have experienced significant fluctuations driven by factors such as inflationary pressures, exchange rate instability, and fiscal deficits. The Bank of Ghana has relied on the policy rate as a primary instrument to control inflation and maintain economic stability. Since 2010, advancements in monetary policy and the adoption of inflation-targeting strategies have contributed to greater rate stability. Nonetheless, challenges remain, including elevated real interest rates that deter borrowing and external shocks, such as the COVID-19 pandemic and global economic disruptions.

## 2.4 Exchange Rate

Exchange rates, the value of one currency relative to another (Yang and Zeng, 2014), have played a pivotal role in global trade, investment, and economic policy. Their evolution reflects historical changes in monetary systems, economic policies, and geopolitical events.

The history of exchange rates is marked by shifts between fixed and floating systems, influenced by technological advancements, financial innovation, and

global economic integration. Exchange rates have existed since ancient times when trade between regions involved the exchange of commodities and precious metals, such as gold and silver. In medieval Europe, currency exchange was facilitated by money changers, who set rates based on the metal content of coins (Rössner, 2015). This was a precursor to modern exchange rate systems. The gold standard linked currencies to gold, providing a fixed exchange rate system. This system facilitated international trade and investment but required countries to maintain large gold reserves, limiting monetary flexibility. The system collapsed during World War I, nations moved away from the gold standard to support the funding of their war-related expenses.

Exchange rates became unstable during the interwar years as countries experimented with different monetary systems (Ghosh et al., 2011). The Great Depression exacerbated economic instability, leading to competitive devaluations. The Bretton Woods Agreement established a system of fixed exchange rates, where national currencies were pegged to the U.S. dollar, while the dollar itself was backed by gold and could be exchanged for it. (Irwin, 2017). This system promoted global economic recovery after World War II but collapsed in 1971 when the U.S. suspended dollar-gold convertibility due to inflationary pressures and trade imbalances. After Bretton Woods, most countries adopted floating exchange rates, where market forces determine currency values. The rise of globalization and financial markets in the 21st century amplified exchange rate volatility, with currencies influenced by trade balances, interest rates, and geopolitical events.

During colonial rule, African economies used currencies tied to their colonial powers, such as the British pound or French franc. Exchange rates were centrally determined and geared toward facilitating trade with the colonizing countries (Gardner, 2012). After independence, many African nations established their own currencies. Fixed exchange rate systems were initially adopted to stabilize trade and attract investment. However, these systems often led to overvalued

currencies, trade deficits, and the depletion of foreign reserves.

The International Monetary Fund (IMF) and World Bank introduced structural adjustment programs, which included currency devaluations and the adoption of market-determined exchange rates (Emeagwali, 2011). These reforms improved competitiveness but increased inflation and the cost of imports, creating economic challenges for many African nations. African exchange rates remain diverse, ranging from fixed systems in countries like the CFA franc zone to floating systems in resource-dependent economies like South Africa and Nigeria. Global economic shocks, such as the COVID-19 pandemic and the Russia-Ukraine war, have recently exacerbated exchange rate volatility across the continent.

Ghana's exchange rate history reflects its transition from colonial monetary controls to modern financial policies, shaped by economic reforms, external shocks, and global integration. Under British colonial rule, Ghana (then Gold Coast) used the British West African pound, pegged to the British pound sterling (Fuller, 2014). This fixed system provided stability but limited monetary autonomy. After independence, Ghana introduced its own currency, the Ghanaian cedi, pegged to the British pound and later to the U.S. dollar. Overvaluation and fiscal deficits led to balance of payments crises, forcing several devaluations. By the late 1970's, currency black markets emerged, reflecting economic mismanagement and eroding public confidence in the official exchange rate. As part of IMF and World Bank structural adjustment programs, Ghana adopted a managed floating exchange rate system. The cedi was devalued significantly to reflect market realities, boosting exports but increasing inflation. Ghana transitioned to a floating exchange rate regime, with the Bank of Ghana intervening occasionally to stabilize the currency. Currency depreciation has remained a persistent challenge, driven by trade imbalances, fiscal deficits, and external shocks. The cedi's value has been particularly volatile during economic crises, such as the global financial crisis of 2008, the COVID-19 pandemic, and recent global supply chain disruptions.

## 2.5 Theoretical Foundations and Key Findings

The theoretical frameworks linking inflation, interest rates, and exchange rates in emerging markets remain a subject of debate within empirical macroeconomic studies (Dash, 2012).

According to the Interest Rate Parity (IRP) theory, disparities in interest rates and currency values between countries influence the movement in exchange rates. This theory suggests a tendency for exchange rates to adjust in response to differences in expected returns across borders.

A comprehensive understanding of the interdependence between macroeconomic indicators is central to the field of financial economics. In the context of Ghana, the interaction between inflation, interest rates, and exchange rates is particularly significant. These variables collectively influence capital movement, investment behavior, and the broader macroeconomic stability of the nation (Issahaku et al., 2023).

To analyze these complex interactions, researchers have employed various econometric models, notably the Vector Error Correction Model (VECM), which provides meaningful insights into both short-term fluctuations and long-term relationships among economic variables.

For instance, Masih and Masih (1996) conducted an investigation into the causal relationships among real output, money supply, inflation, interest rates, and exchange rates in Indonesia, a developing country. Using a blend of techniques such as unit root testing, Johansen cointegration, VECM, variance decomposition, and impulse response functions the study uncovered that Indonesia's real output was highly influenced by agriculture and export performance. The output variable exhibited strong exogeneity, prompting internal adjustments from other macroeconomic indicators like prices, interest rates, and the money supply.

Similarly, Del Negro et al. (2019) examined the co-movement of short- and long-term interest rates, inflation, and consumption patterns across seven advanced

economies using a VAR model with common global trends. Their results showed a notable decline in real interest rates over the past three decades. A central finding was the global trends dominance in influencing real returns on safe assets, particularly since the 1970s. The study linked this to factors such as slower global growth and rising demand for secure financial instruments, driven by demographic shifts and a surplus in global savings.

Beyer and Milivojevic (2023) applied Bayesian techniques to estimate equilibrium real interest rates across 50 countries, using a stochastic volatility model with unobserved components. Their results indicated a shift in patterns over time, while advanced economies initially had higher real interest rates, emerging markets have experienced relatively elevated rates since the early 2000s.

In another study, Asari et al. (2011) emphasized the exchange rates crucial role in economic stability and trade competitiveness. Focusing on Malaysia between 1999 and 2000, the study analyzed the links between inflation, interest rates, and exchange rate volatility using VECM techniques. Findings revealed that inflation influenced interest rates, which subsequently affected exchange rates. Over the long run, a positive relationship existed between interest rates and exchange rates, while inflation demonstrated a negative correlation.

Furthermore, Beyzatlar et al. (2014) explored the connection between real GDP per capita and transportation infrastructure across 15 EU countries over the period 1970-2008. Employing panel data and Granger causality tests, the research found mostly bidirectional causality between income and transportation metrics. However, in lower-income nations like Portugal, Greece, and Italy, the relationship was either unidirectional or statistically insignificant, suggesting that mutual influence only emerged after certain development thresholds were crossed.

Finally, Chamalwa and Bakari (2016) analyzed the impact of financial deepening on economic growth in Nigeria from 1981 to 2012. Using data from the Central Bank of Nigeria, the study investigated the roles of money supply and private sector credit. The application of the ADF test, Johansen cointegration, and

VECM revealed that the variables became stationary after differencing, showed cointegration, and maintained both short- and long-term relationships. The bidirectional causality suggested by the model highlighted the intertwined nature of financial development and GDP growth.

Molefe and Choga (2017) examined how government spending correlates with economic growth in South Africa by utilizing a Vector Error Correction Model (VECM) and analyzing time series data from 1990 to 2015. The study focused on variables such as Gross Domestic Product (GDP), public expenditure, government debt, national savings, and inflation (measured via the Consumer Price Index). Results revealed a negative long-run link between government expenditure and economic expansion. Moreover, it was estimated that nearly half (49%) of the deviations in GDP from its equilibrium state are adjusted annually. The causality analysis supported Wagners Law in the South African context, suggesting that economic expansion drives government spending rather than the reverse.

In Ghana, Ahiadorme et al. (2019) employed Johansen's cointegration framework to explore the volatility of interest rates and their impact on stock market returns. Contrary to prior empirical evidence, the study found a statistically significant and positive long-run relationship between interest rate variations and stock returns. These results were partly attributed to the dominance of banking stocks on the Ghana Stock Exchange. Short-term deviations were shown to revert toward equilibrium following market shocks.

Further research by Asigbetse et al. (2022) investigated how inflation and exchange rate movements influence Ghana's sectoral economy and overall growth. Using data from 1980 to 2019, the study performed unit root and co-integration tests followed by regression analysis. Findings indicated a negative association between inflation and exchange rate levels. It was noted that Ghana's economy is predominantly service-driven, followed by industrial and agricultural sectors. The transition toward a service-based economy was linked to policy reforms

and liberalization efforts. The study recommended economic restructuring and heightened public awareness to encourage local consumption, thereby mitigating adverse exchange rate effects.

Kodongo and Ojah (2012) analyzed the connection between real exchange rates and international portfolio investments across four African countries: Egypt, Nigeria, Morocco, and South Africa using monthly data from 1997 to 2009. Findings highlighted significant volatility and a lack of persistence in portfolio flows. Granger causality tests and innovation accounting confirmed that the relationship between foreign exchange rates and capital flows varied across countries and changed over time, validating the robustness of the findings across multiple VAR configurations.

In another study, Kovanen (2011) assessed how policy rate changes affect wholesale and retail interest rates in Ghana. Time series and bank-level data revealed that the transmission of policy rate adjustments is slow in the wholesale market, largely due to factors such as weak policy credibility, liquidity management issues, and signal misinterpretation. The study also found that retail market responses were gradual and incomplete, indicating inefficiencies in policy transmission mechanisms.

Using annual data from 1987 to 2016, Bulu studied the relationships among inflation, interest rates, and national savings in Nigeria. The analysis applied unit root tests, VAR models, co-integration techniques, and Granger causality methods. While inflation negatively influenced savings, the relationship lacked statistical significance. Interest rates had a positive but also insignificant impact on savings. The study concluded that savings growth was primarily influenced by its own innovations, with inflation, GDP growth, financial deepening, and interest rates contributing to variation. Policy suggestions included inflation control, supportive macroeconomic policies, and increased financial inclusion.

Boako et al. (2016) explored the interaction between exchange rates and stock returns in Ghana by employing Bayesian quantile regression and causality tests

on daily data from 2011 to 2014. The study concluded that market behavior aligns more with international trade models than portfolio balance theory, and identified the USD/GHS exchange rate as having the most immediate impact on the equity market among six currency pairs analyzed.

Akinbobola (2012) quantitatively evaluated the interactions among money supply, exchange rates and inflation in Nigeria from 1986 to 2008 using quarterly data. Employing a Vector Error Correction Model, the findings showed a long-term negative effect of both money supply and exchange rate movements on inflation. However, foreign price changes and real output growth contributed positively to inflationary pressure, underscoring the significance of supply-side shocks. The model also revealed feedback mechanisms from long-run to short-run dynamics and established significant causal relationships among the variables.

In a related study, Adam and Tweneboah (2008) investigated how macroeconomic factors influences stock prices in Ghana using data from 1991 to 2006. The study utilized Johansens cointegration test along with innovation accounting. The analysis confirmed both short- and long-term linkages between stock prices and macroeconomic indicators, including foreign direct investment inflows, T-bill rates, inflation, and exchange rates. Inflation and exchange rate fluctuations had pronounced short-term effects on stock performance, while interest rates and inflation were more influential over the long run.

Owusu Junior et al. (2018) used Continuous Morlet Wavelet Transforms to assess the lead-lag dynamics and co-movement between two major indices on the Ghana Stock Exchangethe GSE Composite Index (GSE-CI) and the Financial Services Index (GSE-FSI)in relation to exchange rates (USD and EUR). Data from 2011 to 2016 showed that these indices had varying correlations and lead-lag relationships with the exchange rates, especially at lower frequencies. The research emphasized the importance of time-frequency analysis in investment strategy and urged policymakers to consider these dynamic interactions when designing regulatory interventions.

Tweneboah (2015) studied the effects of dollarization on exchange rate volatility between the Ghanaian cedi and the U.S. dollar from 1990 to 2015 using an Exponential GARCH model. Results revealed a positive relationship between dollarization and nominal exchange rate volatility. The findings suggest that higher demand for foreign currency increases exchange rate instability. The symmetric impact of shocks further indicated that volatility is not direction-sensitive. The study recommended policies aimed at reducing dollarization to promote exchange rate stability.

Finally, Fagbemi and Ajibike (2019) examined the causal interactions between inflation, output and exchange rates in Nigeria between 1999 and 2017 using a Vector Error Correction Model and Granger causality testing. Findings pointed to a one-way causality from GDP to exchange rates, with inflation showing a long-term negative impact on output. The study also showed that currency depreciation can support long-term growth, especially when aligned with real sector development. Policy recommendations included support for domestic production and quality assurance programs to reduce inflationary pressure from imports.

Yusuf and Babangida (2019) analyzed the interactions among consumption expenditure, output, and the real exchange rate in Nigeria, emphasizing the role of per capita income as a major determinant of consumer spending. The study, which used time series data from 1988 to 2019, applied the ARDL bounds testing approach to investigate co-integration. Findings revealed evidence of a long-term relationship among the variables only when consumption expenditure served as the dependent variable. In the short term, none of the key variables real exchange rate, GDP, or consumption were statistically significant. However, over the long term, the real exchange rate exhibited a significant negative effect on consumption expenditure, while GDP showed a positive, albeit statistically insignificant, relationship. The study emphasized the greater influence of exchange rate movements over output in shaping consumption patterns and recommended

policies focused on ensuring monetary stability, maintaining price control, and enhancing productivity.

In the context of East Asia, Ning et al. (2019) applied VECM and Granger causality analysis to assess the influence of key macroeconomic variables namely, interest rates, inflation, and exchange rates on equity market returns. Their investigation centered on the Hong Kong and Shanghai stock indices. Cointegration analysis confirmed long-term associations among these variables and stock market returns, while VECM results illustrated dynamic short-run adjustments. Granger causality tests indicated that variables like money supply, exchange rate, and interest rates had a positive relationship with stock indices, whereas inflation negatively influenced returns. The researchers suggested that long-term investment strategies are more suitable for navigating these macroeconomic fluctuations.

