University of Rwanda college of business of economics

IMPACT OF EXCHANGE RATE FLUCTUATION ON FOOD SECURITY IN RWANDA

The thesis was submitted to the Department of Economics University of Rwanda University of Rwanda as a Partial Fulfilment of the Requirements for the Degree of Postgraduate, Master of Science in Economics with Applied Quantitative Economics Specialization.

By

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Dedication

My thesis is dedicated to my dear family and friends, whose steadfast encouragement and support have served as the cornerstone of my academic career. Your confidence in my skills and persistent encouragement have been crucial to my success. I sincerely appreciate all of your unending love, compassion, and sacrifices during this project. I am fortunate to have my family by my side because you have given me strength and direction at every turn. To my dear friends: I am incredibly grateful for your unwavering support and for the joy and solace that your friendship and companionship have brought me. This thesis is a sincere expression of my love and gratitude to each and every one of you for helping me become the person I am today and for making this accomplishment possible.

Declaration

Declaring that the thesis "Impact of Exchange Rate Fluctuation on Food Security in Rwanda" is the product of my own original work, I, Antoine KARANGWA, hereby make this declaration. I declare that, with the exception of instances in which specific citations to outside sources are provided, all of the research I did, the data I examined, and the conclusions I came to for this thesis were the result of my own efforts. I have appropriately acknowledged any help and resources I received in order to prepare this thesis.

In addition, I guarantee that this thesis has never been submitted before, in whole or in part, for any other degree or certification at this university or any other educational establishment.

Signed: Antoine KARANGWA Date**: ……**

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Abstract

This study investigates the impact of exchange rate fluctuations on food security in Rwanda, focusing on the short-term and long-term effects on key food security indicators, including unemployment and interest rates. Using panel data analysis from 1990 to 2022, the research reveals that exchange rate volatility significantly influences food security, particularly through its effects on unemployment and interest rates. The findings highlight that a depreciating exchange rate exacerbates food insecurity by increasing the cost of food imports, raising interest rates, and reducing household purchasing power due to higher unemployment. The analysis underscores the need for policy interventions to stabilize the exchange rate, enhance domestic agricultural production, and strengthen the resilience of the financial sector. Recommendations include maintaining exchange rate stability through targeted monetary and fiscal policies, investing in agricultural infrastructure to boost domestic food production, and implementing social protection programs to mitigate the adverse effects of unemployment on food security. Additionally, the study advocates for ongoing research and monitoring to inform policy decisions and adapt to evolving economic conditions. By addressing these critical areas, Rwanda can mitigate the negative impacts of exchange rate fluctuations on food security, ensuring a more stable and secure food supply for its population. The study contributes to the broader understanding of the complex relationship between macroeconomic variables and food security in developing countries, offering practical solutions for policymakers to enhance food security in the context of exchange rate volatility.

Key words: Exchange rate fluctuations, Food security.

Contents

Chapter 1. General Introduction

1.0. Introduction

Although the Republic of Rwanda has made great strides toward economic growth and the reduction of poverty, there are still issues with food security, particularly for the most vulnerable rural residents. The bulk of the workforce in Rwanda is employed in agriculture, which contributes significantly to the country's GDP. The standard of living and well-being of Rwandan households can be significantly impacted by changes in food prices and agricultural productivity(Ayittey, 2017).

The volatility of exchange rates is one important factor affecting Rwanda's food security. The dynamics of trade, monetary policy decisions, and world economic conditions are just a few of the variables that can cause the Rwandan franc (RWF) to fluctuate in value relative to other major international currencies. Since Rwanda mainly depends on imports to meet its domestic food needs, especially for staples like rice, wheat, and cooking oil, these exchange rate fluctuations may have an effect on the price of imported food items. Exchange rate fluctuations can also have an impact on Rwanda's agricultural exports' profitability and competitiveness, which could make the country's problems with food security worse by lowering farmer incomes and productivity (IMF, 2022).

Policymakers, researchers, and development practitioners must comprehend how exchange rate fluctuations affect Rwanda's food security (Huber-Lee et al., 2023). Understanding how changes in exchange rates affect food security indicators like food prices, household incomes, nutritional outcomes, and agricultural productivity can be obtained by looking at this relationship. These understandings are crucial for creating successful policy interventions that will increase Rwanda's food security, livelihoods, and economic resilience (IMF, 2022).

Using a Vector Autoregression (VAR) modeling approach, this study aims to examine the effect of exchange rate fluctuations on food security in Rwanda. Through the use of VAR analysis, we hope to provide a more nuanced understanding of the mechanisms through which exchange rate volatility influences food security outcomes by capturing the dynamic interactions between exchange rates and food security indicators over time. With a focus on evidence-based policy recommendations and rigorous empirical analysis, this research seeks to support Rwanda's ongoing efforts to address issues related to food security and sustainable development.

2.1. Background of the Study

Even after undergoing a dramatic economic shift in recent years, Rwanda, an East African landlocked nation, continues to face difficulties with food security. Much of the population is still at risk of food insecurity despite progress made in reducing poverty and growing the economy, especially in rural areas where agriculture is the main source of income. Rwanda's GDP is largely derived from agriculture, which also employs the vast majority of its labor force. Nonetheless, the industry is vulnerable to a number of risks and vulnerabilities, such as market volatility, land degradation, and climate change (Danso-Abbeam et al., 2021).

The volatility of exchange rates is one important factor affecting Rwanda's food security. The value of the Rwandan franc (RWF) varies compared to other major world currencies, which can affect the price of imported food, inputs for agriculture, and export revenue (Huber-Lee et al., 2023). Rwanda's domestic food needs are largely met by imports, particularly for staples like rice, wheat, and cooking oil (Kuperman, 2000). As a result, changes in exchange rates may have a significant impact on the availability, accessibility, and consumption of food, which may have an adverse effect on Rwandan households' standard of living (Niragire et al., 2022).

Comprehending the intricate correlation between fluctuations in exchange rates and food security is imperative for the successful development and implementation of policies (Hassan, 2022). Prior studies have examined the wider factors influencing food security in Rwanda; however, there is a dearth of empirical data regarding the precise influence of fluctuations in exchange rates on crucial indicators of food security (Kuperman, 2000). By performing a thorough analysis with the use of sophisticated econometric techniques, particularly Vector Autoregression (VAR) modeling, this study seeks to close this gap. The study looks at the dynamic relationships between exchange rates and the results of food security with a focus on Rwanda (Manirambona et al., 2021). The study intends to provide a deeper understanding of how exchange rate volatility affects Rwandan food security through the use of VAR modeling (Baraka et al., 2022).

2.2. Problem Statement

Notwithstanding Rwanda's endeavors to enhance food security, susceptibilities endure, and fluctuations in exchange rates may jeopardize the nation's advancement in this domain (Umoru et al., 2023). It is still unclear how exchange rate volatility affects measures of food security like food costs, household incomes, nutritional results, and agricultural output (Nsabimana et al., 2020).

Policymakers' capacity to create focused interventions to lessen the negative effects of exchange rate fluctuations on vulnerable populations is hampered by this lack of empirical evidence (Wibowo et al., 2023).

The literature that is currently available on exchange rate fluctuations and food security frequently ignores the unique dynamics and context of Rwanda in favor of focusing on larger macroeconomic relationships (IMF, 2022). Furthermore, prior research frequently uses aggregate-level data or oversimplified modeling techniques, which makes it difficult to understand the complex and dynamic relationship between exchange rates and food security outcomes (IMF 2022).

Therefore, in order to fully examine the effects of exchange rate fluctuations on food security in Rwanda, rigorous empirical research utilizing advanced econometric techniques such as VAR modeling is desperately needed. This research aims to inform evidence-based policy formulation and support Rwanda's sustainable development goals by offering solid evidence and insights into the mechanisms through which exchange rate volatility affects food security outcomes

.1.3. Research Objectives

This study aims specifically to:

1) Examine the immediate and long-term impacts of changes in exchange rates on important measures of Rwanda's food security.
2) Determine the channels of transmission via which fluctuations in exchange rates impact Rwanda's food security results.

1.4. Research Questions

This study attempts to answer the following research questions:

1) What effects do changes in exchange rates have on Rwandan food prices, nutritional outcomes, and agricultural production?
2) What are the mechanisms by which fluctuations in exchange rates impact the nation's food security outcomes?

