NEAR EAST UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
DEPARTMENT OF MATHEMATICS

THE GAMBIAN CURRENCY AND ITS RELATION TO OTHER MAJOR INTERNATIONAL CURRENCIES

M.Sc. THESIS

ALPHA CEESAY

Supervisor
Prof. Dr. EVREN HINCAL

Nicosia
June, 2023

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Approval

We certify that we have read the thesis submitted by Alpha Ceesay titled **"The Gambian Currency and Its Relation to Other Major International Currencies"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Educational Sciences.

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Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Alpha Ceesay

17th/6/2023

Dedication

I dedicate this thesis to two important men in my family who have never stopped pushing and encouraged me to further my education. They have gone above and beyond to make sure I do not rest on my laurels. To Alhagie Babou Sarr, a Customs Officer, a statesman, a politician, a community leader, and above all someone that held on to the ties of kinship, who passed away the 11th November, 2021. To Alhagie Tamsir S.A. Njie, an Agriculturist, an Economist, a Banker, a financial analyst, and a family man, who passed away the 23rd July, 2022.

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I want to thank my parents, my siblings, my wife, and my son for motivating and supporting me throughout this journey of a lifetime. The prayers, messages, calls, and photos kept and comforted me all through.

I rekindle the flame deep within me that made me pursue this program, to believe in myself, believe in self-advancement, and belief to continuously seek knowledge in order to serve humanity. I hope that belief in myself will keep me to pursue higher knowledge, take up new challenges, serve humanity to the best of my ability.

Alpha Ceesay

Abstract

The Gambian Currency And Its Relation To Other Major International Currencies

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The Gambia is a small country in West Africa bordered on three sides by Senegal and facing the Atlantic Ocean on the fourth side, it has a robust and growing economy which is amongst the smallest in the world. The currency of the country has changed from the franc coin, and British sterling during colonial rule under Great Britain, to the Dalasi after Independence which is the subject of this study.

This thesis looks at how Interest rates, Inflation, Exchange rate, Remittances, and the Central Bank of The Gambia affect the international value of the Dalasi. The Dalasi is compared to the United States Dollar, the Great British Pound, the Euro, and the Senegal CFA as the four major currencies that affect the economy the most.

Weekly Exchange rate data is analyzed for the four currencies against the Dalasi from 2000 to 2022 using the ARIMA-GARCH model. Based on the AIC criteria, the ARIMA (5,1,1)-GARCH (2,1) were applied to the EUR/GMD weekly series returns, ARIMA (1,1,2)-GARCH (1,1) to the GBP/GMD, ARIMA (19,1,1)-GARCH (2,1) to the USD/GMD, and ARIMA (5,1,1)-GARCH (2,1) to the XOF/GMD.

The studies also show that the Dalasi will continue to depreciate against these currencies in the near future, it also shows that the Central Bank can opt to use Euro as its main reserve currency.

***Key Words**:* The Gambia, Dalasi, GARCH model, Exchange rate volatility

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List of Abbreviations

ADB: African Development Bank

AIC: Akaike Information Criterion

ARCH: Auto Regressive Conditional Heteroskedasticity

ARIMA: Autoregressive Integrated Moving Average

CBG: Central Bank of The Gambia

ERP: Economic Recovery Program

EU: European Union

FDI: Foreign Direct Investment

GARCH: Generalized Auto Regressive Conditional Heteroskedasticity

GBP: Great British Pound

GMD: Gambian Dalasi

IMF: International Monetary Fund

UK: United Kingdom

USD: United States Dollar

WACB: West African Currency Board

CHAPTER I

Introduction

Country and Economic Overview

Except for a 60-kilometer Atlantic Beach front, The Gambia is a little country in West Africa that expands 450 kilometers along the Gambia Waterway. Senegal surrounds the country, which is 10,689 square kilometers in size. The country's population is 2.65 million as of 2021. With 176 people per square kilometer, it is one of the countries in Africa with the highest population density. In 2022, the World Bank estimates that 58% of the population reside in or near urban and peri-urban areas. Economic growth in 2019 was robust at 6.2%, supported by rising tourist arrivals and aided by sound macroeconomic management, which helped to reduce the fiscal deficit, emerge from debt burden, and bring international currency reserves closer to levels that are considered sensible. The GDP per capita in Gambia was $772.15 in 2021, and GDP was worth 2.08 billion US dollars.

The COVID-19 pandemic slowed growth to 0.6% in 2020, resulting in a 2.3% decline in income per capita and a reversed reduction in poverty. Due to strong tourism and construction activity, which boosted services and industry, and favorable weather, which encouraged agriculture, the economy rebounded in 2021 to 4.3%. As a result of the economic recovery, more than 8,000 people were lifted out of extreme poverty, and the percentage of Gambians living below the international poverty line of $2.15 decreased from 11.7 percent in 2020 to 11.1 percent in 2021. The fiscal deficit more than doubled in 2021, rising from 2.2% of GDP in 2020 to 4.6% of GDP which is a primary deficit of about 1.6% of GDP as development partners withdrew their financial support during the COVID-19 pandemic. Average inflation rose to 7.4% in 2021, up from 5.9% in 2020 and above the Central Bank's medium target of 5% (World Bank, 2023).

Source: PeterHermesFurian | Credit: Getty Images/iStockphoto

Figure 1: Map of The Gambia

The future economic outlook remains daring and dependent on the global economy's recovery through tourism and international trade. It is anticipated that the digital economy, transportation, energy, tourism, finance, and agriculture will all contribute to growth of about 5.9% in 2023 and 4.9% in 2022, respectively. In 2022, the conflict between Russia and Ukraine is expected to raise food and energy prices by about 8.1%. However, as global supply chains normalize, inflation may fall to 7.5% in 2023. As a result of higher debt service and subsidies, the fiscal deficit is expected to reach 4.7% of GDP in 2022. However, it is expected to fall to 3.2% of GDP in 2023 as a result of more efficient tax administration and wiser spending. The ADB claims that the current account deficit will reach 14.8% of GDP in 2022 as a result of imports related to infrastructure and rising oil and food import bills. In 2023, it is anticipated that re-exports will pick up, bringing the deficit down to 11.9% of GDP. A weekly exchange rate series for the five years from January 2018 to December 2022 is included in Appendix A. It depicts the most recent trend of the Dalasi against the four major international currencies that are the subject of the investigation.

Problem Statement

This is my research question: The Dalasi in comparison to the four most common international currencies. The following are the four major currencies I will compare: the Euro, the Senegal CFA, the Great British Pound, and the United States Dollar. The Gambia is included in the Senegal CFA because it is primarily a part of Senegal and its people engage in cross-border trade with citizens of both countries who live in another country.

Objectives

Main Objective

The Gambian Dalasi and its relationship to other major international currencies that directly affect it, as well as factors that support or affect its value, are the primary goals of this thesis.

Specific Objectives

To identify an appropriate ARMA–GARCH model for the Gambian exchange rate return series, to use the estimated models to forecast volatility, and to model volatility in the Gambian exchange rate data between the years 2000 and 2022.

Limitations of the Research

The Gambians use a variety of currencies, including the United States dollar, Canadian dollar, euro, British pound, Danish kroner, Norwegian kroner, Swedish kroner, Saudi riyal, and Senegal CFA. These currencies are exchanged for the dalasi at fixed rates by the local Bureau de Change. Despite the fact that all of these other currencies have an impact on the Dalasi and Gambian economies, this study will only focus on the Dollar, the Great British Pound, the Euro, and Senegal CFA.

Justification

In terms of developing and maintaining its finances, economy, and currency, The Gambia has made significant progress. To better comprehend the trend of the Gambian Dalasi, the purpose of

this thesis is to examine the various aspects of the factors that influence it and the volatility of the foreign exchange rate over the past 22 years. This thesis examines the Euro, the United States Dollar, the Great British Pound, and the Senegal CFA, which is essential to the Gambian economy, businesses, and individuals because Senegal is the Gambia's sole neighbor and primary local trading partner. The majority of studies only tend to focus on a short period of time when analyzing the Dalasi. Because exchange rate fluctuations have an effect on governments, banks, businesses, organizations, and individuals in The Gambia, the Dalasi has a significant impact on the country's monetary system. The aim of the thesis is to inform other researchers and readers who are interested in the Dalasi of additional information.

CHAPTER II

Literature Review

History of The Dalasi

Through the majority of the nineteenth century, the growing groundnut trade in the Senegambia region made the five-franc coin the most valuable (Gardner, 2015).

The British set the local sterling value of the five-franc coin at 3s 10½d in 1843 in order to establish themselves on the West African coast of The Gambia, regulate the financial system for official transactions, collect taxes, and benefit British traders (Gardner, 2015). However, outside of official transactions, the usual local rate was four shillings (Gardner, 2015). In 1892, the African Banking Corporation in Lagos, Nigeria, was given the task of providing new British coins to the British colonies in West Africa. In 1894, the Bank of British West Africa (CBG) took over this task.

Even though a number of new coins were introduced in The Gambia in 1907, 1913, and 1911, the French Five-Franc silver coins still dominated (CBG). The West African Currency Board (WACB) was established in 1912 as part of an effort to standardize the currency of British colonies (CBG, Gardner, 2015). This committee looked into ways to create a more uniform currency. The following year, the Board introduced the West African Pound, a new currency, in the four West African colonies (Gardner, 2015).

By the end of 1915, the WACB had changed their constitution and proposed issuing currency notes to each colony with the distinctive mark of each issuing office but with a uniform design (CBG). The constitution was to remain unchanged until 1949, and the issuance was stated to be "under the authority of the Currency Board in London" (CBG).

In the meantime, after World War I, the value of the five-franc began to decline on international markets. Despite mounting costs, the colonial government in Bathurst (now Banjul) ignored calls from traders, banks, and the Colonial Office to demonetize the coin (Gardner, 2015). The announcement in the Gazette on January 15, 1922, that the coins, "commonly known in the Colony and the Protectorate as “Dollars” will, up to and including the 31st January, 1922, be exchanged by the Government for the sterling equivalent of 3s 10½d each," was the final act that resulted in the coin's demonetization. The British colony spent more than a year's earnings on the

demonetization (Gardner, 2015). The Gambia began self-government in October 1963, and the Gambia Currency Board was established one year later, on October 1, 1964. On the 21st, it also introduced its own coinage, produced by Royal Mint, to replace the WACB coin. November of 1966 (Marreh, 2014). On February 18, 1965, The Gambia got its independence. The Gambia Currency Board transferred all of its assets and liabilities to the Central Bank of The Gambia (CBG) in 1971, and the country's currency was decimalized so that one Dalasi equals one hundred Bututs (CBG) According to (Touray, Dibba, and Jallow (2017), the Dalasi (GMD) was linked to the British pound sterling. The Royal Mint produced the Dalasi coins, and Bradbury Wilkinson & Co. Ltd printed the notes, both of which featured a portrait of H.E. The President of the Republic of The Gambia (CBG) in place of the royal effigy. The Dalasi peg gave way in the middle of the 1980s, following a crisis in the country's balance of payments and external debt (Touray et al., 2017). (Touray et al., 2017) claim that the peg was removed as part of a larger program to liberalize the entire exchange system. This meant that the value of the dalasi would be determined by the forces of supply and demand on the foreign exchange market. In accordance with the CBG Act, which was amended in 2005, the Central Bank of The Gambia's mandate is to maintain exchange rate stability. As a result, it keeps a foreign reserve cover in case of significant exchange rate fluctuations. As a result, the country's exchange system is a controlled but freely floating system. The Bank additionally uses other financial approach apparatuses in liquidity management (Touray et al., 2017).

