IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ECONOMICS

MASTER THESIS

INVESTIGATING THE RELATIONSHIP BETWEEN EXCHANGE RATE AND FOOD PRICES IN THE WEST AFRICAN ECONOMIC AND MONETARY UNION STATES

DELWENDE ARTHUR KABORE

THESIS SUPERVISOR
ASSIST. PROF. ASAD UL ISLAM KHAN

ISTANBUL, 2023

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by
DELWENDE ARTHUR KABORE

A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Arts in Economics

THESIS SUPERVISOR
ASSIST. PROF. ASAD UL ISLAM KHAN

ISTANBUL, 2023

APPROVAL PAGE

This is to certify that we have read this thesis and that, in our opinion, it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts in Economics.

Thesis Jury Members

Title - Name Surname	Opinion	Signature

This is to certify that the School of Graduate Studies at Ibn Haldun University has not imposed any additional requirements on this thesis beyond those that it already fulfills.

Submission Date   Signature/Seal

ACADEMIC HONESTY ATTESTATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Signature:

ÖZ

BATI AFRİKA EKONOMİK VE PARASAL BİRLİK ÜLKELERİNDE DÖVİZ KURU VE GIDA FİYATLARI ARASINDAKİ İLİŞKİNİN İNCELENMESİ

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Gıda güvensizliği, gelişmekte olan ülkelerde büyümenin önünde önemli bir engel teşkil etmektedir. Bu ekonomiler, iç ve dış krizler sırasında sıklıkla akut yoksulluğa maruz kalmaktadır. COVID-19 salgını ve Rusya'nın Ukrayna'yı işgali gibi son olaylar, gelişmekte olan ekonomiler üzerinde ciddi etkileri olan dünya ekonomisini durdurmuştur. Dolayısıyla Batı Afrika Ekonomik ve Parasal Birliği (WAEMU), ticaret para birimi olan ABD doları karşısında yerel para biriminin değer kaybetmesiyle daha da kötüleşen bir gıda krizi yaşamaktadır. Bu tez, CFA hareketlerinin WAEMU ülkelerindeki gıda fiyatları üzerindeki mevcut aktarım etkilerini incelemeyi amaçlamaktadır. Çalışma, Ocak 2004'ten Aralık 2022'ye kadar sekiz WAEMU ülkesinde CFA frangının değer kaybetmesi (değer kazanması) ile gıda fiyatları arasındaki ilişkiyi araştırmamızı sağlayan yenilikçi bir yaklaşım benimsemektedir. NARDL sonuçları, döviz kuru hareketleri ile gıda fiyatları arasında asimetrik ve doğrusal olmayan bir bağlantı olduğunu ortaya koymaktadır. Tüm WAEMU ülkelerinde değer kazanma ve kaybetme gıda fiyatlarını farklı şekilde etkilemektedir. Döviz kurunun kısa vadede değer kazanmasının gıda maliyetleri üzerinde önemli bir etkisi yoktur; ancak yerel para biriminin değer kaybetmesi Benin, Burkina Faso, Gine Bissau, Mali, Nijer ve Togo'da gıda fiyatlarını olumlu yönde etkilemektedir. CFA frangının uzun vadede değer kaybetmesi tüm CFA bölgesi ülkeleri üzerinde olumlu bir etkiye sahiptir. Buna karşılık, CFA frangının değer kazanması Benin, Fildişi Sahili ve Nijer'de gıda fiyatları üzerinde olumsuz bir etkiye sahiptir. Bu nedenle politika önerisi, birliğin para politikasını geliştirirken asimetrik ilişkiyi dikkate almak, gıda işleme ve depolama firmalarının finansmanını kolaylaştıran politikalar benimsemek ve ortak pazarda rekabetçi yerel ürünleri teşvik etmek ve desteklemektir.

Anahtar Kelimeler: Covid-19, CFA Frangı, Döviz Geçiş Çukuru, Gıda fiyatları, NARDL, WAEMU.

ABSTRACT

INVESTIGATING THE RELATIONSHIP BETWEEN EXCHANGE RATE AND FOOD PRICES IN THE WEST AFRICAN ECONOMIC AND MONETARY UNION STATES

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August 2023, 134 Pages

Food insecurity constitutes a significant obstacle to growth in developing nations. These economies are frequently exposed to acute poverty during internal and foreign crises. Recent events, such as the COVID-19 pandemic and Russia's invasion of Ukraine, have stopped the world economy, with severe effects on developing economies. Thus, the West African Economic and Monetary Union (WAEMU) is experiencing a food crisis, exacerbated by the local currency depreciation as opposed to the trading currency, the US dollar. This thesis is intended to examine the existing transmission effects of the CFA movements on food prices in the WAEMU nations. The study adopts an innovative approach that enables us to investigate the relationship between the depreciation (appreciation) of the CFA franc with that of food prices in the eight WAEMU countries from January 2004 to December 2022. The NARDL results reveal an asymmetric and nonlinear connection between the exchange rate movements and food prices. Appreciations and depreciations affect food prices differently in all WAEMU countries. An appreciation of the exchange rate in the short term has no substantial effect on food costs; however, the local currency depreciation influence positively food prices in Benin, Burkina Faso, Guinea Bissau, Mali, Niger, and Togo. A depreciation of the CFA franc in the long term has a positive impact on all CFA zone nations. In contrast, the CFA franc appreciation has a negative effect on food prices in Benin, Côte d’Ivoire, and Niger.

Therefore, the policy recommendation is to regard the asymmetrical relationship in improving the monetary policy of the union, adopt policies that facilitate the financing of food processing and storage firms, and promote and support competitive local products in the common market.

Keywords: Covid-19, CFA Franc, Exchange Pass Trough, Food prices, NARDL, WAEMU.

DEDICATION

I dedicate this thesis to my family. No words to express my appreciation and admiration for its diverse support and encouragement. This work is in appreciation of the extraordinary love my family shows me regularly.

ACKNOWLEDGEMENT

I thank Almighty God for granting me the health and determination to begin and complete my thesis.

First and foremost, this study would be as rich and would only have seen the light of day with the guidance of my supervisor, Assist. Prof. Asad Ul Islam Khan. I want to thank him for the quality of his advice, patience, and availability during the preparation of this thesis.

I want to thank and express my deep gratitude to the head of the Economics department, Prof. Dr. Muhittin Kaplan, for guiding me and for his encouragement and precious advice.

My gratitude also extends to my professors for their dedication and professionalism in instructing me.

Delwende Arthur KABORE

ISTANBUL, 2023

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LIST OF SYMBOLS AND ABBREVIATIONS

ARDL	Autoregressive Distributed Lag
BCEAO	Central Bank of West African States
CFA	French Colonies in Africa
ECM	Error Correction Model
ECOWAS	Economic Community of West African States
ERPT	Exchange Rate Pass-Through
IMF	International Monetary Fond
LOOP	Law of One Price
NARDL	Nonlinear Autoregressive Distributed Lag
PPP	Purchasing Power Parity
SVAR	Structural Vector Autoregression
WTO	World Trade Organization
XOF	West African CFA franc
WAEMU	West African Economic and Monetary Union
WAMZ	West African Monetary Zone

CHAPTER I

INTRODUCTION

1.1. Brief Background

The outbreak of the pandemic of COVID-19 led the world into an unparalleled economic catastrophe in the twenty-first century. It has caused a decline in global economic productivity across all development sectors. The crisis-induced recession has progressively driven the world into a food crisis, exacerbated by the conflict between Ukraine and Russia. This food crisis is the third in a succession of crises in the twenty-first century. It comes after the food crises of 2007-2008 and 2010-2012. In contrast to the precedent crises (2007-2008 and 2010-2012), this latest one is the most serious since it not only lasts several years but also has terrible consequences such as slowed economic growth, the rise of income inequality, the death of millions of people, the increase in poverty, and affecting the accessibility of foods for millions of people across the globe. Even if advanced economies survive, the same cannot be said for developing economies. Several African countries, notably Burkina Faso, Somalia, and South Sudan are experiencing severe food scarcity and famine.

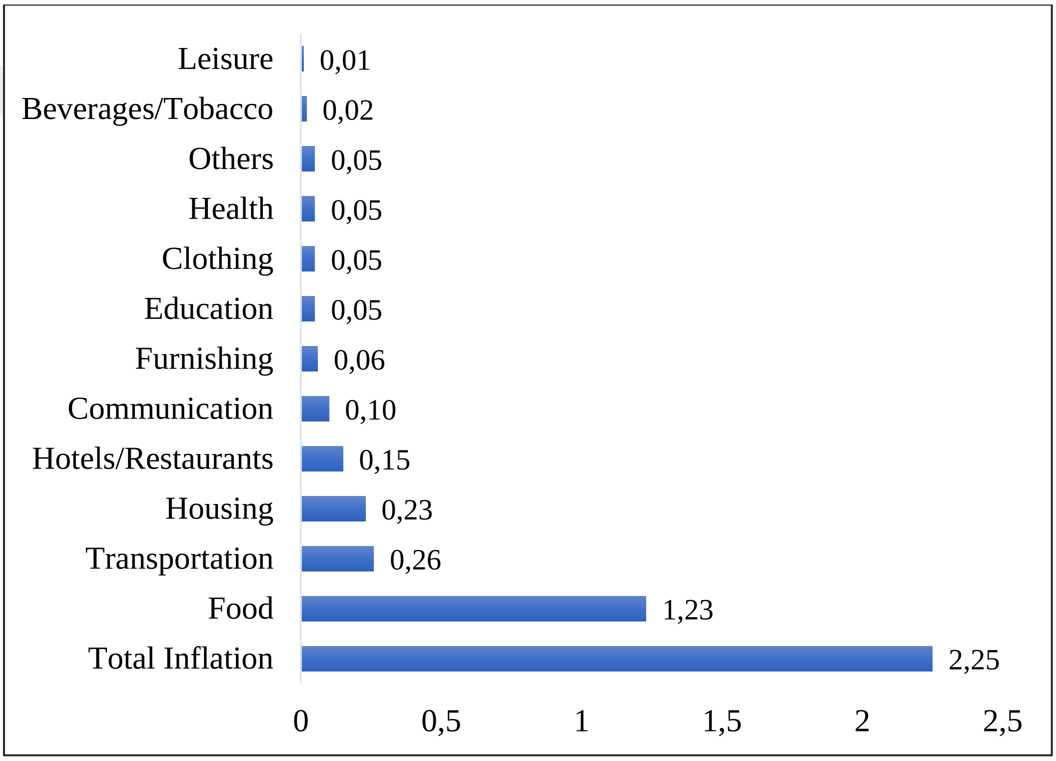
In addition, the international's trade currency, the American dollar, depreciated against the West African Franc (XOF) following quantitative easings in the United States during the two precedent crises. The current challenge, on the other hand, is distinct. The US dollar has appreciated following a raise in the interest rate to slow domestic inflation in March 2022. This has likely worsened the strain on nations still recovering from the severe COVID-19 crisis. The WAEMU countries are counted among those experiencing complex challenges. Most of its countries are facing a severe economic crisis and growing poverty.

Globalization has enabled various economies to open themselves to one another, enhancing their interconnectivity. This interdependence, in turn, boosts the competitiveness of trade across borders. Indeed, the international trade system serves as a bridge between bilateral and multilateral interactions. The diversification of economies, differentiated by the sequence of growth, has enhanced the diversification of production owing to comparative advantages; countries market what they can produce at a cheaper cost and pay for what they cannot produce at a lower price. The evolution of competition and the openness of economies to one another add to the complexity of commerce. Furthermore, being the world's primary currency, the US dollar is regularly used as an intermediary in global trade. As a result, an economy is exposed to the influence of foreign inflation, which will undoubtedly affect local prices.

1.2. Motivation of the Study

Food prices drive the degree of inflation in developing economies. Indeed, agricultural commodity prices began to rise without precedent from the start of 2006. This has resulted in at least a 50% spike in the price of food in several countries. However, Africa continues to be the most affected; rises in food costs have been in tandem with soaring energy prices. Protests have erupted across Africa, for example, in Burkina Faso, Senegal, Mauritania, Guinea, etc. (Baker, 2008; FAO, 2008). The number of individuals living in poverty has progressively grown. In Niger, for example, almost 2.7 million people were affected by starvation, and about 5.1 million were at risk in 2010, according to Famine Early Warning Systems Network of the United States Agency for International Development. Previous food crises like the 2007-2008 food crisis were caused by a combination of factors, including a slight increase in global demand for cereals and oils linked to increased agrofuel production and a tiny slowdown in global cereal supply growth caused by poor seasons in agricultural products exporting countries such as Vietnam and Australia.

Furthermore, the global economy has seen a reduction (depreciation) in the US dollar price during these years, which has helped to alleviate the burden of pricing issues. Unfortunately, the advent of COVID-19 towards the end of 2019, which caused a halt in global economic activity, resulted in substantially greater inflation in practically all nations. On top of that, the commencement of the war between Ukraine and Russia triggered a rise in the price of energy and wheat, and many other cereals, as well as a loss in supplies. Thus, to reduce its soaring inflation, the United States, through its Federal Bank, has implemented a series of policy rate rises. In March 2022, its interest rate was raised by 0.25%. All these reasons have contributed to the globe's unprecedented food crisis, with developing nations being the most susceptible. Food inflation, for example, accounts for more than half of the headline inflation in West Africa, specifically the WAEMU countries (according to BCEAO and IMF data, food contributions averaged 1.23 percentage points between January 1999 and October 2022, compared to a 2.25 percent average inflation rate during this period) Figure 1.1



Average Contributions, January 1999 - October 2022 (percentage points)

Figure 1.1. Average Inflation and Contributions

Source: BCEAO, IMF calculations

Despite the monetary policy goal of keeping overall inflation below 3%, after a negative record at the beginning of 2019, headline inflation has more than quadrupled in the following years, hitting 8.8 percent in August 2022 (see

Figure 1.2.). This spike, precipitated by the COVID-19 outbreak and exacerbated subsequently by the war in Ukraine, is throwing the region, among others, into an unprecedented food catastrophe.

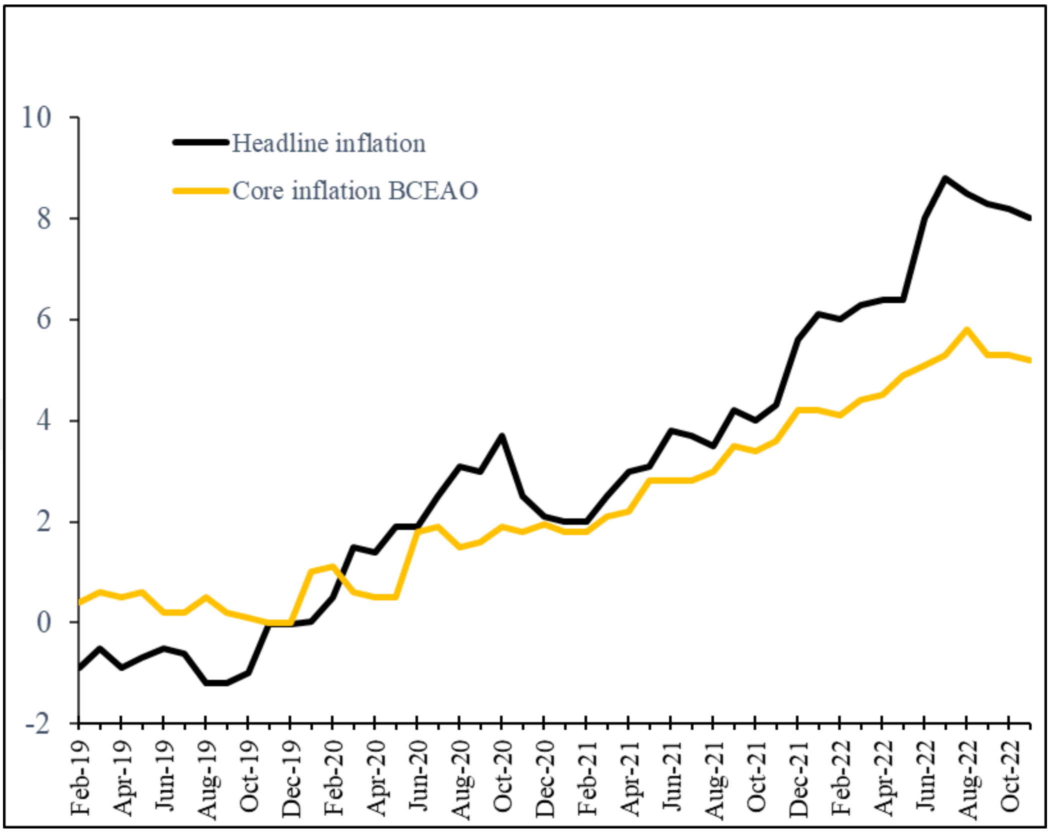


Figure 1.2. Inflation

Source: BCEAO, IMF

1.3. Literature Gap

Although the connection exchange rate inflation is not directly related to our research, it is essential to acknowledge the apparent interest in understanding how an exchange rate fluctuation might affect inflation in an economy. Exchange rate pass-through (ERPT) is the degree of price changes concerning a one percent change in the exchange rate. Studies that have analyzed the pass-through of foreign prices into inflation consider headline inflation. They vary in scope, with some focusing on a single nation while others would gather multiple countries for a panel study. Some researchers have discovered that the ERPT lowers in an environment where inflation is not high, as indicated by Taylor et al. (2000), Takhtamanova (2008), and Campa &

Goldberg (2002). However, due to the heterogeneous character of the consumer price index, such a method may suffer from aggregation bias and fail to detect disparities in pass-through. Research on the ERPT into consumer price index’s components is very scarce, especially on food prices which is a necessity.