1.5. Limitations of the Study

External factors: Results related to food security may also be influenced by other external factors that are outside the purview of this study, such as global market trends and climatic conditions.

Methodological restrictions: VAR modeling has built-in restrictions and presumptions that need to be taken into account, even though it offers insights into the dynamic interactions between variables.

1.6. Organization of the Study

An overview of the research background, problem statement, objectives, and research questions can be found in the first chapter on general introduction. In order to offer theoretical and empirical insights, the second chapter concentrates on a review of the literature on exchange rate fluctuations, food security, and related subjects. The third focuses on the methodology, outlining the data sources, analytical methods, and research design, which includes the VAR modeling strategy. The VAR analysis's results are presented in the fourth, along with their implications for Rwanda's food security. Discussion of Policies and Suggestions, examines the results in light of the body of existing literature and makes recommendations for concrete policy measures to strengthen the resilience of food security. Briefly summarize the main findings, their ramifications, the study's contributions, and potential directions for future research in your concluding remarks.

Chapter 2. Literature Review

2.0. Introduction

Food security is significantly impacted by changes in exchange rates. Research has indicated that fluctuations in exchange rates have an adverse impact on international trade flows, potentially leading to detrimental effects on global food supply chains (Steinbach, 2023). It has also been discovered that shocks to the price of crude oil and exchange rates both raise the cost of food, with the impact of oil price shocks being larger than that of exchange rate shocks (Aminah, 2022). The Consumer Price Index (CPI) of Agri-food and exchange rate change have an inverse relationship, meaning that a high exchange rate reduces consumers' purchasing power (El et al., 2022). Food security may suffer from price volatility in global commodity markets, which is partially caused by exchange rates, especially for low-income populations. For vulnerable populations, price spikes and misguided policy responses can make food insecurity worse (Naylor & Falcon, 2010). Exchange rate volatility affects the security markets as well; in certain BRICS nations, it has a positive impact on bond yields and equity returns (Bonga-Bonga, 2020).

2.1. Theoretical Literature Review

2.2.1. Exchange Rate Volatility and Food Prices

Exchange rate fluctuations can impact food prices, as explained by theoretical frameworks like the purchasing power parity (PPP) theory and the exchange rate pass-through (ERPT) mechanism (Chevillon & Mignon, 2004). PPP theory states that changes in exchange rates should affect the relative costs of goods, including food, and thus affect domestic prices. The ERPT mechanism investigates the extent to which changes in exchange rates impact domestic prices in more detail (Obansa & Obansa, 2018). Theoretical research indicates a negative correlation between foreign trade flows and exchange rate volatility, which would have a detrimental effect on the world's food supply chains (Hasan & Masih, 2018). It can be difficult for policymakers to stabilize food inflation when exchange rate fluctuations, which are influenced by external factors like supply and demand for currencies, result in asymmetric short-run effects on food prices (Emmanuel, 2014). Furthermore, poor policies intended to stabilize prices worsen the effect of exchange rate volatility on food prices by increasing volatility and food insecurity among vulnerable populations (Steinbach, 2021). Additionally, empirical data highlights the negative effects of exchange rate shocks on food prices in commodity-exporting countries by showing how exchange rate variations,

when combined with interest rate fluctuations, positively affect food commodity prices in African countries (Naylor & Falcon, 2010).

2.2.2. Impact of Exchange Rates on Agricultural Production

The competitiveness hypothesis and the J-curve theory are two theoretical models that contend that changes in exchange rates can affect input costs, export competitiveness, and farmer incomes, all of which have an impact on agricultural production (Mendis, 2016). A rise in the value of the home currency could make agricultural exports less profitable, while a decline in value could make exports more competitive but also increase input costs, which could affect production choices (Husain, 2018).

One important factor that is influenced by a number of macroeconomic variables is the effect of exchange rates on agricultural production. Exchange rate misalignment has a substantial impact on imported goods, including agricultural products, according to studies (Asma Fiaz et al., 2023). Furthermore, research on the connection between exchange rates and agricultural exports has shown that changes in exchange rates have a favorable effect on agricultural exports from Nigeria (Bocock, 2006). Additionally, research has been done on the impact of exchange rates on foreign direct investment in the agriculture sector, showing both positive and negative correlations with factors like GDP and money supply (Okafor & Isibor, 2021). Both inflation and interest rates are important; research indicates that inflation hurts the agriculture industry, but interest rates might not have a big impact (Olufemi et al., 2022).

2.2.3. Transmission Channels of Exchange Rate Effects on Food Security

Exchange rate fluctuations have the potential to impact food security through multiple transmission channels, as highlighted by theoretical frameworks (Headey & Fan, 2010). These include impacts on trade balances, macroeconomic stability, farmers' and consumers' income, and direct effects on food prices. To lessen the negative effects of exchange rate volatility on food security, policymakers must have a thorough understanding of these transmission channels in order to develop appropriate policy responses (Ngaruko et al., 2019).

Important insights are revealed by the theoretical literature on the transmission channels of exchange rate effects on food security, which focuses on factors like inflation, interest rates, income, and food security. Research suggests that fluctuations in exchange rates have an adverse

effect on global trade flows (Li Fei, 2012), impacting the security of food. Furthermore, changes in exchange rates can cause shocks in the world's food markets to spread through trade relations, which can be especially detrimental to developing nations (Steinbach, 2021). Additionally, research highlights how critical it is to comprehend how economic shocks spread, including how exchange rates affect important macroeconomic indicators like GDP, public debt, and exchange rates (Galoyan & Hovsepyan, 2023). The complex interactions among exchange rates, economic shocks, and food security are highlighted by these findings, underscoring the necessity of thorough analysis to reduce risks and improve the resilience of the world's food supply chains.

2.2. Empirical Literature Review

2.2.1. Impact of Exchange Rates on Food Prices

Numerous nations' empirical research has looked at the connection between food prices and exchange rates (Chevillon & Mignon, 2004; Obansa & Obansa, 2018; Kumar & Suresh, 2019).

Research has indicated that fluctuations in exchange rates can have a negative impact on the cost of food (Köse & Ünal, 2022). Furthermore, there is a complex relationship between exchange rates and food prices, with some countries benefiting from fluctuations in exchange rates (Umoru & Amedu, 2022). Furthermore, in countries that export commodities, where terms of trade fluctuations can result in unstable exchange rates, the impact of exchange rates on food prices is especially significant (Steinbach, 2021). The study highlights how crucial it is to comprehend how food prices and exchange rates interact in order to create effective inflation control measures (Bala & Abdullahi, 2019). The literature, taken as a whole, emphasizes the necessity of comprehensive strategies that take exchange rate fluctuations into account as a major factor in determining food prices in different regions (Rehman & Chisti, 2020).

2.2.2. Effects of Exchange Rates on Agricultural Production

There is conflicting empirical data regarding how exchange rates affect agricultural productivity (Mendis, 2016; Husain, 2018; Headey & Fan, 2010). According to studies, changes in exchange rates can cause shifts in the excess supply and demand between nations in the global market, which can have an impact on trade in agricultural products (Bocock, 2006). It has been discovered that real exchange rate increases lower export volumes and the likelihood of reaching target markets (Mao, 2019). Furthermore, it has been discovered that positive exchange rate shocks have a

negative impact on agricultural investment, whereas negative exchange rate shocks have a positive one (Baghestany & Sherafatmand, 2019). Compiling de-identified data on specific commodities is crucial to comprehending the extent to which exchange rates impact agricultural trade (Yanikkaya et al., 2013). Regarding India, there is a long-term, unidirectional causal relationship between agricultural exports and the foreign exchange rate of the nation (Sinha & Partha Pratim Sengupta, 2017).

2.2.3. Transmission Channels of Exchange Rate Effects on Food Security

Research examining the pathways through which exchange rate impacts affect food security have brought attention to the significance of elements like market structure, trade openness, and governmental regulations (Ngaruko et al., 2019).

The effect of exchange rate fluctuations on inflation and the ensuing consequences for food security have been the subject of numerous studies. Chen and Li (2019) examined the dynamic relationships between food security, inflation, and exchange rates in developing nations using a Vector Autoregression (VAR) model. According to their research, lower exchange rates raise import costs, which exacerbates inflationary pressures and food insecurity, especially for disadvantaged groups. Similarly, Karim and Asim (2018) used a structural VAR model to investigate how Pakistan's inflation and food security are affected by changes in the country's exchange rate. Their findings suggest that changes in exchange rates have a considerable trickle-down effect on domestic prices, increasing food inflation and worsening food security conditions.