Central Bank of The Gambia

According to the CBG Act of 2005, the Central Bank of The Gambia (CBG) is responsible for achieving and maintaining price stability, directing and regulating the financial, banking, and insurance systems, promoting and maintaining the stability of the Gambian Dalasi (GMD), encouraging and promoting sustainable economic development, and making effective and efficient use of The Gambia's resources through the operation of a financial system (CBG). After its introduction, the economy performed fairly well in the 1970s before a slight decline brought on by growing imbalances in the balance of payments, new financial policies, and an overvalued exchange rate led the government to implement the Economy Recovery Program (ERP) in 1985 (Nyong, 2014).

The Monetary Policy Committee (MPC) of the International Monetary Fund (IMF) pursues a monetary targeting framework to achieve price stability and foster economic growth. This program was initiated by the CBG Act of 2005. According to Nyong (2014), prior to the Act, the CBG had followed an interest rate targeting regime in which the bank rate, controlled inflation and effective demand. CBG currently uses a monetary targeting framework that emphasizes broad money as the intermediate target and reserve money as the operating target (CBG). Nyong (2014) says that the Central Bank of The Gambia's continued use of monetary targeting is "misguided and suboptimal" because there is no link between inflation and money supply. He argued that exchange rate targeting and interest rate targeting are also ineffective, stating that The Gambia might benefit from a flexible combination of inflation targeting and money supply targeting.

The foreign component of the money supply is foreign reserves, which buffer irregular demand and supply of foreign currency; To fund the reserve, the central bank purchases foreign currency from the FX markets and performs Open Market Operations (OMO) by issuing Treasury bills. According to the (Sriram, 2009, the nation operates a floating exchange rate system because it is controllably pegged to the US dollar, so the Central Bank is able to maintain a stable foreign exchange rate by maintaining high foreign reserves (Joof & Tursoy, 2020). According to Joof & Tursoy (2020), it is essential for a Central Bank to be independent so that monetary policy is not influenced by the government and is delegated to officials who were not elected.

Remittance

According to Joof & Touray (2021), studies have demonstrated that remittances and other forms of foreign capital flow significantly contribute to economic expansion as well as the lives and livelihoods of citizens of recipient nations. According to a study (Joof & Touray, 2021), remittances can affect the real exchange rate of the local currency in three ways: First, a country's stock of foreign assets and liabilities is affected by remittances that are received as international capital, which in turn affects the real equilibrium exchange rate. Second, the demand for services increases as a result of remittances, which raises inflation in these areas and results in an increase in the real exchange rate. Tradeable sectors may experience employment adjustments as a result of remittances, while non-tradeable sectors may see price increases as a result. Thirdly, the stock of net foreign assets as a percentage of GDP has an inverse relationship with the exchange rate. As a result, an increase in growth would result in a decrease in the stock of net foreign assets, which in turn would result in an increase in the real exchange rate. This is because an increase in growth would result in a decrease in the liabilities to GDP and an increase in the exchange rate. Most non-industrial nations have an extraordinary number of their residents living in far off nations and they will generally uphold their families particularly in the midst of emergency and monetary hardships. One of the largest sources of foreign currency, remittances complement the unreliable agriculture, tourism, and foreign direct aid, and they greatly aid in the stabilization of the Gambian economy. The formal sector, which includes international Money Transfer Operators (MTOs) like Western Union and local commercial banks, is regulated and accurately recorded by the CBG. On the other hand, the local transfer agents and small Bureau De Change, which are difficult to trace and record, also receive remittances in The Gambia (Ceesay et al., 2019). According to Bolarinwa & Akinbobola (2020), an increase in remittance inflows over time has led to an increase in the demand for financial services and, as a result, financial sector growth. This is evident in the rise of numerous financial institutions and Bureau de Change, all of which provide international remittance services. Remittances to the Gambia rose from USD 174.1 million in 2009 to USD 329.8 million in 2019 and even higher in 2020 with USD 589.8 million recorded through official transfer channels by CBG, continuing to grow strongly to US$777 million, or 38 percent of GDP in 2021. The Gambia is one of the countries in sub-Saharan Africa that receives the most remittances.

We can see that remittances have a direct effect on the Gambia Dalasi GMD and the real effective exchange rate; for every one percent increase in remittances, the GMD will rise by 0.27 percent in real terms (Joof & Touray, 2021), as concurred by Acosta et al. (2009).

Interest Rate, Inflation Rate, Exchange Rate and Economic Growth in The Gambia

We now examine the connection between the Dalasi and economic factors. The domestic foreign exchange market in The Gambia continues to function smoothly despite inflation and interest rate variations. The annual percentage change in the cost of goods and services for the average Gambian consumer is the indicator of inflation, which is measured by the consumer price index. According to Joof & Jallow (2020), an increase or decrease in interest rates, combined with an increase or decrease in the price of goods and services, results in a decrease in the value of the local currency and an increase or decrease in the rate of inflation. From USD 156.1 million in March 2018, USD 192.4 million in March 2019, USD 221.99 million in March 2020, and USD 275.14 million in March 2021, the volume of transactions in the foreign exchange market has steadily increased, according to CBG. In developing economies, the exchange rate has a significant impact on all sectors, from trade volumes to individuals and businesses. Since the government's reserves are held in foreign currency and the majority of exports and imports are paid for in foreign currency, the Gambia is directly exposed to exchange rate fluctuations. As a sign of the significance of the exchange rate, all remittances are also made in foreign currency (Marreh et al., 2014).

The Gambia's inflation is influenced by a variety of factors, including domestic prices, commodities' international prices, trading with its neighbors, exchange rate volatility, an expansionary money supply, the high price of imported goods, and monetary policy, making it difficult to control inflation solely with monetary policy tools. There is an immediate positive connection between cash, swapping scale, and expansion which infers that conversion standard pass-through is positive. According to Cham (2017), domestic prices in Gambia's trading neighbors, particularly Senegal, have a positive effect on prices in the Gambia. In his research, Lowe, (2019) proposed Friedman's (1982) monetarist view of inflation, which states that inflation occurs when economic growth outpaces money supply growth.

According to the quantity theory of money, the central bank's interest rates have an effect on inflation, with lower interest rates typically leading to higher inflation and higher interest rates typically leading to lower inflation.

United States Dollar USD and The Gambian Dalasi GMD

The dollar of the United States, symbol: $; ISO number: USD; which is also known as the United States dollar and is the nation's standard form of currency. Over US$ 6.47 trillion is held by nations worldwide, making it the world's largest reserve currency (Currency Composition of Official Foreign Exchange Reserve - IMF Data, 2022). In the interest of achieving high economic growth, developing nations have pondered whether to float or fix their exchange rates. According to Heller's (1978) research, the economy's openness largely accounts for the choice between peg and float. According to Khamfula (1999), it was observed that nations that had their currencies linked to a composite of foreign currencies prior to 1971 changed their arrangement. It is evident that the size of the economy, rather than the degree to which it is open, appears to be the determining factor. For instance, Brazil has a GDP of $3.34 trillion, which is 570 times greater than the GDP of the Gambia, which is $5.87 billion. The dollar is the most widely used reserve currency by governments and central banks all over the world, and its share of international reserves has been rising. According to Eichengreen (2005), the fact that the United States treasury securities market is still the single most liquid financial market in the world makes it appealing for central banks to hold their reserves in this form. According to Central Bank of the Republic of Turkey [CBRT], 2019: "to increase the effectiveness of monetary policy, reduce risk premiums, and create a buffer against possible shocks," central banks accumulate foreign reserves. The United States of America and Europe both have strong institutions and sound macroeconomic policies in comparison to the rest of the world, making their currencies favorable for international transactions (Eichengreen, 2005). Since the dollar is still the predominant vehicle currency and invoicing currency in international trade, it makes sense for import-dependent countries like The Gambia to choose the USD Dollar as its primary trading and reserve currency. Nonetheless, lately, the US, the save cash country, is running current record shortages and causing a huge net unfamiliar obligation which emerging nations like The Gambia should know about in the event that the Dollar loses its situation as investor to the

world. Since the United States' foreign debt to GDP ratio is rising, the Gambia, which has the majority of its reserve currency in the United States dollar, runs the risk of putting all its eggs in one basket. According to Eichengreen (2005), governments and central banks around the world are becoming less willing to hold dollars as reserves because of the potential for currency depreciation and inflation in the United States.

Euro and The Gambia Dalasi GMD

The Euro's emblem: €; ISO code: EUR. 20 of the 27 countries that make up the European Union (EU) use the euro as their official currency. One of the most significant developments in the recent history of international finance was the introduction of the Euro. The Euro has quickly become the second most widely held international reserve currency after the US dollar since its introduction in 1999. Because the majority of previous studies examined FX rates against US dollars, its importance suggests that a deeper comprehension of the behavior of Euro-based exchange rates is required (Cheung et al., 2011). With over US$ 2.27 trillion held by nations worldwide (IMF Data, 2022), the euro is the second-largest reserve currency and the second most traded currency worldwide after the US dollar. The euro has one of the highest combined values of banknotes and coins in circulation worldwide as of December 2022, with more than €1.57 trillion in circulation (ECB). 100,000 Gambian migrants and refugees live in Europe, which accounts for at least 60% of the global Gambian diaspora, according to the European Council on Refugees and Exiles (ECRE). This explains the large number of remittances that the majority of them send to their families back home, mostly in Euros. Because it determines how much a family can receive as remittance from relatives in Europe, the Euro exchange rate and its volatility are therefore very important. The European Union regularly supports and funds the Gambia Government and its development goals, and it is regarded as the largest donor to the Gambia Government. Over the years, the EU has provided a significant amount of aid and funding, making it a major source of Euro for the nation. Over €365 million was provided from 2017 to 2020, and EUTF provided €38.95 million to Gambia's development agencies (ECRE 2020). As a result, it can be seen that the Gambia still has a significant advantage over Senegal, whose CFA is hard-pegged to the Euro, in terms of the Euro.