Apart from a handful, the small number of research on the subject uses a linear and symmetrical approach. Indeed, to understand how the exchange rate affects household consumption designated by food imports in Malaysia, Jibrilla et al. (2017) use annual data from 1980 to 2012. The study’s findings conclude that food imports in Malaysia are inelastic in terms of both income growth and relative import prices. Barkov (2016) investigates the reaction of the costs of seven agricultural products following currency rate and oil bill fluctuations in Russia. He employed a VAR model covering the period from January 1999 to October 2015 and found that in the short run, changes in the price of oil and the exchange rate do not affect agricultural food prices.

Some scholars have concluded that changes in the exchange rates do not have a symmetrical but rather an asymmetrical effect since the exchange rate knows changes over time. Indeed, Kai et al. (2017) added to the economics literature by researching the impact of crude oil prices, real growth, and exchange rates on food prices using the Nonlinear ARDL model. Indeed, it is based on Malaysian quarterly data from 2000Q1 to 2016Q2, and it investigates the asymmetrical relationship between the study's independent variables and food prices. According to the survey, a depreciation of the Malaysian currency increases food prices, although an appreciation has the opposite impact; it decreases the cost of food. Furthermore, the magnitude of an appreciation of the Malaysian currency is small compared to depreciation. Kadanalı (2021) also utilized the modified version of the Pesaran et al. (2001) ARDL model proposed by Shin et al. (2011) to examine the asymmetric effects of diesel price changes and the exchange rate on Turkey's food costs. The study's findings support the asymmetrical connection between changes in the exchange rate and food prices. Only a depreciation of the currency impacts food costs in the long term.

A study of the available empirical literature shows the limited research on the relationship between exchange rate movements and food costs. Thus, studies on this topic have yet to address the scenario of a monetary zone and attempt a possible comparison between nations. We also observe the absence of a monetary variable (money supply) in the research. This variable is equally relevant in the analysis since the pass-through is similarly connected to the monetary policy determining the exchange rate. In reality, no study stretches to COVID-19, the major crisis that shook the world, and no literature on the subject exists, even in one of the WAEMU nations. The existing studies are also confined to giving credence to cointegration relationships. However, determining the sort of pass-through that occurs between the exchange rate and the food prices remains crucial.

Our study employs an asymmetrical approach to the subject, using the NARDL model to estimate the long-run influence of the exchange rate on food prices. The study adds to the literature by investigating the exchange rate pass-through on food prices in a monetary zone comprised of eight West African nations. This study will compare countries' pass-throughs in the same economic area. Another novel feature is that the analysis considers the monetary variable (money supply) and the different food crises of the 21st century. The study is based on monthly data from January 2004 through December 2022. We may also identify the type of exchange rate pass-through on food costs.

1.4. Objectives of the Study

The study aims to explore the relationship between the CFA franc movements and food costs in the WAEMU. The objectives of the study are threefold and consist of:

- determining whether there is a presence of an asymmetric relationship between exchange rate and food prices.
- determining whether a long-run relationship exists between exchange rate and food prices.
- identifying the type of pass-through existing between exchange rate and food prices.

The hypotheses derived from the three objectives are as follows:

- Is there a symmetrical connection between changes in the exchange rate and food costs?
- Is there any insignificant long-term relationship between food prices and changes in the exchange rate in the WAEMU countries?
- Is there evidence of a complete pass-through between food prices and exchange rate in the WAEMU?

1.5. Significance of the Study

The study attempts to help reduce poverty in the eight WAEMU countries. Indeed, the research sheds light on the relationship between food prices and the exchange rate in the WAEMU nations. This will serve to safeguard WAEMU economies from shocks during international transactions, as well as to restrict food imports more accurately to minimize food insecurity. This study will also assist decision-makers in developing policies that would boost the growth of the eight countries while reducing African countries' reliance on international food exports.

1.6. Organization of the Study

The rest of the study is organized into five chapters. Chapter 2 elaborates on the organization and background information on the macroeconomic performance of the WAEMU. The theoretical and applied literature are discussed in Chapter 3. Chapter 4 elaborates on the empirical model and the numerous econometric methodologies to investigate food prices and exchange rate relationships. The investigation findings will be presented in Chapter 5, with a conclusion and suggestions in Chapter 6.

CHAPTER II

ORGANIZATION AND BACKGROUND INFORMATION ON THE MACROECONOMIC PERFORMANCE OF THE WEST AFRICAN ECONOMIC AND MONETARY UNION

The West African Economic and Monetary Union (WAEMU) is a common economic area created in 1994 by the union of former French African colonies in response to a desire for mutual growth and cohesion among themselves. Its implementation and successful operations depend on various conditions and goals the union established. Thus, the WAEMU will be presented in this study section, followed by the countries' recent macroeconomic trends.

2.1. Presentation of the West African Economic and Monetary Union

Covering a surface area of 3,505,126 km², the WAEMU is a monetary union that brings together eight West African states with common boundaries. These eight nations contain five coastal countries, including Benin, Côte d'Ivoire, Togo, Senegal, and Guinea Bissau, as well as three Sahelian countries, Burkina Faso, Mali, and Niger. The signing of the WAEMU Treaty on January 10, 1994, united seven out of the eight countries into a single region of mutual interest. Guinea Bissau joined the union in 1997.

The WAEMU promotes regional integration, which includes the free movement of goods, services, and capital. The WAEMU treaty was signed with the adoption of a common currency for all its members. The West African CFA franc (XOF), frequently referred to as the CFA franc, is a currency of a fixed parity with the euro. Indeed, on January 12, 1994, two days following the signing of the treaty uniting the nations under the same authority, the CFA franc underwent a 50% depreciation against the French franc, then the euro after its inception on January 1, 1999. The parity between the XOF and the euro is 655.957 (1 euro for 655.957 XOF). The West African States Central Bank (BCEAO) oversees the union's monetary policy as well as the issuing of the CFA franc.

2.1.1. Objectives

WAEMU's primary goal is to support its members' growth and social development. In its impetus to get there, five sub-objectives have been defined:

- The establishment of a common market to facilitate interactions among the eight countries. This market's purpose is to allow free trade and movement of people.
- The promotion of worldwide competitiveness for the union's products.
- The definition of convergence criteria to ensure the seamless operation of shared goals.
- The Coordination of sectoral policies via adopting standard policies in several sectors of activity, such as transportation, telecommunications, environment, agriculture, energy, and mining, and their strict observance.
- Harmonize and ensure the legislation and the common zone market's respect.

2.1.2. Monetary System

The WAEMU is distinguished by a shared currency and a fixed parity mechanism tied to the euro. Previously tied to the French franc since the passage of the WAEMU treaty, the XOF is now exchangeable at a fixed rate of 655.957 against 1 euro since the foundation of the Eurozone on January 1, 1999. The XOF is built on four primary pillars:

- First, the French Treasury (FT) ensures unrestricted convertibility of the XOF by creating an operating account for the BCEAO, allowing it to carry out its operations.
- Second, a fixed exchange rate of 655.957 between the euro and XOF (1 euro is exchanged at 655.957 XOF).

- Third, the openness and unrestricted transfer of reserves inside the economic zone.
- Fourth, the unlimited convertibility of the XOF is predicated on the centralization of the foreign exchange reserves of the WAEMU at the French Treasury. The French Treasury receives 50% of the union's foreign exchange reserves annually.

The Economic Community of West African States (ECOWAS)[1], on the other hand, has expressed a willingness to create a West African-specific shared currency. The ECO is a currency that will be used in 15 West African nations, comprising the WAEMU on the one hand and the WAMZ[2] on the other. Eventually, this decision led the WAEMU to reconsider and amend some XOF agreements with France. As a result, three adjustments were implemented in 2019 and 2020 to promote the convergence from XOF to ECO.

- To begin, the WAEMU states have declared their desire to alter the currency's name from West African CFA franc to ECO, whereas the convertibility rate with the euro stays the same.
- End the centralization of the foreign reserves at the French Treasury. This reserve was required to ensure the unlimited convertibility of the XOF.
- France's non-interference in the management and decision-making of the Central Bank.

The revisions took effect in May 2020. The advent and spread of the COVID-19 disease in 2019, swiftly becoming a pandemic, hindered the ECO's progress.

The BCEAO conducts the monetary policy of the eight states. The BCEAO aims to maintain its member countries' price stability and economic growth. Its missions include defining the union's monetary policy, encouraging financial transactions, and supervising and securing payment networks. The implementation of the exchange rate strategy by the agreements in 1994. The administration of the members' foreign

[1] It is a regional political and economic union of fifteen countries located in West Africa.
[2] The West African Monetary Zone (WAMZ) is a monetary zone established in 2000 and regroups six ECOWAS member countries. WAMZ's member countries are Gambia, Ghana, Guinea, Nigeria, and Sierra Leone.

exchange reserves. In addition to these goals, the BCEAO can carry out initiatives inside the member states to improve the economic and financial capability of the eight countries. Above all, establish a healthy and appealing financial environment.

2.1.3. Foreign Policy

The fixed exchange rate adoption between the CFA franc and the euro is sealed by an agreement governing exchanges inside and between the union and France. The XOF is consistently converted into euro between France and the union's member nations in international transactions. However, trading a foreign currency other than the euro is formed based on the euro. And all financial transactions are administered by the BCEAO. Capital transfers within the union are free except for the sale or purchase of gold, issuance, advertising, and offering of financial instruments.

2.1.4. Economic Policy

The WAEMU has implemented economic measures to support its monetary policy to attain its goals. Indeed, a monetary zone must guarantee convergence of its economic and monetary policies for effective coordination of activities and development strategies. As a result, the WAEMU has set convergence and monitoring criteria for a consistent economic strategy throughout its eight members. The system of surveillance is based on Act N0. 01/2015/CCEG/UEMOA of January 19, 2015, on the WAEMU member states' Convergence, Stability, Growth, and Solidarity Pact (PACSCS).

The surveillance system supports the convergence criteria. The pact primarily establishes two categories of criteria, each of which is further divided into sub-criteria. It should be noted that the criteria are subject to adjustment every five years. The latest in the title is from 2019.

The first category concerns the balanced budget requirement and comprises three sub-criteria.

- From 2019 onwards, the budget balance as a proportion of nominal GDP must be less than or equal to 3%.

- Maintain yearly average inflation below 3%.
- Total outstanding debt (domestic and external) should not exceed 70% of nominal GDP.

The second category of criteria includes two subcategories which are:

- From 2019, the payroll-to-tax-revenue ratio is limited at 35%.
- Beginning in 2019, the tax pressure rate must be more than or equal to 20%.

2.1.5. Trade Policy

The WAEMU's trade with its partners is governed by regional (integration process), bilateral (Interim Economic Partnership Agreement - IEPA), and international (World Trade Organization - WTO and regional EPA) agreements. Market structures arising from agreements to ensure good trade policy at the national and intercommunity levels are as follows:

- The common market adoption resulted in a standard external tariff (CET).
- EPA led to a market between the West African region and the European Union.
- The international market (WTO), of which it is a member.

The WAEMU common market is based on a common commercial policy implemented on July 1, 1996, for the trade of local, unprocessed products and traditional crafts, then was expanded to include industrial products in January 2000. This market originally reserved for WAEMU countries was extended to the rest of the ECOWAS members in 2004. The region implemented a customs union based on a CET, which considers product categories whose tax rate falls between 0 and 20%. That of ECOWAS subsequently replaced this CET. Harmonization of Value-Added Tax (VAT) and excise taxes, harmonization and mutual agreement on standards, safeguard, and common protection measures (Digressive Protection Tax (DPT), Export Short-term Tax (EST), reference values, and anti-dumping duty).

Furthermore, WAEMU has a program to promote fair trade and trade aid to assist its members in promoting and increasing their export of goods.

2.1.6. Trade Situation

The WAEMU's openness has improved since the 1990s as the trade flows of goods and services have increased. This growth resulted from changes in the diversification of the portfolio of products and trade partners supported by a context of rising prices of primary products internationally.

i. Exports of the WAEMU

The union's export statistics indicate a consistent increase. Export growth increased from 7.2% between 2000 and 2004 to 9.7% between 2005 and 2011. This improvement is primarily due to increased mining exploitation over the period. WAEMU export growth continued between 2012 and 2017, from 11.201 billion XOF to 14.542 billion XOF in 2017. In 2020, its exports increased by 11.8% from previous years due to increased rubber, oil products, cotton, cocoa, and gold sales. Rising prices drive rubber, oil products, cotton, and cocoa growth.

The primary goods exported are mining products such as oil, gold, and uranium. This product group provides 38.3% of export revenues, compared to 25.3% for agricultural products such as cocoa, cotton, and coffee. This trend was reversed since, from 2000 to 2004, the mining and oil commodities rates were 20.1% and 33.6% for agricultural products.

African countries mostly absorbed the increasing exports. Indeed, WAEMU's exports to the rest of Africa climbed by 4.2%. Exports are oriented towards ECOWAS and South Africa. Shipments to Europe and Asia contributed 1.7% and 1.1%, respectively, to the rise of union exports. Oil, cocoa, gold, and cotton are WAEMU's main export commodities and the union's primary source of revenue, accounting for 60% of total exports. Agricultural products lost their leading position in exports as mining and oil sites grew and international prices soared. Following the discovery of new reserves of oils, for example, cocoa loses its dominant position as an export agricultural production. Cotton's third place has been usurped by gold exploitation because of issues in the cotton sector and increased gold output in Côte d'Ivoire, Burkina Faso, Mali, Niger, and Senegal. Between 2005 and 2010, gold extraction grew from third to first place, accounting for 20.1% of total exports in 2011. France and the rest of the European Union zone are the primary markets for WAEMU exports. The goods exported to Europe include cocoa, oil products, gold, fish, rubber, uranium, and timber. ECOWAS countries and South Africa account for the majority of African exports. South Africa, Nigeria, and Ghana remain the key African trading partners. Among the goods supplied to these countries are oil products, gold, cement, oils, chemicals, livestock products, fruits and vegetables, and cigarettes.