Capital markets function as significant barometers of a country's economic direction. They facilitate investment activity and compel investors to make informed choices by identifying sectors or stocks with high return potential.

Suharsono et al. (2017) conducted a cross-country study on ASEAN stock markets, focusing on both advanced and developing economies including Singapore, Malaysia, Thailand, and the Philippines. Using Vector Autoregression and VECM models, the study sought to predict and interpret stock index behavior. The analysis identified VAR as the most appropriate modeling framework for the ASEAN stock indices and recommended incorporating additional variables and exploring new methodologies for improving future forecast accuracy.

In Ghana, Amoah (2017) investigated the implications of exchange rate misalignment for economic performance using the behavioral equilibrium exchange rate model, in combination with cointegration and error correction techniques. The study covered the period from 1980Q1 to 2013Q4 and included recalculated real effective exchange rate values based on IMF data revisions.

The results revealed periods of significant undervaluation prior to the 2007 currency redenomination and overvaluation thereafter. The research underscored the dangers of sustained exchange rate misalignments and proposed corrective measures, including potential one-time devaluations and structural reforms targeting export expansion and productivity improvement.

Yemidi et al. (2023) explored how changes in the monetary policy rate impact inflation via supply-side channels in an emerging market setting. The study, which used semiannual data from 2007 to 2020, focused on the influence of policy rates, lending rates, and sectoral output (agriculture and industry). Using a vector autoregression model and counterfactual simulations, the analysis showed that a 200-basis point reduction in the monetary policy rate led to a 1.3% drop in inflation during the simulation period. The researchers noted the limited availability of data and recommended further investigations using expanded time series models. They also advised that gradual adjustments in monetary policy may be more effective in sustaining inflation control.

Monetary policy is a fundamental tool in achieving economic stability. In Ghana, despite persistent inflation and moderate growth since the 1980s, the precise impact of monetary policy has not been fully established. Abdulai (2022) addressed this gap by examining the effectiveness of monetary policy in curbing inflation and fostering growth over the 1980-2017 period. Using a blend of FCVAR, NARDL, and SVAR models, the analysis was segmented into two phases: pre-2002 (focused on monetary aggregates) and post-2002 (characterized by inflation targeting). The findings showed that inflation targeting through the Monetary Policy Rate (MPR) was more effective in stabilizing prices and encouraging growth compared to earlier monetary aggregate controls.

While traditional parametric time series models have been widely used to study macroeconomic dynamics, they often fail to capture the nonlinearities present in real-world interactions. Standard Impulse Response Functions (IRFs) based on linear VAR models assume uniformity in variable responses, regardless of the

economic state, be it recession, boom, or inflation. This assumption overlooks the context-dependent nature of economic shocks and weakens the applicability of these models under variable conditions.

The reality is that macroeconomic variables evolve through intricate, state-dependent interactions, often producing effects that are asymmetric and dynamic. For instance, a shock during a financial crisis may yield different outcomes than the same shock during stable economic periods. As noted by Nsor-Ambala and Amewu (2023), these conventional models fall short in addressing the complexity of the macroeconomic innovation process, where overlapping feedback loops and interdependencies blur clear-cut distinctions between drivers and outcomes.

## 2.6 Nonlinear Multivariate Time Series

Nonlinear multivariate time series analysis is a branch of time series analysis that specifically addresses the examination of time series data exhibits nonlinear correlations among variables. According to Goswami (2019), non-linear time series analysis gained prominence in the late 1980s, primarily due to its ability to describe, interpret, and forecast complex aspects within data sets spanning various disciplines, including finance, music, psychology, cognitive science, astrophysics, climatology, and engineering.

The integration of TVAR with VECM extensions provides a powerful framework for identifying and understanding nonlinear relationships and interdependencies in economic systems (Hadji et al., 2024). This approach addresses critical gaps in standard methods, offering a richer and more nuanced perspective that aligns with the complexities of real-world dynamics. It is particularly well-suited for your thesis topic, allowing you to uncover unique insights into how inflation, interest rates, and exchange rates interact in a nonlinear and state-dependent manner.

Koop et al. (1996), introduced GIRFs to extend traditional IRF analysis to nonlinear contexts. Their framework allows for the assessment of shock impacts

without relying on linearity assumptions, making it applicable to a broad class of nonlinear models.

Recent advancements in econometrics have broadened the estimation of Impulse Response Functions (IRFs) through the application of local projection methods within nonlinear dynamic frameworks. Unlike traditional methods that often rely on stringent parametric assumptions, local projection techniques provide a more flexible and robust approach to modeling dynamic relationships. Specifically, the work by (Gourieroux and Lee, 2023) demonstrates how these methods can effectively capture complex nonlinearities inherent in economic systems.

The key advantage of local projections lies in their simplicity and adaptability. By directly estimating the relationship between shocks and subsequent outcomes at each time horizon, local projections avoid the need to specify or estimate a complete structural model. This is particularly beneficial in nonlinear settings, where specifying an accurate functional form for the entire system can be challenging or infeasible. Instead, local projections allow for a more targeted and granular analysis, enabling researchers to account for potential asymmetries, thresholds, or other nonlinear effects in the data.

Moreover, the use of local projections enhances the robustness of impulse response analysis. Traditional methods, such as Vector Autoregressions (VARs), can be sensitive to misspecification of the underlying dynamics or distributional assumptions. In contrast, local projection techniques reduce the risk of model misspecification by focusing on estimating individual responses over time, making them particularly suited for analyzing data with nonlinear or heterogeneous dynamics.

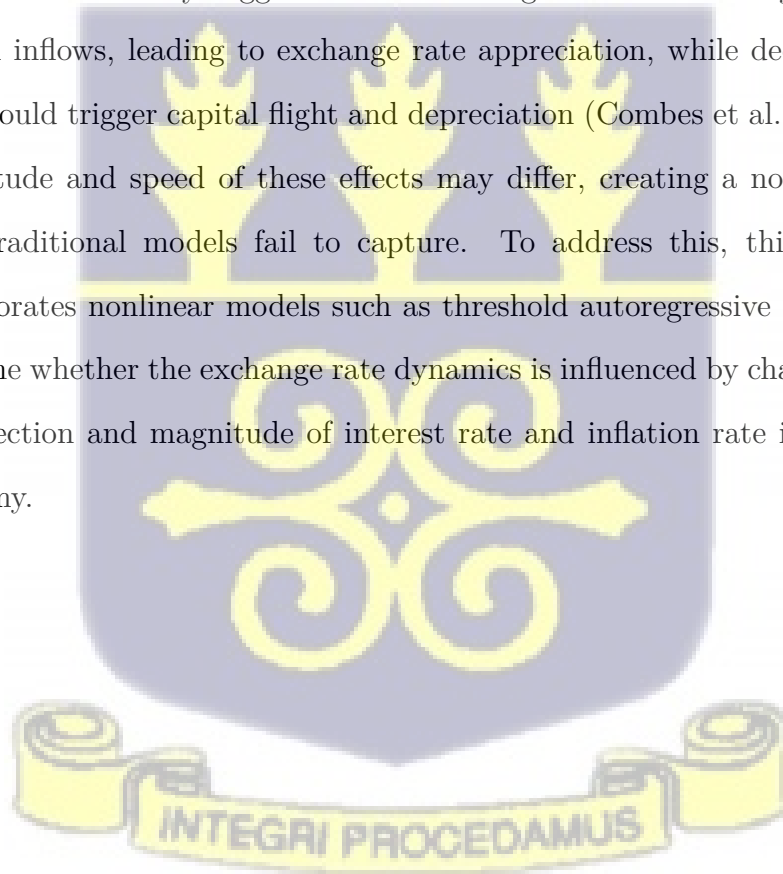
In summary, the extension of IRF estimation to nonlinear dynamic frameworks through local projections, represents a significant methodological advancement. This approach not only improves the flexibility and accuracy of capturing nonlinearities but also provides a robust alternative for impulse response analysis in complex economic systems. As such, it holds considerable promise for

applications in macroeconomics, finance, and other fields where nonlinear dynamics play a crucial role.

## 2.7 Research Gap

Current studies acknowledge that interest rates influence both inflation and exchange rates (Özen et al., 2020). However, the potential asymmetry in this relationship remains underexplored. Specifically, existing models often assume a uniform effect of interest rate changes, neglecting the possibility that interest rate hikes and reductions may have different impacts on exchange rate movements and inflationary pressures.

The economic theory suggests that increasing interest rates may attract foreign capital inflows, leading to exchange rate appreciation, while decreasing interest rates could trigger capital flight and depreciation (Combes et al., 2012). Yet, the magnitude and speed of these effects may differ, creating a nonlinear dynamic that traditional models fail to capture. To address this, this research work incorporates nonlinear models such as threshold autoregressive (TAR) model to examine whether the exchange rate dynamics is influenced by changes vary based on direction and magnitude of interest rate and inflation rate in the Ghanaian economy.



## CHAPTER 3

# METHODOLOGY

### 3.1 Introduction

This section outlines the research methodology employed to analyze the dynamic interactions between Ghanaian interest rates, inflation, and exchange rates. The study utilizes advanced econometric models, including Vector Error Correction Models (VECM), Granger Causality Tests, Impulse Response Functions (IRF), and Threshold Vector Autoregression (TVAR) analysis, to investigate the asymmetric relationships of these variables.

### 3.2 Research Design

The research adopts a quantitative approach, leveraging time series econometric techniques to capture short- and long-term dependencies between economic indicators, as well as unique interconnectedness between these macroeconomic indicators.

### 3.3 Data Source and Processing

The dataset comprises monthly data from 2015 to 2024 on the Ghanaian exchange rate, interest rate and inflation rate. Data were obtained

from the Ghana Statistical Service's official website with address "https://statsbank.statsghana.gov.gh/pxweb/en/Macroeconomic

### 3.4 Time Series Analysis

Time series analysis refers to a statistical method used to examine data points collected or recorded at consistent time intervals (Montgomery et al., 2015). It is particularly important in the fields of economics and finance, where recognizing patterns, long-term trends, and interdependencies in variables such as interest rates, inflation, and exchange rates is vital for accurate forecasting and effective policy-making.

This type of data is characterized by features like trends, seasonal effects, and autocorrelation, necessitating the use of tailored analytical methods. Popular techniques include econometric frameworks such as Vector Autoregression (VAR) and the Vector Error Correction Model (VECM), among others.

The key aim of time series analysis in this study is to deterministically unearth hidden relationships, interconnectedness and dependencies that cannot be merely determined in a set data. Time series modeling assumes that the underlying patterns in the data can be explained by fixed, non-random components such as trends and seasonality (Chatfield, 2013). Unlike stochastic models that incorporate probabilistic elements, deterministic models rely on structured relationships to describe and predict future values (Wilkinson, 2018). In economic studies, deterministic models help in capturing long-term trends and cyclical behaviors that influence financial markets and macroeconomic indicators.

The goal of time series analysis is to extract meaningful insights from past data to predict future movements and understand the underlying economic dynamics (Gershenfeld and Weigend, 2018).

### 3.4.1 Stationarity

In time series analysis, stationarity is a fundamental property that ensures the reliability of statistical inference. A time series is considered stationary if its statistical properties such as mean, variance, and autocorrelation remain constant over time. Non-stationary time series can lead to spurious regressions, making it difficult to derive meaningful economic relationships (R Rosca, 2011).

To assess stationarity, the study employs the Augmented Dickey-Fuller (ADF), which examine the presence of a unit root in the data. These tests help determine whether differencing is required to transform the series into a stationary process to ensure reliable econometric modeling. The Augmented Dickey-Fuller (ADF) test is defined as:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^p \delta_i \Delta Y_{t-i} + \epsilon_t \quad 3.1$$

where:

- $Y_t$  is the time series being tested,
- $\Delta Y_t = Y_t - Y_{t-1}$  is the first difference of the series,
- $\alpha$  is a constant (drift term),
- $\beta t$  represents the deterministic trend component,
- $\gamma$  is the coefficient of  $Y_{t-1}$ , which determines whether the series has a unit root,
- $\sum_{i=1}^p \delta_i \Delta Y_{t-i}$  accounts for autocorrelation by including  $p$  lagged difference terms,
- $\epsilon_t$  is a white noise error term.

Subject to the Hypothesis;

- **Null Hypothesis ( $H_0$ ):** The time series has a unit root (i.e., it is non-stationary).

- **Alternative Hypothesis ( $H_1$ ):** The time series is stationary (i.e., no unit root is present).

The test focuses on the value of  $\gamma$ :

- If  $\gamma = 0$ , the time series has a unit root (non-stationary).
- If  $\gamma < 0$ , the time series is stationary.

**The test results of ADF Test is interpreted as ;**

- If the p-value is low (e.g.,  $p < 0.05$ ), reject  $H_0 \Rightarrow$  The series is stationary.
- If the p-value is high (e.g.,  $p > 0.05$ ), fail to reject  $H_0 \Rightarrow$  The series is non-stationary (contains a unit root).

(Paparoditis and Politis, 2018)

For the purpose of this study, only stationarized data will be used for tests that require stationarity as a prerequisite for further analysis. These tests include the Granger causality test, impulse response function analysis, and forecast error variance decomposition.

### 3.4.2 Granger Causality Test

The Granger Causality Test is a method used in time series analysis to assess whether historical values of one variable can provide predictive information about another Troster (2018). Unlike simple correlation, which only shows how two variables move together, this test evaluates whether past data from one series can improve the prediction of another. It is particularly valuable for identifying directional linkages among economic variables such as inflation, exchange rates, and interest rates enabling policymakers to recognize which indicators may serve as early signals in the context of monetary policy.