Great British Pound GBP and The Gambian Dalasi GMD

The Great British Pound, also known as the British pound sterling; ISO code: GBP is the currency used in the nine associated territories of the United Kingdom. It is the world's oldest circulating currency. Since it was pegged to the pound sterling from 1965 to 1985, the Gambian currency, which was once a British colony, was known as the Gambia pound. The pound peg was removed at the beginning of 1986 and a flexible exchange rate system was implemented as a result of market strains between the official rate and parallel market rates. However, due to differences in the local and international cross rates, the dalasi has continued to be affected by the pound sterling (Walsh, 1993). After the US dollar, the euro, and the Japanese yen, the pound sterling is the fourth most traded currency on the foreign exchange market and the fifth most held international reserve currency (IMF Data, 2022). It is the oldest currency still in use. The four quarters of Q3 2022 saw a decrease in UK exports to The Gambia of £52 million, or £19 million in current prices, compared to the four quarters of Q3 2021; on the other hand, the four quarters of Q3 2022 saw an increase in UK imports from The Gambia of £66 million, or £31 million in current prices, compared to the four quarters of Q3 2021. During the same time frame, the Gambia was the UK's 145th largest trading partners. According to Trade and Investment Factsheets, 2023, FDI from the UK in The Gambia was $1 million in 2021. These numbers reveal a lot about The Gambia's trade with the UK many years after independence and, most importantly, after the Dalasi-Pound peg broke down.

Senegal CFA and The Gambia Dalasi GMD

The Republic of Senegal is the official name of the country in West Africa that is located on the Atlantic Ocean coast. The Gambia, a country that separates Senegal's southern region of Casamance from the rest of the country, is almost entirely surrounded by Senegal. As of April 2023, 17.96 million people live in Senegal, which has a land area of almost 197,000 square kilometers (76,000 square miles) (World Population Prospects).
Senegal's exports to the Gambia have increased at an annualized rate of 11.8%, from $9.79 million in 1995 to $178 million in 2021, while the Gambia's exports to Senegal have increased at an annualized rate of 10.9%, from $627 thousand in 1995 to $9.25 million in 2021. (OEC 2021)

In 1945, the French West African franc was replaced by the CFA (Communauté Financière Africaine) franc, which was introduced to the French colonies in West Africa. Ivory Coast, Dahomey (Benin), French Sudan, Mauritania, Niger, Senegal, Togo, and Upper Volta (Burkina Faso) were the West African colonies that used the franc CFA. Even after these colonies gained independence, the currency continued to be used. Since the French franc (FF) is merged into the euro in accordance with the Maastricht Treaty, the franc CFA was also to be tied to the euro on January 1, 1999 (Kohnert, 1998). The franc CFA has since been pegged to the Euro at €1 = F 6.55957 = F.CFA 655.957, which is what is used in this thesis and its calculations. There are 15 states in the African CFA zone, divided into three zones, each with a central bank; I) Eight nations in West Africa (UEMOA, Union Economic and Monetary Ouest-Africaine: Benin, Burkina Faso, Guinea-Bissau, Côte d'Ivoire, Mali, Niger, Senegal, and Togo; with the Bank of Central African States (BCEAO)); II) 6 Focal African nations (CEMAC, Communauté Economique et Monétaire de l'Afrique Centrale: Chad, Equatorial Guinea, Gabon, Cameroon, Congo-Brazzaville, and the Central African Republic (with the BEAC) and (III) the Comoros, where the "Franc Comorien" is issued by the Banque Centrale des Comores (Kohnert, 1998). The CFA ISO code: XOF for the West African franc: Because it is the currency that Senegal uses, the XOF will be the primary focus of this research.

CHAPTER III

Methodology

We now explain the terms we used, explain how we looked at the data, and give an estimate of how the Dalasi might react to the important global monetary standards discussed in this review. We also explain how we analyzed the data and the methods we used to get results and important conclusions.

Financial time series' primary characteristics, which include high frequency values, volatility clustering, excess kurtosis, heavy-tailed distribution, leverage effect, and long memory properties, were investigated using the Autoregressive Conditional Heteroscedasticity ARCH and its Generalized form GARCH models. Standard time series analysis is supported by important concepts like stationarity, autocorrelation, white noise, and innovation as well as the autoregressive moving average ARMA models.

Volatility

Typically, volatility, or the degree of variation in a trading price series over time, is measured by the standard deviation of logarithmic returns. In statistical terms, volatility is a measure of the data's variance. Volatility, also known as the standard deviation, is an important indicator of market risk. It is often used to price derivative instruments. High volatility data indicate greater risks in comparison to low volatility data. Calculating volatility, such as forecasting volatility, is necessary for risk management, asset allocation, and forecasting future volatility. Homoscedasticity means volatility that stays the same while heteroscedasticity means volatility that doesn't stay the same.

ARMA and ARIMA Models

The objective of time series analysis is the creation of a model for the underlying stochastic process. Using this model, the best predictions or the causal structure of the process can then be made.

A method for comprehending and possibly predicting future values in a time series of data known as M_t is the ARMA model. The AR part involves regressing the variable based on its own previous values. Part of the MA part involves modeling the error term as a linear combination of error terms that happened simultaneously and at different times in the past. The model is usually called the ARMA (b, c) model, with b denoting the order of the AR parts and c denoting the order of the MA parts. The ARMA model class is the one that is used the most frequently to predict second-order stationary processes. The notation AR(b) is used to refer to the autoregressive model of order b. The form of the AR(b) model is

$$x_t = \sum_{i=1}^{b} \lambda_i M_{t-i} + \varepsilon_t$$

where the parameters λ1, ..., λp and the random variable $_t$ are white noise normal variables of chance. The model's characteristic polynomial must have roots outside of the unit circle for it to remain stationary.

The moving average model of order c is referred to by the notation MA(c):

$$M_t = \beta + \varepsilon_t + \sum_{i=1}^{c} \delta_i \varepsilon_{t-i}$$

where β, δ1, …δc is the expectation of M_t often assumed to be zero and the white noise values of εt, εt-1, and... are the model's parameters, respectively. white noise error terms that are typically normal random variables. The model with b autoregressive terms and c moving-average terms is called ARMA (b, c). The AR(b) and MA(c) models are included in this model.

$$M_t = \varepsilon_t + \sum_{i=i}^{b} \lambda_i M_{t-i} + \sum_{i=1}^{c} \delta_i \varepsilon_{t-i}$$

All finite-order moving averages are therefore abundant in the set of second-order stationary and purely nondeterministic processes. The class of ARMA models is frequently favored over the MA models for closeness because they typically require fewer parameters.

ARMA (b, c) process

ARMA (b, c) is the name for a second-order stationary process M_t, where b and c are integers, if the real coefficients h, a1, ..., ap, k1, ..., kq are such that,

$$\forall t \in Z, M_t + \sum_{bi=1} a_i M_{t-i} = h + \epsilon_t + \sum_{cj=1} k_j \epsilon_{t-j}$$

where (ϵ_t) is the linear innovation process of (M_t).

The autoregressive and moving average polynomials' zeros are subject to restrictions as a result of this definition,

$$a(z) = 1 + \sum^{b}_{i=0} a_i z^i \text{ and } \mathrm{d}(z) = 1 + \sum^{c}_{i=0} d_i z^i$$

The time series data that are going to be used to model the ARMA process have to be stationary and have a mean and a variance that are about the same over time. The logarithmic difference between the series can be used to differentiate them. The Augmented Dickey and Fuller (1979) and Phillips and Perron (1988) tests are used to determine whether or not the return series are stationary after observing the plotted series.

ARIMA (b, d, c) process

Let d be a positive integer. The process (M_t) is said to be an ARIMA (b, d, c) process if, for f = 0, ..., d − 1, the processes ($\Delta \mathrm{f} X_t$) are not second-order stationary and ($\Delta d M_t$) is an ARMA (b, c) process.

The ARIMA (0, 1, 0), also known as the random walk, is the simplest ARIMA process.

$$M_t = \epsilon_t + \epsilon_{t-1} + \cdots + \epsilon_1 + M_0, \qquad t \geq 1$$

where ϵ_t is a weak white noise.

The autocorrelation function of an ARMA process provides a comprehensive description of the process's orders (b, c).

Box–Jenkins Methodology

This approach aims to use the ARIMA (b, d, c) model for forecasting by locating the most suitable one. The Box–Jenkins ARIMA modeling technique is more discretionary form than a science; Choosing the right ARIMA model takes a lot of effort. Checking to see if the model's estimated residuals are white noise is a straightforward test; assuming they are, we can acknowledge the specific fit; If not, we must begin again. The Box-Jenkins method is therefore a step-by-step procedure of how to get the right model. It employs a six-stage iterative plan:

(i) a priori identification of the differentiation order d (or choice of another transformation);

(ii) a priori identification of the orders b and c;

(iii) estimation of the parameters (a1, ..., ap, k1, ..., kq and σ2 = Var ϵt);

(iv) validation;

(v) choice of a model;

(vi) prediction.

Step 1. still largely relies on examining the series graph, despite the introduction of numerous unit root tests. It will not be appropriate to select d = 0 if the data clearly deviate from stationarity. The first-difference series $\Delta M_t = M_t - M_{t-1}$ should not have a trend $E\Delta M_t = a$ and could be stationary if this assumption is correct. In the event that no other indication of nons-tationarity can be identified like heteroscedasticity, the decision d = 1 appears to be reasonable. In step 2, the sample autocorrelation function ACF serves as the primary instrument. M_t is an MA (1) process in this instance. The partial autocorrelation function PACF serves a similar function in the identification of AR processes. Step 2 frequently leads to the selection of multiple candidates (b1, c1), …, (bk, ck) for the ARMA orders.

In step 3, the least-squares method, for instance, is used to estimate these k models. Step 4 aims to determine whether the estimated models and the data are reasonably compatible. Examining the residuals, which should have the appearance of white noise if the model is satisfactory, is an essential part of the procedure. Portmanteau tests are used to see if the residuals are sufficiently close to white noise in the correlogram plots.

We are brought back to step 1 or 2 if this step results in the rejection of all estimated models or the consideration of other models. The Akaike (AIC) and Bayesian (BIC) information criteria are the most commonly used selection criteria if multiple models pass validation step 4. Finally, Gaussian assumptions serve as the foundation for the interval predictions made in step 6 of the Box–Jenkins method.