Exports shared by the country reveal that Côte d’Ivoire came on the top with 40.6% of WAEMU’s foreign sales in 2021. It holds the line with the sales of cocoa, oil, gold, and rubber, followed by Burkina Faso with 15% of the exports. Burkina Faso's economy is based mainly on gold, cotton, and shea nuts exports. Senegal accounts for 13.9% and Mali 13.6% (Mali's revenue is based on gold exploitation). Benin and Togo’s market shares increased by 1.4 and 0.4 percent, respectively. Niger follows with 3.3% of WAEMU’s export. The contribution of Guinea Bissau remained at 0.6%.

ii. Imports

Compared to exports, the growth rate of WAEMU imports fell from 7.5% between 2000 and 2004 to 7.1% between 2005 and 2011. This decline is not attributable to WAEMU's independence from foreign goods but to a rise in oil bills generated by growing global energy prices. The oil bill has a significant influence on imports from the region. It accounted for 23.8% of the total cost of Union imports. Imports of food fell between 2004 and 2011. This period includes drought years (2004-2005, 2006-2007, and 2009-2010), which drove a spike in global food prices, most notably in 2008, with the financial crisis in the United States influencing the global economy. The union's cereal costs increased, partly due to a scarcity of local suppliers, aggravated by an increase in overseas prices.

WAEMU's imports increased from 14.830 billion XOF in 2012 to 17.511 billion XOF in 2017. This increase was encouraged by the fall in international energy prices. Thus, food and capital goods imports grew during the period. Europe remains the biggest supplier of the WAEMU countries, followed by Asia.

In 2021, imports of goods and services increased by 16.9%. Acquisitions climbed from 23.7% to 25.7% of GDP. This pattern corresponds to the growth in the cost of capital and intermediate goods. The growth of imports depends on an increase in the supply of consumer goods, particularly food. External food purchases increased by 24.8% over the previous years, mainly owing to price increases in the primary commodities imported into the Union. In 2021, their percentage of total foreign purchases was 19.8%, up from 18.6% in 2020. The increase in food imports is mainly attributable to foreign acquisitions of wheat (42.0%), rice (33.3%), dairy products (15.5%), and sugar (3.0%).

Côte d’Ivoire concentrated 31.1% of purchases outside the union in 2021, followed by Senegal with 20.9%. Mali comes with 14.1% and Burkina Faso (10.2%). Most providers remain in Côte d'Ivoire, Senegal, and Mali. Benin contributed 1.7% to the rise in Union imports, more than Niger and Togo combined. In 2021, Burkina Faso and Guinea-Bissau’s contribution has risen by 0.1% of Union imports.

2.1.7. Inflation Dynamics

Over the period 2002-2011, the average annual inflation rate was 2.7%. Over time, food and energy items had high overall growth. This downward tendency has increasingly continued. The WAEMU inflation rate dropped in 2016 owing to lower energy and food prices. The average inflation rate in 2016 was 0.3%, compared to 1% in 2015. This rate rose in 2021 as food prices increased. In 2021, the WAEMU rate was 3.6%, up from 2.1% in 2020. It should also be noted that the union deplores a need for improvement in the convergence of inflation rates between its member countries. The price increases result from rising international oil prices and food imports.

In the monetary zone, 2005, 2008, 2011, and 2022 were more or less significant, with average inflation rates hitting 4.4%, 7.4%, 3.9%, and 7.5%, respectively. These periods of growing inflation were caused by the drought in the Sahelian nations (2005), the food and energy crises (2008), the disruptions created by the post-election crisis in Côte d'Ivoire (2011), and the COVID-19 crisis (2020) then the Russian Ukraine war.

Food costs grew by an average of 4.1% in the WAEMU countries, driving the rise in inflation. Cereals, meat, and fish goods are the most expensive. Unprocessed grains, for example, contributed nearly 10% of the price rise between 2011 and 2022.
The disparities in inflation across WAEMU countries remained large. This dispersion in inflation rates is explained by the asymmetric shocks, the impact of the socio-political situation, and insecurity in specific nations. Indeed, the disparity in inflation rates is amplified during years of tensions affecting food prices (2008, 2020), which disproportionately burden landlocked Sahelian countries. Thus, a country-by-country examination of inflation volatility is especially significant in the Sahelian landlocked nations (Burkina Faso, Mali, and Niger), which are suffering the effects of food supply shocks, and in Guinea Bissau, where there are regular disruptions in the supply of imported goods.

Relevant factors explain the rise of inflation. Production fell significantly during the seasons of 2004/2005, 2007/2008, 2009/2010, 2011/2012, and 2021/2022, primarily because of adverse weather conditions. Food accounts for 31% of the total weight of the household basket. It accounts for over half of the price rise over the last three years. However, the agricultural campaign in 2015/2016 increased by 11.3% over the previous one. This growth is seen in all member nations except Burkina Faso and Togo, whose output decreased by 6.3% and 3%, respectively. Furthermore, the rising tendency was maintained during the 2016/2017 season. Consecutive improvements in production over the last three years slowed cereal price rise in 2016. Cereal production had a mixed trend between 2018 and 2020. Following a 2.7% loss in the 2019/2020 agricultural campaign, cereal production climbed by 3.2% in 2020/2021 before falling by 13.1% in 2021/2022.

The frictions observed on international markets influence inflation in the WAEMU. The WAEMU inflation trend was highlighted by a rising tendency in global inflation in 2008, 2010, 2011, and 2022 following the COVID-19 and post-crisis periods. The major drivers of the union's explosive rise in inflation are global oil and food costs.

2.2. Recent Macroeconomic Trends

i. Benin

Benin is the sixth most populous nation in the WAEMU, with an area of 114,763 km^2 and a population of about 13,077,353 people. Its economy is mainly focused on agriculture and trade activities. Indeed, all economic sectors have contributed to the economy's growth, reaching 7.2% in 2021; however, this growth has been hindered by numerous factors, including COVID-19 and the war opposing Ukraine to Russia. As a result, real GDP growth has slowed to 6% in 2022. The country's budget deficit persists at 5.5% of GDP in 2022, down from 5.7% in 2021. Similarly, the country's trade balance is negative, with imports rising faster than exports. Despite the increase owing to different shocks in 2022, Benin's inflation rate remains the lowest in the whole monetary zone, at 2.5% compared to 1.7% the previous year, with 38.5% of its inhabitants living below the poverty threshold, according to the statistics for 2019. In 2022, the current account deficit and government debt growth were 0.8% and 2.5% of GDP, respectively.

ii. Burkina Faso

The country's population is estimated at 22,625,776 in 2022, placing it third among the WAEMU most populous countries. Burkina Faso's economy is mainly agricultural, with agriculture employing 80% of the population. Due to its surface area of 274,000 km^2, the country has many cultivable lands but faces pockets of drought and insufficient rainfall. Gold exploitations constitute the primary source of revenue of the country. However, in 2022, this extraction experienced a slowdown due to the COVID-19 crisis and insecurity reasons. This led to a considerable decrease in real growth. Indeed, the real growth has slowed to 3.2%, down from 6.9% respectively in 2022 and 2021. The insecure environment and related humanitarian catastrophes have significantly exacerbated poverty, estimated at 51.1% in 2019. To address insecurity and humanitarian issues, government expenditure increased to 26.1% of GDP in 2022 from 25.6% in 2021, resulting in a rise in the budget deficit. The trade balance marked a weak increase in exports. A deficit of 5.2% of GDP in the current account balance was recorded caused by soaring food and energy import prices. Food price increases have also prompted the inflation rate to grow to 14.4% in 2022.

iii. Côte d'Ivoire

After the independence, agricultural production overtook forestry regarding economic contribution in Côte d'Ivoire. With a total population of 28,339,024 inhabitants, the sector employs approximately 70% of the population. Cote d'Ivoire is the most developed country in the WAEMU zone. It stands out from the others by its performance and its level of industrialization. Mining, construction, telecommunications, public and private investment, and other industries drive the country's growth. The war between Ukraine and Russia, as well as the COVID-19 pandemic, have impeded its progress, as has that of other WAEMU countries. Indeed, real GDP growth fell from 7.4% to 6.7%, respectively, in 2021 and 2022. Inflation surged from 4.2% in 2021 to 5.2% in 2022 because of increases in energy and food prices. As a result, the Ivorian government has taken steps to subsidize energy prices and raise public sector salaries to mitigate the impact of inflation on household purchasing power. This caused a rise in the budget deficit, from 4.9% in 2021 to 6.8% of GDP in 2022. The degradation of the trade balance has caused the current account deficit to widen from 4% of GDP to 6.9% of GDP, respectively, in 2021 and 2022.

iv. Guinea Bissau

Guinea Bissau is the least populous country in WAEMU, with a population of 2,130,000. It also holds the record of the smallest country in the monetary zone, with an area of 36,125 km^2. The country is still the least efficient in economic performance among the eight countries in the monetary zone. The economy is also based on agriculture, fishery, and livestock. Between 2021 and 2022, its macroeconomic performance can be summarized as follows: in 2021, Guinea-Bissau recorded a 6.4% increase in real GDP; however, this trend is declining, as it fell to 3.7% in 2022 due to the economic shocks of the COVID-19 and the war in Ukraine. These shocks triggered inflationary pressures, limiting private spending and lowering the country's productivity. Inflation in the country reached 7.9% in 2022, up from 3.3% in 2021, owing to increased energy and food prices. In 2022, the government deficit was at 6.3% of GDP, up from 5.6% in the previous year. This expansion can be attributed to government measures to redefine the economy, such as revising the wage bill and election expenses. The current account has deteriorated markedly with the pandemic. In 2022 it presented a deficit of 5.8% of GDP against 0.8% in 2021 because characterized by higher imports of goods and lower exports. The poverty rate followed the upward trend to around 68.4% in 2021.

v. Mali

Mali's economy is primarily agrarian. It is the second-largest country in the region after Niger. It has a population of roughly 22,003,885 people and a land area of 1.24 million km^2. The desert covers most of the country’s site, and like Burkina Faso and Niger, it has no access to the sea. In addition to being Sahelian, these three nations share an insecure environment characterized by terrorism. Added to this is the pandemic of COVID-19 consequences, which increased the country's inflation rate to 9.7% in 2022 from 3.9% in 2021. Unlike the rest of the union, Mali's national debt has fallen to 49.9% of GDP in 2022 from 52% in 2021. Similarly, the current account deficit dropped in 2021 from 7.7% of GDP to 7.5% in the next period. In addition, the budget deficit has risen from 4.9% of GDP in 2021 reaching 5% in 2022. The population's living conditions have also deteriorated, with the poverty rate rising from 44.6% to 45.5% by 2022. Despite a low real GDP growth, the country experienced a minor increase in 2022. The real growth grew from 3.1% in 2021 to 3.7% in 2022.

vi. Niger

The primary sector, which includes agriculture, livestock forestry, hunting, and fishing, is the principal driver of growth in Niger, a nation of 1,267 million km^2 with a population of 26,841,912 people. Its recent economic situation shows real GDP growth of 7.2% in 2022, indicating a significant improvement. This was possible thanks to solid performance across all sectors. However, the country's expenditure exceeds its revenue, increasing its budget deficit. It goes from 6.1% of GDP to 6.6% in 2021 and 2022. External resources finance the budget deficit. Therefore, public debt rose by 0.3% between 2021 and 2022, reaching 51.2% of GDP in the same year. The country is experiencing a persistent current account deficit which widened to 15.1% of GDP in 2022 against 13.9% for the previous year. Inflation has also risen dramatically, exceeding the 3% target established by the community. It was 4.2% in 2022, compared to 3.8% in 2021. Citizens' living conditions have likewise deteriorated, with a poverty rate of 42% in 2021.

vii. Senegal

The Senegalese economy is based on agriculture and employs more than 60% of its population. With an area of 196,712 km^2, Senegal has 18,068,584 inhabitants. It represents the second-largest economy in the monetary zone after Côte d’Ivoire. However, the COVID-19 situation and the war in Ukraine have significantly affected the country's growth. Its growth has slowed considerably, from 6.5% in 2021 to 4.0% in 2022. This is exacerbated by a weak agricultural season in 2021-2022. As a result, Senegal's inflation rate has risen to 9.7% in 2022, a new high. The rise in energy and food prices explains this growth. Furthermore, the country's exports have dropped, prompting ECOWAS' application of economic sanctions in Mali following the military coup in 2021. Indeed, Mali is a significant importer of Senegalese commodities. However, the budget deficit has been reduced in 2022 to 6.1% of GDP, down from 6.3% in 2021. The increase in government revenue has made it possible. The current account deficit has increased once again, and it is now forecast to be 17.5% of GDP in 2022, up from 12.1% in 2021. In 2022, the poverty rate remained unchanged at 37%.

viii. Togo

The second-smallest country in the WAEMU zone is also the second-smallest regarding land area. Togo has a land area of 56,785 km^2 and a population of

8,861,621 inhabitants. Agriculture is vital in Togo's economy. Over the last two years, its macroeconomic performance has been defined by upheavals: the first with COVID-19 and the second with the crisis between Russia and Ukraine. Indeed, these shocks have caused its growth rate to fall from 6.0% in 2021 to 5.5% in 2022. Inflation in the country has risen dramatically over a year, jumping from 4.7% in 2021 to 7.8% in 2022. The budget deficit has also grown due to government expenditure to encourage economic activities. This has led to significant spending on oil and food imports. Thus, the current account deficit increased from 4.7% of GDP to 8.4%, respectively, in 2021 and 2022. However, public debt fell from 63.1% of GDP in the previous period to 55.9% in 2022.

CHAPTER III

LITERATURE REVIEW

This chapter comprises two main sections: theoretical and empirical approaches to the exchange rate pass-through (ERPT) problem. The theoretical approach explains the pass-through hypothesis by investigating its expression and how much it influences pricing. The second section of the empirical literature review is divided into two parts: a discussion of broad evidence of the ERPT and subsequent specific evidence of the influence of exchange rates on food prices.

3.1. Theoretical Literature

The ERPT theory has risen from the Law of One Price (LOOP), the Purchasing Power Parity (PPP), and the monetary method of determining the exchange rates.

3.1.1. Law of One Price and Purchasing Power Parity

The PPP foundation is the LOOP. It is an economic concept that assumes all homogenous goods are offered without additional costs, including transport, tariffs, ... The law assumes that homogenous products must be provided at the same price on the global market regardless of location. The product's price remains constant in the domestic and destination markets. Prices stay the same after exchange rate adjustments.

$$P_t^i = Ex_t P_t^{i*}$$

P^i indicates the price of similar items, Ex consists of the nominal exchange rate, and the * marks a foreign magnitude.

This remains true for a batch of similar items sold in different countries. As a result, the price level will be calculated by adding the cost of all identical products.

$$P_t = \sum_{i=1}^{n} \alpha^i \, P_t^i$$

$$P_t^* = \sum_{i=1}^{n} \alpha^i \, P_t^{i*}$$

α is the weight of aggregate individual prices, and it is assumed that the weights are the same across nations.

i. Absolute Purchasing Power Parity

According to absolute PPP, the nominal exchange rate of a country is obtained by the ratio of overall domestic prices and foreign countries. This indicates that a country's domestic currency will depreciate concerning its trading partners. However, because of its limitations, this approach is subject to questions. First, it presupposes that the goods are identical regardless of location. It is not easy to envisage a product X produced in nation A similar to one made in country B. Second, an equal weight is considered for setting the price level of all countries. This approach needs to be revised, given that various countries have different levels of development. Third, determining the market price of the products does not account for the cost of the transaction.

ii. Relative Purchasing Power Parity

The relative PPP is considered an alternative to the absolute PPP. The relative PPP is calculated by taking into account changes in the variables.

$$\Delta E_t = \Delta p_t - \Delta p_t^*$$

Δ represents the initial difference operator. According to the RPPP, countries with relatively significant inflation will see their currency depreciate.

3.1.2. Channels of the Exchange Rate Pass-Through

The influence of the exchange rate on prices may be assessed through import, export, producer, and consumer. Its impacts can be determined on two levels. While the first relates to its influence on import prices after a one percent change in the exchange rate, the second emphasizes the response of the consumer price concerning changes in the exchange rate.

Changes in exchange rates occur through two different methods, namely, the direct and indirect channels. There are two mechanisms of direct effect. The first channel affects pricing through input imports, followed by domestic products. Indeed, the manufacturers mark up the final product so that import costs rise before reaching the ultimate customer. The second channel encompasses imported final products. These are goods that do not require processing but transit via domestic suppliers. It also reveals itself through the substitution of local products and foreign products. The degree of substitution determines the degree to which currency fluctuations are transmitted. ERPT can also indirectly influence consumer prices through changes in demand mix, aggregate demand, and wage levels.