The literature on how changes in exchange rates affect food security places special emphasis on the direct and indirect ways that changes in exchange rates affect the availability, accessibility, and consumption of food. De Schutter (2013) emphasized how vulnerable populations experiencing food insecurity are to fluctuations in exchange rates, especially in low-income nations that depend significantly on food imports. Furthermore, Reardon et al. (2018) carried out a cross-national analysis to look at the connections between agricultural trade policies, exchange rates, and the results of food security. Their research showed that changes in exchange rates have an impact on the competitiveness of agricultural imports and exports, which in turn has an impact on domestic food access and availability.

Changes in exchange rates have a profound effect on trade dynamics and food security, especially in nations where the supply of food is largely dependent on foreign markets. Ahmed and Azid (2017) examined the connection in a few Asian nations between exchange rate volatility, agricultural trade openness, and food security. Similarly, Kilic et al. (2016) investigated how exchange rate policies affect the results of food security in Sub-Saharan Africa. These studies highlight the importance of exchange rate stability as a critical factor influencing food security, especially in areas where the supply of food is largely dependent on international trade.

When it comes to mediating the relationship between exchange rate fluctuations and food security outcomes, income levels are vital. Focusing on the income channel, Haggblade et al. (2019) examined how changes in exchange rates affected Malawian households differently in rural and urban areas. Moreover, Osabohien and Odebiyi (2017) examined how Nigerian household welfare and food security were affected by exchange rate volatility's effects on income. These studies underline the necessity of focused policy interventions to reduce income-related vulnerabilities and emphasize the significance of income dynamics in determining the transmission channels of exchange rate effects on food security.

2.3. Conceptual framework

The impact of exchange rate fluctuations on food security in Rwanda remains a critical issue that intertwines various economic indicators, including interest rates, unemployment, and overall economic stability. The conceptual framework focuses on four key variables: exchange rate, interest rate, unemployment, and food security. This streamlined approach aims to clarify the direct and indirect relationships between these variables, thereby providing a more focused analysis of how exchange rate dynamics influence food security in Rwanda.

Exchange Rate (ER)

Exchange rate fluctuations are central to this framework, as they directly affect the cost of imports and exports, influencing the prices of goods, including essential food items. A depreciation in the exchange rate typically makes imports more expensive, which can lead to higher food prices and increased food insecurity. Conversely, an appreciation of the exchange rate might lower the cost of imports but could also adversely affect domestic sectors that are in competition with cheaper foreign goods, which might result in employment losses.

Interest Rate (INTR)

Interest rates are a major factor in determining the cost of borrowing and are intimately related to changes in exchange rates. High interest rates have the potential to draw in foreign capital, which would increase the value of the local currency. They may, however, also raise the cost of borrowing for consumers and companies, which could have a negative impact on economic activity and food security by limiting access to reasonably priced credit for the production and acquisition of food.

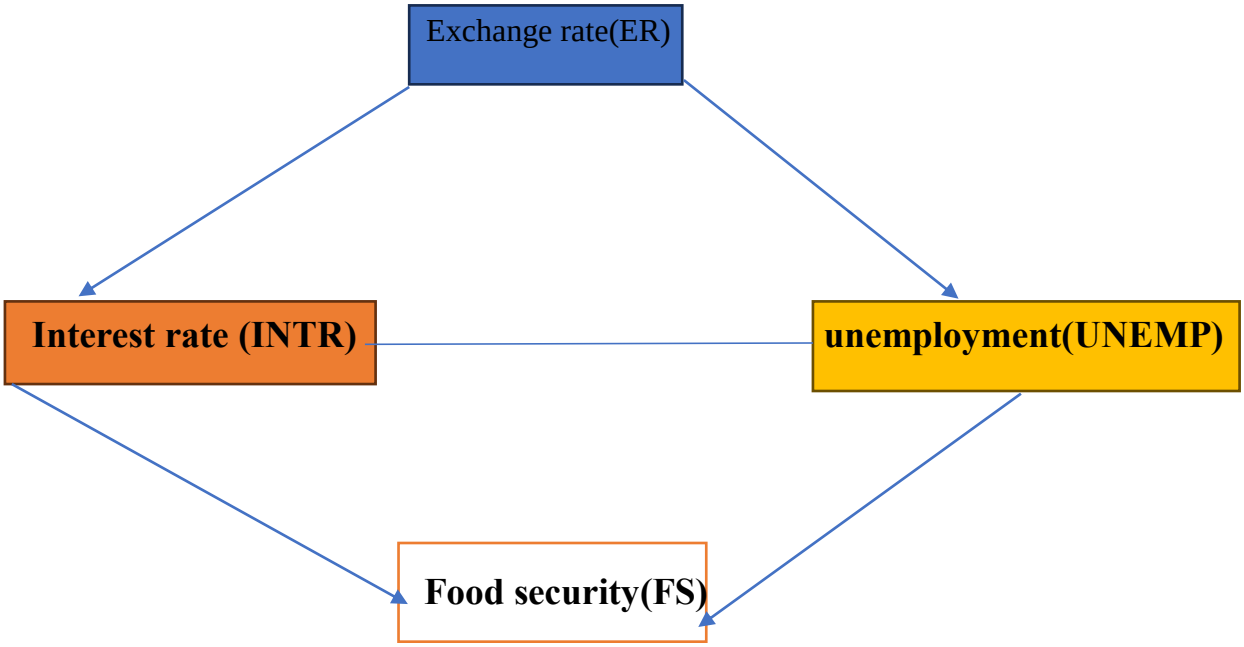
Unemployment (UNEMP)

Unemployment is a critical variable in the framework, as it directly impacts household income and purchasing power. High unemployment rates can exacerbate food insecurity by reducing the ability of households to afford food. Exchange rate fluctuations can affect employment levels by influencing the competitiveness of domestic industries. For instance, a weaker exchange rate might boost export-oriented industries, potentially increasing employment, but could also lead to higher import costs and job losses in sectors reliant on imported inputs.

Food Security (FS)

Food security is the ultimate outcome of interest in this framework. It is directly affected by the other three variables exchange rate, interest rate, and unemployment. The framework posits that exchange rate fluctuations, through their impact on prices, interest rates, and employment, can significantly influence food security. Understanding these relationships is crucial for policymakers aiming to ensure food security in the face of economic volatility.

Thus, income disparity may be harmful to a country's capacity for economic growth and development (Agwu & Oteh, 2014). When income inequality increases, food security decreases (Grzelak, 2017).


Exchange rate(ER)
Interest rate (INTR)
unemployment(UNEMP)
Food security(FS)

Chapter 3. Methodology

3.0. Introduction

This study's methodology examines how changes in exchange rates impact Rwanda's food security indicators using advanced econometric techniques, particularly Vector Autoregression (VAR) modeling. The objective of this study is to offer significant perspectives on the intricate relationships between exchange rates and food security outcomes by means of an extensive analysis of various data sources, such as household income, agricultural productivity, food prices, and nutritional outcomes. In order to guarantee the accuracy of the outcomes, the estimation method employs statistical

3.1. Research Design

This study uses a quantitative research design to examine how changes in exchange rates affect Rwanda's food security metrics. Econometric methods, specifically Vector Autoregression (VAR) modeling, are employed in the study to investigate the dynamic connections between exchange rates and food security results.

3.2. Data sources

Exchange rate information is one of the many sources from which data will be gathered: data on the Rwandan franc's (RWF) quarterly exchange rate against major foreign currencies, sourced from Rwanda's National Institute of Statistics. Food safety: Information obtained from the National Institute of Statistics of Rwanda (NISR) and other pertinent government agencies about the costs of staple foods (such as rice, wheat, and maize) in both retail and agricultural markets. NISR interest rate data. The data set includes Q1 2006 and Q4 2023.

3.3. Variable Selection, definitions and measurement

The following variables will be included in the VAR model of the study: Endogenous variables include interest rates and food security. Exchange rates are an exogenous variable.

Food Security: The availability, accessibility, and consumption of food within a specific population or area are represented by this variable. It might include metrics like food production, consumption trends, nutritional status, and obstacles to food access.