ARCH models

Let denote the error terms $_t$, also known as the series terms, with respect to a mean process in order to model a time series with an ARCH process. A stochastic component z_t and a time-dependent standard deviation t, which describe the typical terms' sizes, are subdivided from these $\sigma_t$so that $\epsilon_t = \sigma_t z_t$

White noise is strong with the random variable z_t. The model for the series σ_t^2 is

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_q \epsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{c} \alpha_i \epsilon_{t-i}^2$$

Where $\alpha_0 > 0$ and $\alpha_i \geq 0, i > 0$

Ordinary least squares can be used to estimate an ARCH (c) model. The Lagrange multiplier test is used to determine whether the residuals $_t$ exhibit time-varying heteroskedasticity. The procedure is as follows:

Determine the autoregressive model AR(c) that fits the best.

$$G_t = \alpha_1 G_{t-1} + \cdots + \alpha_q G_{t-c} + \epsilon_t = \alpha_0 + \sum_{i=1}^{c} \alpha_i G_{t-i} + \epsilon_t$$

Regress the squares of the error $_t^2$ using a constant and the q lagged values:

$$\epsilon_t^2 = \alpha_0 + \sum_{i=1}^{c} \alpha_i \epsilon_{t-1}^2$$

where c is the length of ARCH lags.

We have $\alpha_i = 0$ for all $i = 1, \dots, c.$ if there are no ARCH components, according to the null hypothesis. In the absence of ARCH components, at least one of the estimated α_i coefficients must be significant, according to the alternative hypothesis. Under the null hypothesis that there are no ARCH errors, the test statistic $T'R^2$ follows the M^2 distribution with c degrees of freedom in a sample of T residuals, where T' is the number of model equations that fit the residuals to the lags ($T' = T - c$). We conclude that there is an ARCH effect in the ARMA model and reject the null hypothesis if $T'R^2$ is greater than the Chi-square table value. We do not reject the null hypothesis if $T'R^2$ is less than the value in the Chi-square table.

GARCH model

If an ARMA model is assumed to be the error variance, the GARCH model is used. The GARCH method is implemented in two ways: Mean process and variance process. The mean process was first proposed by Box & Jenkins (1976) by combining auto-aggressive AR, moving average MA, and time series analysis. This method is then combined to form ARIMA in order to obtain the stationary time series. The mean equation cannot be applied in practice to account for the heteroscedasticity effect time series processes, such as fat-tails, volatility clustering, and leverage effects. A GARCH model incorporates these characteristics (Marreh, 2014). The GARCH (b, c) model is given in that case, where b is the order of the GARCH terms σ^2 and c is the order of the ARCH terms ϵ^2.

$$G_t = M_t' b + \epsilon_t$$

$$\epsilon_t | \psi_{t-1} \sim N(0, \sigma_t^2)$$

$$\sigma_t^2 = \eta + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_c \epsilon_{t-c}^2 + \xi_1 \sigma_{t-1}^2 + \cdots + \xi_p \sigma_{t-b}^2 = \eta + \sum_{i=1}^{c} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{b} \eta_i \sigma_{t-i}^2$$

When testing for heteroskedasticity in econometric models, the White test typically performs best. Time series data must, on the other hand, be examined for ARCH and GARCH errors in order to perform this.

GARCH (b, c) model specification

A GARCH (b, c) process's lag length p is determined in three steps:

1. Determine the AR (c) model with the best fit.

$$G_t = \alpha_0 + \alpha_1 G_{t-1} + \cdots + \alpha_c G_{t-c} + \epsilon_t = \alpha_0 + \sum_{i=1}^{c} \alpha_i G_{t-i} + \epsilon_t$$

2. Calculate the autocorrelations of ϵ^2 by and plot them.

$$\rho = \frac{\sum_{t=i+1}^{w}(\epsilon_t^2 - \sigma_t^2)(\epsilon_{t-1}^2 - \sigma_{t-1}^2)}{\sum_{t=1}^{w}(\epsilon_t^2 - \sigma_t^2)^2}$$

3.The asymptotic, that is for large samples, standard deviation of $\rho(i)$ is $1/\sqrt{W}$. GARCH errors are indicated by individual values that are larger than this. Utilize the Ljung–Box test to estimate the total number of lags until their values are less than, say, 10% significant. If the squared residuals ϵ_t^2 are uncorrelated, the Ljung–Box Q-statistic follows the M^2 distribution with n degrees of freedom. The null hypothesis states that neither ARCH nor GARCH errors exist. It is suggested that W/4 values of n be taken into consideration. This indicates that the conditional variance contains such errors when rejecting the null.

Akaike information criterion (AIC)

A method for selecting a model is provided by AIC. The process that generated the data will almost never be accurately represented using a statistical model; because when the process is represented by the model, some information will be lost. The relative amount of information lost by a given model is estimated by AIC: The higher the quality of a model, the less information it loses. The AIC is used in the following ways:

AIC = −2log(T) + 2j

The term 2j is a penalty that grows in proportion to the number of estimated parameters, with log(T) representing the maximum likelihood of the parameters for the estimated model and j representing the number of parameters.
For both the ARMA process and the GARCH process, this AIC function is used to determine the orders B and C. The model with the lowest AIC value is preferred out of all the ARMA and GARCH orders.

Bayesian information criterion (BIC)

Similar to the AIC, the BIC is a criterion for selecting a model from a limited set of models; Most of the time, researchers prefer models with a lower BIC. Adding parameters to models can increase the likelihood of fitting them, but doing so could lead to overfitting. By introducing a penalty term for the number of model parameters, both BIC and AIC attempt to address this issue; For sample sizes greater than 7, the penalty term in BIC is longer than in AIC. Formally, the BIC is defined as

$$BIC = J \ln(n) - 2 \ln(T)$$

T is the likelihood function's maximum value, or T= p(v| θ, M), where and are the parameter values that maximize the likelihood function, respectively. v is the data that was seen. n is the number of observations, the sample size, or the number of data points in v. j is the number of parameters that the model estimates.
The intercept, the c slope parameters, and the errors' constant variance are, for instance, the estimated parameters in multiple linear regression; Consequently, k = c + 2

Statistical Tests

Augmented Dickey-Fuller Test

The null hypothesis that a time series has a unit root (stationarity) is put to the test with an Augmented Dickey–Fuller test ADF. The term "test statistic" refers to

$$\Delta S_t = f_t + \eta s_{t-1} + \sum_{i=1}^{b-1} \xi_i \, \Delta s_{t-i}$$

where Δ is the differenced operator and f_t is a deterministic function of the time index t. The Augmented Dickey-Fuller's null hypothesis is η = 0 (the returns have a unit root), while the alternative hypothesis is η < 0 (the returns lack a unit root).

Phillips-Perron Test

A regression of the form is involved in the Phillips-Perron test;

$$s_i = \alpha + \rho s_{i-1} + u_i$$

on the time series return data. A trend term can be included or excluded from the intercept term. Against the null hypothesis that the variable was generated by a stationary process, there is a unit root.

ARCH test for Heteroscedasticity

The Lagrange Multiplier test is a variant of the conditional heteroscedasticity test.

$$\varepsilon_t^2 = \alpha_0 + \sum_{i=1}^{m} \alpha_i \, \varepsilon_{t-i} + \alpha_t, t$$

$$= i + 1, \ldots, n,$$

where m is a predetermined integer and αt is an error term. The test is distributed $M_1{}^2{}_{-\alpha}$ with m degrees of freedom and is the significance level under the null hypothesis of no ARCH effect. When the test's reported p-value falls below the significance level, the null hypothesis is rejected.

Jarque-Bera Test for Normality

The Jarque–Bera test is a goodness-of-fit test used to determine whether the kurtosis and skewness of sample data are consistent with a normal distribution. There is never a negative value for the test statistic. The residuals of the fitted ARMA model for the mean equation are the subject of this test. That is shown by the data;

$$JB = \frac{n-j}{6}(r^2 + \frac{(J-3)^2}{4})$$

J is the Kurtosis, n is the number of observations, R is the sample skewness, and j is the number of estimated parameters. Because it asymptotically has a chi-squared distribution with two degrees of freedom if the data come from a normal distribution, the JB statistic can be used to test the hypothesis that the data are from a normal distribution. The null hypothesis is rejected when the test's p-value falls below the 5% significance level.

Ljung-Box Test

The Ljung-Box Test, also known as the Ljung–Box Q test, is a statistical test that is used to determine whether any of a group of autocorrelations in a time series is different from zero. It has the results of the test;

$$Y = n(n+2)\sum_{k=1}^{u}\frac{\rho_j^2}{n-j}$$

where;

$$\rho_t = \frac{\sum_{t=i+1}^{n}(\varepsilon_t - \bar{\varepsilon})(\varepsilon_{t-1} - \bar{\varepsilon})}{\sum_{t=1}^{n}(\varepsilon_t - \bar{\varepsilon})^2}$$

Furthermore, the quantity of slack autocorrelations to be considered is n. The choice rule is to dismiss the invalid speculation if the p-esteem is not exactly or equivalent to, the importance level, under the invalid speculation that there is no sequential reliance in the primary m autocorrelations. The Ljung–Box test is frequently used in ARIMA modeling.

It should be noted that it is applied to the residuals of a fitted ARIMA model rather than the original series. The hypothesis that the ARIMA model's residuals lack autocorrelation is being tested in such instances. The levels of opportunity should be acclimated to mirror the boundary assessment while testing the residuals of an expected ARIMA model.