ERPT can theoretically be complete, incomplete, or even zero. Import bills are determined in the producer currency for complete pass-through. This means that foreign pricing (exporter's currency) for imports results in a complete transmission in the exchange movements. However, the pass-through is likely nonexistent if exporters set their pricing in importing country's currency (no impact). And incomplete if the influence of pass-through is only partially reflected in the importing country.

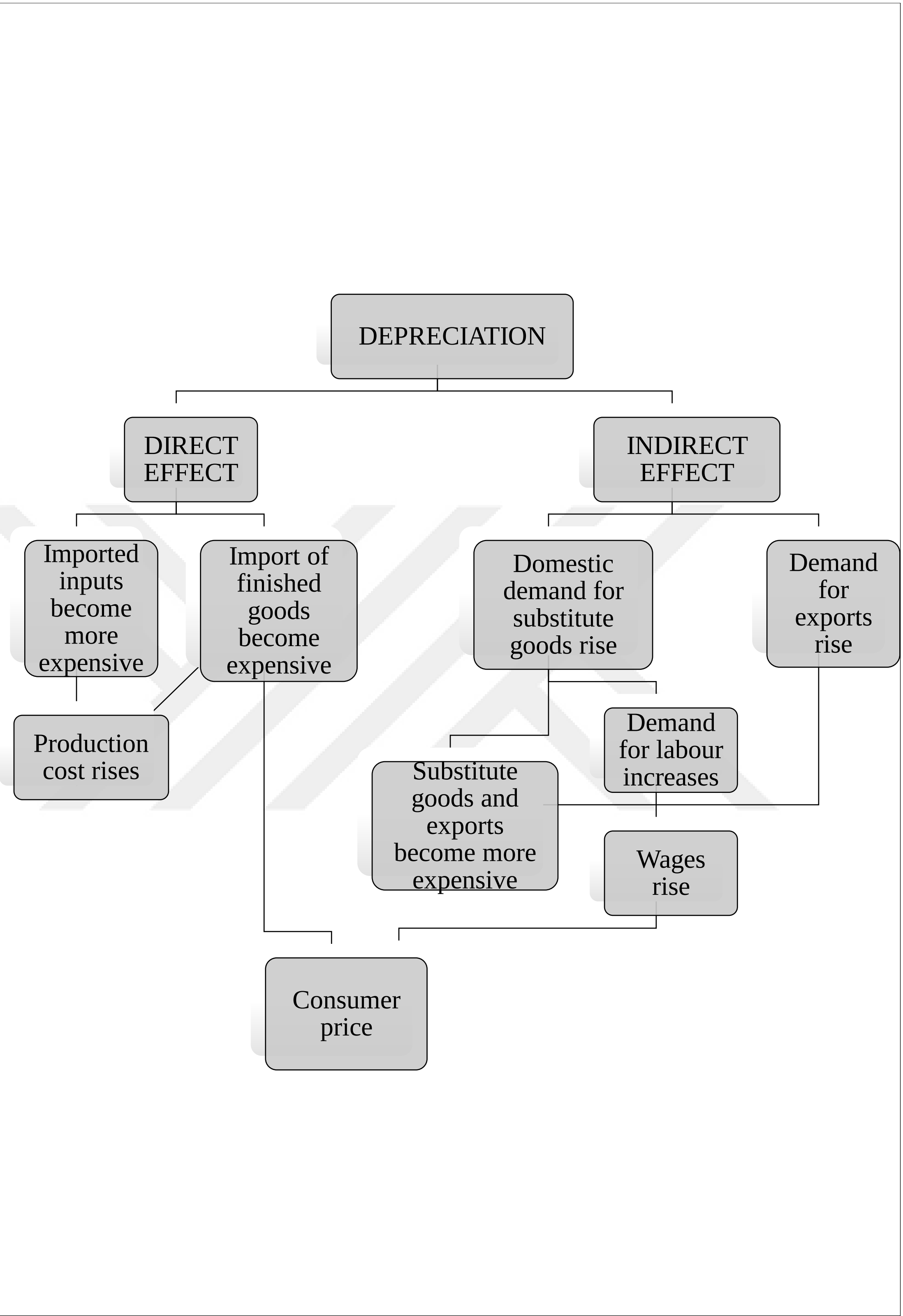


Figure 3.1. Channels of Exchange Rate Pass-Through

Source: Laflèche 1996–97

3.1.3. Market Structure and Product Characteristics

i. Perfect Competition and Homogeneity

The first market structure analysis considers the perfect competition market where the imported and domestic goods are perfectly substitutable.

Let's denote $D(P)$, the demand for domestic and foreign goods, and $S_D(P)$ and $S_M(P/Ex)$ the supply of local and foreign products where Ex is the exchange rate. At the equilibrium level, demand is equal to supply, therefore:

$$D(P) = S_D(P) + S_M(P/Ex)$$

Differentiation of the equation gives us the formula for the transmission:

$$\partial P/_{\partial Ex} = \frac{\epsilon_S^M \alpha}{\{\epsilon_D + \epsilon_S^D(1-\alpha) + \epsilon_S^M \alpha\}}$$

$\epsilon_D = \frac{-D'P}{D}$ is the domestic demand elasticity; $\epsilon_S^D = \frac{S_D' P}{S_D}$ is the elasticity of supply of the domestic good; $\epsilon_S^M = \frac{S_M' P}{(Ex_M^S)}$ is the elasticity of foreign goods and α the market share.

The preceding equation, ($\partial P/_{\partial Ex}$) emphasizes the role of the demand and supply elasticities in determining how the price responds following a fluctuation in currency in a perfect competition market.

ii. Imperfect Competition and Product Differentiation

In an imperfect competition market, firms charge prices above marginal costs and can earn above-normal profits. It is important to emphasize that an imperfect competition market expresses how prices charged over marginal cost might be subject to variation depending on an exchange rate fluctuation. There are two factors to consider: the degree of interchangeability between domestic and imported commodities and market integration or separation. Sellers' market strength will be more significant when substitutability and market integration are lower. Dornbusch (1985) argues that the degree of transmission directly correlates to that of substitution between domestic and imported commodities.

3.1.4. Market Structure and the Exchange Rate

Krugman (1987) and Dornbusch (1985) first argued on the importance of the market structure in explaining deviations from PPP. The market structure explains the systematic movement in the real exchange rate regarding the relative price of traded goods. The best-known aspect of the market structure is the pricing market.

i. Pricing to Market and Pass-Through

Several arguments explain why imported manufactured products sold in the domestic country do not reflect the effects of exchange rate fluctuations and guarantee price stabilization in the domestic country. The most prevalent include imperfect competition, the cost of supply adjustment, menu costs, market share concerns, and the significance of currencies in the international financial system. If the price of imports is set in domestic currency (importer’s currency), exchange rate variations do not affect domestic prices; therefore no transmission from the currency movements to domestic pricing. Many traded items are billed in US dollars because the dollar is considered the trade currency. Stabilization of domestic currency and the zero pass-through for economies with currencies out of the trade invoicing can also be explained by pricing to market (PTM), differentiated products, and imperfect competition resulting in price discrimination across export markets. Yet, the alternative paradigm of a perfectly competitive market system might have the same result. For example, suppose a country's currency increases somewhat due to increased global demand, which boosts marginal costs. Therefore, the pass-through is incomplete.

ii. Theory of Pricing to Market

Pricing to Market's approach following the exporter behavior is taken from Exporters & Knetter (1989). Let's consider that a firm exports to N different countries, and imports in each of the N countries are supposed to have a unique form:

$$x_{it} = f_i(E_{it}p_{it})v_{it}, \qquad i = 1,\dots,N \quad t = 1,\dots,T$$

x_{it} is the demand by the foreign market i in period t, p_{it} is the price in terms of the exporter's currency, E is the exchange rate, and v is the demand shift variable.
The costs of exporter are given by:

$$C_t = C\left(\sum x_{it}\right)\delta_t$$

C_t denotes domestic costs in currency units, the sum comprises all i countries markets, and δ_t represents an arbitrary variable changing depending on the cost function. Hence, the profit of the exporter is given as follows:

$$\Pi_t = \sum p_{it}x_{it} - C\left(\sum x_{it}\right)\delta_t$$

After substitution of the previous equation into the profit function and then maximizing it, the equation becomes:

$$p_{it} = c_t\left(\frac{\varepsilon_{it}}{\varepsilon_{it}-1}\right) \; i = 1,\dots,N \;\; t = 1,\dots,T$$

c_t represents the marginal cost at time t, and ε_{it} denotes the demand elasticity in destination market i. The price discrimination is then captured in the new equation: the price in the exporter's currency is a markup over marginal cost, with the markup set by demand elasticity in the various destination markets. Suppose the exporter faces a constant elasticity of demand schedule. In that case, the price charged above the marginal cost will be a constant markup, and there will be a complete pass-through, according to the suggested equation. This is because as the exchange rate falls, the invoicing in the exporter's currency stays constant, while the pricing in the destination market reflects the fall in the exchange rate. It is critical to realize that the marginal cost, and the markup across destinations, might alter over time. In the case of a monopolist that discriminates across export markets, demand schedules that are more elastic than a constant elasticity schedule will result in local currency stability and hence market pricing: as the depreciation drives the fall of the markup. On the other hand, if the monopolist's demand is inelastic, the opposite effect will be produced by a constant elasticity, with markups growing as the consumer's currency falls.

Domestic currency price stability is a type of pricing to market that generate sellers to cut the markup they charge purchasers whose currencies have depreciated, ultimately stabilizing the price.

One consequence of the invoicing set in the importer's currency is that the firm will wish to eliminate some risk currency fluctuations through forward market hedging since it is risk averse. The exporter determines the price (in the currency of the importer) in time $t-1$ at the time t, but the time $-t$ exchange rate remains unknown; therefore, the revenue of the currency from the trade remains uncertain. However, the uncertainty can be reduced by selling the importer's currency in the forward market. In particular, by trading in the importer's currency, the exporter maximizes its expected utility of earnings in its currency. Here's an example equation that illustrates that:

$$Max\ E_{t-1}\{U[(s_t p_t - c_t^*)x(p_t, v_t, z_t) + y_t(f_{t-1}^t - s_t)]\}$$

U denotes the company's utility function, p_t is the price importer established in time $t-1$ for t, c^* is the production costs given in the exporter's currency, x is the demand function of import, v represents imported commodities prices under competition, and Z is the consumer spending. The last element in the equation represents the cost forward cover, where y represents the importer's currency traded on the forward market. The sole stochastic factor is the nominal exchange rate; S, is expressed in the exporter's currency units. The first order condition for this maximizing issue is:

$$p_t\left(1-\frac{1}{\eta_t}\right)=\left(\frac{E_t-1c_t^*}{t-1f_t}\right)$$

η denotes the price elasticity of demand. The exporter's marginal costs, $E_t - 1c_t^*$, are converted to the currency of the importing nation with the help of the forward exchange rate in the equation, and the forward rate, together with demand elasticity, is now a determinant of the optimum price. It is a typical example of Ethier's (1973) theorem of separation, which claims a change does not influence the ideal price in the spot rate. According to Feenstra & Kendall (1994), the initial order requirement for a firm whose bills are in its currency is:

$$p_t^*\left(1-\frac{1}{\eta_t^*}\right)=(E_t-1c_t^*)$$

p_t^* represents the price in the exporter's currency, and η_t^* is the forward rate.

3.1.5. Market Structure and the Distribution Sector

The distribution sector productivity comprises two effects: first, it lowers the cost of tradable goods by reducing the cost of distributing inputs, raises the relative wage, and appreciates the real exchange rate; Second, it lowers the consumer price of tradable and depreciates the real exchange rate.

3.1.6. Monetary Theory Approach

The monetary theory integrates Krugman's (1986) exchange rate model with LOOP and PPP to describe the transmission of exchange rate movement to prices. The monetary approach suggests that the increase in the money supply should be operated at the same rate as the inflation and currency depreciation rates. The approach argues that money supply, interest rate, price level, and exchange rate are interconnected in the long run.

3.1.7. Asymmetry in Exchange Rate Transmission

The usual method assumes ERPT is linear. However, newer researchers have studied asymmetry in domestic pricing sensitivity to exchange rate movements. Asymmetric pass-through occurs when the depreciation of a currency causes a different degree or speed of pass-through than the appreciation of the same currency Aron et al. (2014). In the case of asymmetric impact, the same degree of change in the exchange rates has a different influence on prices concerning appreciation or depreciation. Depreciation has a higher impact than appreciation, particularly in countries with import-based economies.

3.2. General Empirical Literature on Exchange Rate Pass-Through

The number and variety of research conducted in this area demonstrate the relevance of the exchange rate's influence on inflation. Indeed, the empirical research includes developed and developing economies, groups of nations, and specific countries. The fact that varied academics have shown interest in the supply chain, from import pricing to final consumer, contributes to the study's variety. In other words, the ERPT is applied to imports, exports, and consumer prices.

Several studies (Campa & Goldberg, 2002; Taylor et al., 2000, among others) based on the symmetrical relationship between the exchange rate and inflation in industrialized nations suggested that the pass-through effect declines over time. According to Marazzi et al. (2005) study, the coefficient of degree of exchange rate pass-through to the United States import prices has steadily declined. The pass-through coefficient hit 0.2 in 2000, down from 0.5 in the 1980s. This demonstrates that the degree of pass-through into import prices in the United States has sustainably declined over the year.

Otani et al. (2003) used the rolling regression approach to investigate the influence of Japan’s currency movements on imports throughout structural economic and international trade changes. Marked by the appreciation of the yen, the study covered the period from January 1978 to October 2002; it concluded that the ERPT in Japan fell in the 1990s because of decreases in the effects of the exchange rate on every imported good. Likewise, Takhtamanova's (2008) empirical study indicates declining incomplete ERPT on imports in 14 OECD nations in the 1990s. The study used the Feasible Generalized Least Squares (FGLS) estimator on quarterly data on the output gap, inflation rate, real exchange rate growth, and growth rate for the price of food and energy. Other study findings support the theory of an incomplete ERPT. Theoretically, this is realized via a degree of pass-through ranging between 0 and 1. Berner (2010), Using the microdata of Germany, investigates the pass-through on imports. The data covers a monthly period starting from January 1988 to December 2008. The investigation revealed an average of 42% incomplete pass-through into imports over three months. The analysis also revealed that European imports had no impact on German pricing. Imports from non-European nations, on the other hand, have incomplete pass-through rates. He also observed a nonlinear ERPT, with the degree of the ERPT being highly significant during a depreciation phase than during an appreciation period.

Bussière et al. (2014) investigate the ERPT on exports and imports of 40 countries, including 22 developing markets. According to the study's findings, the ERPT coefficient in export pricing is more significant in developing nations than in industrialized ones. Ca' Zorzi et al. (2007) research examines 12 rising markets in Asia, Latin America, and Central and Eastern Europe. The findings of this analysis contradict the widely held idea that ERPT into both import and consumer pricing is always more pronounced in developing nations than in advanced countries. The degree of pass-through into import and consumer prices is roughly comparable to advanced economies for nations with relatively low (one-digit) inflation, most notably Asian countries.

Bhundia (2002) evaluated the ERPT in South Africa's consumer prices using the structural vector autoregression (SVAR) model. The country's average pass-through is low. However, it is substantially higher for nominal shocks than for real shocks. Barhoumi (2006) investigates the long-term behavior of the ERPT in import prices for 24 emerging economies from 1980 to 2003 and concludes that there is homogeneity of pass-through among the selected countries. Using the prices of eight commodities observed in 76 developing countries, Frankel et al. (2012) discovered that in the 1990s, developing countries, like high-income countries, witnessed a fast decrease in the ERPT rate in the short term. Nonetheless, they display a high speed of adjustment in the long term compared to industrialized economies. The literature is no exception in the context of inflation-targeting regimes. Indeed, according to Ho & Mccauley's (2003) research on the importance of the exchange rate in inflation targeting regimes, emerging markets economies are the most vulnerable to changes in the exchange rate. The author's study included 12 countries and six emerging market economies.