An interest rate represents the portion of the principal that a lender charges a borrower for the use of assets. The common way to express interest rates is as an annual percentage of the principal.

Exchange Rates: Exchange rates, which describe the value of one currency in relation to another, are important in financial transactions and international trade. Changes in exchange rates can have an impact on import prices, export competitiveness, and general economic stability. These factors can then have an impact on food prices and the results of food security. The exchange rate used in this study is expressed in Frw per US dollar.

Unemployment: Changes in exchange rates can have an impact on employment levels through industries like manufacturing, services, and agriculture. These effects can then have an impact on people's ability to afford food and contribute to food security.

3.4. Model Specification

The variables that have been chosen, their lag times, and any potential covariates will be used to specify the VAR model. Information criteria (e.g., Akaike Information Criterion, Bayesian Information Criterion) will be used to choose the lag length. We'll perform robustness checks to make sure the model is valid and stable.

The VAR model internalizes the variables that will be investigated and determines the lag value in order to investigate the dynamic relationship between the variables. This model can demonstrate how changes in one variable impact other internal variables in the system, accurately illustrating the relationship between variables. These are the equations that were examined in this study:

$Y_t = \emptyset_1 Y_{t-i} + \cdots + \emptyset_p Y_{t-p} + DX_t + \varepsilon_t$ where $t = 1,2,\cdots,T, Y_t$ is a k−spacial endageous colimn vector, X_t is an n−spacial exogenous variable, and p is a lag order, and $\emptyset_1, \emptyset_2, \emptyset_3, \cdots, \emptyset_p$ and D are coefficient matrices that need to be estimated, and ε_t is K as a disturbance term. The best lag order should be determined using the AIC and SC rules prior to configuring the VAR model, and stability analysis should be performed once more to ascertain whether the VAR model is appropriate. Presuming the VAR (2) model is real:

$$X_t = A_1 X_{t-i} + A_2 X_{t-i} + B_1 Y_{t-i} + B_2 Y_{t-i} + \varepsilon_{1t}$$

$$Y_t = C_1 X_{t-i} + C_2 X_{t-i} + D_1 Y_{t-i} + D_2 Y_{t-i} + \varepsilon_{2t}, t = 1, 2, \cdots, T$$

The iterative method is the primary means of achieving the impulse response analysis. Iteration can be used to obtain X_0, X_1, X_2, ⋯ and Y_0, Y_1, Y_2, ⋯ when $\varepsilon_1 = 1$, $\varepsilon_2 = 0$. X shock is the cause of all the data above. The sequence in which Y and X answered. The corresponding shock reflection function can be obtained simultaneously when $\varepsilon_1 = 0$ and $\varepsilon_2 = 1$(Zhou, 2020).

By substituting the variables into the VAR model equations, as outlined by Zhou (2020), For my research, the equations corresponding to the Vector Autoregression model are created.

$$\boldsymbol{ER}_{\boldsymbol{t}} = \delta_1 + \sum_{i=1}^{K} \beta_i \, INTR_{i_{t-i}} + \sum_{J=1}^{K} \emptyset_j \, FS_{t-J} + \sum_{m=1}^{K} \gamma_m \, ER_{t-m} + \sum_{k=1}^{v} \rho_k \, UNEMP_{t-k} + u_{1_t} \quad (1)$$

$$\boldsymbol{INTR}_{\boldsymbol{t}} = \delta_2 + \sum_{i=1}^{K} \beta_i \, INTR_{i_{t-i}} + \sum_{J=1}^{K} \emptyset_j \, FS_{t-J} + \sum_{m=1}^{K} \gamma_m \, ER_{t-m} + \sum_{k=1}^{v} \rho_k \, UNEMP_{t-k} + + u_{2_t} \quad (2)$$

$$\boldsymbol{FS}_{\boldsymbol{t}} = \delta_3 + \sum_{i=1}^{K} \beta_i \, INTR_{i_{t-i}} + \sum_{J=1}^{K} \emptyset_j \, FS_{t-J} + \sum_{m=1}^{K} \gamma_m \, ER_{t-m} + \sum_{k=1}^{v} \rho_k \, UNEMP_{t-k} + u_{3_t} \quad (3)$$

$$\boldsymbol{UNEMP}_{\boldsymbol{t}} = \delta_5 + \sum_{i=1}^{K} \beta_i \, INTR_{i_{t-i}} + \sum_{J=1}^{K} \emptyset_j \, FS_{t-J} + \sum_{m=1}^{K} \gamma_m \, ER_{t-m} + \sum_{k=1}^{v} \rho_k \, UNEMP_{t-k} + u_{5_t} \quad (4)$$

ER: **E**xchange **R**ate

FS: **F**ood **S**ecurity

UNEMP: Unemployment

INTR: Interest rate

3.5. Stationarity teste

Because using non-stationary time series data modeling can lead to "pseudo regression" problems and erroneous test results. In order to reduce the likelihood of "pseudo regression," the validity of the first variable is evaluated using the ADF approach. The general expression of the model is as follows:

$$\Delta y_t = \alpha_1 + \alpha_2 + (\rho - 1) y_{t-1} + \sum_{i=1}^{m} \beta_i \, y_{t-1} + \varepsilon_t$$

According to the first theory, H0: ε_(t) = 1, where ε_(t) is a white disturbance, arrangement Y is unstable and contains a unit root. If the value of the F variable in the computation results is higher than the boundary value, the empirical conclusion is to reject the initial conjecture. If not, the test shows that Y is a stationary process and that the initial variable is not.

3.5. Estimation Technique

We will use statistical software such as EViews to estimate the VAR model. The lagged variables' coefficients will be estimated using Ordinary Least Squares (OLS) estimation. A battery of diagnostic tests will be performed to evaluate the goodness of fit and validity of the model, including tests for serial correlation, heteroscedasticity, unit root test, and normality of residuals.

3.6. Impulse Response Analysis

To investigate the dynamic reactions of food security indicators to exchange rate shocks, impulse response analysis will be done. This analysis will shed light on how changes in exchange rates affect food security outcomes over the short- and long-terms.

3.7. Variance Decomposition Analysis

To determine how much exchange rate shocks contribute to the explanation of variations in food security indicators relative to other factors, variance decomposition analysis will be performed. This analysis will assist in determining the main forces behind Rwanda's dynamics of food security.

Chapter 4: RESULTS

4.1. Descriptive statistics

The variables under consideration are thoroughly outlined by the descriptive statistics, spanning from 2007Q1 to 2023Q4. The descriptive statistics for the study on the impact of exchange rate fluctuation on food security in Rwanda provide an insightful overview of the key variables: exchange rate, food security, interest rate (INTR), and unemployment (UNEMP) over the period from 2006Q1 to 2023Q4. The mean exchange rate during this period was 753.50 Rwandan francs per unit, with a standard deviation of 188.18, indicating moderate variability around the mean. Food security had a mean index of 288.39, with a standard deviation of 69.08, suggesting significant fluctuations. Interest rates averaged 6.68%, with a slightly lower variability (standard deviation of 1.65). Unemployment had a mean rate of 12.29%, with the highest skewness (1.53), indicating a distribution with a long tail on the right. Notably, the Jarque-Bera test for unemployment shows a probability of 0.000, suggesting a non-normal distribution.

Date: 08/28/24
Time: 06:40
Sample: 2006Q1 2023Q4

	EXCHANGE_RATE	FOOD_SECURITY	INTR	UNEMP
Mean	753.5000	288.3889	6.678801	12.28677
Median	696.5000	291.5000	6.375741	11.77350
Maximum	1239.000	391.0000	11.30167	15.79000
Minimum	543.0000	163.0000	3.454333	10.76000
Std. Dev.	188.1771	69.08386	1.650839	1.329243
Skewness	0.618924	-0.100391	0.598490	1.534699
Kurtosis	2.289590	1.693467	3.306206	3.819604
Jarque-Bera	6.110848	5.242025	4.579573	30.27887
Probability	0.047103	0.072729	0.101288	0.000000
Sum	54252.00	20764.00	480.8737	884.6477
Sum Sq. Dev.	2514154.	338853.1	193.4941	125.4490
Observations	72	72	72	72

4.2. Stationarity test

1.Food security

The stationarity test results for the logarithm of food security (LFOOD_SECURITY) using the Augmented Dickey-Fuller (ADF) test indicate that the variable is stationary at the first difference. The ADF test statistic is -4.987272, which is significantly higher in absolute value than the critical values at the 1%, 5%, and 10% levels (-3.531592, -2.905519, and -2.590262, respectively). This result leads to the rejection of the null hypothesis that the differenced series has a unit root, with a p-value of 0.0001, indicating strong evidence of stationarity.