The test involves estimating the following hypothesis in regression modeling:

### Granger Causality Hypothesis

Let  $X_t$  and  $Y_t$  represent two economic variables, where  $X_t$  can be exchange rate (ER), interest rate (IR), or inflation (INF), and  $Y_t$  represents another economic variable from the same set. The Granger causality test is based on the following vector autoregressive (VAR) model:

$$Y_t = \alpha + \sum_{i=1}^p \beta_i Y_{t-i} + \sum_{i=1}^p \gamma_i X_{t-i} + \epsilon_t \quad 3.2$$

$$X_t = \delta + \sum_{i=1}^p \theta_i X_{t-i} + \sum_{i=1}^p \lambda_i Y_{t-i} + \eta_t \quad 3.3$$

#### Null Hypothesis ( $H_0$ ) No Granger Causality

- $H_0 : \gamma_i = 0$  for all  $i \Rightarrow X_t$  does not Granger-cause  $Y_t$ .
- $H_0 : \lambda_i = 0$  for all  $i \Rightarrow Y_t$  does not Granger-cause  $X_t$ .

#### Alternative Hypothesis ( $H_1$ ) Presence of Granger Causality

- $H_1 : \gamma_i \neq 0$  for at least one  $i \Rightarrow X_t$  Granger-causes  $Y_t$ .
- $H_1 : \lambda_i \neq 0$  for at least one  $i \Rightarrow Y_t$  Granger-causes  $X_t$ .

If the null hypothesis is rejected, it implies that past values of  $X_t$  significantly improve the prediction of  $Y_t$ , indicating a causal relationship in the Granger sense (Shahbaz et al., 2012).

### 3.4.3 Johansen Cointegration Test

The Johansen Cointegration Test is a statistical approach used to assess whether multiple non-stationary time series exhibit a stable long-term relationship, even if they experience short-term deviations. It evaluates whether these variables tend to move in unison over time (Johansen and Nielsen, 2019).

The Johansen test is based on a Vector Autoregressive (VAR) model of order  $p$ :

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + \epsilon_t \quad 3.4$$

where:

- $Y_t$  is a vector of non-stationary time series variables (e.g., exchange rate, interest rate, inflation).
- $A_i$  are coefficient matrices.
- $\epsilon_t$  is a white noise error term.

Rewriting the VAR model in Error Correction Form (VECM):

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \epsilon_t \quad 3.5$$

where:

- $\Pi$  is the cointegration matrix, which determines the presence of cointegration.
- $\Gamma_i$  are short-term adjustment matrices.

The rank of  $\Pi$  determines the number of cointegration relationships:

- If  $\text{rank}(\Pi) = 0$ , no cointegration exists (variables are not related in the long run).
- If  $0 < \text{rank}(\Pi) < n$ , some cointegration relationships exist.
- If  $\text{rank}(\Pi) = n$ , all variables are stationary.

Bayer and Hanck (2013)

### Hypotheses of the Johansen Test

The test uses two statistics to determine the number of cointegration vectors:

**Trace Test;**

$$\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^n \ln(1 - \lambda_i) \quad 3.6$$

- **Null Hypothesis ( $H_0$ ):** There are at most  $r$  cointegration relationships.
- **Alternative Hypothesis ( $H_1$ ):** There are more than  $r$  cointegration relationships.

#### Maximum Eigenvalue Test;

$$\lambda_{\max}(r, r + 1) = -T \ln(1 - \lambda_{r+1}) \quad 3.7$$

- **Null Hypothesis ( $H_0$ ):** There are at most  $r$  cointegration relationships.
- **Alternative Hypothesis ( $H_1$ ):** There are exactly  $r + 1$  cointegration relationships.

If the test statistic exceeds the critical value, the null hypothesis is rejected, indicating the presence of cointegration.

It follows that;

- If no cointegration is found, use a VAR model with first differences.
- If cointegration exists, Vector Error Correction Model (VECM) is used to analyze long-term relationships (Ghanbari and Moradi, 2017).

#### 3.4.4 Vector Error Correction Model (VECM)

The Vector Error Correction Model (VECM) is an econometric tool designed to examine the long-run associations between non-stationary time series that are cointegrated. In contrast to conventional Vector Autoregression (VAR) models, which assume data stationarity, the VECM integrates an error correction component to capture both immediate fluctuations and gradual long-term adjustments (Mohammed et al., 2021). This feature makes it especially effective for exploring the dynamic relationships among key macroeconomic indicators like interest rates, inflation, and exchange rates.

When economic variables are cointegrated, it implies that despite short-term fluctuations, they share a stable long-term relationship. The VECM helps

quantify the speed at which deviations from this long-run equilibrium are corrected over time (Pietrzak et al., 2017). This is particularly relevant for policy analysis, as it allows policymakers to understand how quickly the economy adjusts to shocks in interest rates and inflation, and how these adjustments impact the exchange rate.

To capture both short-term and long-term relationships, a VECM is used:

$$\Delta Y_t = \alpha + \beta(Y_{t-1} - \theta X_{t-1}) + \sum_{i=1}^{p-1} \gamma_i \Delta Y_{t-i} + \sum_{j=1}^{q-1} \delta_j \Delta X_{t-j} + \epsilon_t \quad 3.8$$

where  $\beta$  is the adjustment coefficient indicating how quickly the variables return to equilibrium (Wang, 2022).

### Hypothesis for Error Correction Term (ECT) in VECM

After establishing cointegration, the Vector Error Correction Model (VECM) incorporates an Error Correction Term (ECT), which reflects the rate at which the system returns to long-term equilibrium following short-term disturbances.

### Hypothesis Testing for the ECT Coefficient ( $\alpha$ )

- **Null Hypothesis ( $H_0$ ):** The ECT coefficient is not statistically different from zero ( $\alpha = 0$ ), indicating that deviations from the equilibrium do not affect short-term dynamics implying no adjustment mechanism.
- **Alternative Hypothesis ( $H_1$ ):** The ECT coefficient is statistically significant ( $\alpha \neq 0$ ), suggesting that any deviation from equilibrium prompts a correction over time.
- If  $p < 0.05$ , reject  $H_0$ : the ECT is significant, indicating a tendency to restore long-term balance.
- If  $p > 0.05$ , fail to reject  $H_0$ : the ECT is not significant, implying little or no adjustment toward equilibrium (Andrei and Andrei, 2015).

A significant error correction term suggests that adjustments occur relatively quickly, while a weak correction term indicates prolonged deviations from equilibrium (Erten and Ocampo, 2013). This reinforces the necessity of coordinated policy measures to ensure exchange rate stability and inflation control in the long run.

### 3.5 Impulse Response Function (IRF)

The Impulse Response Function (IRF) is a key analytical tool in time series econometrics that helps evaluate how economic variables react to unexpected changes or shocks over time (Barnichon and Matthes, 2018). Within frameworks such as the Vector Autoregression (VAR) or Vector Error Correction Model (VECM), the IRF illustrates the impact of a sudden, one-time disturbance in one variable on its own future values and on other variables in the system. It is especially valuable for exploring the evolving relationships among macroeconomic indicators like interest rates, exchange rates, and inflation.

By visualizing the response of variables to shocks, IRF analysis helps policymakers understand the transmission mechanisms of monetary and fiscal policies. It provides a clear representation of the dynamic responses, making it an essential tool for economic policy formulation.

IRF assesses the impact of a shock in one variable on others over time. The impulse response function is computed from the moving average representation:

$$Y_t = \sum_{i=0}^{\infty} \Phi_i \epsilon_{t-i} \quad 3.9$$

where  $\Phi_i$  are the impulse response coefficients.

The IRF analysis provide insights into the dynamic interactions between the variables in the model, particularly the response of dependent variable to shocks in independent variables (Kirchner, 2022).

### 3.6 Forecast Error Variance Decomposition (FEVD) Analysis

After estimating the VECM, FEVD is applied to analyze how the forecast error variance of the exchange rate, interest rate and inflation rate is explained by shocks from each independent variable over different time horizons. The FEVD for variable  $Y_j$  at horizon  $h$  is computed as:

$$FEVD_j(h) = \frac{\sum_{i=1}^h \theta_{ji}^2}{\sum_{k=1}^n \sum_{i=1}^h \theta_{ki}^2} \quad 3.10$$

where:

- $\theta_{ji}$  represents the impulse response coefficient of variable  $j$  due to a shock in variable  $i$  over period  $h$ .
- The numerator represents the contribution of variable  $j$  to the total forecast error variance of  $Y_j$ .
- The denominator represents the total forecast error variance explained by all variables in the system, (Isakin and Ngo, 2020).

### 3.7 Threshold Vector Autoregression (TVAR)

Threshold Vector Autoregression (TVAR) is an extension of the standard Vector Autoregression (VAR) model that accounts for nonlinear relationships between economic variables by allowing different regimes based on threshold values (Baba and Sevil, 2020). In contrast to traditional VAR models, which assume constant linear relationships, TVAR enables regime-dependent dynamics, making it particularly useful in capturing asymmetric effects of policy interventions and external shocks.

TVAR is highly relevant in analyzing economic systems where the effects of exchange rate, interest rate, and inflation rate vary under different economic

conditions or regimes (low or high regime). By distinguishing between these regimes, TVAR provides deeper insights into the underlying structural relationships and helps policymakers design more adaptive economic policies.

The TVAR model is given by:

$$Y_t = \Phi_1 Y_{t-1} I(\tau_t \leq d) + \Phi_2 Y_{t-1} I(\tau_t > d) + \epsilon_t \quad 3.11$$

where  $\Phi_1$  and  $\Phi_2$  are the parameter matrices for low and high regimes, respectively, and  $d$  is the threshold level.

Based on the threshold effects identified in the model, the null hypothesis (H) is rejected or otherwise, which posits that there are no regime-dependent effects in the relationship between economic variables. The estimated threshold parameter is statistically significant at the 5% level, indicating that the economic dynamics vary across regimes.

The likelihood ratio test and regime-switching coefficients confirm that the effects of independent variable on dependent variable significantly differ across regimes (p-value < 0.05). This suggests that conventional linear models may overlook critical nonlinear interactions in the data, (Yuhan and Sohíben, 2018).

### 3.8 Model Performance and Validation

Evaluating the accuracy and effectiveness of econometric models is essential to ensure their reliability in policy analysis. Model performance metrics provide quantitative measures to assess how well a model fits the data and probably predicts future values (Bennett et al., 2013). These metrics help to compare different models and select the best one for economic analysis.

This study employs key model selection criteria, namely the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). These indicators assess model performance by weighing the trade-off between model accuracy and complexity, taking into account the number of parameters estimated. By

using AIC and BIC, the most suitable model can be identified for analyzing the interconnections among exchange rates, interest rates, and inflation.

To assess model accuracy, AIC and BIC were used:

$$AIC = 2k - 2 \ln(L) \quad 3.12$$

$$BIC = 2 \ln(L) - k \ln(n) \quad 3.13$$

where  $k$  is the number of estimated parameters and  $L$  is the likelihood function (Pham, 2019).

This methodological framework enables a comprehensive examination of the interplay between exchange rates, interest rates, and inflation in Ghana. The integration of advanced econometric models provides robust insights into both linear and nonlinear dependencies, ensuring more accurate forecasting and policy recommendations.



## CHAPTER 4

# ANALYSIS, RESULTS AND DISCUSSIONS

### 4.1 Introduction

This study explores the complex relationships between inflation rate, interest rates, and exchange rate volatility in Ghana's economy. It examines historical trends to identify patterns and employs econometric methods to analyze the directional and temporal interactions among these variables.

The study further quantifies the impact of inflation and interest rates on exchange rate volatility, which effectively capture conditional volatility and the propagation of economic shocks.

Based on these findings, policy recommendations are proposed to stabilize exchange rates by addressing inflation and optimizing interest rate policies, supporting sustainable economic growth and resilience. This comprehensive approach combines empirical analysis with theoretical insights to achieve the study's objectives.

## 4.2 General Trends of Inflation, Interest and Exchange Rates in Ghana

The figure below displays the raw behavior of the economic variables in the Ghanaian economy.

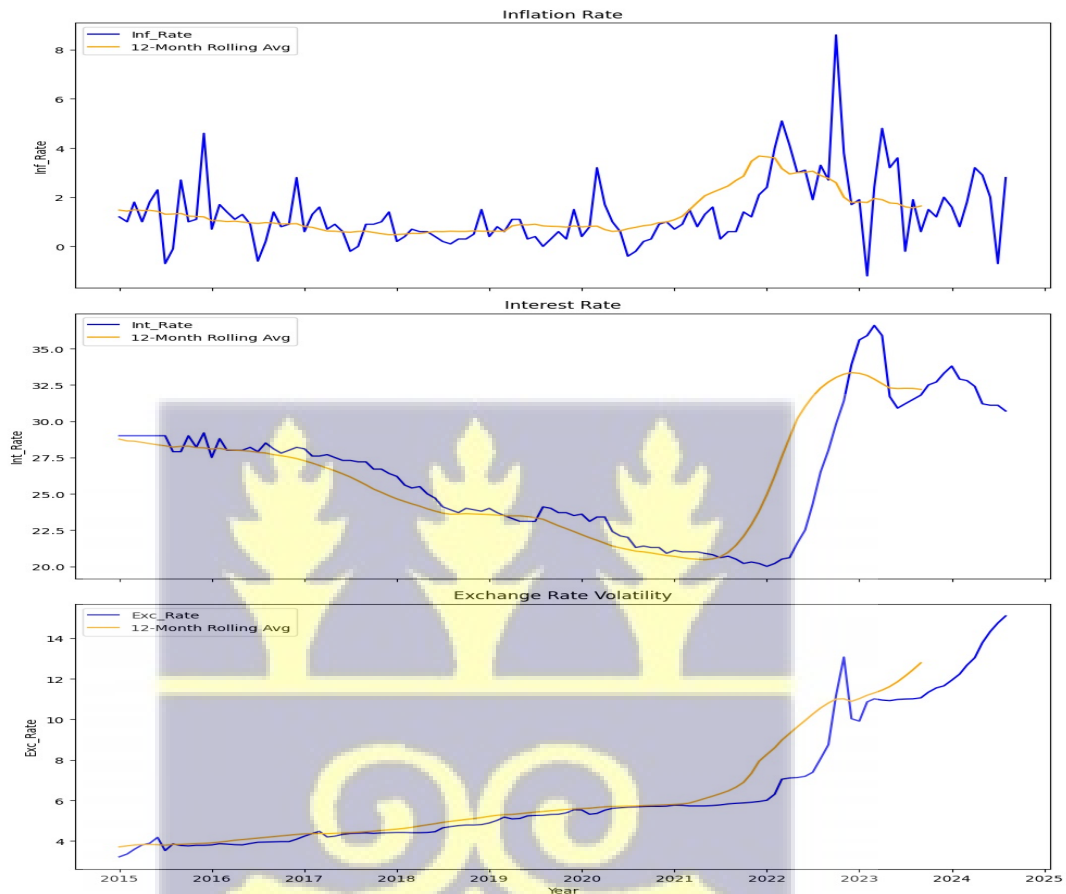


Figure 4.1: Trends of Inflation, Interest, and Exchange Rates in Ghana

From the plot, inflation rate exhibits significant volatility, characterized by sharp peaks and troughs over time. The 12-month rolling average (orange line) smooths these fluctuations, showing an overall trend of increasing inflation from around 2015 to 2023, followed by a decline. These fluctuations likely reflect economic shocks or policy adjustments impacting inflation levels.