Many notable improvements have been made in the research on the exchange rate's impact on inflation. Indeed, numerous studies in the field now consider the asymmetry and nonlinearity in the relationship between exchange rates and prices. Once again, this new method includes advanced and developing economies. In a quarterly examination of 33 advanced and emerging markets economies from 1980 to 2010, Brun-Aguerre et al. (2017) found that breaking down exchange rate swings into appreciation and depreciation gives beneficial information. In the long term, currency depreciation has a significantly more significant influence on pass-through than currency appreciation. The distinction is important in countries that rely on imports.

Ben Cheikh's (2012) research on the link between ERPT and consumer price index in 12 European Union countries examines the occurrence of an asymmetrical relationship between ERPT and prices. To do this, the author employs two ways (the direction and size of the changes in the exchange rate), both of which are based on the Nonlinear Smooth Transition Model method. However, an asymmetric association was discovered in 5 of the 12 nations. In five European countries, the order of terms ERPT into consumer prices was asymmetric.

Coughlin & Pollard (2003) examine the ERPT related to US import prices for 30 industries. Their methodology addresses two essential questions: whether the change in the exchange rate is significant for the pass-through and whether the size is likewise substantial. The research reveals that, in more than 15 firms, the reaction to the importance of changing direction is favorable, but it differs. Numerous industries respond favorably to small and large currency movements regarding change magnitude.

Delatte & López-Villavicencio (2012) explored the asymmetric connection of exchange rate pass-through into prices in the short and long run for four industrialized countries: Japan, Germany, the United Kingdom, and the United States. Using a pricing technique based on the markup model, the authors discovered that prices responded differently to long-term appreciation and depreciation from 1980-2009. They believe that depreciation is more pronounced than appreciation on prices.

Developing economies are included. Asymmetrical and nonlinear relationships are also of interest to various authors. Darnor Maka (2013) employs the Structural Vector Autoregression (SVAR) model to assess the symmetrical and asymmetrical ERPT in consumer prices in Ghana from 1990M01 to 2011M12. He considered the components of the consumer price, and he discovered that the pass-through to non-food costs is complete but incomplete for food prices. Furthermore, ERPT is asymmetric, with depreciation positively affecting inflation. He also founds that the magnitude of the changes does not affect pass-through.

3.3. Empirical Literature on Exchange Rate and Food Prices

In their research, Kwon & Koo employed the Granger causality tests method proposed by Toda & Yamamotob (1995) and Dolado (1996) to determine how the exchange rate and price of different energy sources affect food costs from farmers to consumers in the United States. The research separates the food sector into four lots: crude, intermediate, finished, and retail, and the energy sector into three: crude, intermediate, and finished. First, using yearly data from January 1998 to July 2008, the study found that the crude and finished food price granger causes the intermediate food (retail) price. Despite the non-existence of a direct relationship between intermediate and finished food prices, the causal flow from crude (and intermediate) to finished (home) food costs is tied to the overall cost push mechanism. Second, crude, intermediate, and finished energy costs substantially impact the crude food price, the effects of which are passed on to food prices at different stages of the process through the food system's cost-push mechanism. Third, because of the multivariate causal relationship between energy and food costs, the exchange rate with energy and food prices provides new insights into understanding inflation. The exchange rate granger causes the intermediate energy price, whereas the exchange rate determines the crude energy price. The identifier connection between the exchange rate, energy, and food prices brings novel insights into comprehending inflation with the multivariate causal relationship between energy prices and food costs. A causal relationship was determined between intermediate energy prices and the exchange rate, while the exchange rate causes crude energy costs.

Burakov (2016) also investigates the influence of oil price movements and Russia's currency rate on the costs of seven agricultural items (buckwheat, grain crops, potatoes, oat, wheat, rye, and barley). He employed a VAR model using monthly data spanning the period January 1999 to October 2015 and found that in the short run, changes in the price of oil and the currency rate have no impact on agricultural prices; however, this is not the case for imported goods. Indeed, the exchange rate affects the imported commodity (buckwheat). Exogenous exchange rate shocks significantly raise the price of buckwheat, posing a danger to food security. Agricultural prices do not Granger cause the oil price, whereas a Granger causality exists between foreign commodities prices and the currency rate. The authors concluded that agricultural commodity exports safeguard a country's economy against shocks. And changes in the exchange rate and oil prices are insufficient to explain Russia's rise in food prices.

Hassan (2022) addressed the issue of volatile oil prices and exchange rates with a panel method including five Asian nations (Indonesia, Malaysia, the Philippines, Thailand, and Vietnam). Like the previous one, the author used a VAR model in its study, a panel VAR analysis to be more precise. The analysis spans 2000 to 2020 and is based on yearly data considering food prices, oil prices, and currency rate variables. The impulse response function (IRF) findings reveal that oil prices and exchange rate movements positively impact food costs. At the same time, the variance decomposition suggests that food costs represent a considerable share of changes in their shock. However, the impacts of exchange rate fluctuations on food prices are lower than the effects of oil prices on food expenses.

Sanusi & Dickason-Koekemoer also addressed the topic in a panel discussion. They focused on the BRIC nations to provide insight into the dynamic connection between oil prices, exchange rates, and food prices while also investigating the direction of causality. The panel VAR and dynamic threshold models were used in the investigation, which included data from January 2003 to March 2022. According to the findings, oil prices and exchange rates are two factors that influence food prices. There is unidirectional causation between oil prices to that of food, as well as from the currency rate fluctuations of the food costs. The outcomes of IRF supported by the variance decomposition reveal a more significant impact on food prices by oil bills. Indeed, the exchange rate accounts for more than 15% of food costs, whereas oil prices account for 30%, or double the exchange rate. Finally, currency movements have a detrimental influence on the BRICS economies.

Another panel VAR research, this time in Iran, aims to comprehend the impact of oil prices, the US dollar exchange rate, and interest rates on household-level food prices. The study examined 12 agricultural products used in rural areas, the currency rate, the oil prices, the interest rate, and the fertilizer cost from 2003 to 2013. Radmehr & Rastegari Henneberry determine that changes in the exchange rate positively impact food costs through their analysis. When the US dollar rises, food prices rise. Furthermore, the IRF shows that the exchange rate has a significant favorable influence on food costs in the concise run (3 months) but then has a negative impact after equilibrium is reached. On the other hand, the interest rate has a short-term positive influence on food prices and a long-term depressing effect. The result of oil prices on food prices is also positive in the short and long term. An increase in the exchange rate increases the government's income and food imports.

Minten & Kyle’s (1995) time series analysis employs two models to investigate how exchange rates affect agricultural food prices and how quickly international prices are transferred to local food prices in Zaire. To do so, the authors divide food prices into tradable and non-tradable categories. The first model uses the cointegration test to assess the long-term connection of the variables. The second choice is a Koyck model. The model is used to integrate the impacts of partial adjustment. The analysis, based on monthly data and spans the period 1984 to 1989, varies from the others in that it includes an extra variable not present in the other research. It is indeed the world market prices. Food prices on wholesale markets representing diverse products and official exchange rates are additional variables. The study's results, shown by the cointegration test referred to the 10% MacKinnon critical values, reveal that, except for maize, no long-term association exists between all the products selected for the study and the exchange rate’s movements and global prices. The Koyck model demonstrates that the currency’s direction significantly affects practically all tradable and some non-tradable products. However, the authors caution against categorizing tradable and non-tradable based on the exchange rate reaction. Changes in global pricing and currency rates are never fully transferred to domestic prices.

To understand the transmission of currency movement on household consumption in Malaysia, Jibrilla et al. (2017) use annual data from the actual demand for food imports, real domestic incomes, and relative food prices of Malaysia from 1980 to 2012. The authors use the ARDL model to interpret the elasticity of food import demand. In addition to the ARDL model, the DOLS is utilized to evaluate and corroborate the model's robustness. The study's findings indicate that increases in national income and relative food prices have a positive relationship with Malaysian demand for food imports. Additionally, each 1% rise in national income is connected with a 0.84% rise in demand for imported food. The ARDL model and the Dynamic OLS demonstrate that a 1% increase in foreign food prices compared to local prices results in a 0.95% to 0.97% increase in import demand. The authors concluded that food imports in Malaysia are inelastic in terms of both income growth and relative food import prices.

Food prices (rice, maize, sorghum, gari) and the exchange rate are inversely related in Nigeria. In addition, the volatility transmission of exchange rate returns to food costs is more significant than it receives, particularly after the currency’s depreciation. Indeed, Akanni (2020) reached this result by studying the degree and direction of returns and volatility spillover transmission between the Nigerian exchange rate and domestic prices. His research uses weekly data from January 2010 to January 2019 based on the improved Diebold & Yilmaz (2012) approach. It is also worth mentioning that the study considers the 2016 currency rate drop in the interconnection of food costs and the change between the naira and the dollar.

Loening et al. (2009) explore the relative impact of factors contributing to total inflation and its three components, grain prices, food prices, and non-food costs. The authors choose Ethiopia as the research example and apply the Error correction model to monthly data from 1999 to 2009. The findings reveal that agricultural supply shocks and inflation inertia significantly impact domestic inflation in the short to medium term, resulting in deviations from long-run price patterns. In the long run, currency rate fluctuation and international food prices affect domestic food and non-food pricing.

Layani & Mehrjou (2023) have also contributed to studying the impact of currency fluctuations on food prices. The research likewise focuses on Iran, but unlike its predecessors, Layani & Mehrjou (2023) take a nonlinear method to assess the existing link between the variables of concern. The Nonlinear ARDL involves the variables food price, exchange rate, oil price, GDP, and trade liberalization and reveals a cointegration relationship between the variables. There is also evidence that changes in the currency rate after depreciation and appreciation affect food prices in Iran in the long run. A 1% increase in the exchange rate translates into a 0.32% increase in the price of food. In contrast to the currency rate, GDP, and trade liberalization, the cost of oil has no significant connection with food prices in Iran.

Kai et al. (2017) added to the economics literature by researching the impact of crude oil prices, real GDP, and exchange rates on food prices. Indeed, it is based on Malaysian quarterly data from 2000Q1 to 2016Q2, and it investigates the asymmetrical relationship between the study's independent variables and food prices. The NARDL model findings indicated that, in the short run, crude oil does not have a significant relationship with food prices; nevertheless, the exchange rate and real GDP positively affect food prices. In the long run, all independent variables, such as oil prices, exchange rates, and GDP, positively influence the dependent variable. According to the study, a depreciation of the Malaysian currency increases food prices, although an appreciation has the opposite impact; it decreases the cost of food. Furthermore, the magnitude of an appreciation of the Malaysian currency is small compared to depreciation.

Boubakri et al. (2019) examine the nonlinearity between real commodity prices and commodity-exporting nations' real effective exchange rates. The analysis spans 42 commodity-exporting countries from 1980 to 2016 and is organized into four panels: food and beverages, energy, metals, and raw materials. The question is approached in two ways by methodology and by specification. The first technique employs a causality test and cointegration to assess the short and long-term linear relationship between food prices and REER. The second method, on the other hand, uses a panel smooth transition regression model (PSTR) to test the nonlinear connection. This methodology permits the regression coefficient to change between nations and over time, depending on the commodity price index and the transition variable. The PSTR focuses exclusively on the short term. The study's findings indicate a nonlinear association between the REER and commodity prices, but this relationship depends on the commodity markets' degree of financing. According to the study, if a nation has insufficient financial integration, its real commodity price volatility significantly and negatively influences the fluctuation in REER. However, during periods of improved financial integration, the effect of real commodity price volatility on REER has decreased, particularly for the two panels of food and beverages and energy.

Kadanalı (2021) also utilized the modified version of the Pesaran et al. (2001) ARDL model proposed by Shin et al. (2011) to examine the asymmetrical impacts of diesel price movements and the exchange rate on Turkey's food prices. The data ranges from 2000 to 2019 and is based on monthly statistics on the price of diesel in Turkey, the exchange rate, and the price index. The study's findings support the asymmetry in the relationship between the exchange rate and food prices. Only a depreciation of the currency effect is transmitted to food costs in the long term. In the short run, currency appreciation has a considerable negative influence on food prices. It is found that a 1% rise in the Turkish lira results in a 0.94% drop in food prices.

CHAPTER IV

DATA AND METHODOLOGY

This part of the study consists of a chronological sequence followed by an explanation of the econometric technics to conduct this research properly. The chapter includes the model specification, the technical estimates used to investigate the relationship between exchange rates and food prices, and the description of the different variables of the study.

4.1. Methodology

To examine the relationship between exchange rate and food prices, the study uses the model given in Equation (4.1). The model is derived from the empirical specification of Delatte & López-Villavicencio (2012) and Brun-Aguerre et al. (2017). The linear relationship between the variables is the foundation of this model. Thus, the study will primarily examine if the relationship between the exchange rate and food prices in the WAEMU is not essentially linear, as some studies have suggested. For instance, Radmehr & Rastegari Henneberry, Loening et al. (2009) used the linear approach and found that change in the exchange rate has a long-term relationship with food costs respectively in Iran and Ethiopia.

4.1.1. Unit Root Test

Before performing any significant data processing, running the unit root test on the variables is critical. The unit root test determines the degree of integration of the research variables. The ARDL cointegration methodology does not require unit root tests. That makes it a preferred model for variables incorporated into various sequences or mixes. However, it should be noted that this model does not consider the integration of order two, $I\ (2)$ (it violates the conditionalities of using ARDL). Indeed, the F-statistic (Wald test) identifies the long-run relationship between the corresponding variables. This long-run relationship is established when the F-statistic exceeds the critical value band. This approach will fail in the presence of an integrated stochastic of order 2. Therefore, to avoid incorrect application, estimation, and interpretation of the model, it is recommended to test for unit roots that are consistent with conditions that give rise to the ARDL cointegration technique.

Several tests have been developed to test for the unit roots. The study focuses on three of them, namely the Augmented Dickey-Fuller test (ADF), the Phillip Perron test (PP), and the Kwiatkowski Phillip Schmidt Shin test (KPSS). The unit root tests are run at the constant, constant, and trend levels.

i. Augmented Dickey-Fuller Test

The Dickey-Fuller, named after American statisticians David Dickey and Wayne Fuller, who developed it in 1979, is used to evaluate if a unit root exists in an autoregressive model. Later, in 1984, they broadened their study to develop the augmented Dickey-Fuller test, an augmented version of the original Dickey-Fuller unit root test Dickey & Fuller (1979).

The ADF unit root test is based on the first-order autoregressive process.

$$y_t = \psi_1 y_{t-1} + \varepsilon_t \ , \qquad\qquad t = 1, \dots, T$$

Where y_{t-1} is the lagged value of the variable y_t, and ψ_1 is its autoregressive parameter. ε_t is the white noise process.

The hypotheses of the test are represented as follows:

$$H_0 = \psi_1 = 1$$
$$H_1 = \psi_1 < 1$$

The null hypothesis (H_0) implies that the process has a unit root, as opposed to the alternative hypothesis (H_1), which asserts that the process is stationary (no unit root).

ii. Phillips-Perron Test

The Phillips-Perron test is a unit root test, comparable to the Augmented Dickey-Fuller test. The test is named after Peter C. B. Phillips and Pierre Perron Phillips & Perron (1988). The unit root test examines the null hypothesis that a time series is a unit root. PP is based on the Dickey-Fuller test of the null hypothesis $p = 1$.

$$\Delta y_t = (p-1)y_{t-1} + \mu_t$$

In which Δ signifies the first difference operator.

iii. Kwiatkowski, Phillips, Schmidt, and Shin

Unlike the preceding two tests (ADF and PP) and many others, the KPSS test is based on the premise that the null hypothesis is stationary compared to the alternative hypothesis, which is a unit root. The implemented approach of the KPSS unit root test is named after Denis Kwiatkowski, Peter C. B. Phillips, Peter Schmidt, and Yongcheol Shin (1992).

$$y_t = d_t + \beta_t + \varepsilon_t$$
$$\beta_t = \beta_{t-1} + \vartheta_t$$

Where d_t denotes the deterministic component.