2.interest rate

The stationarity test results for the interest rate (INTR) using the Augmented Dickey-Fuller (ADF) test indicate that the variable is stationary at the first difference. The ADF test statistic is -6.670102, which is significantly higher in absolute value than the critical values at the 1%, 5%, and 10% levels (-3.527045, -2.903566, and -2.589227, respectively). This strong result leads to the rejection of the null hypothesis that the differenced series has a unit root, with a p-value of 0.0000, providing compelling evidence of stationarity.

3. unemployment

The stationarity test results for the unemployment rate (UNEMP) using the Augmented Dickey-Fuller (ADF) test indicate that the variable is stationary at the second difference. The ADF test statistic is -7.143688, which is significantly higher in absolute value than the critical values at the 1%, 5%, and 10% levels (-3.548208, -2.912631, and -2.594027, respectively). This strong result leads to the rejection of the null hypothesis that the differenced series has a unit root, with a p-value of 0.0000, providing compelling evidence of stationarity.

4. exchange rate

The stationarity test results for the exchange rate (LEXCHANGE_RATE) using the Augmented Dickey-Fuller (ADF) test indicate that the variable is stationary at the second difference. The ADF

test statistic is -9.130605, which is significantly higher in absolute value than the critical values at the 1%, 5%, and 10% levels (-3.528515, -2.904198, and -2.589562, respectively). This result leads to the rejection of the null hypothesis that the differenced series has a unit root, with a p-value of 0.0000, providing strong evidence of stationarity.

Summary tables of stationarity test

Variables	ADF Test				Decision
	Model	$ADF_{calculated}$	$ADF_{critical}$	Probability	
unemploymen	Intercept	-7.143688	1% level: -3.548208 5% level: −2.912631 10% level: −2.594027	0.0000***	UNMP is stationary at the 2nd difference
interest rate	Intercept	-6.670102	1% level: −3.527045 5% level: −2.903566 10% level: −2.589227	0.0000***	INTR is stationary at 1st difference
Exchange rate	Intercept	-9.130605	1% level: −3.528515 5% level: −2.904198 10% level: −2.589562	0.0000***	The exchange rate is stationary at 2nd difference
food security	Intercept	-4.987272	1% level: -3.531592 5% level: −2.905519 10% level: −2.590262	0.0001**	food security is stationary at 1st difference

4.3. Lag section order

The Selection Criteria for VAR Lag Orders results suggest that a three-lag model is optimal for examining the relationships between the variables: exchange rates, food security, unemployment, and interest rates. The criteria, which comprise the Final Prediction Error (FPE), Hannan-Quinn Criterion (HQ), and Akaike Information Criterion (AIC), consistently indicate that a three-lag model provides the best fit for the data.

VAR Lag Order Selection Criteria
Endogenous variables: LEXCHANGE_RATE LFOOD_SECURITY UNEMP INTR
Exogenous variables:
Date: 08/28/24 Time: 15:33
Sample: 2006Q1 2023Q4
Included observations: 66

Lag	LogL	LR	FPE	AIC	SC	HQ
1	237.4392	NA	1.43e-08	-6.710278	-6.179453	-6.500524
2	306.3276	121.0766	2.90e-09	-8.312958	-7.251307	-7.893449

3	342.4234	59.06589*	1.59e-09	-8.921922	-7.329446*	-8.292659*
4	359.5353	25.92710	1.58e-09*	-8.955615	-6.832314	-8.116598
5	373.3096	19.20055	1.75e-09	-8.888170	-6.234043	-7.839399
6	391.7162	23.42656	1.73e-09	-8.961097*	-5.776145	-7.702571

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

4.4. VAR estimation

Key insights into the short- and long-term dynamics are provided by the results of the Vector Autoregression (VAR) analysis of the impact of exchange rate fluctuations on food security in Rwanda, which are included in the Appendix. The exchange rate (LEXCHANGE_RATE), food security (LFOOD_SECURITY), unemployment (UNEMP), and other variables are included in the model and interest rate (INTR), with observations spanning from 2006Q4 to 2023Q4. The lagged values of the exchange rate have a significant impact on its current value, with the first lag being particularly strong, indicating a high degree of persistence in exchange rate fluctuations. However, the exchange rate's influence on food security appears less direct, with no significant short-term effects observed, as indicated by the non-significant coefficients for the lagged exchange rate variables.

Interestingly, the first lag of food security has a positive and significant impact on its current value, underscoring the inertia in food security outcomes. This suggests that food security conditions are relatively stable over time but are influenced by previous periods' conditions rather than immediate changes in the exchange rate. The unemployment variable shows significant persistence with a strong impact of its first lag, while its relationship with other variables like food security and exchange rate is more complex, with no clear direct effects observed. The interest rate variable also shows some persistence, but its impact on food security and exchange rate is minimal in the short term.

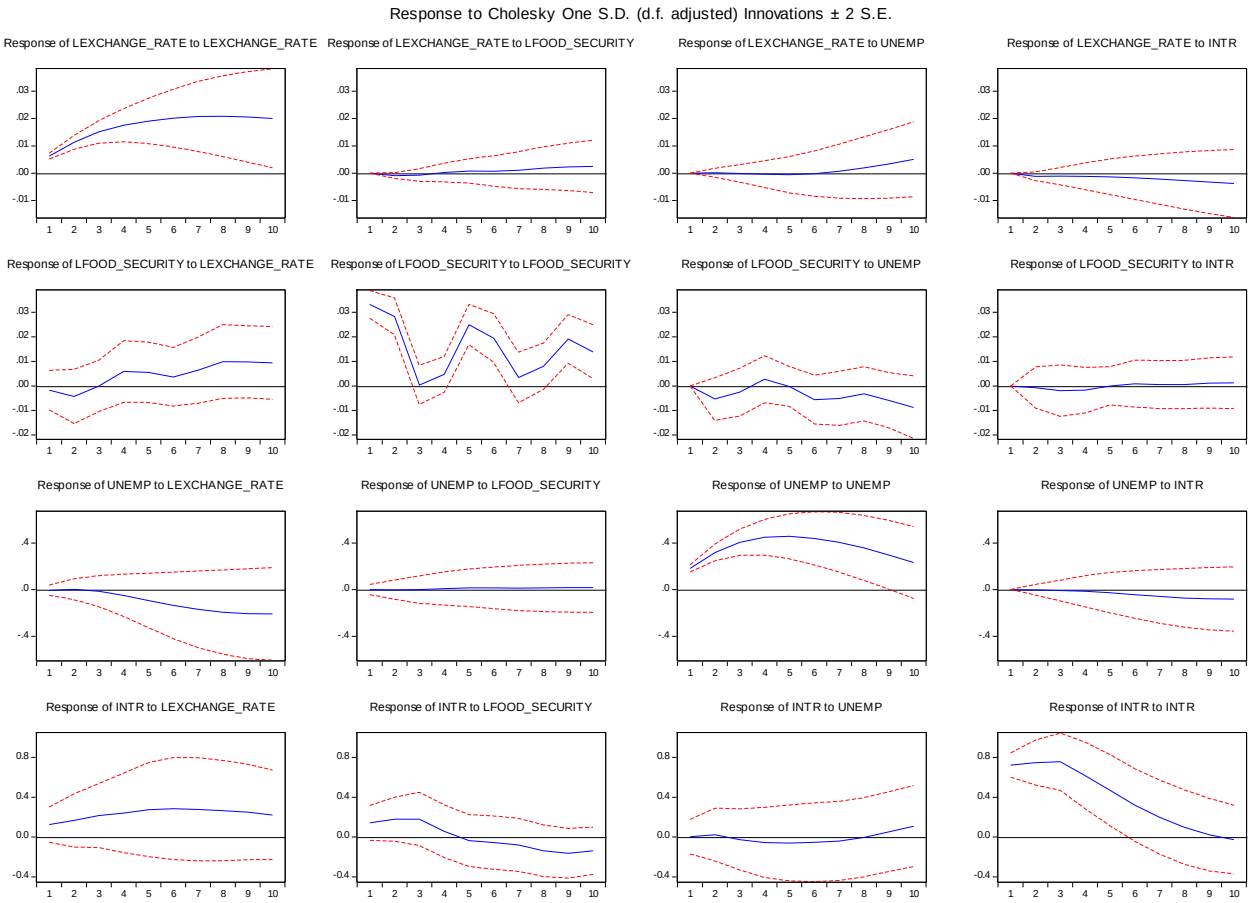
4.5 IMPULSE RESPONSE FUNCTION

The impulse response functions depicted in the graph offer valuable insights into the dynamic relationships between exchange rate fluctuations and key variables, including food security, unemployment, and interest rates in Rwanda. The primary focus is to assess fluctuations in

exchange rates' short- and long-term effects on food security, as well as to identify the transmission channels through which these fluctuations impact food security outcomes.