Interest rate shows a general downward trend from 2015 to 2021, stabilizing at lower levels before experiencing a sharp rise around 2022. The 12-month rolling average highlights this trend, emphasizing a more gradual decline followed by a

spike in interest rates. This shift might be attributed to changes in monetary policy aimed at addressing inflation or stabilizing the economy.

The exchange rate volatility shows a steady upward trend, with sharp increases observed from 2022 onward. The 12-month rolling average reflects the gradual escalation, underscoring increasing pressure on the currency, likely due to external shocks or imbalances in the trade and financial sectors.

The co-movement of these variables over the period suggests inter-dependencies, where shifts in inflation and interest rates may have contributed to changes in exchange rate volatility. These patterns are critical for understanding the dynamic interplay among these economic indicators, providing insights into macroeconomic stability and the effectiveness of monetary policy. This analysis lays the foundation for further econometric investigations into causal relationships and the establishment of impacts, aligning with the thesis objectives.



### 4.3 Cyclical Trends of Inflation, Interest and Exchange Rates in Ghana

The figure below show the cyclical pathways of the economic variables in the Ghanaian economy.

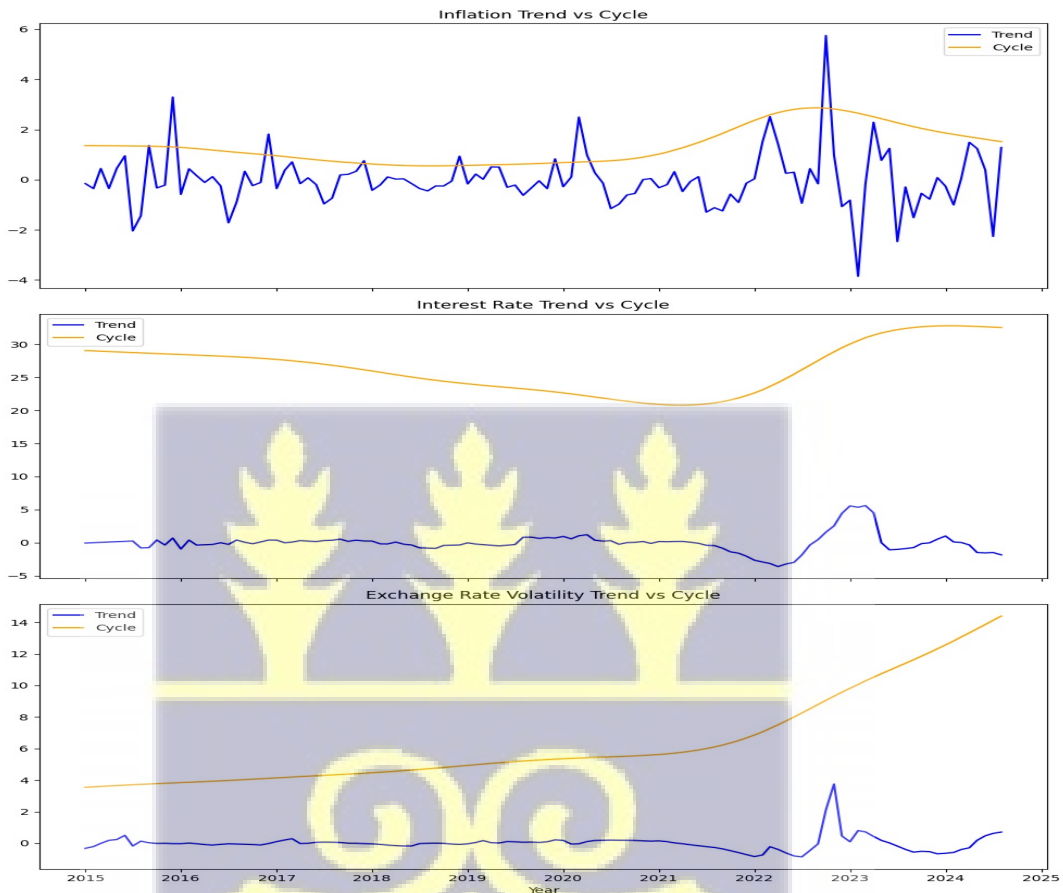


Figure 4.2: Cyclical Trends of Inflation, Interest, and Exchange Rates in Ghana

Inflation trend line (Blue) reflects the long-term behavior of inflation, smoothing out short-term fluctuations to show the overall direction of inflation over the years. In this case, the trend remains relatively stable, with slight upward and downward movements. These subtle shifts might suggest:

- **Economic Growth or Stability:** A stable trend may indicate a balance between economic output and demand, where inflationary pressures are being managed effectively through monetary or fiscal policies.
- **Structural Changes:** The absence of extreme movements in the trend

suggests that there were no significant structural economic shocks, such as hyperinflation or deflation, during the observed period.

- **Policy Efficacy:** Stability in the trend could be a result of effective inflation-targeting measures by monetary authorities, ensuring that inflation remains within acceptable bounds.

Interest rate trend (Blue line) remains relatively flat, indicating that the overall policy direction for interest rates aimed at stability. However, slight decreases toward the middle period could signify efforts to stimulate economic growth by lowering borrowing costs.

The cyclical component (Orange line) shows deviations from the trend, with visible peaks and dips. Notably, the increase in cycles in the latter period reflects active monetary policy adjustments, likely aimed at addressing inflationary pressures or stabilizing the currency. Rising interest rate cycles typically strengthen the local currency by attracting foreign capital, while declining cycles could signal easing monetary policies that might weaken the currency, thereby impacting exchange rate volatility.

Exchange rate trend (Blue line) remains relatively low and stable for most of the period but starts to rise noticeably around 2022. This could correspond to heightened uncertainty or economic stress during that period. The cyclical component (Orange line) shows significant spikes, particularly around periods of economic instability or sharp adjustments in inflation or interest rates. These spikes represent periods of heightened volatility in the exchange rate, driven by short-term speculative behavior or external shocks. Exchange rate volatility appears to mirror changes in inflation and interest rate cycles. The significant rise in exchange rate volatility cycles in 2023 aligns with inflationary peaks or active interest rate adjustments, underscoring the interconnectedness of these variables.

## 4.4 Correlation Among Economic Variables and Policy Implications

The figure below present the correlation heatmap amongst the economic variables.

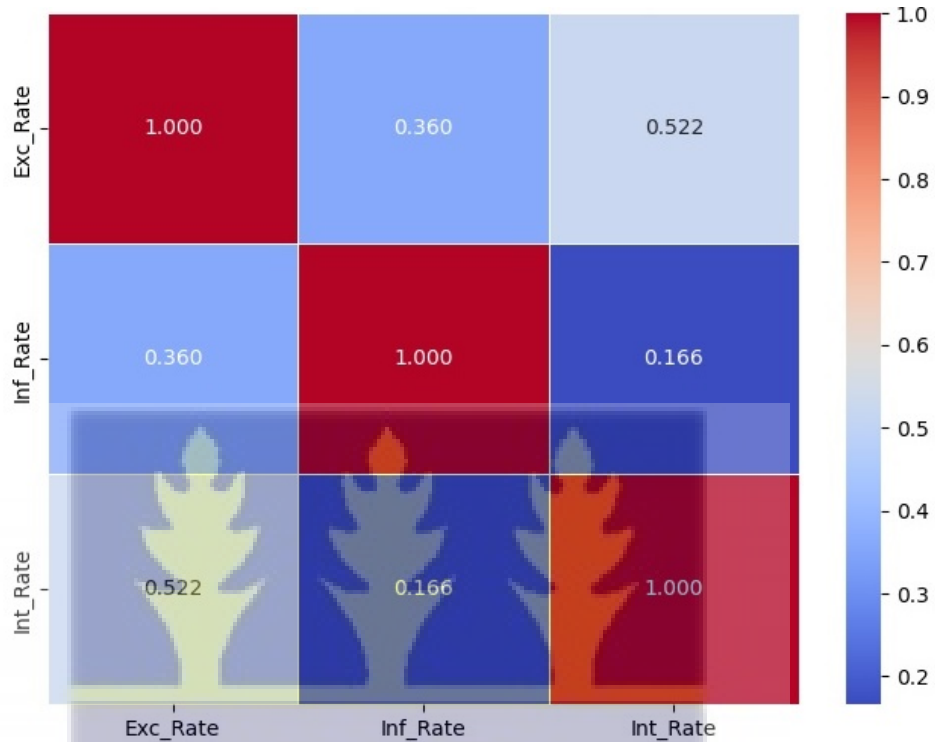


Figure 4.3: Correlation Heatmap of Exchange Rate, Inflation Rate and Interest Rate

The relationship between exchange rates, interest rates, and inflation rates is crucial in shaping economic policies and financial stability. From the correlation heatmap analysis, we observe that these economic variables exhibit varying degrees of association, which suggests potential nonlinear interactions that policymakers should consider.

The exchange rate and interest rate show a moderate positive correlation (0.522), indicating that as interest rates increase, the exchange rate tends to rise as well. This can be explained by the fact that higher interest rates attract foreign investment, increasing demand for the local currency and causing it to appreciate. However, this relationship is not always straightforward. In some

cases, high interest rates may signal economic distress, discouraging investment and leading to a depreciation of the currency instead. Therefore, while interest rate adjustments are commonly used to influence exchange rate movements, their effectiveness depends on broader economic conditions, investor confidence, and external market forces.

The relationship between the exchange rate and inflation rate is weaker and positive (0.360), suggesting that higher inflation may contribute to currency depreciation. This aligns with economic theory, as inflation erodes the purchasing power of money, making the local currency less attractive to investors (Muchiri, 2017). However, the relatively weak correlation implies that inflation alone does not fully explain exchange rate fluctuations. Other factors, such as trade balances, foreign reserves, and global economic trends, may play a more significant role. Policymakers aiming to stabilize the exchange rate must therefore adopt a more comprehensive approach that goes beyond inflation control, incorporating measures such as foreign exchange interventions and structural economic reforms. The correlation between interest rates and inflation rates is very weak (0.166), suggesting that changes in interest rates do not directly translate into predictable changes in inflation. This contradicts the traditional expectation that higher interest rates should reduce inflation by limiting money supply and borrowing. The weak correlation may be attributed to external inflationary pressures, such as supply chain disruptions, global commodity price shocks, and fiscal policies that influence demand. As a result, relying solely on interest rate adjustments to control inflation may not be sufficient, and additional policy tools, such as targeted fiscal measures and price stabilization strategies, may be necessary.

One key takeaway from the correlation analysis is the possibility of nonlinear relationships among these economic variables as emphasized by (Nsor-Ambala and Amewu, 2023) in the literature. If the relationships were purely linear, we would expect much stronger and more predictable correlations. However, the varying degrees of association suggest that interest rate and inflation effects

on exchange rates depend on multiple interacting factors, but beyond a certain threshold, it could lead to capital flight if investors perceive the economy as unstable. Similarly, inflation may not always lead to immediate currency depreciation if other economic fundamentals remain strong.

Given these complexities, economic policymakers should not rely solely on traditional linear models to forecast exchange rate movements. Instead, more advanced techniques such as Threshold Vector Autoregression models can help capture the underlying nonlinear patterns. These methods can provide more accurate predictions by considering complex interactions and hidden dependencies that certain traditional statistical models may overlook.

While the correlation analysis provides valuable insights into the relationship between exchange rates, interest rates and inflation rates, it also highlights the limitations of assuming simple linear relationships in economic policymaking. Policymakers should consider the broader economic context, external shocks, and nonlinear dynamics when designing monetary policies. A combination of interest rate management, inflation control, and structural reforms will be more effective in maintaining exchange rate stability than relying on any single policy tool.

## 4.5 Test of Stationarity

Stationarity tests are essential in time series analysis to determine whether a dataset exhibits consistent statistical properties over time. Exchange rate, Inflation rate and Interest rate are subject to stationarity testing as a requirement for most econometric modeling.

### 4.5.1 Hypothesis for Stationarity Testing

#### 1. Exchange Rate

Null Hypothesis  $H_0$ : Exchange rate series has a unit root.

Alternative Hypothesis  $H_1$ : Exchange rate series does not have a unit root.

## 2. Inflation Rate

Null Hypothesis  $H_0$ : Inflation rate series has a unit root.

Alternative Hypothesis  $H_1$ : Inflation rate series does not have a unit root.

## 3. Interest Rate

Null Hypothesis  $H_0$ : Interest rate series has a unit root.

Alternative Hypothesis  $H_1$ : Interest rate series does not have a unit root.

Table 4.1: Stationarity Test Results for Exc\_Rate, Inf\_Rate, and Int\_Rate

Variable	Test	Statistic	P-value	CV (5%)	Diff Steps
Exc_Rate	ADF	-3.7352	0.0036	-3.4896	1
	KPSS	1.4220	0.01	—	—
Inf_Rate	ADF	-1.7995	0.3807	-3.4955	1
	KPSS	0.6668	0.0166	—	—
Int_Rate	ADF	-2.0210	0.2775	-3.4896	1
	KPSS	1.2241	0.01	—	—

The results of the stationarity tests presented in Table 4.1 offer critical insights into the behavior of the exchange rate, inflation rate, and interest rate, laying the foundation for understanding their dynamic relationships and implications for economic modeling.