4.1.2. Autoregressive Distributed Lag Model

The empirical model can be represented as follow:

$$\boldsymbol{lfpi_{i,t} = \alpha_i + \beta_i ler_{i,t} + \gamma_i loil_{i,t} + \delta_i lm2_{i,t} + \theta_i gap_{i,t} + \zeta_i Gfc_i + \eta_i covid_i + \varepsilon_{i,t}} \quad (4.1)$$

where $lfpi$ is the food price, ler is the nominal exchange rate that indicates the amount of CFA franc required to buy one US dollar, $loil$ is the international oil price, $lm2$ is the money supply, gap is the country production gap (output gap), Gfc

is the dummy for global food crisis, $covid$ is the dummy that captures the effect of COVID-19 and $\varepsilon_{i,t}$ is the error term. The subscripts i and t represent country and time specifications, respectively.

4.1.3. Autoregressive Distributed Lag Error Correction Model

The next step is determining the Error Correction Model (ECM) for short- and long-term dynamics. The ARDL bounds test is a method for detecting the probable long-term relationship between the independent variables and the dependent variable. The study uses the F-test proposed by Pesaran et al. (2001) and the T-test by Banerjee et al. (1998) to assess whether cointegration exists between the variables under examination.

The Error Correction Model (ECM) of Equation (4.1) is determined as follows:

$$\Delta lfpi_{i,t} = \alpha_i + p_i lfpi_{i,t-1} + \beta_i ler_{i,t-1} + \gamma_i loil_{i,t-1} + \delta_i lm2_{i,t-1} + \theta_i gap_{i,t-1} + \zeta_i Gfc_i + \eta_i Covid_i + \sum_{j=1}^{u-1} \iota_{i,j} \Delta lfpi_{i,t-j} + \sum_{j=0}^{v-1} k_{i,j} \Delta ler_{i,t-j} + \sum_{j=0}^{w-1} \lambda_{i,j} \Delta loil_{i,t-j} + \sum_{j=0}^{x-1} \mu_{i,j} \Delta lm2_{i,t-j} + \sum_{j=0}^{y-1} \nu_{i,j} gap_{i,t-j} + \varepsilon_{i,t} \quad (4.2)$$

Where Δ is the difference operator, α_i denotes the country-specific intercept. $p_i, \beta_i, \gamma_i, \delta_i, \theta_i, \zeta_i, \eta_i, k_i, \iota_i, \lambda_i, \mu_i, \nu_i$ are the coefficients to be estimated (short- and long-term), and $\varepsilon_{i,t} \sim \mathrm{N}(0, \sigma^2)$. u, v, w, x, y represent the optimal lags. To ensure that all the countries under the study have the same number of specifications, we chose four lags that will allow us to assess the impact over four months, given that our data is monthly. Three lags measure the seasonal effects, and we added an extra lag to capture any potential effect in the 4th month (the beginning of the second season).

Equation (4.1) implies that the relationship between exchange rate and food prices is linear and symmetric. In the long term, the estimate of the linear model reveals no significance in the relationship between the exchange rate and food prices **(Appendix A).** Following the cointegration test, the Bound test indicated that the exchange rate has no linear effect on food prices in any WAEMU nation. The diagnostic tests were performed to confirm that the model (4.1) was correctly specified and that the coefficients produced were robust **(see Appendix A).** As a result, the study will investigate whether there is a nonlinear connection between the exchange rate and food prices.

To the economic theory of the exchange rate, domestic currency depreciation influences the price of foreign goods. Indeed, it raises the cost of imported goods, reducing demand for imports. However, depreciation benefits exports by making local goods more affordable and attractive globally. An appreciation has a different effect than depreciation. The impact of currency appreciation is not instantaneous, and its magnitude may differ from that of currency decline. This can be explained by price stickiness. It is the lack of market prices to adjust fast, notwithstanding a fall in import costs. Kai et al. (2017) and Boubakri et al. (2019) have supported the asymmetric and nonlinear relationship between exchange rates and food prices by the results of their empirical studies, which lead to the conclusion that depreciation and appreciation have different impacts on food prices.

Thus, for a perfect match with the study objectives, the proper conduct of the analysis must be based on an econometrics model that considers the exchange rate's nonlinearity and asymmetry, which should allow for a dissociation of the exchange rate into depreciation and appreciation. This difference is intended to determine whether depreciations and appreciations affect food prices differently. The model should also enable testing whether the relationship between the exchange rate and food prices exists in the short and long term. Finally, the model must support the inclusion of different orders of integration, such as unit root and stationary variables.
The structural Vector Autoregression (SVAR) model introduced by Jean & Quah (1987) and the Nonlinear Autoregression Distributed Lags (NARDL) model proposed by Shin et al. (2011) piqued our interest. Following the confrontation of the two models, the SVAR model was eliminated because it has a constraint that makes it impossible to employ variables with different orders of integration. The SVAR model uses variables integrated in the same order. On the other hand, the NARDL model fits the study's objectives. It allows for using unit root and stationary variables and decomposing the exchange rate into depreciation and appreciation.

4.1.4. Nonlinear Autoregressive Distributed Lag Model

The NARDL is an asymmetric version of Pesaran et al.'s (2001) linear ARDL model. The NARDL analyses the negative and positive variations of the independent variables that have diverging effects on the dependent variable. The NARDL, like the linear ARDL, is also suitable for short-term and long-term investigations. Based on the study objectives, it is an appropriate model for capturing both the short and long-run effect of the independent variables, notably the exchange rate appreciations and depreciations to food prices.

The Nonlinear form of the equation (4.1) is:

$$lfpi_{i,t} = \alpha_i + \beta_i^+ ler_{i,t}^+ + \beta_i^- ler_{i,t}^- + \gamma_i loil_{i,t} + \delta_i lm2_{i,t} + \theta_i gap_{i,t} + \zeta_i Gfc_i + \eta_i Covid_i \quad (4.3)$$

4.1.5. Nonlinear Autoregressive Distributed Lag Error Correction Model

The Error Correction Model (ECM) of the NARDL, which allows for short- and long-term dynamics, varies from the linear ARDL model in that it takes partial decomposition of the exchange rate in depreciation and appreciation into account. The Bound test (the F-test proposed by Pesaran et al. (2001) and the T-test offered by Banerjee et al. (1998)) also allows the nonlinear connection between the research variables to be verified. The evaluation processes are:

The T-test approach:

$$H_0 = p_i = 0$$
$$H_1 = p_i < 0$$

The F-test approach:

$$H_0 = p_i = \beta_i^+ = \beta_i^- = \gamma_i = \delta_i = \theta_i = 0$$
$$H_1 = p_i \neq \beta_i^+ \neq \beta_i^- \neq \gamma_i \neq \delta_i \neq \theta_i \neq 0$$

The F-test and the T-test test the null hypothesis of no cointegration against the alternative of the presence of cointegration (long-run relationship).

According to the Bound test, if the calculated F-statistic and T-statistic are greater than the upper critical values, there is cointegration between the dependent and independent variables. However, these tests are not concluded if the calculated statistics (F-statistic and T-statistic) fall between the upper and lower critical values. The NARDL model error correction form of the equation (4.3) is given as follows:

$$\Delta lfpi_{i,t} = \alpha_i + p_i lfpi_{i,t-1} + \beta_i^+ ler_{i,t-1}^+ + \beta_i^- ler_{i,t-1}^- + \gamma_i loil_{i,t-1} + \delta_i lm2_{i,t-1} + \theta_i gap_{i,t-1} + \zeta_i Gfc_i + \eta_i Covid_i + \sum_{j=1}^{u-1} \iota_{i,j} \Delta lfpi_{i,t-j} + \sum_{j=0}^{v-1} \kappa_{i,j}^+ \Delta ler_{i,t-j}^+ + \sum_{j=0}^{w-1} \kappa_{i,j}^- \Delta ler_{i,t-k}^- + \sum_{j=0}^{x-1} \lambda_{i,j} \Delta loil_{i,t-j} + \sum_{j=0}^{y-1} \mu_{i,j} \Delta lm2_{i,t-j} + \sum_{j=0}^{z-1} \nu_{i,j} gap_{i,t-j} + \varepsilon_{i,t} \quad (4.4)$$

The difference operator is represented by Δ, and ler^+ and ler^- denote positive and negative partial sums of the exchange rate, indicating depreciation and appreciation of the CFA franc respectively. α_i denotes the country-specific intercept. $p_i, \beta_i^+, \beta_i^-, \gamma_i, \delta_i, \theta_i, \zeta_i, \eta_i, \kappa_i^+, \kappa_i^-, \iota_i, \lambda_i, \mu_i, \nu_i$ are the coefficients to be estimated (short- and long-term), and $\varepsilon_{i,t} \sim N(0, \sigma^2)$. u, v, w, x, y, z represent the selected lags. To ensure that all the countries under the study have the same number of specifications, we chose four lags that will allow us to assess the impact over four months.

The long-term parameters are calculated as follows:

$\Omega^+ = -\beta_i^+/p$ and $\Omega^- = -\beta_i^-/p$; denote the long-term effects of depreciation and appreciation, respectively on CFA franc.

$k_{i,j}^+$ and $k_{i,j}^-$ represent the coefficients of the short-term effects of depreciation and appreciation on the food prices.

The decompositions of the partial sum of the exchange rate are calculated:

$$ler_{i,t}^+ = \sum_{j=1}^{t} \Delta ler_{i,j}^+ = \sum_{j=1}^{t} max\left(\Delta ler_{i,j}, 0\right)$$

and

$$ler_{i,t}^{-} = \sum_{j=1}^{t} \Delta ler_{i,j}^{-} = \sum_{j=1}^{t} min\left(\Delta ler_{i,j}, 0\right)$$

Where $ler_{i,t}^{+}$ and $ler_{i,t}^{+}$ denote the CFA franc depreciation and appreciation, respectively.

4.1.6. Symmetry Test

In keeping with one of our research goals, the asymmetric connection of the exchange rate is subjected to a symmetry test to discover whether an appreciation and a depreciation of the domestic currency affect food prices differently. Indeed, Wald tests enable the symmetry test to be performed in both the short and long run. The following are the hypotheses of the symmetry test:

Hypothesis 1. The short-run symmetry

$$H_0^1: \sum_{j=0}^{v-1} \kappa_{i,j}^{+} = \sum_{j=0}^{w-1} \kappa_{i,j}^{-}$$

$$H_1^1: \sum_{j=0}^{v-1} \kappa_{i,j}^{+} \neq \sum_{j=0}^{w-1} \kappa_{i,j}^{-}$$

Hypothesis 2. The long run asymmetry

$$H_0^2: \Omega_i^{+} = \Omega_i^{-}$$

$$H_1^2: \Omega_i^{+} \neq \Omega_i^{-}$$

The null hypothesis H_0^1 (H_0^2) states that there is a symmetry relationship in the short run (long run). Thus, rejecting the null hypothesis H_0^1 (H_0^2) shows evidence of a short-run asymmetry (long-run asymmetry).

4.1.7. Category of Pass-Through

Understanding the impact of the exchange rate on food prices requires establishing the type of pass-through. It enables a more in-depth examination of its influence on pricing and identifies its source.

Theoretically, there are two sorts of pass-through Goldberg & Knetter (1997). The pass-through might be either complete or incomplete. Following this approach, our research hypotheses will consider these two categories before incorporating a hypothesis regarding the absence of pass-through.

Hypothesis 3. Complete /incomplete pass-through in the short term.

$$H_0^3: \sum_{j=0}^{v-1} k_{i,j}^{+} \geq 1, \quad \left(\sum_{j=0}^{w-1} k_{i,j}^{-} \geq 1\right)$$

$$H_1^3: \sum_{j=0}^{v-1} k_{i,j}^{+} < 1, \quad \left(\sum_{j=0}^{w-1} k_{i,j}^{-} < 1\right)$$

Hypothesis 4. Complete/incomplete pass-through in the long term.

$$H_0^4: \Omega_i^{+} \geq 1, (\Omega_i^{-} \geq 1)$$
$$H_1^4: \Omega_i^{+} < 1, (\Omega_i^{-} < 1)$$

Hypothesis 5. Zero pass-through in the short term.

$$H_0^5: \sum_{j=0}^{v-1} k_{i,j}^{+} = 0, \quad \left(\sum_{j=0}^{w-1} k_{i,j}^{-} = 0\right)$$

$$H_1^5: \sum_{j=0}^{v-1} k_{i,j}^{+} \neq 0, \quad \left(\sum_{j=0}^{w-1} k_{i,j}^{-} \neq 0\right)$$

Hypothesis 6. Zero pass-through in the long run.

$$H_0^6: \Omega_i^+ = 0, (\Omega_i^- = 0)$$

$$H_1^6: \Omega_i^+ \neq 0, (\Omega_i^- \neq 0)$$

As a guideline for the tests, exchange rate pass-through is complete in the short run (long run) if the coefficient of an appreciation (depreciation) is more significant than one and incomplete in the short run (long run) if the coefficient is between 0 and 1. The coefficient is equal to 0 in the event of zero pass-through.

4.1.8. Diagnostic Tests

Diagnostics tests ensure that calculated coefficients are robust. The diagnostic test depends on the modeling approach employed. The most popular types, however, are coefficient diagnostics and residual diagnostics. The residual diagnostic is the most important since the regression attempts to reduce errors (it examines whether the error terms are independently and identically distributed, $i.i.d.$). The predominant test methods for residual diagnostics are serial correlation and heteroskedasticity tests.

i. Heteroskedasticity Test

The optimal application of the least squares technique, often known as the OLS estimator, assumes that the error component has equal/constant variance (homoskedasticity) across all observations. If this requirement is not satisfied, we speak about heteroskedasticity, which indicates that the variances are not constant. In the case of our study, we refer to the statistic test (Breusch-pagan test) proposed by Breusch & Pagan (1979) to assess whether there is any presence of heteroskedasticity.

The Breusch-Pagan LM test auxiliary equation:

$$\hat{\mu}_i^2 = \delta_0 + \delta_1 x_{1i} + \delta_2 x_{2i} + \cdots + \delta_k x_{ki} + \upsilon_i$$

We derive the hypotheses as follows:

$H_0 = \delta_1 = \delta_2 = \cdots = \delta_k = 0$
$H_0 = at\ least\ one\ of\ the\ \delta_s\ is\ different\ from\ zero.$

The criteria of decision:
If $LM = nR^2_{\hat{\mu}_i^2}\ statistic > \chi^2_k$, we reject the null hypothesis and conclude significant evidence of heteroskedasticity.
Alternatively, if the $p - value < 0.05$, we reject the null hypothesis.

ii. Serial Correlation LM Test

If residuals are serially correlated, past residuals impact current residuals, causing the estimation to be biased (untrustworthy). As a result, checking for autocorrelation issues with our model is critical. The statistics employed to carry out this test is the Breusch-Godfrey serial correlation LM test. The most frequent type of serial correlation is a first-order serial correlation, in which the error of the current period is connected to the error of the preceding period.

$\varepsilon_t = p\varepsilon_{t-1} + \upsilon_t, \qquad \mathrm{t} = 1, \dots, \mathrm{T}$

If $\begin{cases} p = 0, \text{there is no presence serial correlation.} \\ p > 0 \text{ it indicates presence of serial correlation} \end{cases}$

iii. Stability Tests

The cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) are used to demonstrate the quality of fit of our model.

4.2. Data Source

This study investigates the asymmetry and nonlinearity of the exchange rate pass-through on food prices in WAEMU member countries. The data employed in the empirical analysis includes monthly data from eight West African developing countries that are all active members of the WAEMU over the period January 2004 to December 2022. The data is obtained from various sources. While the food price index and money supply are obtained from the Central Bank of West African States (BCEAO), the nominal exchange rate, international crude oil price, and gross domestic product were obtained from International Monetary Fund statistics (IMF). The definition of variables subject to empirical analysis is as follows:

The food price index ($lfpi$): is measured as a monthly change in the prices of a basket of food commodities. It is calculated by taking the average of commodity group price indices and weighting them by the average export share of each group.

Nominal exchange rate (er)**:** is 1 US dollar for a certain amount of West African CFA franc. It should be noted that the American dollar is still regarded as the worldwide trade currency. This is how we choose to refer to this currency throughout our research.

Crude oil price ($loil$): is the international oil price per barrel in US dollars. The data is provided as monthly bases.