CHAPTER IV

Data Analysis and Discussions

The Data

The weekly exchange rates of the Euro (EUR), the United States Dollar (USD), the Great British Pound (GBP), and Senegal's XOF against the Gambian Dalasi (GMD) over a twenty-two-year period comprise the data used in this thesis. Each of the 1200 observations in the data spans the months of January 2000 through December 2022. Banks and other financial institutions buy and sell foreign currencies at these average weekly spot price exchange rates, as depicted in the data. We analyzed the collected data with the EViews software package, data was obtained from **investing.com**

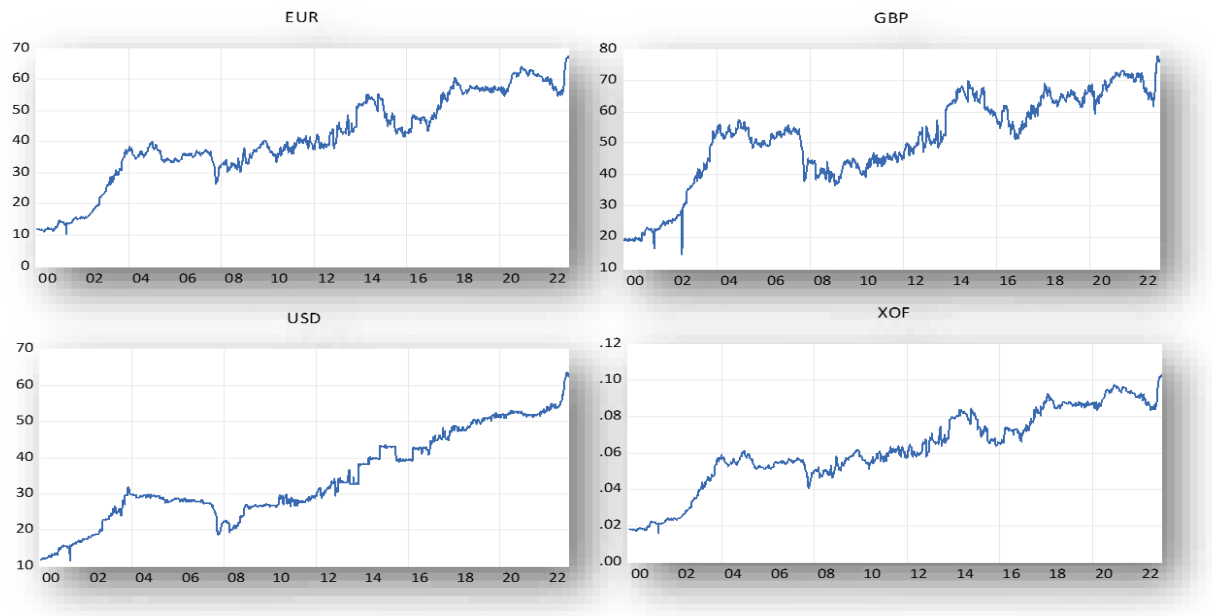

Figure 2: Weekly exchange rate; EUR/GMD, GBP/GMD, USD/GMD, XOF/GMD (2000–2022)

The mean and variance of the requirements for time series analysis ought to be consistent. Using the graphic test, one method of testing stationarity is to determine whether or not it has the unit root. An observation is compared to the correlogram in the test; which is the partial autocorrelation and the graphic of the auto-correlation function. It is possible to say that the data have been stationary (it does not have a unit root) and that the data process moves on to the next stage if the auto-correlation function of the correlogram shows a gradual decline as more lags participate and directly leads to zero in the second lag (Yunita, 2016). We must change the original series to make it stationary because our weekly exchange rate series in this study is not stationary. Time series models can now be used without going against the underlying theory thanks to this.

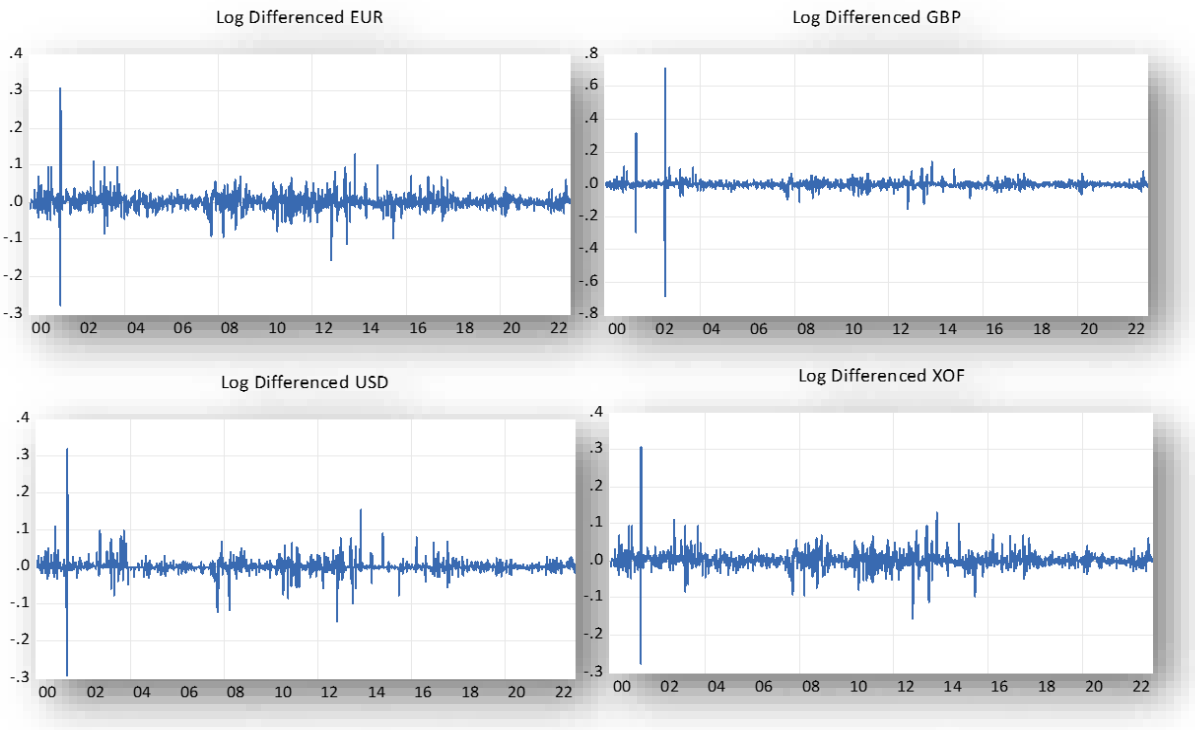

Figure 3: Weekly returns series; EUR/GMD, GBP/GMD, USD/GMD, XOF/GMD (2000 - 2022)

Over time, the return series appear to be stationary and occasionally fluctuating around mean zero. The plots show the volatility clustering as well. This is obvious because periods of high return values typically are followed by additional high values, whereas periods of low return values typically are followed by additional low values.

Descriptive Statistics

The original and return series' descriptive statistics are the subject of discussion in this section. From 2000 to 2022, the following is the average exchange rate of currencies against Dalasi: from D13.86/1$ to D55.38/1$ for USD, from D12.76/1€ to D58.26/1€ for EUR, from D20.95/1£ to D68.35/1£ for GBP, and from D0.0187/1CFA to D0.0888/1CFA for XOF.
The weekly kurtosis of the exchange rates is as follows: 2.50 for the EUR/GMD, 2.73 for the GBP/GMD, 2.02 for the USD/GMD, and 2.50 for the XOF series, indicating that the kurtosis of the distributions is approximately the same as that of a normal distribution, which is 3 in this context. With values of 36.99, 194.92, 64.74, and 36.99 for EUR, GBP, USD, and XOF, respectively, the kurtosis of returns indicates that they are heavy-tailed. All of the return series have a mean that is close to 0.001. For the EUR, USD, and XOF, the standard deviation of the returns is close to 0.02, indicating that the spread of the returns from their mean value is very small. For the GBP, the standard deviation is 0.04, indicating that the spread is slightly better. The fact that the series' skewness is greater than zero and positive indicates that the returns' distribution is slightly biased in the right direction. The positive skewness of exchange rates indicates that the Gambian dalasi depreciates more frequently than it appreciates.

Table 1: Weekly series statistics; EUR/GMD, GBP/GMD, USD/GMD, XOF/GMD

Weekly Series				
	EUR	GBP	USD	XOF
Mean	40.86961	51.29527	34.15168	0.062305
Median	39.32500	52.88500	29.75000	0.059951
Maximum	67.43500	77.86500	63.40000	0.102804
Minimum	10.25500	14.47500	11.36000	0.015634
Std. Dev.	13.87261	14.11031	12.21584	0.021149
Skewness	-0.349976	-0.603214	0.242346	-0.349976
Kurtosis	2.505727	2.736094	2.022972	2.505727
Jarque-Bera	36.71193	76.25575	59.47549	36.71193
Probability	0.000000	0.000000	0.000000	0.000000
Sum	49043.53	61554.32	40982.01	74.76638
Sum Sq. Dev.	230746.8	238722.0	178922.7	0.536272
Observations	1200	1200	1200	1200

Table 2: Weekly return series statistics; EUR/GMD, GBP/GMD, USD/GMD, XOF/GMD

Return Series				
	EUR	GBP	USD	XOF
Mean	0.001443	0.001157	0.001400	0.001443
Median	0.000964	0.001011	0.000000	0.000964
Maximum	0.306997	0.712984	0.318774	0.306997
Minimum	-0.276774	-0.682905	-0.292840	-0.276774
Std. Dev.	0.025060	0.038184	0.022641	0.025060
Skewness	0.423780	0.713685	0.544373	0.423780
Kurtosis	36.99497	194.9295	64.74166	36.99497
Jarque-Bera	57770.64	1840413	190502.0	57770.64
Probability	0.000000	0.000000	0.000000	0.000000
Sum	1.730433	1.387673	1.679076	1.730433
Sum Sq. Dev.	0.752351	1.746701	0.614116	0.752351
Observations	1199	1199	1199	1199

In order to achieve stationarity using the AIC criterion and the 5% significance level, the p-values of the Augmented Dickey-Fuller and Phillips-Perron tests are greater than or equal to that

level. Because the p-values associated with the tests are all less than the respective significance levels, all of the tests for the returns suggest stationarity at the first difference of 1%, 5%, and 10%, respectively.

Table 3: Augmented Dickey-Fuller and Phillips Perron Tests for Unit Test (weekly series)

Weekly Series				
Augmented Dickey-Fuller Test				
	EUR	GBP	USD	XOF
Test Statistics P-value	-2.8320 0.1859	-2.5132 0.3216	-1.4712 0.8390	-2.8320 0.1859
Phillips Perron Test				
	EUR	GBP	USD	XOF
Test Statistics P-value	-3.1372 0.0981	-2.6265 0.2684	-1.7847 0.7118	-3.1372 0.0981

Table 4: Augmented Dickey-Fuller and Phillips Perron Tests for Unit Test (return series)

Return Series				
Augmented Dickey-Fuller Test				
	EUR	GBP	USD	XOF
Test Statistics P-value	-12.1313 <0.001	-28.4392 <0.001	-23.0398 <0.001	-12.1313 <0.001
Phillips Perron Test				
	EUR	GBP	USD	XOF
Test Statistics P-value	-38.8313 <0.001	-43.4533 <0.001	-42.7517 <0.001	-38.8313 <0.001

Selection of ARMA–GARCH Model

The appropriate ARMA–GARCH model for modeling the mean and variance equation for the Euro, GBP, USD, and XOF returns is selected in this section.

Selection of ARIMA (P, D, Q) model

Since the mean equation is based on the AIC, an ARIMA model with the simplest case of ARIMA (0,1,0) was required to fit the returns because the data reached stationarity after the first difference. This criterion was used to fit and evaluate a number of ARIMA models. The AIC is a proportion of the decency of-spasm of an expected measurable model. The model with the lower AIC value should be chosen out of any two estimated models.