Exchange rate exhibited stationarity after one differencing step, as evidenced by the Augmented Dickey-Fuller (ADF) test at 5% significance level. The p-value of 0.0036 is noticeably below the 0.05 threshold, confirming the rejection of the null hypothesis of non-stationarity. This finding indicates that the exchange rate, once differenced, fluctuates around a stable mean without a persistent trend. The stationarity of exchange rate suggests that its short-term dynamics can be effectively captured without the influence of long-term trends, making it suitable for predictive models and analyses that focus on short-term variability.

In contrast, inflation rate demonstrated non-stationarity in its original form, with an ADF statistic of -1.7995, which is greater than the critical value of -

2.8900 at the 5% level. The corresponding p-value of 0.3807 further supports the conclusion that the null hypothesis of non-stationarity cannot be rejected. After one differencing step, however, the inflation rate achieved stationarity, indicating that changes in the inflation rate rather than its absolute levels, are more stable and predictable over time. This behavior reflects the influence of persistent trends or cycles in inflation, which are common in economic data due to factors such as monetary policy adjustments, external shocks, and market dynamics.

Similarly, interest rate also required one differencing step to achieve stationarity. The initial ADF test result with a statistic of -2.0210 and a p-value of 0.2775, failed to reject the null hypothesis of non-stationarity. This indicates that the raw interest rate series contains trends or long-term dependencies that need to be removed for effective analysis. Once differenced, the interest rate series stabilizes, allowing for a clearer understanding of its short-term movements. This finding accentuates the role of structural economic factors, such as central bank policies and global financial conditions, in shaping the long-term behavior of interest rates.

The implications of these findings are significant for economic modeling and forecasting. The stationarity of the exchange rate achieved with minimal transformation, suggests that its fluctuations are primarily short-term and driven by immediate market forces. In contrast, inflation and interest rates' non-stationary nature highlights their susceptibility to persistent trends and external influences, necessitating differencing to remove these effects. These differences in behavior reflect the complex interplay of these economic variables and emphasize the need for analytical approaches capable of capturing both short-term and long-term dynamics.

## 4.6 Granger Causality

The Granger Causality test checks whether lagged values of one variable significantly improve the prediction of another variable beyond its own lags. The

results are provided for multiple lag lengths, each reporting several test statistics.

#### 4.6.1 Causal Relationship Between Inflation Rate and Interest Rate

The results of the Granger causality test between inflation and interest rates reveal varying degrees of causality across different lags, with some lags indicating significant relationships and others showing no significant effects.

Table 4.2: Granger Causality: Inf\_Rate  $\rightarrow$  Int\_Rate

Lags	Likelihood Ratio Test	Parameter F-Test
1	$\chi^2 = 2.9817, p = 0.0842$	$F = 2.9415, p = 0.0891$
2	$\chi^2 = 6.4895, p = 0.0390$	$F = 3.1920, p = 0.0450$
3	$\chi^2 = 8.0215, p = 0.0456$	$F = 2.5987, p = 0.0561$
4	$\chi^2 = 6.4099, p = 0.1706$	$F = 1.5159, p = 0.2031$
5	$\chi^2 = 9.9752, p = 0.0759$	$F = 1.8795, p = 0.1047$

At Lag 1, the Chi-squared statistic is 2.9817 ( $p = 0.0842$ ), and the F-statistic is 2.9415 ( $p = 0.0891$ ). The p-values for both tests are greater than the conventional significance level of 0.05, suggesting that there is no statistically significant causality from inflation to interest rates at this lag. This implies that past inflation values do not have a predictive power over future interest rate changes at the immediate time period.

At Lag 2, the results show a Chi-squared statistic of 6.4895 ( $p = 0.0390$ ) and an F-statistic of 3.1920 ( $p = 0.0450$ ), with p-values less than 0.05. This indicates that there is significant causality from inflation to interest rates at this particular lag. It suggests that past inflation values play a role in predicting future changes in interest rates, highlighting a more meaningful relationship at this lag compared to Lag 1.

At Lag 3, the Chi-squared value is 8.0215 ( $p = 0.0456$ ), and the F-statistic is 2.5987 ( $p = 0.0561$ ). Although both tests show marginal significance, the p-value for the F-test is slightly above the 0.05 threshold, indicating that the evidence of

causality is weaker compared to the previous lag. The results suggest that while there is some indication of causality, it is not as robust as at Lag 2.

Finally, at Lags 4 and 5, both the Chi-squared and F-tests show p-values greater than 0.05, indicating no significant causality from inflation to interest rates at these higher lags. This suggests that the relationship between inflation and interest rates weakens and becomes non-significant as the time lag increases.

Overall, the Granger causality test reveals that inflation has a significant predictive effect on interest rates at Lag 2, but this relationship diminishes at longer lags, with no significant causality detected at Lags 4 and 5. This finding suggests that inflation influences interest rates primarily in the short-term, and the effect weakens as time progresses.

#### **4.6.2 Causal Relationship Between Inflation Rate and Exchange Rate**

The results of the Granger causality test between inflation and exchange rates reveal varying levels of significance across different lags, with substantial evidence of causality emerging at higher lags.

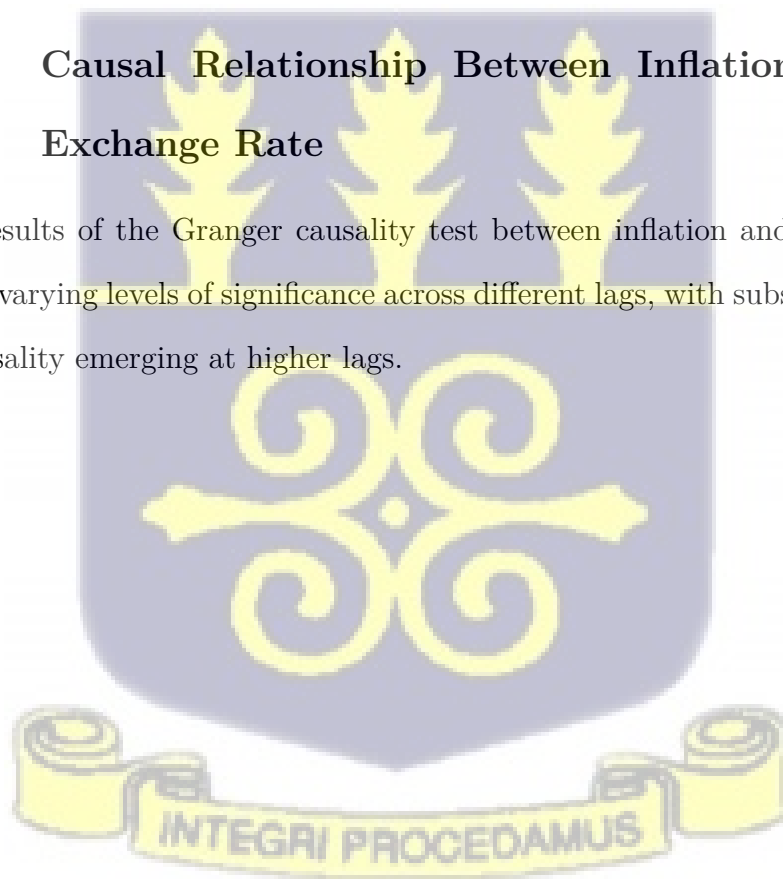


Table 4.3: Granger Causality: Inf\_Rate  $\rightarrow$  Exc\_Rate

Lags	Likelihood Ratio Test	Parameter F-Test
1	$\chi^2 = 2.6017, p = 0.1067$	$F = 2.5624, p = 0.1123$
2	$\chi^2 = 2.1461, p = 0.3420$	$F = 1.0354, p = 0.3586$
3	$\chi^2 = 16.3858, p = 0.0009$	$F = 5.5141, p = 0.0015$
4	$\chi^2 = 33.1417, p = 0.0000$	$F = 8.8723, p = 0.0000$
5	$\chi^2 = 36.7111, p = 0.0000$	$F = 7.8443, p = 0.0000$

At Lag 1, the Chi-squared statistic is 2.6017 ( $p = 0.1067$ ) and the F-statistic is 2.5624 ( $p = 0.1123$ ). The p-values for both tests exceed the conventional significance threshold of 0.05, indicating that there is no statistically significant causality from inflation to exchange rates at this initial time lag. This suggests that past inflation values do not significantly influence or predict future changes in exchange rates at the immediate time period, implying that the relationship between these two variables does not manifest in the short run.

The results at Lag 2 are consistent with those at Lag 1. The Chi-squared statistic is 2.1461 ( $p = 0.3420$ ), and the F-statistic is 1.0354 ( $p = 0.3586$ ), both of which have p-values greater than 0.05. This reinforces the lack of significant causality between inflation and exchange rates at this lag, further suggesting that past inflation does not significantly affect exchange rate movements in the short-to-medium term.

However, at Lag 3, a notable shift occurs. The Chi-squared statistic increases to 16.3858 ( $p = 0.0009$ ), and the F-statistic rises to 5.5141 ( $p = 0.0015$ ), both of which have p-values well below the 0.05 threshold. This indicates significant causality from inflation to exchange rates, implying that inflation has a predictive effect on future exchange rate movements at this time lag. The results suggest that inflation, although not immediately impactful, begins to influence the exchange rate starting from Lag 3, highlighting the delayed nature of this relationship.

At Lags 4 and 5, the causality becomes even more pronounced. At Lag 4, the Chi-

squared statistic is 33.1417 ( $p = 0.0000$ ) and the F-statistic is 8.8723 ( $p = 0.0000$ ), while at Lag 5, the Chi-squared statistic further increases to 36.7111 ( $p = 0.0000$ ) and the F-statistic is 7.8443 ( $p = 0.0000$ ). The extremely low p-values at these lags confirm that past inflation strongly predicts future exchange rate changes, with the causality becoming highly significant. These results suggest that the relationship between inflation and exchange rates strengthens over time, with past inflation becoming a reliable predictor of future exchange rate movements at these longer lags.

In summary, the Granger causality test results reveal that inflation begins to significantly affect exchange rates starting at Lag 3, with a progressively stronger influence at Lags 4 and 5. This pattern suggests that inflation has a delayed effect on exchange rates, with its predictive power increasing over time. These findings indicate that inflation is a key factor influencing exchange rate movements, albeit with a lag, and emphasize the importance of considering the temporal dimension when analyzing the impact of inflation on exchange rates in economic modeling.

### 4.6.3 Causal Relationship Between Interest Rate and Inflation Rate

The Granger causality results examining the relationship between Interest Rates and Inflation Rates provide valuable insights into the temporal dynamics of these two economic variables. The analysis focuses on different time lags, revealing varying degrees of causality.

Table 4.4: Granger Causality: Int\_Rate  $\rightarrow$  Inf\_Rate

Lags	Likelihood Ratio Test	Parameter F-Test
1	$\chi^2 = 3.5508, p = 0.0595$	$F = 3.5118, p = 0.0636$
2	$\chi^2 = 6.4052, p = 0.0407$	$F = 3.1493, p = 0.0468$
3	$\chi^2 = 8.7073, p = 0.0334$	$F = 2.8296, p = 0.0420$
4	$\chi^2 = 7.6175, p = 0.1066$	$F = 1.8114, p = 0.1323$
5	$\chi^2 = 7.8704, p = 0.1635$	$F = 1.4686, p = 0.2069$

At Lag 1 to Lag 3, the results suggest a weak but potentially meaningful relationship between interest rates and inflation. The Chi-squared statistic at Lag 1 is 3.5508 with a p-value of 0.0595, while at Lag 2, the Chi-squared statistic is 6.4052 with a p-value of 0.0407. These values, although marginally above the traditional significance threshold of 0.05, suggest that there may be some influence of interest rates on inflation during these time periods. The p-values are close to 0.05, indicating that there could be a causal link between interest rates and inflation, but the strength of this relationship is not robust enough to be deemed statistically significant at a conventional level. This marginal significance suggests that while interest rates may have some predictive power for inflation, the effect is not strong enough to be conclusive. Therefore, there is some evidence to suggest that interest rates could influence inflation within the first three lags, but this influence is relatively weak and requires further investigation.

Moving to Lag 4 and Lag 5, the results show a stark contrast. At Lag 4, the Chi-squared statistic is 7.6175 with a p-value of 0.1066, and at Lag 5, the Chi-squared statistic remains high at 7.8704 with a p-value of 0.1635. These results indicate that there is no statistically significant causality from interest rates to inflation at these longer lags. The p-values are clearly above the 0.05 threshold, suggesting that interest rates do not significantly influence inflation in the longer run. This absence of significant causality at Lags 4 and 5 implies that any potential impact of interest rates on inflation is likely to be limited to shorter time periods, with no meaningful long-term effect.

The findings from the Granger causality analysis between interest rates and inflation reveal a weak and marginally significant relationship at shorter lags, specifically from Lag 1 to Lag 3. This suggests that interest rates may offer limited short-term predictive insight into inflation. However, this influence appears to weaken over time, as evidenced by the lack of statistical significance at Lag 4 and Lag 5. These results imply that any causal effect of interest rates on inflation is likely to be short-term rather than persistent. Consequently, while interest rates

might contribute to inflation dynamics in the immediate future, their long-term influence seems negligible.

#### 4.6.4 Causal Relationship Between Interest Rate and Exchange Rate

The Granger causality test assessing the link between interest rates and exchange rates sheds light on how these two variables interact over time. Findings across multiple lags point to a potential delayed impact of interest rate movements on exchange rate behavior.

Table 4.5: Granger Causality: Int\_Rate  $\rightarrow$  Exc\_Rate

Lags	Likelihood Ratio Test	Parameter F-Test
1	$\chi^2 = 3.0830, p = 0.0791$	$F = 3.0428, p = 0.0839$
2	$\chi^2 = 9.8093, p = 0.0074$	$F = 4.8971, p = 0.0092$
3	$\chi^2 = 9.9743, p = 0.0175$	$F = 3.2360, p = 0.0252$

At the first lag, the analysis yields a Chi-squared value of 3.0830 and a corresponding p-value of 0.0791. Although this p-value does not meet the standard threshold of 0.05 for statistical significance, it hints at a possible, albeit weak, association. This marginal result implies that any causal influence of interest rates on exchange rates at Lag 1 is limited and lacks robust statistical support. As such, the evidence is insufficient to assert a significant causal relationship at this lag.