Firstly, the response of food security to a one standard deviation shock in the exchange rate reveals that in the short term, food security initially declines. This suggests that an appreciation or depreciation in the exchange rate leads to immediate adverse effects on food security, likely due to the increased cost of imported goods or the volatility in export revenues that may affect the availability and affordability of food. However, over time, the response stabilizes, indicating that while the short-term effects are detrimental, they may not persist in the long term, or there could be mitigating factors or adaptive mechanisms that help stabilize food security.

The analysis of the channels of transmission via which exchange rate fluctuations affect food security is further elucidated by the responses of other variables. For instance, the exchange rate's impact on unemployment is noteworthy. A positive shock to the exchange rate appears to initially increase unemployment, which could be due to the reduced competitiveness of exports, leading to job losses in export-oriented sectors. This increase in unemployment, in turn, exacerbates food insecurity, as more individuals may struggle to afford basic necessities. Additionally, the response of interest rates to exchange rate fluctuations shows that exchange rate shocks tend to result in a gradual increase in interest rates. Higher interest rates can further strain the economy by increasing the cost of borrowing, reducing investment, and potentially worsening food security if agricultural and food-related investments decline.



Source: Author calculation from EViews

4.8. VARIANCE DECOMPOSITION

As the results in appendix, the variance decomposition analysis provides a comprehensive breakdown of the contributions of various economic factors to the fluctuations in exchange rates, food security, unemployment, and interest rates over time. Given your research objectives to assess the short- and long-term impacts of changes in exchange rates on Rwanda's food security, as well as to pinpoint the channels of transmission through which these fluctuations affect food security the results reveal significant insights into the dynamic relationships between these variables.

Starting with the variance decomposition of the exchange rate, we observe that in the initial period, the exchange rate explains 100% of its own variance, indicating that in the very short term, other variables do not contribute to its fluctuations. However, as time progresses, the contributions from food security, unemployment, and interest rates gradually increase. By the 10th period, approximately 3.23% of the variance in the exchange rate can be attributed to food security,

unemployment, and interest rates, with interest rates having the most significant impact at 1.39%. This suggests that in the long term, fluctuations in food security and unemployment do influence the exchange rate, highlighting the interconnectedness of these economic factors.

The variance decomposition of food security shows that the exchange rate plays a progressively more substantial role in explaining the fluctuations in food security over time. Initially, food security is largely self-explanatory, with 99.7% of its variance attributable to itself. However, by the 10th period, the exchange rate explains about 10.01% of the variance in food security, indicating that exchange rate fluctuations have a significant long-term impact on food security outcomes in Rwanda. This finding aligns with your research objective of assessing the long-term effects of exchange rate fluctuations on food security, underscoring the critical role of exchange rate stability in ensuring food security.

In terms of unemployment, the variance decomposition reveals that while unemployment largely explains its own variance Within the short term, the influence of the currency rate changes to more pronounced over time. By the 10th period, the exchange rate explains approximately 11.85% of the variance in unemployment. This suggests that exchange rate fluctuations can lead to changes in employment levels, which could subsequently affect food security through reduced household incomes and purchasing power.

Finally, the variance decomposition of interest rates indicates that while the exchange rate's contribution to interest rate fluctuations is relatively small in the short term, it increases over time. By the 10th period, the exchange rate explains around 17.8% of the variance in interest rates. This finding highlights the transmission channel through which exchange rate volatility impacts the broader economy, including food security, by influencing the cost of borrowing and investment.

the variance decomposition analysis corroborates the findings from the impulse response functions, providing robust evidence that exchange rate fluctuations have significant short-term and long-term effects on food security in Rwanda. The analysis also identifies key transmission channels particularly through unemployment and interest rates how the fluctuations in exchange rates impact the results of food security. These insights are crucial for policymakers aiming to lessen the negative impact of fluctuating exchange rates on the availability of food by stabilizing the exchange rate and addressing the economic factors that exacerbate food insecurity in the country.

4.9. Discussion

The examination of how changes in exchange rates affect Rwanda's food security from 2006Q1 to 2023Q4 offers vital insights into the complex dynamics among exchange rate, food security, interest rates, and unemployment. The descriptive statistics reveal a landscape marked by moderate variability in the exchange rate and significant fluctuations in food security, alongside a skewed unemployment distribution. This variability sets the stage for understanding how economic instability, as indicated by exchange rate movements, can ripple through the economy, affecting key indicators of well-being such as food security. The stationarity tests underscore the necessity of transforming the data to ensure reliability in further analysis, with variables like food security and interest rates becoming stationary at the first difference, while exchange rates and unemployment require second differencing. This transformation enables a robust exploration of the dynamic relationships between these variables through a Vector Autoregression (VAR) model.

The VAR estimation reveals a complex interplay between exchange rates and food security, with the former demonstrating a significant persistence, indicating that past exchange rate levels heavily influence current levels. However, the direct impact of exchange rate fluctuations on food security in the short term appears limited, suggesting that the immediate effects may be buffered by other factors or delayed responses in the food security index. Interestingly, food security exhibits a strong inertia, where previous conditions significantly influence current outcomes, highlighting the potential resilience or lagged adaptation mechanisms within Rwanda's food security framework. Unemployment also shows considerable persistence, yet its relationship with food security and exchange rates remains convoluted, pointing to potential indirect effects rather than direct causation. The minimal short-term impact of interest rates on both food security and exchange rates further complicates the economic narrative, suggesting that while interest rates are crucial, their effects may manifest more significantly over longer periods or through more complex transmission mechanisms.

The impulse response functions delve deeper into these dynamics, illustrating the immediate and long-term consequences of exchange rate shocks. In the short term, a depreciation or appreciation in the exchange rate adversely affects food security, likely due to changes in the cost of imports and export revenues, which in turn influence food prices and availability. However, the long-term stabilization of food security in response to exchange rate shocks suggests the presence of mitigating factors, possibly including government interventions, market adjustments, or

international aid, which help buffer the economy against sustained food insecurity. The exchange rate's impact on unemployment further illuminates the transmission channels at play; an initial increase in unemployment following an exchange rate shock can exacerbate food insecurity by reducing household income and purchasing power, thereby limiting access to adequate food. Additionally, the gradual increase in interest rates in response to exchange rate shocks highlights another layer of economic strain, where higher borrowing costs may reduce investments in critical sectors like agriculture, further threatening food security.

Finally, the variance decomposition analysis ties these findings together by quantifying the contributions of various economic factors to the fluctuations in exchange rates, food security, unemployment, and interest rates over time. The progressive increase in the exchange rate's role in explaining food security variance underscores its long-term significance, affirming the critical need for exchange rate stability in maintaining food security in Rwanda. Similarly, the exchange rate's growing influence on unemployment and interest rates over time emphasizes the interconnectedness of these variables and the potential for exchange rate volatility to trigger broader economic disruptions. These findings align closely with the research objectives, providing a comprehensive understanding of the effects of exchange rate fluctuations on food security, both short- and long-term, and highlighting the key transmission channels through which these effects propagate. The results underscore the importance of coherent economic policies that stabilize exchange rates, support employment, and manage interest rates to safeguard food security in Rwanda, particularly in the face of global economic uncertainties. As noted by other studies, such as Yousuf and Zaman (2021), exchange rate volatility often results in inflationary pressures, disproportionately affecting low-income households by reducing their purchasing power. Furthermore, Obstfeld and Rogoff (1995) highlight the transmission mechanisms through which exchange rate fluctuations affect economic variables, such as inflation and interest rates, which are crucial in understanding their broader impact on food security. These transmission channels, including changes in the cost of imports and adjustments in monetary policy, exacerbate the vulnerability of food security in developing economies like Rwanda. Additionally, Thompson et al. (2014) emphasize the importance of stabilizing exchange rates to mitigate these adverse effects on food security, suggesting that a stable macroeconomic environment is crucial for ensuring food accessibility and affordability.