Since they have the lowest values, the ARIMA (5,1,1) for the EUR, the ARIMA (1,1,2) for the GBP, the ARIMA (19,1,1) for the USD, and the ARIMA (5,1,1) for the XOF return series were chosen to model the mean equation for weekly series. By filtering out serial dependence, these ARIMA Models produce independent and identically distributed (i.i.d.) data errors.

Heteroskedasticity Test

A heteroskedasticity test, which is the main feature of conditional heteroscedasticity models for ARCH and GARCH models, is now being administered to the models. The heteroscedasticity test looks to see if the variance from the return data changes over time or stays constant. The least square method is used to estimate the moving average equation as the first step. The heteroscedasticity test, either using the White Heteroscedasticity Test or the ARCH-LM Test, is the next step (Yunita, 2016). Ho is rejected because it tends to be heteroscedastic if the probability is less than 5%. The ARCH/GARCH method is used to determine the volatility value if it is heteroscedastic.

Table 5: Heteroskedasticity Test for ARCH effects

Heteroskedasticity Test: ARCH effects			
	EUR		
F-statistic	246.7902	Prob. F (1,1195)	0.0000
Obs*R squared	204.8896	Prob. Chi-Squared (1)	0.0000
	GBP		
F-statistic	137.6641	Prob. F (1,1196)	0.0000
Obs*R squared	123.6605	Prob. Chi-Squared (1)	0.0000
	USD		
F-statistic	238.6939	Prob. F (1,1195)	0.0000
Obs*R squared	199.2870	Prob. Chi-Squared (1)	0.0000
	XOF		
F-statistic	246.7902	Prob. F (1,1195)	0.0000
Obs*R squared	204.8896	Prob. Chi-Squared (1)	0.0000

The fact that the probability of the F-statistic as shown in table 5 is 0.000000, indicates that the data are heteroscedastic and contain the ARCH effect at the estimated model; consequently, the search for the ARCH/GARCH model can continue.

Selection of GARCH (P, Q.) Model

The AIC and the highest number of Log Likelihoods are used to select the appropriate GARCH from competing models. At various GARCH model p and q combinations, the AIC is evaluated. For parsimonious reasons, small lags for p and q are frequently utilized in empirical applications. According to Marreh (2014), GARCH (1,1), GARCH (1,2), and GARCH (2,1) are typically sufficient for modeling volatilities in financial time series over extended sample periods. The non-significant coefficient is the hypothesis Ho that is about to be rejected by this significance test. If the probability of the Z-statistic value is less than the probability of the critical value (less than 5%), the model is thought to be significant. Additionally, the smallest AIC and SIC values in addition to the highest adjusted R-Squared value are observed.

A number of GARCH models are included to see if they might be useful for modeling the heteroscedasticity in our data. As with the ARMA model, a better corresponding model has a smaller AIC.

The best GARCH model against the return data for the EUR series is the GARCH model (2.1), the GARCH model (1,1) for the GBP series, the GARCH model (1,1) for the USD series, and the GARCH model (2,1) for the XOF series.

In the figures 4 to 7 beneath, the GARCH restrictive change for the series is plotted against the first week after week series of our information. It clearly depicts the series' volatility and variance, indicating clustering in all weekly series. It also shows that our model works well with the data.

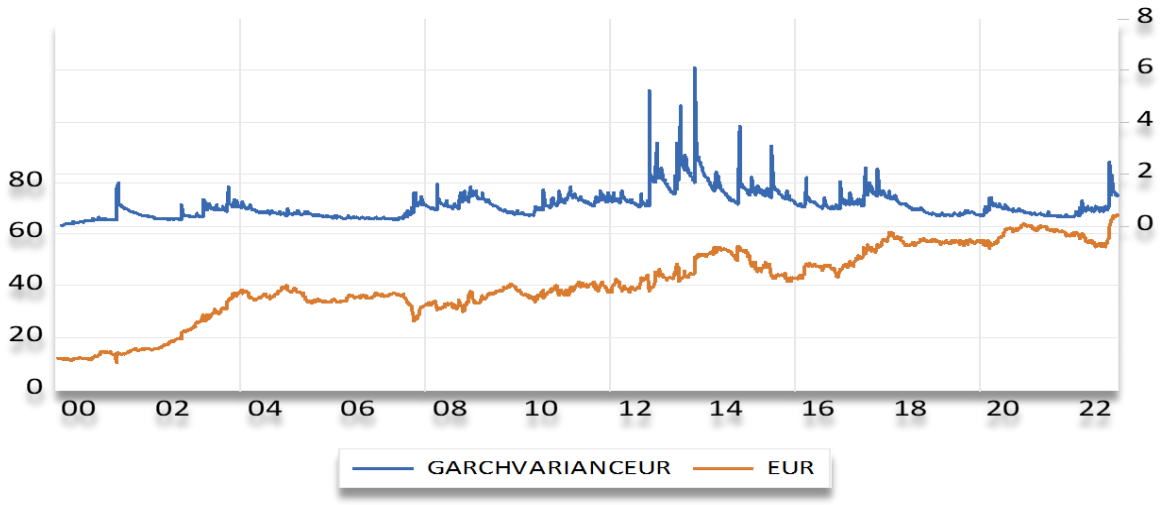

Figure 4: GARCH Covariance and weekly series (EUR/GMD)

Figure 5: GARCH Covariance and weekly series (GBP/GMD)

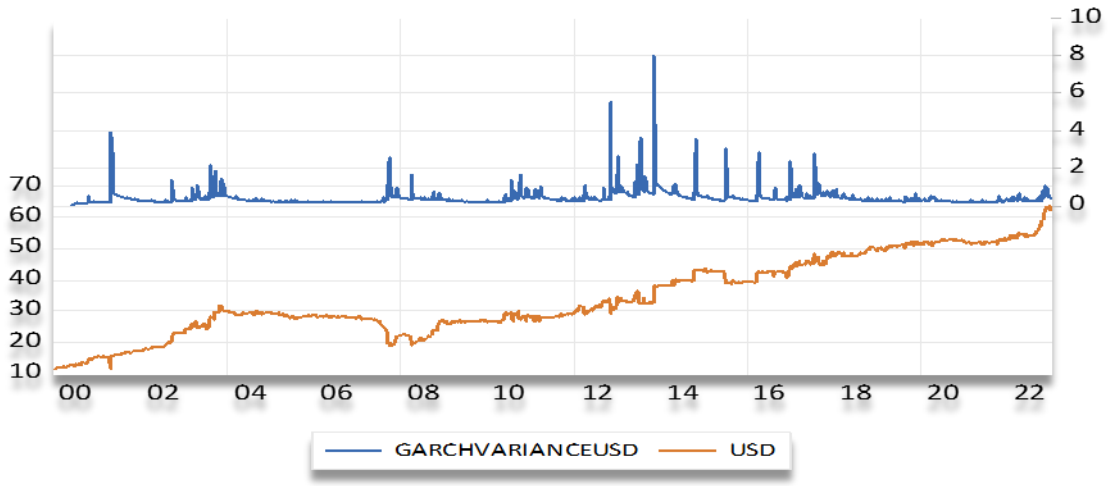

Figure 6: GARCH Covariance and weekly series (USD/GMD)

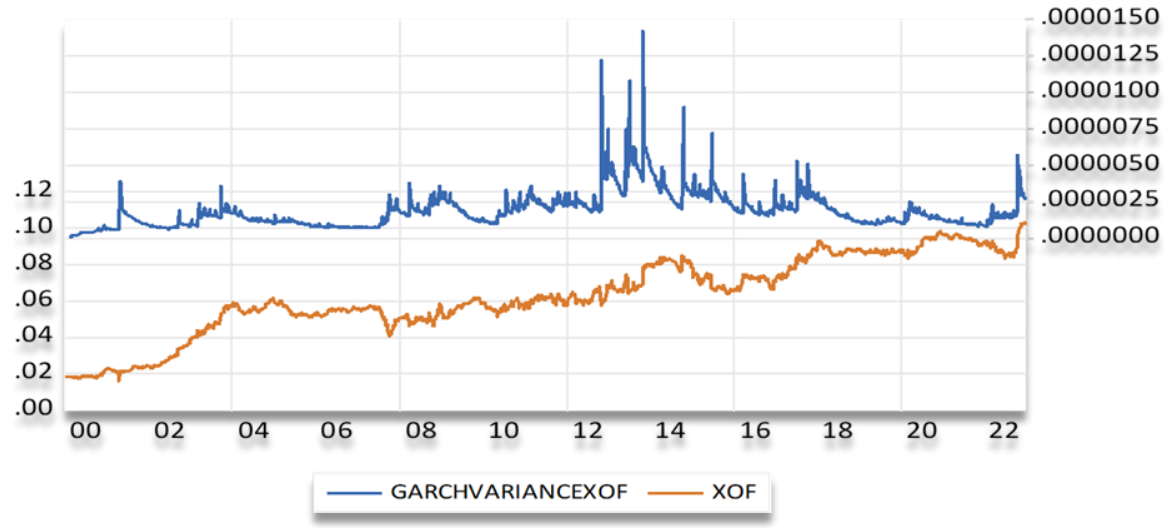

Figure 7: GARCH Covariance and weekly series (XOF/GMD)

ARCH-LM Test of ARCH/GARCH Model

After the best model from each file is acquired, the following stage is by leading ARCH LM test to assess the assessment results regardless of whether the model actually contains the heteroscedastic component. The LM test procedure is used to carry out the testing.

Therefore, the heteroscedasticity issue is not present in the model if Obs*R-Squared is less than the value of the X^2 or the probability is greater than 5%. The significance value of more than 5% demonstrates that the GARCH model's estimation results are free of heteroscedasticity thanks to the ARCH-LM test.

Forecasting Dalasi volatility using the ARIMA model

After choosing the right ARIMA models for each of the weekly series, we now run a forecast of the series and rank the currencies in order of volatility.

Table 6: ARIMA model and Volatility (EUR/GMD, GBP/GMD, USD/GMD, XOF/GMD)

Currency	ARIMA Model	Volatility
EUR/GMD	(5,1,1)	0.755021
GBP/GMD	(1,1,2)	1.552752
USD/GMD	(19,1,1)	0.364844
XOF/GMD	(5,1,1)	0.0000018

According to table 6, the most volatile currency comparison in our series is GBP/GMD, followed by EUR/GMD, which is second most volatile, and USD/GMD, which is third most volatile. On the other hand, the least volatile currency comparison in our series is XOF/GMD. This may explain why the United States dollar is regarded as a more reliable currency in The Gambia and why the central bank still holds the majority of its foreign reserves in the currency.