In contrast, the outcomes at Lag 2 and Lag 3 reveal stronger signs of statistically significant causality. Specifically, Lag 2 produces a Chi-squared value of 9.8093 with a p-value of 0.0074, while Lag 3 yields a Chi-squared value of 9.9743 and a p-value of 0.0175. Both p-values fall well below the conventional 0.05 significance level, providing robust evidence that interest rates exert a meaningful causal influence on exchange rate movements at these particular lags. These results suggest that changes in interest rates can help predict future movements in

exchange rates, with the effect becoming apparent after a short delay. The significant results at Lag 2 and Lag 3 reflect the delayed nature of this relationship, suggesting that while interest rate changes influence exchange rates, their impact takes a few periods to materialize.

Overall, the Granger causality results indicate that interest rates have a significant effect on exchange rates, but with a slight delay. The lack of significance at Lag 1 suggests that immediate changes in interest rates may not be sufficient to predict exchange rate movements. Instead, it is at Lag 2 and Lag 3 that the relationship between the two variables becomes statistically meaningful, supporting the idea that interest rates have a delayed impact on exchange rate dynamics. This delayed causality could be attributed to the time it takes for market participants to adjust to interest rate changes and for these adjustments to be reflected in exchange rate movements.

In conclusion, while Lag 1 does not show significant causality, the results at Lag 2 and Lag 3 provide robust evidence that interest rates influence exchange rates with a slight delay. This finding aligns with economic theories that suggest interest rates can affect exchange rates through mechanisms such as capital flows and investor expectations, but the full effect may take some time to become apparent.

## 4.7 Johansen Cointegration Test

The Johansen Cointegration Test results provide insights into whether the economic variables under study move together over time, suggesting a meaningful economic relationship. Identifying cointegration is crucial for building reliable econometric models and ensuring that regression analysis does not lead to spurious results. The test results will guide subsequent analysis by confirming the presence or absence of cointegrating relationships and their implications for policy and decision-making.

#### 4.7.1 Johansen Cointegration Test Result

$$\text{Eigenvalues: } \begin{bmatrix} 0.2476 & 0.1165 & 0.0174 \end{bmatrix}$$

$$\text{Trace Statistic: } \begin{bmatrix} 48.5473 & 16.1136 & 1.9969 \end{bmatrix}$$

$$\text{Critical Values: } \begin{bmatrix} 27.0669 & 29.7961 & 35.4628 \\ 13.4294 & 15.4943 & 19.9349 \\ 2.7055 & 3.8415 & 6.6349 \end{bmatrix}$$

The test produced eigenvalues of 0.2476, 0.1165, and 0.0174, which provide an indication of the strength of the cointegration relationships. The largest eigenvalue, 0.2476, suggests a relatively strong long-term connection among the variables, while the smaller eigenvalues indicate weaker, though still present, contributions. These eigenvalues highlight the varying degrees of influence that the variables have on one another in the long term.

The trace statistic values further support the conclusion of cointegration. For the null hypothesis that there are no cointegration relationships ( $r = 0$ ), the trace statistic of 48.55 significantly exceeds the critical value of 29.80 at the 5% significance level. This allows us to reject the null hypothesis and confirms the presence of at least one cointegration relationship.

Similarly, for the hypothesis that there is at most one cointegration relationship ( $r \leq 1$ ), the trace statistic of 16.11 exceeds the critical value of 15.49, indicating the existence of a second cointegration relationship. However, for the hypothesis of at most two cointegration relationships ( $r \leq 2$ ), the trace statistic of 2.00 falls below the critical value of 3.84, suggesting that there are no more than two significant relationships among the variables.

These findings have important implications for understanding the dynamics of the exchange rate in relation to inflation and interest rates. The presence of

two cointegration relationships implies that these variables are not independent in the long run but instead move together to maintain a long-term equilibrium. This interconnectedness suggests that changes in inflation and interest rates have a lasting impact on the exchange rate. For instance, persistent inflationary pressures or adjustments in interest rates will influence the exchange rate over time, aligning with economic theories that emphasize the role of macroeconomic fundamentals in determining exchange rate stability.

The policy implications of these results are profound. The interconnected nature of the exchange rate, inflation rate, and interest rate implies that mismanagement of monetary or fiscal policies in one area could disrupt the equilibrium and lead to exchange rate instability. Policymakers in Ghana must therefore consider the broader impacts of inflation and interest rate policies when striving to achieve exchange rate stability. Coordinated policies that address these interdependencies are essential to ensure sustainable economic outcomes.

The findings from the Johansen cointegration test justify the use of Vector Error Correction Model (VECM). The VECM framework is particularly suited for capturing the short-term dynamics while ensuring that the long-term equilibrium relationships are respected. This approach is invaluable for developing predictive models that account for the intricate interplay between inflation, interest rates and exchange rates in Ghana.

The Johansen cointegration test results also emphasize the existence of two significant cointegration relationships among exchange rate, inflation rate, and interest rate. This accentuates the importance of understanding their long-term equilibrium and the need for coordinated policies to ensure macroeconomic stability.

## 4.8 Analysis of the VECM

The Vector Error Correction Model (VECM) results offer valuable understanding of both the short-run interactions and the long-term equilibrium relationships

among the exchange rate, inflation, and interest rate. The following discussion breaks down the main findings of each equation, focusing on coefficient estimates, their statistical relevance, and the broader economic interpretations.

## 4.9 Deterministic Terms Outside the Cointegration Relation & Lagged Endogenous Parameters for Equation Exchange Rate

The equation for the exchange rate incorporates the lagged values of exchange rate, inflation rate, and interest rate. These lagged values are important as they represent the past information that may influence the current exchange rate.

Table 4.6: VECM Coefficients: Equation for Exchange Rate

Variable	Coefficient	p-value	Confidence Interval
L1.Exc_Rate	-0.1125	0.319	(-0.334, 0.109)
L1.Inf_Rate	-0.1278	0.001	(-0.205, -0.050)
L1.Int_Rate	0.0034	0.960	(-0.128, 0.135)

The estimated coefficient for the first lag of the exchange rate is -0.1125, indicating a slight negative association between previous and current exchange rate values. Despite this inverse relationship, the corresponding p-value of 0.319 exceeds the 0.05 threshold, suggesting that the effect is not statistically significant. Therefore, past exchange rate values appear to have limited influence in predicting current exchange rate movements.

The first lag of the inflation rate has a coefficient of -0.1278 and a p-value of 0.001, which is well below the 0.05 significance level. This confirms a statistically significant negative effect of lagged inflation on the exchange rate. In essence, elevated inflation in the preceding period appears to contribute to a decline in

the exchange rate, implying that inflationary trends may weaken the value of the domestic currency.

The first lag of the interest rate yields a coefficient of 0.0034, accompanied by a high p-value of 0.960, which exceeds the standard 0.05 threshold. This indicates that the relationship is not statistically meaningful. As a result, short-term fluctuations in interest rates appear to exert minimal or no influence on the exchange rate.

#### 4.10 Deterministic Terms Outside the Cointegration Relation & Lagged Endogenous Parameters for Equation Inflation Rate

The inflation rate equation includes lagged values of the exchange rate, inflation rate, and interest rate, showing the relationship between past values of these variables and the current inflation rate.

Table 4.7: VECM Coefficients: Equation for Inflation Rate

Variable	Coefficient	p-value	Confidence Interval
L1.Exc_Rate	-0.1695	0.458	(-0.618, 0.279)
L1.Inf_Rate	0.1139	0.156	(-0.043, 0.271)
L1.Int_Rate	0.3838	0.005	(0.118, 0.650)

The coefficient for the first lag of the exchange rate is -0.1695, with a p-value of 0.458, which exceeds the 0.05 significance level. This implies that previous exchange rate fluctuations do not have a statistically significant impact on current inflation. In other words, past changes in the exchange rate do not appear to play a direct role in shaping present inflation trends.

The first lag of the inflation rate has a coefficient of 0.1139 and a p-value of

0.156, which is slightly above the conventional 0.05 cutoff. This suggests a modest influence of past inflation on current inflation levels, though the effect lacks statistical significance. Therefore, inflation does not appear to be a strong predictor of its own future behavior.

The first lag of the interest rate has a coefficient of 0.3838 and a p-value of 0.005, which falls below the 0.05 significance level. This signifies a statistically significant positive relationship between past interest rates and current inflation. The result implies that an increase in interest rates during the prior period may contribute to rising inflation, aligning with theoretical expectations that higher interest rates can influence aggregate demand and potentially fuel inflationary trends.

#### 4.11 Deterministic Terms Outside the Cointegration Relation & Lagged Endogenous Parameters for Equation Interest Rate

The interest rate equation considers the lagged values of exchange rate, inflation rate, and interest rate, showing how the past values of these variables influence current interest rates.

Table 4.8: VECM Coefficients: Equation for Interest Rate

Variable	Coefficient	p-value	Confidence Interval
L1.Exc_Rate	-0.0742	0.618	(-0.366, 0.217)
L1.Inf_Rate	-0.0343	0.511	(-0.137, 0.068)
L1.Int_Rate	-0.4255	0.000	(-0.599, -0.252)

The coefficient for the first lag of the exchange rate is -0.0742, accompanied by a p-value of 0.618. This high p-value suggests that previous changes in the exchange

rate do not exert a statistically significant influence on the current level of interest rates.

The first lag of the inflation rate has a coefficient of -0.0343 and a p-value of 0.511, indicating a lack of statistical significance. This implies that previous inflation levels have minimal impact on current interest rate movements, suggesting a limited influence of inflation on monetary policy at this specific lag.

The coefficient for the first lag of the interest rate is -0.4255, with a p-value of 0.000, indicating a highly significant statistical relationship. This strong negative association implies that elevated interest rates in the prior period are often followed by a reduction in current rates. Such a pattern may reflect monetary policy adjustments by the central bank, potentially intended to ease borrowing conditions or support economic growth in response to earlier tightening.

## 4.12 Loading Coefficients (Alpha) for the Equations

These coefficients represent the adjustment speed of each variable in returning to equilibrium when there is a deviation from the long-run relationship (i.e., cointegration).

Table 4.9: VECM Loading Coefficients (Alpha)

Equation	Coefficient	p-value	Confidence Interval
Exc_Rate: ec1	-0.1935	0.029	(-0.367, -0.020)
Inf_Rate: ec1	1.9842	0.000	(1.632, 2.336)
Int_Rate: ec1	0.0695	0.552	(-0.160, 0.299)

The Exchange rate (ec1) error correction term has a coefficient of -0.1935 and a p-value of 0.029, indicating statistical significance. This means the exchange rate corrects deviations from the long-term equilibrium at a speed of approximately 19.35%. The negative sign reflects that when imbalances occur, the exchange

rate tends to adjust in the direction that restores equilibrium over time.

Inflation rate (ec1) error correction term has a coefficient of 1.9842 and a p-value of 0.000, signifying a high level of statistical significance. This result implies that inflation adjusts rapidly toward restoring long-run equilibrium, with an adjustment rate of approximately 198.42%, indicating a strong corrective response to deviations from the equilibrium path..

Interest rate (ec1) error correction term has a coefficient of 0.0695 and a p-value of 0.552, indicating that the interest rate's adjustment toward long-term equilibrium is not statistically significant. This weak response suggests that when interest rates deviate from their equilibrium path, they exhibit little tendency to revert promptly.

### 4.13 Cointegration Coefficients and Long-Run Equilibrium Relationships

The cointegration coefficients ( $\beta$ ) provide critical insights into the long-run equilibrium relationships between economic variables. These coefficients indicate how the variables adjust to maintain equilibrium over the long term.

Table 4.10: Cointegration Vector Estimates (Beta)

Coefficient	Value	p-value	Confidence Interval
beta.1	1.0000	0.000	(1.000, 1.000)
beta.2	-0.7999	0.000	(-0.920, -0.680)
beta.3	-0.2682	0.000	(-0.411, -0.125)

Using Exchange Rate as the Baseline, the first cointegration coefficient,  $\beta_1$ , is normalized to 1.0000. This normalization establishes the exchange rate as the baseline variable against which the effects of the other variables; inflation and interest rates, are assessed. Normalization ensures interpretability and provides a reference point for understanding how deviations in other variables influence

the exchange rate in the long run.

The second cointegration coefficient,  $\beta_2$ , for inflation rate is -0.7999. This value, combined with a p-value of 0.000, signifies a highly statistically significant relationship. The negative coefficient indicates that inflation has an inverse relationship with the exchange rate in the long run. Specifically, for every one-unit increase in inflation, the exchange rate decreases by approximately 0.7999 units. This suggests that higher inflation tends to strengthen the local currency relative to foreign currencies. This result aligns with economic theories that link inflation to exchange rate behavior through purchasing power parity (PPP). When inflation is high, local goods become relatively more expensive, reducing demand for foreign currency and appreciating the exchange rate Vo and Vo (2023). The third cointegration coefficient,  $\beta_3$ , for the interest rate is -0.2682, with a p-value of 0.000, again highlighting statistical significance. The negative sign of the coefficient suggests that interest rates also have an inverse long-term relationship with the exchange rate. This indicates that a one-unit increase in the interest rate corresponds to a 0.2682-unit decrease in the exchange rate. This finding reflects the complex dynamics between interest rates and currency values. Although higher interest rates often attract foreign capital, strengthening the currency in the short term, the long-term effect may involve currency depreciation. This could arise from higher borrowing costs or diminished economic growth, both of which can exert downward pressure on the currency.

Overall, the cointegration coefficients reveal that both inflation and interest rates have significant, negative long-term effects on the exchange rate. The strong statistical significance (p-values of 0.000) underscores the robustness of these relationships. This analysis provides valuable evidence supporting economic theories that describe how macroeconomic variables interact in the long run. Policymakers and researchers can leverage these insights to better understand the dynamic interplay between inflation, interest rates, and the exchange rate, ultimately informing strategies for stabilizing currency values and achieving

economic objectives.