Money supply ($m2$): refers to broad money as a percentage of GDP. It is the total amount of money in circulation within an economy.

Output gap (gap): the nominal gross domestic product (GDP) annual data converted into monthly data using the low to high-frequency technique in EViews 13. Then, the deviation of the GDP from its trend is utilized to calculate the output gap. The trend of the nominal GDP is obtained using the Hodrick-Prescott filter technic.

Dummy 1 (gfc): This dummy variable represents the global food crisis of 2008. It is set to 1 for 2007-2008 and 0 otherwise.

Dummy 2 (Covid): this dummy variable captures the impact of the covid-19 in the analysis. From 2020 onwards, the number 1 will be used. Otherwise, the value 0 is used.

CHAPTER V

EMPIRICAL ANALYSIS OF THE DETERMINANTS OF FOOD PRICES

Having discussed the model and estimation methodology in previous chapters, in this section of the study, we will primarily focus on estimating the model of Nonlinear Autoregressive Distributed Lag and interpreting the analytical results to understand the topic under consideration. We will begin with a statistical description of the data selected for the study, followed by the stationary test, and then analyze the NARDL estimates of the WAEMU countries.

5.1. Descriptive Statistics

Table 5.1 presents descriptive statistics of the data subject to empirical analysis. **Table 5.1** shows that each country's average Food price index gets close to 100. Indeed, all WAEMU nations are witnessing increased food costs since they are heavily reliant on food imports and are vulnerable to price increases when global food prices rise. Togo ranks top with an average of 99.87, followed by Senegal, Guinea, Burkina Faso, Cote d'Ivoire, Benin, Mali, and Niger. In Burkina Faso, however, a high price of 150.2 was recorded. Burkina Faso is the WAEMU member states the most hit by the global food crisis. Since the beginning of the COVID-19 pandemic, its economic condition has deteriorated, as demonstrated by inflation of 12.2 percent in November 2022 compared to 3.2 percent in the same month in its neighboring Benin.

Benin has the lowest inflation of the union, and because headline inflation is driven by food inflation, its prices are substantially lower. Senegal follows Burkina Faso with a maximum of 146.5. Senegal has always experienced a high cost of living among the other WAEMU countries and is even ranked first in West Africa. Its standard deviation of 15.155 demonstrates that the price variance remains near the average of 98.831, one of the highest. Furthermore, Burkina Faso has a substantially more significant standard deviation of 17.951 than Senegal. However, Niger had the lowest minimum price, followed by Burkina Faso, Mali, Togo, Ivory Coast, Guinea, and Senegal. As reported, Senegal has a minimum price that continues to outperform the rest of the nations in the region.

Burkina Faso recently had a price spike due to its insecurity problem, exacerbated by the COVID-19 pandemic that hit the world in 2020. These factors have made the country one of the most inflationary in West Africa. Benin is a small nation with relatively small food imports compared to other countries in the region. The abundance of rainfall also allows the country to have better harvests than Sahelian countries such as Burkina Faso, Mali, and Niger, which are vulnerable to rainfall disruptions.

The exchange rate of the eight countries remains the same because they belong to the same monetary zone. Indeed, the CFA franc is a currency pegged to the euro by a fixed parity of 655.957. Since the beginning of the 21st century, the euro has always appreciated strongly against the US dollar. Still, this trend has reversed in 2022 with the advent of COVID-19 and the war between Russia and Ukraine. Indeed, these two crises have hurt the global economy, creating unprecedented increases in inflation in several nations. This led the United States, through its Federal Bank, to increase its interest rate, which prompted its currency to appreciate, causing the dollar to appreciate. Thus, the euro-dollar exchange rate declined. This was also felt in the WAEMU nations, which have a currency directly tied to the euro.

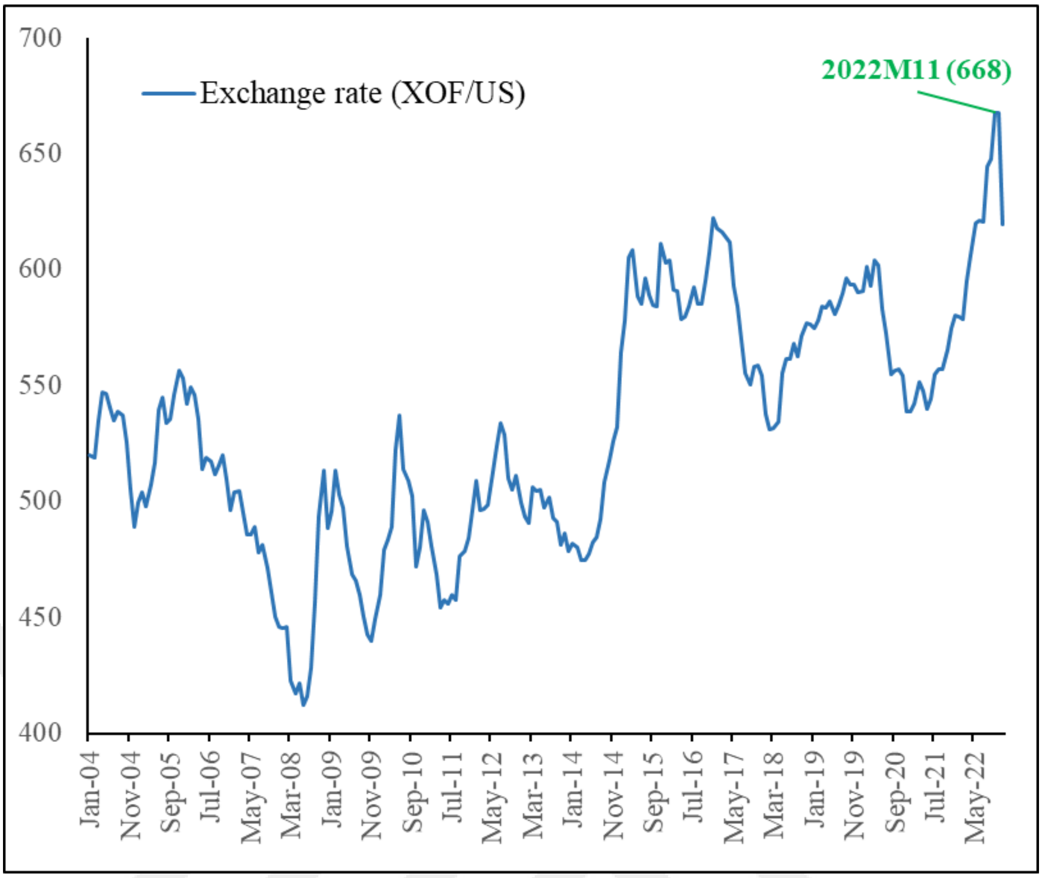


Figure 5.1. Exchange Rate

The average, minimum, and maximum values remain the same for every country, 531, 412.19, and 667.663 CFA francs, respectively. The dollar reached a new high of 667.663 CFA franc in October 2022 **(**see **Figure 5.1),** surpassing the previous high set in December 2016. Since the beginning of the century, the dollar's value has never reached that of the euro in the WAEMU zone; it has always been limited to fluctuating between 420 and 600 CFA francs.

The oil price is the same in all member countries since we have chosen to utilize data on the international crude oil price. This decision is influenced because no oil price data at the pump is available for all nations, let alone for the whole research period. The price of oil fluctuates over time. It fluctuates due to shocks that induce either a fall or a rise. The monthly cost of a barrel of oil has reached a low of 24.41 USD versus a high of 132.542 USD during the first months of the conflict between Ukraine and Russia, which began in February 2022. This conflict hampered oil and gas supplies, causing price spikes. Three of the eight nations in the UEMOA zone are small-scale oil producers, although they all rely on foreign oil. Furthermore, variations in oil prices are mirrored in the economies of the zone's members.

The BCEAO is the bank that oversees the monetary policy of the WAEMU economies. The table shows the money supply as a proportion of GDP. For Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo, the average money supply as a percentage of GDP is 25.93, 31.83, 25.59, 35.09, 27.44, 15.58, 32.92, and 40.52. Indeed, we observed that broad money accounts for 40% of Togo's GDP, which is relatively significant compared to the others. Guinea Bissau comes in second place with 35.09. The tiniest fraction was documented in Niger.

The output gap is the difference between what economies produced from 2004 to 2022 and what they might have produced if all the conditions for a more stable economic climate had been met. It is the difference between the GDP and the trend generated using the Hodrick Prescott Filter method to filter the GDP. On average, all nations have a negative production gap with a maximum between 2 and 4. Mali has the highest figure at 2.39, which can be attributed to the deterioration of its security situation, which has resulted in the loss of several parts of its territory, some of which have since been recovered. Others are on their way by the regular army, as well as the decline in its productivity, resulting in galloping inflation. Togo has a score of 4.04 and is the only country in the region that has overperformed in capacity.

Table 5.1. Descriptive Statistics

		BENIN	BURKINA FASO	COTE D’IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Food price index	Mean	92.424	96.857	96.658	97.904	94.089	92.251	98.831	99.870
	Median	97.355	100.230	100.770	100.520	98.475	96.550	99.365	102.885
	Maximum	117.780	150.200	135.100	134.900	127.800	122.600	146.500	140.400
	Minimum	63.900	58.100	64.700	71.500	62.200	56.900	71.500	64.400
	Std. Dev.	13.839	17.951	17.463	14.022	13.739	15.522	15.155	17.192
	Skewness	-0.656	0.157	-0.109	-0.045	-0.415	-0.610	0.346	-0.222
	Kurtosis	2.212	3.808	2.407	2.652	2.811	2.540	3.433	2.893
	Jarque-Bera	22.222	7.135	3.799	1.229	6.897	16.152	6.331	1.978
	Probability	0.000	0.028	0.150	0.541	0.032	0.000	0.042	0.372
	Sum	21072.570	22083.290	22038.070	22322.090	21452.250	21033.320	22533.410	22770.310
	Sum Sq. Dev.	43475.877	73149.544	69224.257	44628.783	42846.219	54694.054	52134.635	67094.460

Table 5.1. (cont.)

		BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Exchange rate	Mean	531.808	531.808	531.808	531.808	531.808	531.808	531.808	531.808
	Median	532.845	532.845	532.845	532.845	532.845	532.845	532.845	532.845
	Maximum	667.663	667.663	667.663	667.663	667.663	667.663	667.663	667.663
	Minimum	412.193	412.193	412.193	412.193	412.193	412.193	412.193	412.193
	Std. Dev.	52.882	52.882	52.882	52.882	52.882	52.882	52.882	52.882
	Skewness	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
	Kurtosis	2.355	2.355	2.355	2.355	2.355	2.355	2.355	2.355
	Jarque-Bera	4.076	4.076	4.076	4.076	4.076	4.076	4.076	4.076
	Probability	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
	Sum	121252.206	121252.206	121252.206	121252.206	121252.206	121252.206	121252.206	121252.206
	Sum Sq. Dev.	634807.291	634807.291	634807.291	634807.291	634807.291	634807.291	634807.291	634807.291

Table 5.1. (cont.)

		BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Oil prices	Mean	71.499	71.499	71.499	71.499	71.499	71.499	71.499	71.499
	Median	67.365	67.365	67.365	67.365	67.365	67.365	67.365	67.365
	Maximum	132.542	132.542	132.542	132.542	132.542	132.542	132.542	132.542
	Minimum	23.339	23.339	23.339	23.339	23.339	23.339	23.339	23.339
	Std. Dev.	24.418	24.418	24.418	24.418	24.418	24.418	24.418	24.418
	Skewness	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
	Kurtosis	2.086	2.086	2.086	2.086	2.086	2.086	2.086	2.086
	Jarque-Bera	12.195	12.195	12.195	12.195	12.195	12.195	12.195	12.195
	Probability	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Sum	16301.714	16301.714	16301.714	16301.714	16301.714	16301.714	16301.714	16301.714
	Sum Sq. Dev.	135345.212	135345.212	135345.212	135345.212	135345.212	135345.212	135345.212	135345.212

Table 5.1. (cont.)

		BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Money supply	Mean	25.927	31.829	25.589	35.097	27.440	15.571	32.925	40.523
	Median	26.816	28.282	25.357	31.970	26.564	16.167	29.845	42.808
	Maximum	34.302	51.811	40.360	53.893	41.416	20.273	48.605	52.698
	Minimum	13.856	17.679	13.566	14.670	16.978	8.778	22.029	23.979
	Std. Dev.	5.474	10.903	7.704	13.230	5.865	3.735	8.535	7.750
	Skewness	-0.664	0.403	0.282	-0.076	1.058	-0.360	0.457	-0.717
	Kurtosis	2.718	1.825	2.417	1.487	3.715	1.831	1.911	2.527
	Jarque-Bera	17.534	19.312	6.260	21.960	47.386	17.910	19.197	21.684
	Probability	0.000	0.000	0.044	0.000	0.000	0.000	0.000	0.000
	Sum	5911.428	7256.967	5834.356	8002.103	6256.363	3550.120	7506.917	9239.206
	Sum Sq. Dev.	6801.695	26985.588	13472.270	39730.376	7807.920	3166.544	16536.233	13632.802

Table 5.1. (cont.)

		BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Output gap	Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Median	-0.088	0.398	-0.069	0.096	-0.091	0.013	-0.066	-0.165
	Maximum	3.342	3.107	4.402	5.169	2.391	3.554	2.934	4.041
	Minimum	-6.000	-5.494	-5.674	-5.027	-3.414	-3.422	-5.078	-4.842
	Std. Dev.	1.343	1.534	1.928	2.016	1.207	1.336	1.117	1.248
	Skewness	-0.223	-0.822	0.180	0.009	-0.197	0.257	-0.576	0.012
	Kurtosis	5.016	3.545	2.738	3.768	2.766	3.271	6.232	4.171
	Jarque-Bera	40.487	28.492	1.881	5.600	1.988	3.202	111.805	13.030
	Probability	0.000	0.000	0.391	0.061	0.370	0.202	0.000	0.001
	Sum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sum Sq. Dev.	409.537	534.008	843.583	922.918	330.790	405.081	283.383	353.713

5.2. Unit Root

Table 5.2 summarizes the three-unit root tests performed (ADF, PP, KPSS) at the first level with constant only and trend and the second with constant alone and trend. Except for the output gap, obtained from GDP using the Hodrick Prescott Filter technic, all variables in the analysis are given in natural logarithm. It should also be mentioned that the log of GDP was considered before determining the output gap.

The ADF test reveals that the $lfpi$ variable performed at the constant level is a unit root, with a trend for all countries. When the first difference is considered, the food price remains stable. The same applies to the exchange rate. Due to the agreement with France, the exchange rate for all nations in the WAEMU zone remains the same. When the first difference is evaluated, the exchange rate assessed under ADF at the level confirms the stationarity of the variable.

The oil price movement reveals an increase from time to time and a propensity that tends to return to the initial cost; increases enhance the volatility and decrease without diverging too much from the original price. Indeed, the unit root ADF test for all nations reveals that the variable is stationary at the 1% significance level and the first difference at 5% significance.

Benin and Togo's money supply performed with a constant is stationary at the 5% significance level. Conversely, when the trend is considered, the variable exhibits unit root. In comparison, the money supply in other nations is unit root with constant and trend. Furthermore, for all countries except Benin, money supply performed with a constant is stationary at the first difference at 1% significance. When the trend is considered in the test, the first difference in money supply is significant at 5% in Benin, Burkina Faso, Guinea Bissau, Niger, and Senegal. However, it is less significant in Cote d'Ivoire, accounting for 10%. For all nations, the output gap is a stationary variable.

The PP test for the unit root produces nearly identical results to ADF. The $lfpi$ is a unit root variable when performed with constant at a level for all countries but stationary once the trend is considered only for Senegal at a 5% significance level.

The variable is free of unit root at the first difference for all nations at a 1% significance level.

The exchange rate is still a unit root variable under the PP test at the level but stationary at the first difference. In this test, the oil price is stationary at 10% at a constant level. Unlike the ADF test, the PP demonstrates that the oil price with the trend is a unit root for all nations. Oil price is stationary at a 1% significance level when performed with constant and trend for all countries.