Table 7: Volatility Comparison for 2002, 2008, 2020

	Volatility		
Currency/Year	**2002**	**2008**	**2020**
EUR/GMD	0.134866	0.943418	0.526005
GBP/GMD	5.288293	1.209325	1.427077
USD/GMD	0.102628	0.233355	0.093937
XOF/GMD	0.00000031	0.0000022	0.0000012

For comparison, we now estimate the return series' volatility using three specific years—2002, 2008, and 2020—from January to December to determine the extent to which international events and shocks affected the weekly exchange rate series against the Gambian Dalasi. For 2002, the ARIMA (8,1,7) was deemed the best fit for the EUR/GMD return series, the ARIMA (1,1,2) the best fit for the GBP/GMD return series, ARIMA (7,1,7) the best fit for the USD/GMD return series, and ARIMA (8,1,7) the best fit for the XOF/GMD return series. For 2008, the ARIMA (2,1,2) was deemed the best fit for the EUR/GMD return series, the ARIMA (2,1,2) the best fit for the GBP/GMD return series, ARIMA (5,1,5) the best fit for the USD/GMD return series, and ARIMA (2,1,2) the best fit for the XOF/GMD return series. For 2020, the ARIMA (1,1,5) was deemed the best fit for the EUR/GMD return series, the ARIMA (7,1,7) the best fit for the GBP/GMD return series, ARIMA (1,1,1) the best fit for the USD/GMD return series, and ARIMA (1,1,5) the best fit for the XOF/GMD return series.

The years chosen for comparison were as a result of the major events around the world that affected the currencies, with uncertainty in 2002 exchange rates as a result of the 2001, September 11 attack on the World Trade Center in the United States; The 2008 financial crisis that hit many international banks around the world and affected international trade; The 2020 Corona Virus pandemic that hit almost the entire world bringing a massive slowdown in trade, movement of goods and services, and development efforts.

The EUR exchange rate return series was most volatile during the 2008 crisis, the GBP exchange rate return series was most volatile following the attacks in 2002, and the USD exchange rate return series was most volatile during the 2008 crisis, as shown in Table 7. So far, we can see that the exchange rate return series against the Dalasi were most volatile in 2002 on average.

We now forecast the performance of the models fitted to the EUR/GMD, GBP/GMD, USD/GMD, and XOF/GMD (2000 - 2022) returns to predict their future trends. The forecast period will be from January 2023 to December 2023.

A forecast of the EUR/GMD was done using the ARIMA (5,1,1) model and a forecast of 12 months was done and the Euro indicated a RMSE (Root Mean Square Error) of 0.466581 and MAPE (Mean Absolute Percent Error) of 0.691897.

This model forecast that the Dalasi will continue to depreciate against the Euro and that by December 2023, it is expected to reach an average of D70.00/1€ as compared to D66.00/1€ as of December 2022 closing.

A forecast of the GBP/GMD was done using the ARIMA (1,1,2) model and a forecast of 12 months was done and the British Pound indicated a RMSE of 0.061066 and MAPE of 0.080113.

This model forecast that the Dalasi will continue to depreciate against the British Pound and that by December 2023, it is expected to reach an average of D80.00/1£ as compared to D74.00/1£ as of December 2022 closing.

A forecast of the USD/GMD was done using the ARIMA (19,1,1) model and with a forecast of 12 months was done and the US Dollar indicated a RMSE of 1.138838 and MAPE of 1.829459.

This model forecast that the Dalasi will continue to depreciate against the US Dollar and that by December 2023, it is expected to reach an average of D70.00/1$ as compared to D61.00/1$ as of December 2022 closing.

A forecast of the XOF/GMD was done using the ARIMA (5,1,1) model and a forecast of 12 months was done and the Senegal CFA indicated a RMSE of 0.000711 and MAPE of 0.691897.

This model forecast that the Dalasi will remain relatively stable against the Senegal CFA by December 2023 maintaining a slight change from its December 2022 closing of D0.101025/1XOF or to put it more accurately D505.00/5000XOF which is the standard for comparison.

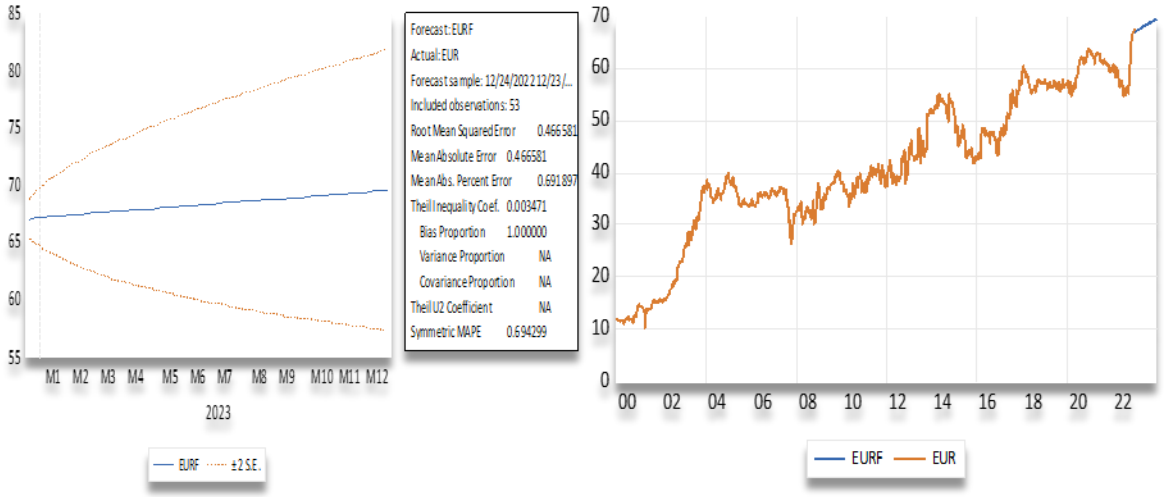

Figure 8: 12-month ARIMA forecast (EUR/GMD)

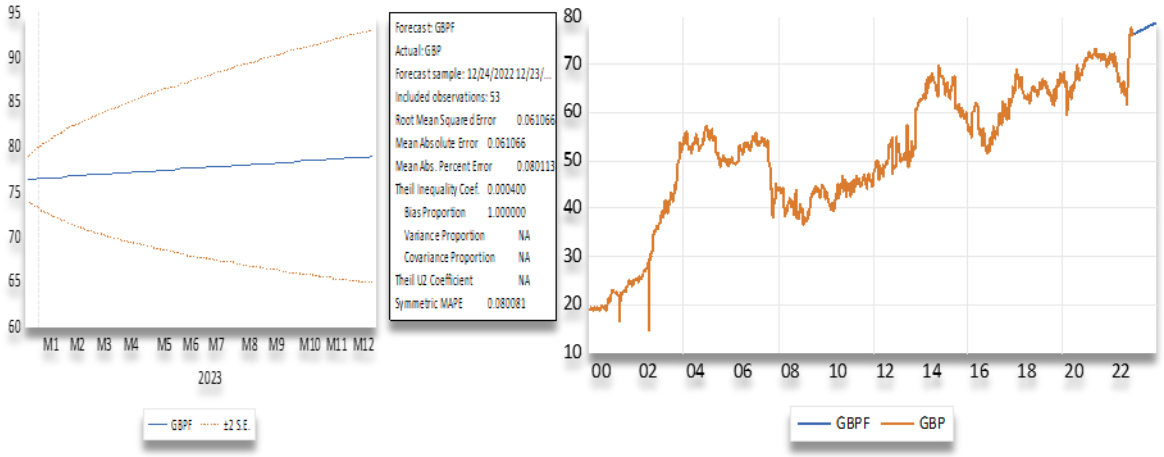

Figure 9: 12-month ARIMA forecast (GBP/GMD)

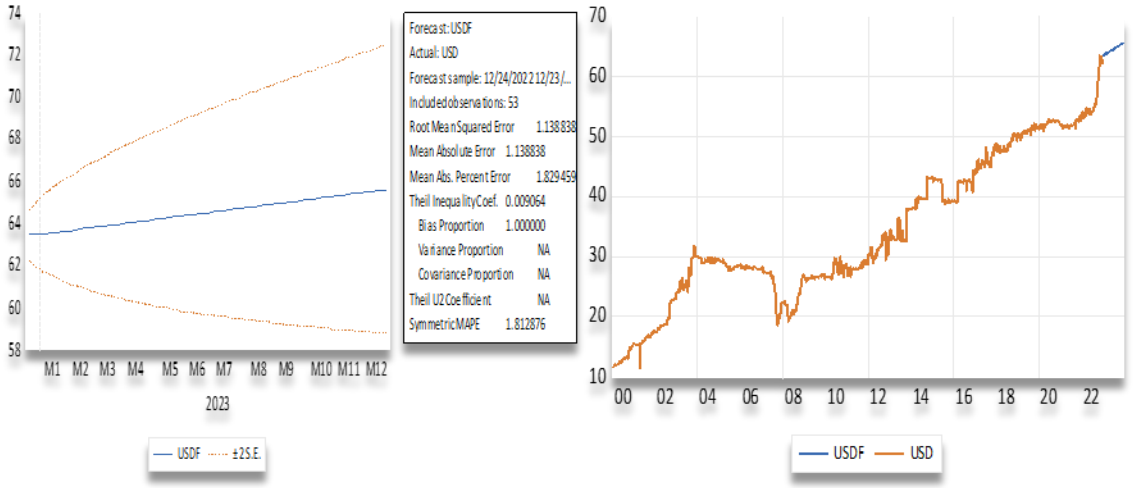

Figure 10: 12-month ARIMA forecast (USD/GMD)