#### 4.14 Forecast Error Variance Decomposition (FEVD) Analysis for Exchange Rate, Inflation Rate, and Interest Rate

Forecast Error Variance Decomposition (FEVD) is a key tool in time series analysis that quantifies the relative contribution of different shocks to the variability of a particular variable over time. It provides a clearer understanding of how the dynamics of exchange rate, inflation rate and interest rate, are driven by their own shocks and those of other variables.

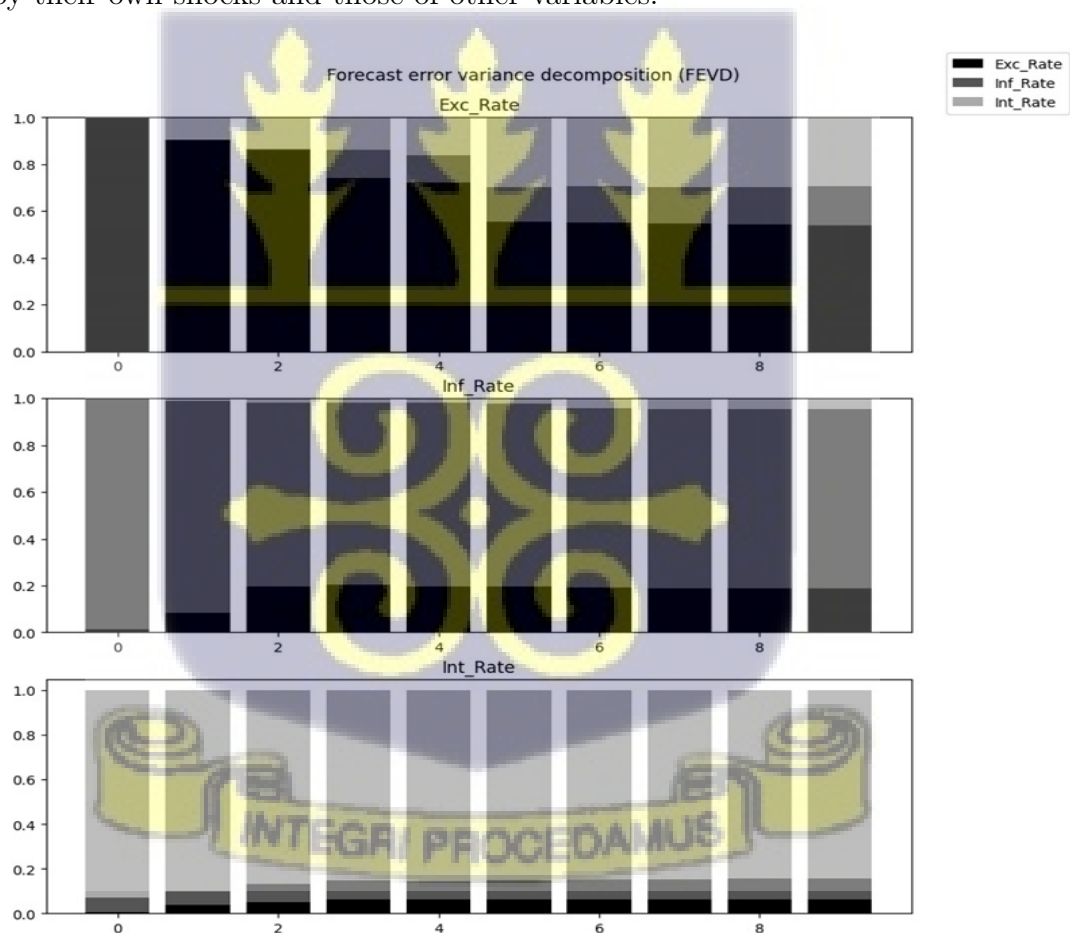


Figure 4.4: Forecast Error Variance Decomposition (FEVD)

#### **4.14.1 Contributions to Exchange Rate Variability**

The FEVD results typically reveal that the exchange rate variability is initially dominated by its own shocks. This suggests that the short-term movements in the exchange rate is largely driven by factors intrinsic to the currency market, such as speculative activities or external market pressures. Over time, however, the contribution of shocks from inflation rate and interest rate, gains prominence. Inflation rate shocks contribute significantly to the medium- and long-term variability of the exchange rate. This reflects the well-established link between inflation and exchange rate dynamics, where high inflation erodes the value of a currency and creates volatility in the foreign exchange market. The increasing influence of inflation shocks over time necessitate the importance of maintaining price stability to ensure exchange rate stability.

Interest rate shocks also play a role in exchange rate variability, albeit to a lesser extent than inflation. The influence of interest rate shocks is more evident in the short to medium term, aligning with the theory that monetary policy adjustments affect exchange rate movements by influencing capital flows. However, their relative contribution tends to diminish in the long term, implying that structural factors may outweigh monetary policy in determining exchange rate trends.

#### **4.14.2 Contributions to Inflation Rate Variability**

The inflation rate variability is predominantly explained by its own shocks, particularly in the short term. This reflects the inertia in inflation dynamics, where price changes tend to persist due to structural factors, such as supply chain disruptions or market rigidities. Over time, the influence of exchange rate shocks becomes more pronounced, highlighting the critical role of the exchange rate in shaping inflationary trends in Ghana.

Exchange rate shocks significantly contribute to inflation variability through the pass-through effect. Currency depreciation increases the cost of imported goods, which feeds into domestic price levels. The growing influence of exchange rate

shocks over time suggests that stabilizing the exchange rate can have a meaningful impact on inflation control.

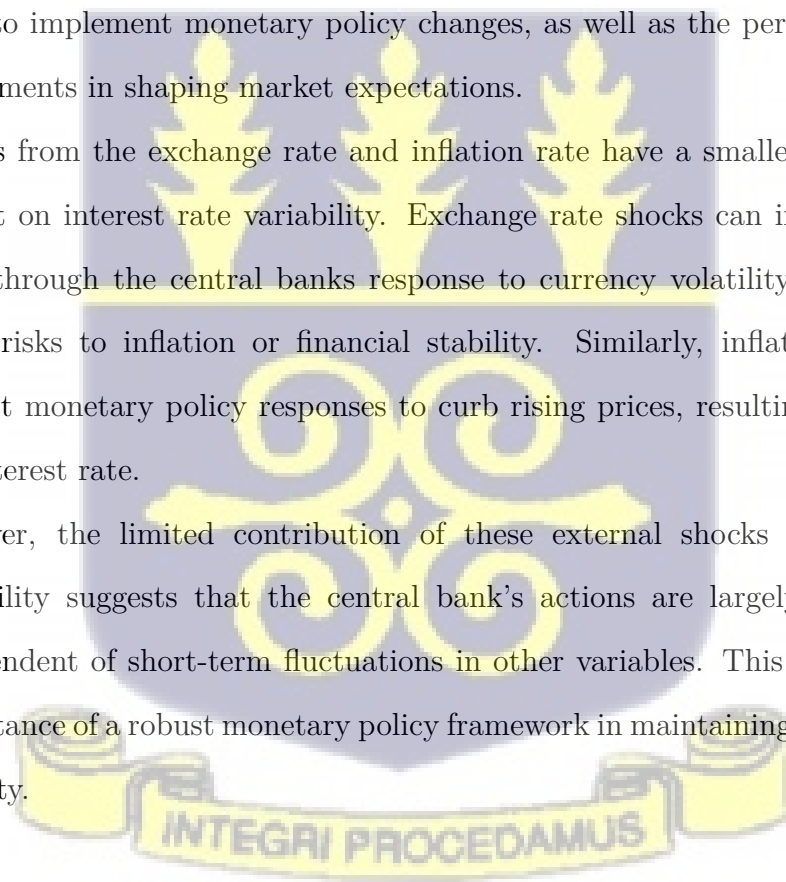
Interest rate shocks have a relatively minor contribution to inflation variability, reflecting the indirect and lagged effect of monetary policy on inflation. While interest rate adjustments can influence inflation by affecting aggregate demand, their impact is often diluted by other structural and external factors, such as supply-side constraints and global commodity prices.

#### 4.14.3 Contributions to Interest Rate Variability

Interest rate variability is largely driven by its own shocks, particularly in the short term. This reflects the deliberate and sustained actions of the central bank to implement monetary policy changes, as well as the persistence of these adjustments in shaping market expectations.

Shocks from the exchange rate and inflation rate have a smaller but noticeable impact on interest rate variability. Exchange rate shocks can influence interest rates through the central banks response to currency volatility, especially if it poses risks to inflation or financial stability. Similarly, inflation rate shocks prompt monetary policy responses to curb rising prices, resulting in changes to the interest rate.

However, the limited contribution of these external shocks to interest rate variability suggests that the central bank's actions are largely proactive and independent of short-term fluctuations in other variables. This underscores the importance of a robust monetary policy framework in maintaining macroeconomic stability.



## 4.15 Impulse Response Function Analysis for Exchange Rate, Inflation Rate, and Interest Rate

The analysis of Impulse Response Functions (IRFs) provides valuable insights into the dynamic relationships between the exchange rate, inflation rate, and interest rate. IRFs measure how a one-unit shock to one variable impacts other variables in an econometric model such Vector Autoregression (VAR) model over time.

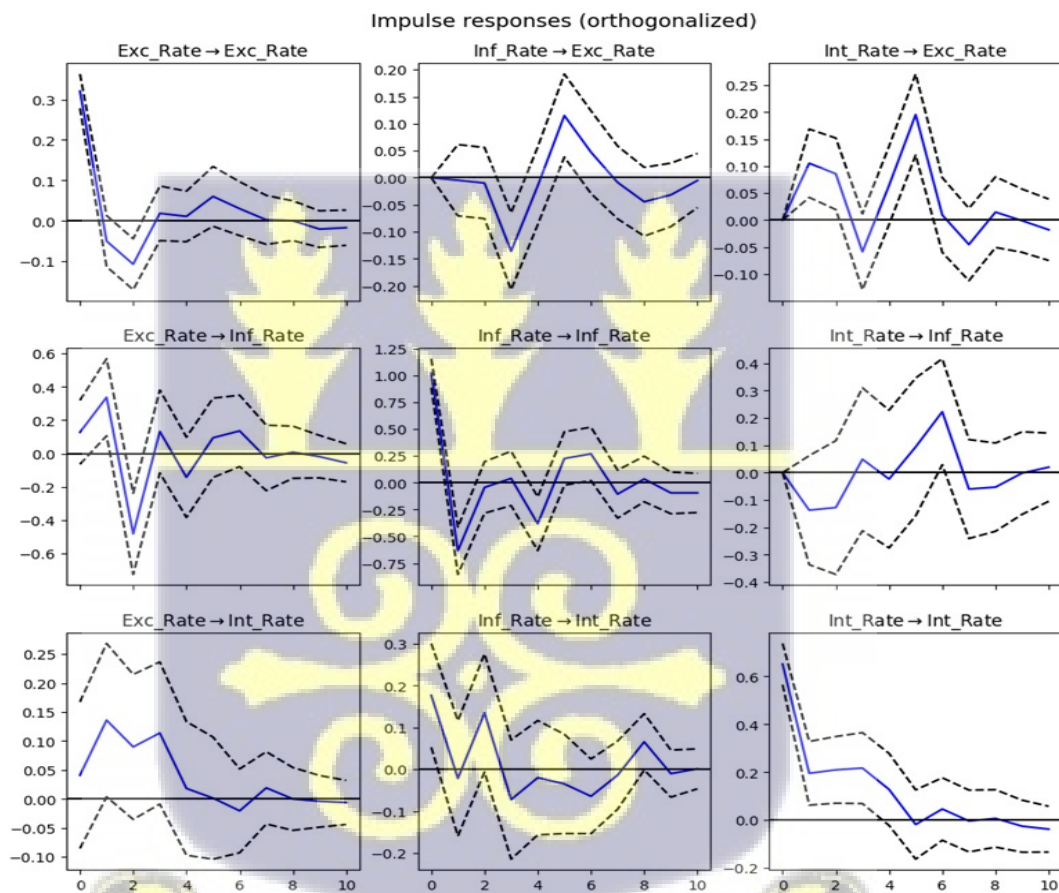


Figure 4.5: Impulse Response Function Analysis for Exchange Rate, Inflation Rate, and Interest Rate

### 4.15.1 Responses of the Exchange Rate

The exchange rate exhibits a self-correcting nature in response to its own shocks. A positive shock to the exchange rate leads to an immediate and sharp increase,

followed by a reversal and stabilization around zero in subsequent periods. This indicates that while the exchange rate may experience short-term volatility due to unexpected shocks, the market mechanisms or policy interventions ensure that such deviations are not sustained over time.

In response to a shock in the inflation rate, the exchange rate initially depreciates, as indicated by the negative response in the early periods. This aligns with economic theories that suggest higher inflation undermines the purchasing power of a currency, leading to depreciation (Muhammad, 2023). However, the impact diminishes over time, suggesting that inflationary pressures may not have long-term effects on the exchange rate under certain conditions.

A shock to the interest rate causes the exchange rate to appreciate in the short term. This reflects the capital inflows associated with higher interest rates, as investors seek to take advantage of better returns (Hau and Rey, 2006). However, this effect gradually fades, indicating that while monetary policy adjustments may influence the exchange rate temporarily, structural factors might determine its long-term trajectory.

#### **4.15.2 Responses of the Inflation Rate**

Inflation exhibits significant inertia when responding to shocks, particularly those originating from itself. A positive shock to the inflation rate leads to a strong and persistent increase, highlighting the sticky nature of inflation. This indicates that once inflationary pressures take hold, they can persist without sustained intervention, reflecting price rigidity in the economy.

Exchange rate shocks also have a notable impact on inflation. A positive shock to the exchange rate, indicative of currency appreciation, initially lowers inflation, as the cost of imported goods declines. However, this effect is oscillatory and diminishes over time, suggesting that the exchange rate plays a critical role in inflation dynamics through the pass-through effect.

The response of inflation to interest rate shocks is characterized by a short-term

reduction in inflationary pressures. This is consistent with the role of monetary policy in curbing inflation. However, the transitory nature of this effect indicates that short-term interest rate adjustments alone may not be sufficient to address underlying inflationary trends, necessitating sustained policy measures.

#### **4.15.3 Responses of the Interest Rate**

The interest rate demonstrates a strong degree of persistence in response to its own shocks. A positive shock leads to a prolonged increase in the interest rate, reflecting deliberate and sustained actions by the central bank to achieve its monetary policy objectives. This suggests that interest rate adjustments are not transient but are maintained to ensure stability in the broader economy.