Chapter5: summary, conclusions and recommendations

5.1. Summary

The study on how changes in exchange rates affect Rwanda's food security reveals significant relationships between key economic variables, namely the exchange rate, food security, unemployment, and interest rates, over the period from 2006Q1 to 2023Q4. The descriptive statistics highlighted moderate variability in the exchange rate, significant fluctuations in food security, and skewed distributions in unemployment, with a non-normal distribution detected for the unemployment rate. Stationarity tests confirmed that the exchange rate and unemployment were stationary at the second difference, while food security and interest rates were stationary at the first difference. A three-lag Vector Autoregression (VAR) model was identified as optimal for examining these variables. The VAR estimation indicated that the exchange rate had a persistent impact on its own fluctuations but did not show a direct short-term effect on food security. However, the impulse response function revealed that exchange rate shocks had adverse short-term effects on food security, with potential long-term stabilization. Additionally, the variance decomposition showed that over time, the exchange rate significantly contributed to the variance in food security, unemployment, and interest rates, emphasizing the interconnectedness of these factors

.5.2. Conclusions

The study concludes that exchange rate fluctuations have a considerable impact on food security in Rwanda, particularly in the long term. While the short-term effects of exchange rate shocks on food security are negative, potentially due to increased costs of imports and reduced export revenues, these effects may stabilize over time. The findings suggest that exchange rate stability is crucial for maintaining food security, as fluctuations in the exchange rate can indirectly influence food security through channels such as unemployment and interest rates. Moreover, the persistence of exchange rate impacts on its own fluctuations and its growing influence on other economic variables over time underscore the need for effective exchange rate management in promoting food security.

5.3. Recommendations

The research findings on the impact of exchange rate fluctuations on food security in Rwanda underscore the intricate relationship between macroeconomic variables and the well-being of the population. Given the significant influence of exchange rate volatility on food security, particularly

through its effects on unemployment and interest rates, several key recommendations emerge to address these challenges.

Prioritizing Exchange Rate Stability: Maintaining exchange rate stability is paramount to safeguarding food security in Rwanda. Fluctuations in the exchange rate can lead to increased costs for imported food and agricultural inputs, adversely affecting the availability and affordability of food. To mitigate these risks, policymakers should prioritize the stabilization of the exchange rate through a combination of monetary and fiscal policies. This could involve maintaining adequate foreign exchange reserves to buffer against external shocks and implementing exchange rate policies that align with the country's broader economic objectives. Additionally, the National Bank of Rwanda could consider targeted interventions in the foreign exchange market during periods of extreme volatility to prevent disruptive fluctuations that could harm food security.

Strengthening Domestic Agricultural Production: Reducing Rwanda's reliance on imported food is essential for enhancing food security in the face of exchange rate fluctuations. Strengthening domestic agricultural production can provide a more stable and resilient food supply, less susceptible to the vagaries of international markets and currency fluctuations. To achieve this, the government should invest to increase productivity and lower post-harvest losses in agricultural infrastructure, such as irrigation systems, storage facilities, and transportation networks. Furthermore, research and development in agriculture should be prioritized to introduce more resilient crop varieties and sustainable farming practices. Supporting smallholder farmers through access to credit, training, and market opportunities will also be crucial in boosting domestic food production and ensuring food security.

Monitoring and Managing Unemployment: Unemployment is another critical factor that mediates the relationship between exchange rate fluctuations and food security. High unemployment can exacerbate food insecurity by reducing household incomes and purchasing power. To mitigate these effects, it is essential to monitor employment levels closely and implement policies that promote job creation, particularly in sectors that are sensitive to exchange rate changes, such as agriculture and manufacturing. The government could also consider targeted social protection programs to support vulnerable populations during periods of economic downturn, ensuring that

they have access to sufficient food even when exchange rate fluctuations negatively impact the economy.

Enhancing Financial Sector Resilience: The financial sector plays a pivotal role in moderating the impact of fluctuations in exchange rates on food security, particularly through its influence on interest rates. High-interest rates can increase the cost of credit for farmers and food producers, limiting their ability to invest in productivity-enhancing technologies and practices. To enhance the resilience of the financial sector, policymakers should focus on developing more robust financial instruments that can help mitigate the impact of exchange rate shocks. This could include promoting access to affordable credit for farmers, encouraging the development of agricultural insurance products, and fostering public-private partnerships to support investment in the agricultural sector. Strengthening the financial sector's capacity to absorb external shocks will contribute to a more stable and secure food supply.

Finally, ongoing research and monitoring are essential to inform policy decisions and adapt to changing economic conditions. The dynamic nature of the global economy means that exchange rate fluctuations and their impact on food security are likely to evolve over time. Therefore, continuous research is needed to explore the effects of exchange rate volatility on food security and to identify emerging risks and opportunities. This research should also consider the broader global context, including trends in international trade, climate change, and geopolitical developments, which could impact Rwanda's exchange rate and food security. By staying informed and proactive, policymakers can develop more effective strategies to mitigate the impact of exchange rate fluctuations and ensure sustainable food security for all Rwandans.

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Appendix

1.Estimation of VAR

Vector Autoregression Estimates
Date: 08/28/24 Time: 15:40
Sample (adjusted): 2006Q4 2023Q4
Included observations: 69 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LEXCHANGE_RATE	LFOOD_SECURITY	UNEMP	INTR
LEXCHANGE_RATE(-1)	1.833048	-0.466082	2.342069	6.377597
	(0.13239)	(0.70585)	(3.86119)	(15.8306)
	[13.8454]	[-0.66031]	[0.60657]	[0.40287]
LEXCHANGE_RATE(-2)	-0.916445	1.368458	-8.106797	-4.456352
	(0.26516)	(1.41367)	(7.73311)	(31.7051)
	[-3.45625]	[0.96802]	[-1.04832]	[-0.14056]
LEXCHANGE_RATE(-3)	0.074489	-0.807039	5.761127	-0.026438
	(0.15198)	(0.81026)	(4.43230)	(18.1721)
	[0.49014]	[-0.99603]	[1.29980]	[-0.00145]
LFOOD_SECURITY(-1)	-0.019793	0.853484	-0.012844	0.946146
	(0.01512)	(0.08059)	(0.44082)	(1.80734)
	[-1.30950]	[10.5910]	[-0.02914]	[0.52350]
LFOOD_SECURITY(-2)	0.039768	-0.713687	0.122863	-0.710335
	(0.01763)	(0.09397)	(0.51403)	(2.10747)
	[2.25630]	[-7.59498]	[0.23902]	[-0.33706]
LFOOD_SECURITY(-3)	-0.011164	0.764987	0.029120	-2.326341
	(0.01432)	(0.07633)	(0.41756)	(1.71196)
	[-0.77977]	[10.0217]	[0.06974]	[-1.35888]
UNEMP(-1)	0.000758	-0.029361	1.748858	0.113377
	(0.00447)	(0.02384)	(0.13041)	(0.53466)
	[0.16963]	[-1.23161]	[13.4108]	[0.21206]
UNEMP(-2)	-0.003451	0.063006	-0.830510	-0.449061
	(0.00827)	(0.04411)	(0.24127)	(0.98920)
	[-0.41712]	[1.42848]	[-3.44218]	[-0.45396]
UNEMP(-3)	0.003915	-0.040118	0.028771	0.372885
	(0.00463)	(0.02467)	(0.13498)	(0.55339)
	[0.84581]	[-1.62586]	[0.21316]	[0.67382]
INTR(-1)	-0.001617	-0.000970	-0.003634	1.036302
	(0.00109)	(0.00581)	(0.03181)	(0.13042)
	[-1.48283]	[-0.16674]	[-0.11424]	[7.94616]
INTR(-2)	0.003084	-0.001760	0.001985	-0.015138
	(0.00164)	(0.00875)	(0.04784)	(0.19613)
	[1.88000]	[-0.20125]	[0.04149]	[-0.07718]
INTR(-3)	-0.001828	0.003438	-0.009539	-0.210650