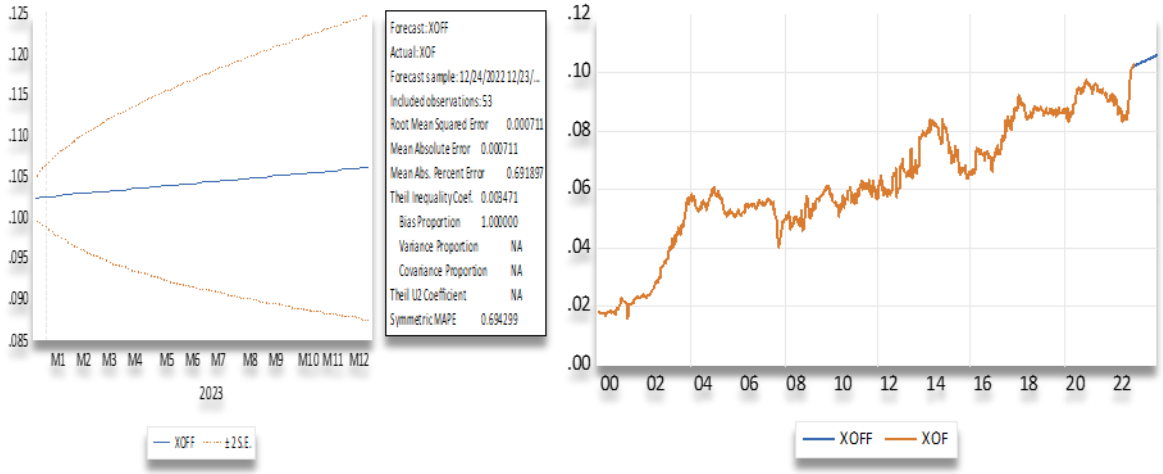

Figure 11: 12-month ARIMA forecast (XOF/GMD)

CHAPTER V

Findings and Discussions

The graphs of the time series of the Gambian exchange rate were non-stationary, consequently, the need to transform them to returns. The Gambian exchange rate returns have been explored and a suitable ARMA-GARCH model was formulated and applied to the data. Based on the AIC criteria, the ARIMA (5,1,1)-GARCH (2,1) were applied to the EUR/GMD weekly series returns, ARIMA (1,1,2)-GARCH (1,1) were applied to the GBP/GMD weekly series returns, ARIMA (19,1,1)-GARCH (2,1) were applied to the USD/GMD weekly series returns, and ARIMA (5,1,1)-GARCH (2,1) were applied to the XOF/GMD weekly series returns. Volatility clustering was observed in all the returns series.

It was observed that the Dalasi against the GBP was the most volatile, followed by the EUR, the USD, and the XOF was the least volatile of all the series. This may justify to a certain extend why the USD is more favored for International and trade transactions in the Gambia and perhaps why the CBG also keep majority of its foreign reserves in USD. This also indicates that a good alternative for the Gambia or any developing nation is the EUR which is very stable and backed by the European Union. The Gambia can switch to the EUR in the near future as confidence in the USD is dwindling in the international business community. According to United Nations COMTRADE, EU imported from The Gambia US$34.43 million in 2022 as compared to US$1.51 million by the United States in the same year. This indicates that the European Union is a better trading and development partner for the Gambia given that the EU has a more engaging approach to development with the Gambia Government.

The studies also show that the Dalasi will continue to depreciate against the currencies except slightly against the XOF. This will be good for remittances but it will affect imports and trade and as such affect the prices of goods and services in the country. It is not favorable to CBG as well given that already the inflation rate in the Gambia is at an all-time high of 14.8% as of March 2023 (CBG).

CHAPTER VI

Conclusions and Recommendations

It is safe to say that despite all factors that affect the Dalasi and the Gambia being at all odds in the international market, the Central Bank of The Gambia has since its introduction done a fairly good job in maintaining and balancing the value of the Dalasi, prices in the economy, and all financial institutions operating within the country.
As the demand for financial services continues to grow together with the economy, the CBG is increasing being able to monitor, control, and measure the transactions and trade volumes of the economy and hence help them to make better- and well-informed decisions regarding the economy and its indicators.
This thesis adds to the long list of studies like (Marreh, 2014) that confirm that most long period financial time series can be modelled using the GARCH (1,1), GARCH (1,2), and GARCH (2,1) models.

This study has confirmed based on literature and various works that remittances play a very important role in the economy of The Gambia and the value of the Dalasi. (Acosta et al., 2009; Ceesay et al., 2019; Joof & Touray, 2021), all suggest a positive impact remittance have on the exchange rate value of a local currency.
We recommend that the CBG not only regulate inflow of remittances and control the new financial institutions that render services to the growing needs of the people but also that the CBG should invest in more financial infrastructure and lead the development and digitalization of remittances in the Gambia. This is in line with observed studies of countries like Kenya and Nigeria which have had significant improvements in this regard according to (Bolarinwa & Akinbobola, 2020). Cost of remittances must also be brought down to encourage development.
We also recommend that the CBG should campaign for more financial inclusion of more members of the public and encourage the population of the Gambia to bank more thus encourage savings, as (Acosta et al., 2009) studies suggest, the most effective way for remittances to positively affect exchange rate value is through proper local investment.

We have shown in our studies that trade between The Gambia and Senegal are very important and that trade has actually been growing over the years between the two neighboring countries but we have also shown that the Senegal CFA is considered stable against the Dalasi and we recommend that the CBG focus more on the EUR to which the CFA is hard pegged. Inflation has been a major factor for the Dalasi over the years with (Joof & Jallow, 2020) showing that inflation has impact on the Dalasi exchange rate while interest rates and exchange rate being reciprocal to each other.

We recommend that The Gambia invest to a better and more advanced financial sector where more financial services and derivatives are available to banks and financial institutions as the studies of (Mbowe, 2018) shows that with all the banks and companies operating in the Gambia, only Trust Bank is among the listings of the Ghanian Stock Exchange.

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Appendices

Appendix A

Weekly exchange rate series (2018 to 2022)

The thesis analyses data over a twenty-two years period from January 2000 to December 2022, it is however important to zoom in to get a better understanding of the trend of the Dalasi in most recent times. This section looks at the Dalasi exchange rate weekly series from January 2018 to December 2022 against the four major currencies being reviewed.

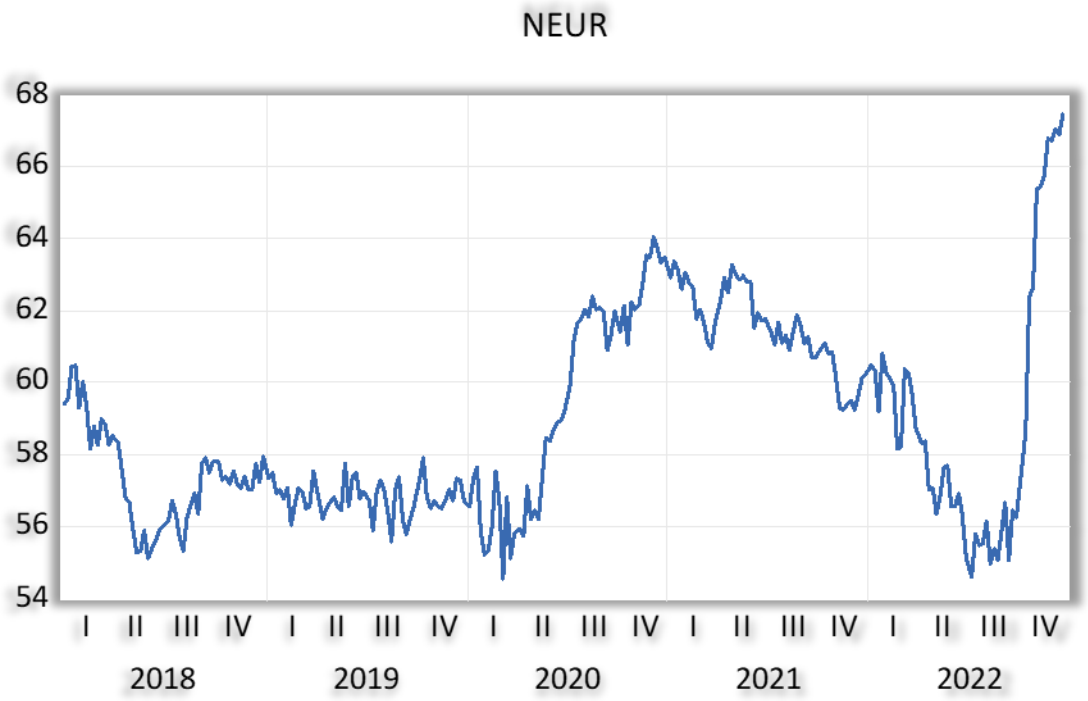

Figure 12: Weekly exchange rate EUR/GMD (2018 to 2022)

Figure 13: Weekly exchange rate GBP/GMD (2018 to 2022)

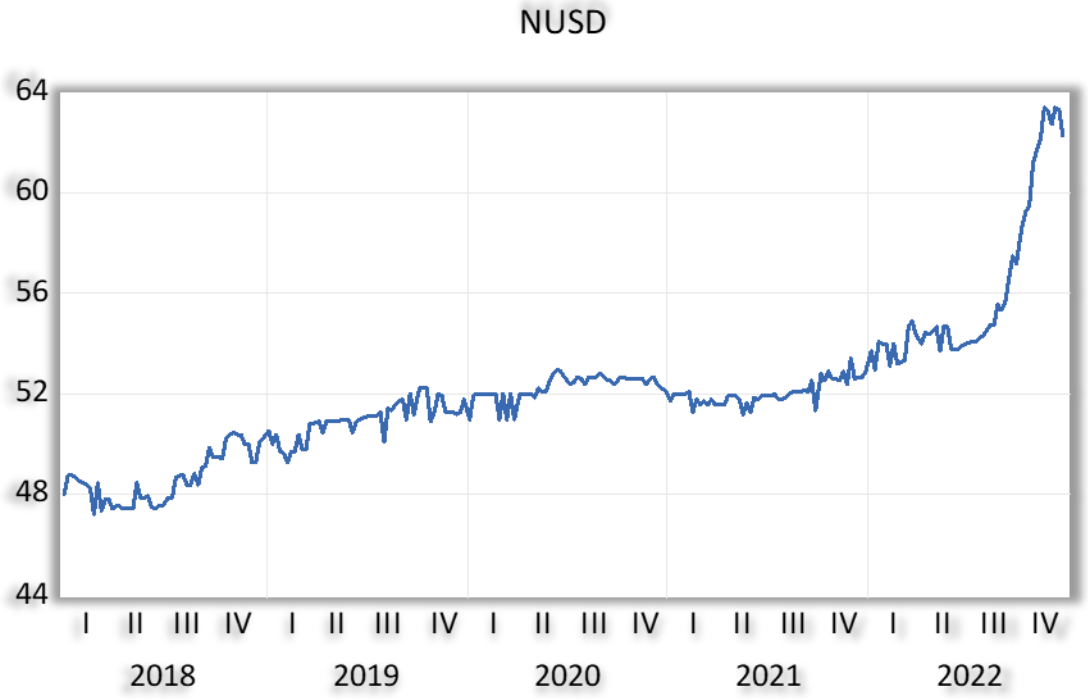

Figure 14: Weekly exchange rate USD/GMD (2018 to 2022)

Figure 15: Weekly exchange rate XOF/GMD (2018 to 2022)

Appendix B