Shocks to the exchange rate have a negligible and short-lived impact on the interest rate. This weak response may imply that the central bank does not react aggressively to exchange rate movements unless they pose significant risks to macroeconomic stability. Similarly, inflation shocks elicit a positive response in the interest rate, as central banks typically raise interest rates to counter inflation. However, this response is temporary, highlighting the need for complementary measures to address persistent inflationary pressures.

#### **4.16 Threshold Vector Autocorrelation (TVAR) Analysis Results**

The analysis of exchange rate dynamics often requires recognizing that economic relationships may not be uniform across different regimes. The Threshold Variance Autocorrelation Model (TVAM) provides insights into how macroeconomic variables, specifically interest rates and inflation rates, affect exchange rates under different economic conditions. This model partitions the data into two distinct regimes based on whether the exchange rate is above or below its median threshold. The resulting estimations offer valuable insights into

how the behavior of these key economic indicators varies across these regimes.

#### 4.16.1 Low Exchange Rate Regime

Table 4.11: Regression Results for Low Regime

Variable	Coef	Std. Err	t-stat	P> t	[0.025	0.975]
Intercept	-0.2450	0.050	-4.852	0.000	-0.346	-0.144
Int_Rate	0.2735	0.074	3.715	0.000	0.126	0.421
Inf_Rate	0.0100	0.032	0.315	0.754	-0.053	0.073
Durbin-Watson	0.963					
Rs	0.206					

In the low exchange rate regime (Exc\_Rate Median Threshold), the regression results suggest that approximately 20.6% of the variance in the exchange rate can be explained by interest rates and inflation rates ( $R^2 = 0.206$ ). This indicates a moderate explanatory power, suggesting that while these macroeconomic variables influence exchange rate movements, other factors also contribute significantly.

Interest Rate (Int\_Rate) coefficient is positive and statistically significant ( $p < 0.05$ ) in this regime. Meaning that, an increase in interest rates corresponds with a rise in exchange rates, Purporting and affirming that higher interest rates in a low exchange rate regime attract capital inflows, leading to exchange rate appreciation as emphasized by (Combes et al., 2012).

Inflation Rate (Inf\_Rate) coefficient is not statistically significant ( $p = 0.754$ ), indicating that inflation has little direct impact on exchange rates when the exchange rate is relatively low.

The negative intercept in the low exchange rate regime regression suggests that, when both interest rates and inflation rates are at zero, the exchange rate is expected to be negative. While a negative exchange rate is not realistic, this statistical result implies that, in the absence of these economic influences, there is an inherent downward tendency in the exchange rate.

Durbin-Watson Statistic value of 0.963 suggests potential positive autocorrelation in residuals. This implies that past exchange rate movements influence current values, highlighting the persistence of exchange rate fluctuations as revealed by the VECM analysis.

The findings for the low exchange rate regime indicate that interest rate movements play a crucial role in influencing exchange rates. An increase in interest rates attracts foreign investment, leading to higher demand for local currency, and consequently, an appreciation of the exchange rate. Conversely, inflation appears to be less influential in this regime, possibly due to the stabilizing effects of monetary policy. The presence of positive autocorrelation suggests that exchange rate movements are somewhat persistent.

#### 4.16.2 High Exchange Rate Regime

Table 4.12: Regression Results for High Regime

Variable	Coef	Std. Err	t-stat	P> t	[0.025	0.975]
Intercept	0.0850	0.048	1.764	0.083	-0.012	0.182
Int_Rate	-0.2195	0.058	-3.760	0.000	-0.337	-0.102
Inf_Rate	0.0948	0.037	2.535	0.014	0.020	0.170
Durbin-Watson	2.554					
Rs	0.260					

In the high exchange rate regime ( $\text{Exc\_Rate} > \text{Median Threshold}$ ), the regression results indicate that approximately 26% of the variance in the exchange rate is explained by the independent variables ( $R^2 = 0.260$ ). This represents a slightly higher explanatory power than in the low exchange rate regime.

The coefficient of Interest Rate in this regime is relatively negative and statistically significant ( $p < 0.05$ ). Meaning that increasing interest rates lead to a decline in exchange rates. This suggests that in periods of high exchange rates, raising interest rates may be perceived as a signal of tighter monetary policy, reducing currency depreciation.

Inflation Rate coefficient is undoubtedly positive and statistically significant ( $p = 0.014$ ), implying that higher inflation is associated with higher exchange rates. This aligns with economic theory that higher inflation erodes the value of a currency, leading to depreciation (Dornbusch, 2019).

The positive intercept in the high exchange rate regime regression indicates that, when both interest rates and inflation rates are at zero, the exchange rate is expected to be slightly positive. However, since the intercept is not statistically significant ( $p = 0.083$ ), this suggests that the baseline level of the exchange rate in this regime is not strongly influenced by other omitted factors.

Durbin-Watson Statistic value of 2.554 suggests little to no autocorrelation, implying that past exchange rate values do not strongly predict current values in this regime.

In the high exchange rate regime, interest rate dynamics exhibit an inverse relationship with exchange rates, contrasting with the low exchange rate regime. This suggests that when exchange rates are already high, increasing interest rates can lead to currency stabilization, possibly due to the perception of tighter monetary policy. Inflation, on the other hand, has a more pronounced effect in this regime, with higher inflation driving exchange rate depreciation. The absence of autocorrelation suggests that exchange rate movements are more independent and less persistent over time compared to the low exchange rate regime.

The findings of this analysis align with current economic realities in Ghana, where exchange rate volatility remains a major concern. In recent years, the Ghanaian cedi has experienced persistent depreciation against major currencies, largely driven by inflationary pressures, external debt burdens and shifts in interest rate policies.

The Bank of Ghana has often increased interest rates to curb inflation and stabilize the exchange rate (Allor, 2020). However, as seen in the analysis, the effect of interest rates is regime-dependent, while high rates may stabilize the currency in periods of volatility, they could also weaken it in stable periods. This

emphasizes the need for dynamic and adaptive monetary policies rather than a one-size-fits-all approach.

Ghana has also experienced rising inflation due to factors such as higher fuel prices, fiscal deficits, and currency depreciation. The results of the TVAR analysis shows that inflation significantly affects the exchange rate only in volatile periods, reinforcing the need for aggressive inflation control measures to prevent exchange rate crises.

The government and central bank must consider targeted interventions, such as increasing foreign exchange reserves and managing speculative trading activities, particularly in high-volatility periods when inflation has a stronger impact on the currency.

The asymmetric impact of interest rates on exchange rates suggests that tightening monetary policy too aggressively during stable periods could unintentionally weaken the currency by reducing economic growth and investor confidence. Policymakers must balance monetary tightening with growth-supportive policies to maintain macroeconomic stability.



## CHAPTER 5

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

### 5.1 Introduction

This section serve to consolidate the findings of the study and provide guidance on future actions and research. The insights aim to guide stakeholders in improving Ghana's economic stability and resilience by leveraging the power of advanced analytics.

Overall, the summary, conclusion, and recommendations collectively bridge the gap between the studys theoretical findings and practical implications, offering a roadmap for future actions and research directions.

### 5.2 Summary

The summary distills the essential aspects of the study, capturing the objectives, methodologies, and key findings. It provides an overview of how advanced econometric modeling techniques was employed to investigate the dynamic relationships among various exchange rate, interest rates and inflation rate. By focusing on the results, the summary sets the stage for understanding the implications of the findings and the effectiveness of the models used.

The study examined the dynamic interactions between Ghanaian interest rates, inflation, and exchange rate volatility using advanced econometric techniques. The research employed methodologies such as Threshold Vector Autoregression (TVAR), Granger causality test, forecast vector error decomposition, Impulse response function and Vector error correction model to investigate and answer the research objectives.

The findings reveal that interest rates exert both short-term and long-term influences on the exchange rate, with notable volatility as evidenced by (Özen et al., 2020) in their study, relative to the research gap identified for the study. The granger causality test confirms a bidirectional causal relationship between inflation and interest rates, implying that past inflation values significantly influence interest rate movements, and vice versa.

The result also noticed a significant lagged effect of inflation on exchange rates, suggesting that inflationary pressures gradually erode currency value rather than causing immediate shocks. Interest rates showed a delayed causal effect on exchange rates at lag 2 and lag 3, supporting theories that capital flows and investor expectations adjust gradually to monetary policy changes (Warjiyo and Juhro, 2019).

The IRF analysis presented that, a positive shock to interest rates leads to an initial appreciation of the exchange rate, reflecting capital inflows in response to higher returns on investments. However, this effect fades over time. Inflation shocks, on the other hand, cause an initial depreciation of the exchange rate but stabilize after several periods, aligning with the purchasing power parity (PPP) theory. But exchange rate shocks exhibit self-correction tendencies, where sharp fluctuations revert to a stable level after external pressures subside.

The Johansen cointegration test confirms two significant cointegration relationships among the exchange rate, inflation rate and interest rate which confirms the findings of Adabor and Buabeng (2022) in investigating the influence of macroeconomic factors on stock prices in Ghana in the literature. The VECM

results indicate that inflation and interest rates have a long-term equilibrium relationship with exchange rate, meaning that policy misalignment can destabilize exchange rates over time. Short-term adjustments are influenced by external shocks, but long-term stability is dictated by structural economic factors.

Finally, the asymmetric effect by TVAR revealed that interest rates significantly impact exchange rate fluctuations but the effect varies across different exchange rate regimes. The TVAR model demonstrated that in a low exchange rate regime, increasing interest rates leads to a depreciation of the exchange rate, whereas in a high exchange rate regime, rising interest rates tend to stabilize or appreciate the currency. Inflation, on the other hand, was found to exert a stronger influence in periods of high exchange rate volatility, indicating its role as a key driver of currency depreciation.

### 5.3 Conclusion

This study provides empirical evidence that Ghana's interest rate, inflation rate, and exchange rate are highly interconnected, emphasizing the complex dynamics that govern financial stability. The findings highlight that economic variables do not operate in isolation; rather, they influence each other in both direct and indirect ways, necessitating an integrated approach to macroeconomic management.

The Granger causality test confirms that inflation and interest rates are key drivers of exchange rate movements. This suggests that policymakers should not only focus on exchange rate stability but also consider inflation and interest rate trends when making monetary policy decisions. The test results indicate that past values of inflation significantly affect interest rates, which, in turn, exert pressure on exchange rate fluctuations. Therefore, strategies that aim to stabilize the exchange rate must incorporate inflation control measures and well-calibrated interest rate adjustments.

The Impulse Response Function (IRF) analysis provides additional insights into

the short-term effects of economic shocks. It reveals that a sudden increase in interest rates initially leads to currency appreciation, primarily due to capital inflows attracted by higher returns. However, this effect tends to diminish over time, suggesting that sustained interest rate hikes may not be a long-term solution for exchange rate stability. Similarly, inflation shocks result in an initial depreciation of the exchange rate before stabilizing, underscoring the importance of inflation-targeting policies.

The Vector Error Correction Model (VECM) highlights the long-term equilibrium relationships between interest rates, inflation, and exchange rates. The presence of cointegration suggests that these variables move together over time, reinforcing the argument that monetary policy interventions should be coordinated rather than implemented in isolation. The VECM results confirm that short-term deviations from equilibrium are corrected over time, indicating that while temporary shocks may cause fluctuations, structural economic policies play a crucial role in long-term stability.

The Threshold Vector Autoregression (TVAR) approach further enriches this analysis by demonstrating that the effects of interest rate changes depend on the prevailing economic regime. During periods of high interest rates, currency appreciation is more pronounced due to increased capital inflows. However, in low-interest-rate regimes, the impact on exchange rates is relatively weaker, suggesting that monetary policy responses should be adaptive rather than static. Policymakers must recognize that interest rate adjustments will not have uniform effects across all economic conditions, and as such, flexible policy frameworks are necessary to respond effectively to different macroeconomic environments.

In conclusion, the study underscores the importance of synchronizing interest rate policies, inflation control measures, and exchange rate interventions to achieve financial stability. A fragmented approach to monetary policy may lead to unintended consequences, such as persistent exchange rate volatility and heightened macroeconomic uncertainty. Failure to consider the interdependencies

among these variables could result in inefficient policy measures that fail to address underlying economic challenges. Therefore, a holistic and data-driven monetary policy framework is essential to mitigate exchange rate fluctuations, control inflation, and sustain long-term economic growth.

## 5.4 Recommendations

This section provides actionable information based on the study findings. They focus on practical steps that policymakers, financial institutions, and researchers can take to harness the economic driven relationships.

### 1. Strengthen Inflation Control to Stabilize Exchange Rates

Since inflation significantly influences exchange rates, the Bank of Ghana should prioritize inflation-targeting policies to reduce currency depreciation. Exchange rate volatility due to inflation shocks can be mitigated through price stabilization mechanisms and strict monetary policy discipline.

### 2. Adjust Monetary Policies Based on Exchange Rate Regimes

The Threshold Vector Autoregression (TVAR) analysis indicates that the effects of economic variables differ significantly between high and low exchange rate environments. As a result, exchange rate adjustments should be made adaptively, taking into account the dynamic interactions between inflation, interest rates, and relevant external factors, rather than relying on rigid or structurally weak fixed exchange rate regimes. High-exchange-rate periods attract capital inflows, but excessive hikes may increase borrowing costs and slow economic growth, hence policymakers should strike a balance.

### 3. Implement Exchange Rate Monitoring Systems

The Granger causality test suggests a delayed impact of interest rate changes on exchange rates. To respond proactively, the government should develop real-time exchange rate monitoring frameworks. These systems can

provide early warnings of exchange rate instability, allowing policymakers to intervene before volatility escalates.

**4. Enhance Data-Driven Policy Decisions**

Further research should incorporate more macroeconomic indicators, such as trade balances and capital flows, to improve model accuracy. Policymakers should adopt data-driven decision-making frameworks, leveraging both traditional econometrics and machine learning techniques for more precise forecasts.

5. Future research should consider how global monetary policy (e.g., U.S. Fed rate hikes) transmits into Ghana's exchange rate dynamics to better understand external vulnerabilities.



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