	(0.00111) [-1.65098]	(0.00590) [0.58220]	(0.03230) [-0.29533]	(0.13242) [-1.59076]
R-squared	0.999430	0.983365	0.984809	0.825798
Adj. R-squared	0.999320	0.980155	0.981877	0.792181
Sum sq. resids	0.002218	0.063035	1.886237	31.70642
S.E. equation	0.006237	0.033255	0.181912	0.745824
F-statistic	9084.710	306.3161	335.9310	24.56429
Log likelihood	259.0102	143.5300	26.27677	-71.08000
Akaike AIC	-7.159717	-3.812462	-0.413819	2.408116
Schwarz SC	-6.771177	-3.423922	-0.025279	2.796656
Mean dependent	6.607606	5.654822	12.31458	6.598121
S.D. dependent	0.239182	0.236061	1.351300	1.636037

Determinant resid covariance (dof adj.)	7.38E-10
Determinant resid covariance	3.44E-10
Log likelihood	360.1532
Akaike information criterion	-9.047918
Schwarz criterion	-7.493757
Number of coefficients	48

2. Variance decomposition

Variance Decomposition of LEXCHANGE_RATE:

Period	S.E.	LEXCHANGE_RATE	LFOOD_SECURITY	UNEMP	INTR
1	0.006237	100.0000	0.000000	0.000000	0.000000
2	0.012958	98.70998	0.468234	0.010600	0.811188
3	0.019929	99.01376	0.326617	0.005558	0.654067
4	0.026574	99.21633	0.192413	0.022922	0.568334
5	0.032752	99.23653	0.185274	0.043799	0.534399
6	0.038472	99.21413	0.172164	0.033988	0.579715
7	0.043768	99.05697	0.194080	0.054351	0.694596
8	0.048622	98.62684	0.298364	0.203444	0.871358
9	0.053034	97.88532	0.435387	0.574612	1.104682
10	0.057070	96.76611	0.564526	1.279537	1.389831

Variance Decomposition of LFOOD_SECURITY:

Period	S.E.	LEXCHANGE_RATE	LFOOD_SECURITY	UNEMP	INTR
1	0.033255	0.274590	99.72541	0.000000	0.000000
2	0.044149	1.113451	97.39834	1.463094	0.025115
3	0.044267	1.107569	96.88769	1.781448	0.223294
4	0.045012	2.765598	94.78658	2.081883	0.365941
5	0.051745	3.224033	94.92213	1.576911	0.276925

6	0.055677	3.216051	94.15455	2.365096	0.264298
7	0.056382	4.425966	92.18573	3.122167	0.266142
8	0.057892	7.111751	89.34985	3.277325	0.261070
9	0.062029	8.672515	87.32100	3.743158	0.263327
10	0.064841	10.01255	84.46056	5.249822	0.277070

Variance Decomposition of UNEMP:

Period	S.E.	LEXCHANGE_RATE	LFOOD_SECURITY	UNEMP	INTR
1	0.181912	0.132299	3.14E-07	99.86770	0.000000
2	0.366303	0.037700	0.000687	99.95649	0.005125
3	0.546577	0.088740	0.000361	99.88387	0.027035
4	0.708875	0.554794	0.014234	99.37476	0.056215
5	0.848873	1.617610	0.043293	98.20326	0.135839
6	0.966529	3.223952	0.056401	96.42247	0.297174
7	1.063291	5.202234	0.059972	94.18440	0.553395
8	1.140375	7.392669	0.068099	91.65779	0.881440
9	1.199212	9.658726	0.081672	89.01994	1.239666
10	1.241856	11.84732	0.094466	86.47446	1.583760

Variance Decomposition of INTR:

Period	S.E.	LEXCHANGE_RATE	LFOOD_SECURITY	UNEMP	INTR
1	0.745824	2.765923	3.616075	0.001375	93.61663
2	1.084158	3.651166	4.418830	0.047542	91.88246
3	1.351105	4.871734	4.621284	0.066247	90.44073
4	1.506781	6.481642	3.858174	0.191406	89.46878
5	1.603548	8.634771	3.460602	0.311631	87.59300
6	1.662005	10.98633	3.336026	0.392037	85.28561
7	1.699029	13.18144	3.418721	0.431452	82.96839
8	1.727986	15.09636	3.956712	0.417746	80.52918
9	1.754544	16.67615	4.702339	0.494057	78.12746
10	1.777503	17.80524	5.193933	0.856108	76.14472

Cholesky Ordering: LEXCHANGE_RATE LFOOD_SECURITY UNEMP INTR

5. Data

	EXCHANGE_RATE	FOOD_SECURITY	INTR	UNEMP
2006Q1	554	163	9.173333	11.65
2006Q2	552	163	8.43	11.64725
2006Q3	551	196	8	11.6445
2006Q4	550	196	7.43	11.64175
2007Q1	548	179	7.93	11.639
2007Q2	546	179	7.43	11.621
2007Q3	548	195	6.086667	11.603
2007Q4	546	195	7.403333	11.585
2008Q1	544	196	7.663333	11.567
2008Q2	543	196	6.433333	11.59425
2008Q3	547	202	7.033333	11.6215
2008Q4	553	202	7.413333	11.64875
2009Q1	566	214	9.303333	11.676
2009Q2	568	214	8.55	11.6775
2009Q3	569	221	9.286667	11.679
2009Q4	570	221	8.093333	11.6805
2010Q1	573	222	7.053333	11.682
2010Q2	579	222	6.336667	11.71175
2010Q3	589	234	7.056667	11.7415
2010Q4	592	234	7.106667	11.77125
2011Q1	599	238	6.73	11.801
2011Q2	601	238	6.926667	11.7765
2011Q3	600	234	6.923333	11.752
2011Q4	602	234	7.64	11.7275
2012Q1	605	264	7.252509	11.703
2012Q2	609	264	8.515667	11.72725
2012Q3	615	248	9.80755	11.7515
2012Q4	628	248	11.30167	11.77575
2013Q1	633	282	10.48027	11.8
2013Q2	640	282	10.90744	11.8165
2013Q3	649	250	8.814323	11.833
2013Q4	664	250	6.124649	11.8495
2014Q1	675	296	5.736457	11.866
2014Q2	681	296	5.681391	11.86275
2014Q3	684	283	5.552145	11.8595
2014Q4	691	283	5.383333	11.85625
2015Q1	702	307	4.037333	11.853
2015Q2	713	307	3.454333	11.8395
2015Q3	725	293	3.486333	11.826
2015Q4	739	293	3.541667	11.8125
2016Q1	759	328	4.970427	11.799

2016Q2	776	328	5.812684	11.81925
2016Q3	800	290	6.170173	11.8395
2016Q4	815	290	6.612209	11.85975
2017Q1	823	332	6.414814	11.88
2017Q2	828	332	6.319917	11.6
2017Q3	834	317	5.937624	11.32
2017Q4	842	317	5.749448	11.04
2018Q1	849	359	5.524799	10.76
2018Q2	856	359	5.641614	10.88
2018Q3	864	328	5.6299	11
2018Q4	875	328	5.499073	11.12
2019Q1	884	372	5.523404	11.24
2019Q2	893	372	5.375003	11.3875
2019Q3	904	342	5.47275	11.535
2019Q4	916	342	5.479947	11.6825
2020Q1	927	365	5.537992	11.83
2020Q2	933	365	5.3547	12.82
2020Q3	947	351	5.273	13.81
2020Q4	966	351	5.245296	14.8
2021Q1	976	391	5.181148	15.79
2021Q2	983	391	5.189548	15.6125
2021Q3	992	374	5.191207	15.435
2021Q4	1004	374	5.171952	15.2575
2022Q1	1014	386	5.292	15.08
2022Q2	1021	386	5.50759	15.04625
2022Q3	1032	372	6.04722	15.0125
2022Q4	1055	372	6.844034	14.97875
2023Q1	1088	374	7.356957	14.945
2023Q2	1127	374	7.74372	14.52186
2023Q3	1187	384	7.993151	14.09872
2023Q4	1239	384	8.3	13.67558

Antoine KARANGWA

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