The money supply variable also produces disparities in PP unit root test findings. The money supply is stationary at the level of 5% significance in Benin; for the rest of the nations, it is denoted by the existence of unit roots at the constant and trend levels. The money supply is stationary at 1%, with constant and trend at the first difference level for all countries.

The output gap shows a mix of significance and non-significance at a level. We underline that only Benin, Burkina Faso, and Cote d'Ivoire have consistent and trending unit roots. The output gap is stationary at the first difference for all countries.

It is essential to point out that the hypothesis test of the preceding two-unit root test (ADF and PP) presupposes that the null hypothesis (ho) is unit root against the alternative ($h1$) that is stationary. This implies that if the p-value is greater than the critical value (10%, 5%, or 1%), the null hypothesis cannot be rejected, and the presence of the unit root is confirmed. Still, the null hypothesis is rejected if the p-value is lower than the critical value.

The third test (KPSS) contains a unique set of assumptions. Indeed, its null hypothesis presupposes stationarity compared to the alternative hypothesis, which is a unit root. The significance of the statistics in **Table 5.2** for the KPSS test indicates the presence of unit root in contrast to the ADF ad PP tests.

Table 5.2. Unit Root

			BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Food prices	**CONSTANT**									
	ADF	Level	-1.787	-1.234	-0.791	-0.233	-1.262	-1.723	0.152	-1.158
		1st diff.	-11.406	-13.311	-4.110	-8.846	-3.332	-3.282	-3.227	-2.980
	PP	Level	-1.566	-1.488	-0.431	-0.650	-1.629	-1.987	-0.306	-1.258
		1st diff.	-20.151	-13.311	-14.310	-13.984	-10.411	-10.730	-9.945	-13.708
	KPSS		1.724	1.668	1.819	1.852	1.663	1.666	1.870	1.652
Exchange rate										
	ADF	Level	-2.107	-2.107	-2.107	-2.107	-2.107	-2.107	-2.107	-2.107
		1st diff.	-10.551	-10.551	-10.551	-10.551	-10.551	-10.551	-10.551	-10.551
	PP	Level	-1.835	-1.835	-1.835	-1.835	-1.835	-1.835	-1.835	-1.835
		1st diff.	-10.452	-10.452	-10.452	-10.452	-10.452	-10.452	-10.452	-10.452
	KPSS		1.164	1.164	1.164	1.164	1.164	1.164	1.164	1.164

Table 5.2. (cont.)

			BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Oil prices	**CONSTANT**									
	ADF	Level	-3.468	-3.468	-3.468	-3.468	-3.468	-3.468	-3.468	-3.468
		1st diff.	-9.256	-9.657	-9.256	-9.256	-9.256	-9.256	-9.256	-9.256
	PP	Level	-2.858	-2.858	-2.858	-2.858	-2.858	-2.858	-2.858	-2.858
		1st diff.	-9.657	-9.657	-9.657	-9.657	-9.657	-9.657	-9.657	-9.657
	KPSS		0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202
Money supply										
	ADF	Level	-3.069	-0.908	-1.753	-1.656	-0.271	-1.889	-0.378	-3.205
		1st diff.	-3.135	-8.576	-3.125	-3.502	-3.857	-3.505	-3.954	-3.502
	PP	Level	-3.061	0.362	-0.721	-1.615	-0.340	-0.984	0.095	-1.820
		1st diff.	-7.729	-8.576	-10.761	-10.658	-11.195	-10.963	-10.739	-11.519
	KPSS		1.611	1.941	1.821	1.852	1.408	1.647	1.965	1.434

Table 5.2. (cont.)

			BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Output gap	**CONSTANT**									
	ADF	Level	-3.370	-3.535	-3.241	-2.632	-3.505	-2.578	-5.209	-4.455
		1st diff.	-4.302	-11.259	-5.106	-5.259	-5.891	-4.328	-4.894	-5.526
	PP	Level	-2.634	-3.064	-2.908	-3.403	-3.383	-3.762	-3.083	-3.989
		1st diff.	-10.705	-11.259	-11.547	-12.164	-11.626	-12.274	-10.901	-10.876
	KPSS		0.033	0.030	0.033	0.038	0.032	0.029	0.021	0.022
Food prices	**CONSTANT AND TREND**									
	ADF	Level	-2.333	-3.298	-1.822	-1.823	-2.386	-2.563	-2.517	-2.612
		1st diff.	-11.433	-13.291	-4.107	-8.831	-3.298	-3.327	-3.250	-2.958
	PP	Level	-2.710	-2.759	-2.277	-2.741	-2.749	-2.234	-3.459	-2.711
		1st diff.	-17.478	-13.291	-14.263	-13.955	-10.404	-10.917	-9.922	-13.719
	KPSS		0.420	0.273	0.334	0.264	0.369	0.376	0.228	0.285

Table 5.2. (cont.)

			BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Exchange rate	**CONSTANT AND TREND**									
	ADF	Level	-3.091	-3.091	-3.091	-3.091	-3.091	-3.091	-3.091	-3.091
		1st diff.	-10.530	-10.530	-10.530	-10.530	-10.530	-10.530	-10.530	-10.530
	PP	Level	-2.850	-2.850	-2.850	-2.850	-2.850	-2.850	-2.850	-2.850
		1st diff.	-10.424	-10.424	-10.424	-10.424	-10.424	-10.424	-10.424	-10.424
	KPSS		0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209
Oil price										
	ADF	Level	-3.453	-3.453	-3.453	-3.453	-3.453	-3.453	-3.453	-3.453
		1st diff.	-9.255	-9.255	-9.255	-9.255	-9.255	-9.255	-9.255	-9.255
	PP	Level	-2.837	-2.837	-2.837	-2.837	-2.837	-2.837	-2.837	-2.837
		1st diff.	-9.649	-9.649	-9.649	-9.649	-9.649	-9.649	-9.649	-9.649
	KPSS		0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210

Table 5.2. (cont.)

			BENIN	BURKINA FASO	COTE D'IVOIRE	GUINEA BISSAU	MALI	NIGER	SENEGAL	TOGO
Money supply	**CONSTANT AND TREND**									
	ADF	Level	-2.706	-2.561	-2.300	-1.471	-2.354	-1.658	-2.553	-2.178
		1st diff.	-3.709	-8.742	-3.259	-3.717	-4.049	-3.695	-3.861	-4.145
	PP	Level	-1.941	-4.924	-1.862	-1.366	-2.225	-1.799	-3.056	-1.519
		1st diff.	-6.442	-8.742	-10.741	-10.823	-11.309	-10.940	-10.743	-11.573
	KPSS		0.360	0.132	0.233	0.330	0.255	0.335	0.232	0.408
Output gap										
	ADF	Level	-3.258	-3.522	-3.207	-2.626	-3.499	-2.513	-5.138	-4.318
		1st diff.	-4.290	-11.381	-5.108	-5.257	-5.919	-4.393	-4.935	-5.493
	PP	Level	-2.584	-2.985	-2.884	-3.386	-3.335	-3.724	-2.978	-3.986
		1st diff.	-10.653	-11.381	-11.568	-12.172	-11.692	-12.296	-11.049	-10.849
	KPSS		0.033	0.030	0.033	0.038	0.032	0.029	0.021	0.022

5.3. Nonlinear Autoregressive Distributed Lag

Before we began analyzing the NARDL model, we first provided the descriptive statistics of the data. The statistical description is significant since it describes the type and nature of the data used in the analysis. Second, we performed the unit root test, which is very important since it indicates the order of integration of the study variables. Indeed, this information allows us to avoid violating the NARDL model's conditionality, which restricts the variables' integration level to order 1.

In this section, the NARDL model determines the short-run and the long-run relationship between the exchange rate and food prices in the WAEMU countries. The study uses data on food prices, exchange rates (appreciation and depreciation), international oil prices, money supply, and the output gap. The study's goals are first to identify if there is an asymmetrical relationship between exchange and food prices in the WAEMU economies. In other words, we assess whether depreciations and appreciations of the CFA franc have a different impact on food prices. Second, the study aims to examine whether changes in the exchange rate affect food prices in the long term, and third, determine the pass-through between the exchange rate and food prices. The exchange rate might be complete, incomplete, or zero (no pass-through). The exchange rate pass-through is complete when invoicing is set and is sticky in the exporter's currency. Variations in the exchange rate do not affect the pricing of foods in the exporter's currency—however, prices of goods in the importing country vary enormously with exchange rate changes. In the case of zero pass-through, exporters set prices in the importing country's currency. Thus, changes in the exchange rate do not affect the importing country. In the event of incomplete pass-through, exchange rate fluctuations are partially reflected in the pricing of the importing country.

We estimate the model using all the study's variables in EViews 13. All independent variables, excluding exchange rates (ler), are evaluated as dynamic linear regressors, including the dependent variable $lfpi$. The exchange rate is an asymmetric dynamic regressor, whereas the dummy variables (GFC and COVID-19) are fixed regressors. Following the model assessment, four dependent and independent variables lags are preserved for the investigation.

The model is evaluated using the HAC (heteroskedasticity and autocorrelation consistent) standard errors or the Newey-West standard errors due to heteroskedasticity in the model detected following prior diagnostics test. Regardless of serial correlation or heteroskedasticity, this option assists the model in producing the correct standard errors for the least squares estimator.

The Cumulative sum (CUSUM) and Cumulative sum of squares (CUSUMSQ) tests demonstrate the NARDL model's goodness of fit.

5.4. Cointegration Test

The Bound test reveals a long-term relationship between the independent and dependent variables.

Table 5.3. Bound Test

Countries	F-statistic	T-statistic
Benin	7.028 ***	-6.395 ***
Burkina Faso	5.725 ***	-5.788 ***
Cote d'Ivoire	10.046 ***	-7.234 ***
Guinea Bissau	4.523 **	-4.914 ***
Mali	6.958 ***	-6.227 ***
Niger	6.996 ***	-6.282 ***
Senegal	8.227 ***	-6.819 ***
Togo	4.980 **	-5.378 ***

The symbols *, **, and *** show significance at 10%, 5%, and 1% levels respectively.

Table 5.3. above determined the evidence of a long-run relationship among the variables. The F-statistic and T-statistic suggested by Pesaran et al. (2001) and

Banerjee et al. (1998) are combined in the Bound test. These two tests are independent and enable one to accept or reject the idea of a long-term relationship. Despite their differences, the two tests follow the same approach. The F-test and the T-test test the null hypothesis of no cointegration against the alternative of the presence of cointegration (long-run relationship). According to the Bound test, if the computed F-statistic and T-statistic are more significant than the upper critical values, there is cointegration between the dependent and independent variables.

The F and T statistics show the significance for all eight countries. Indeed, the T statistic is highly significant at 1% for all countries. However, a percentage difference is noted at the level of F-statistic. Guinea Bissau and Togo are the only countries with a long-term relationship with a significance of 5%, while the rest are significant at 1%. The exchange rate impacts the food price in the long run. The long-term relationship findings go hand in hand with the observations of (Kadanalı, 2021; Kai et al., 2017; Layani & Mehrjou, 2023), who also find a long-run relationship between exchange rates and food prices.

5.5. Symmetry Test

One of the study's aims is to test the presence of an asymmetric relationship between the exchange rate and food prices in the WAEMU economies. The empirical literature on the analysis of ERPT to domestic pricing is quite diversified. Furthermore, while most studies have focused on linear price sensitivity to changes in the exchange rate, a sizable number of scholars have chosen to examine this sensitivity by applying an asymmetric approach. According to the theoretical literature, the exchange rate has an asymmetrical relationship with prices since depreciation and appreciation affect prices differently in an economy. Imported food prices become more expensive when the local currency depreciates. However, it encourages product exports by making them more accessible and attractive. This observation is supported by price stickiness. Indeed, a depreciation of the CFA franc will make food imports more expensive for retailers, leading to a rise in food costs in WAEMU nations that rely on food imports. However, because traders purchased food before an eventual appreciation and needed to make profits or at least cover their expenses, an appreciation of the domestic currency would not instantly drive the fall in food prices. As a result, the size of an appreciation impact will differ from that of depreciation. It is the lack of market prices to adjust fast, notwithstanding a fall in import costs. Kai et al. (2017) and Boubakri et al. (2019) have supported the asymmetrical relationship between exchange rate and food price with the results of their empirical studies, which lead to the conclusion that depreciation and appreciation have different impacts on food prices.

The symmetry test **Table 5.4** is used to establish the nature of the relationship (symmetric/asymmetric) between the exchange rate and food prices in the short and long term. The test reveals an asymmetrical relationship between the exchange rate and food price inflation in the short term. In Benin, Burkina Faso, Guinea Bissau, and Togo, this asymmetrical association is significant at 5%. In Cote d'Ivoire, the figure is 10%. As a result, the first hypothesis (H_0^1) testing the symmetrical relationship between the exchange rate and food prices in the short term, was firmly rejected. Indeed, the hypothesis (H_0^1) is rejected at 5% in Benin, Burkina Faso, Guinea Bissau, Niger, and Togo, at 10% in Cote d'Ivoire, Mali, and 1% in Senegal.

In the long term, the hypothesis (H_0^2) was universally rejected at 1% significance in the union's eight nations. These findings lead us to conclude that the exchange rate has a variable impact on food costs in WAEMU countries, depending on whether the CFA franc depreciates or appreciates versus the US dollar in the short and long run. Thus, the asymmetric relationship between exchange rate and food prices is confirmed.

In summary, an appreciation of the CFA franc significantly differs from a depreciation of the food price in the WAEMU countries. This supports the work of Delatte & López-Villavicencio (2012), who finds that prices react differently following appreciations and depreciations of exchange rates.

Table 5.4. Symmetry Test

Country	Short term	Long term
Benin	3.925 **	28.701 ***
Burkina Faso	3.866 **	13.038 ***
Cote d'Ivoire	1.670 *	12.636 ***
Guinea Bissau	6.349 **	8.022 ***
Mali	1.951 *	18.894 ***
Niger	4.677 **	18.708 ***
Senegal	6.781 ***	13.140 ***
Togo	4.220 **	7.704 ***

The symbols *, **, and *** show significance at 10%, 5%, and 1% levels respectively.

5.6. Asymmetric Exchange Rate Pass-Through on Food Prices

After testing the NARDL model for all eight nations in the monetary zone, the findings have been combined in the table below for a better approach and comprehension.

Table 5.5. Asymmetric Exchange Rate Pass-Through

	Asymmetry Exchange rate pass-through						
		Long-run		Short run			
		Depr. (+)	Appr. (-)	Depr. (+)	Appr. (-)	F-statistic	Prob.
Country	Adj. speed						
Benin	-0.502 ***	0.581 ***	-0.462 ***	0.483 ***	-0.231	2.906	0.000
Burkina Faso	-0.259 ***	0.973 ***	0.173	0.417 ***	0.004	3.339	0.000
Cote d'Ivoire	-0.407 ***	0.335 ***	-0.222 **	0.125	-0.107	3.665	0.000
Guinea Bissau	-0.237 ***	0.241 **	0.103	0.192 *	-0.123	2.414	0.000
Mali	-0.287 ***	0.617 ***	-0.170	0.205 *	0.066	4.615	0.000
Niger	-0.267 ***	0.615 ***	-0.268 *	0.407 ***	-0.031	4.231	0.000
Senegal	-0.341 ***	0.222 **	-0.019	-0.076	-0.105	4.971	0.000
Togo	-0.269 ***	0.594 ***	-0.215	0.299 *	-0.165	2.195	0.001

The symbols *, **, and *** show significance at 10%, 5%, and 1% levels respectively.

The results reveal the significance of the coefficients in the short and long run. The NARDL results in **Table 5.5** show that the exchange rate has a long-term influence on food prices. Following the asymmetrical relationship, we discover that depreciations and appreciations influence food prices differentially in the long term. This finding supports the conclusion of Delatte & López-Villavicencio (2012), who argue that prices react differently following exchange rate depreciations and appreciations. The NARDL estimates show that depreciation positively affects food prices in WAEMU countries. Thus, a 1% positive change in CFA franc (depreciation) raises food costs in Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo by 0.581%, 0.973%, 0.335%, 0.241%, 0.617%, 0.615%, 0.222%, and 0.594%, respectively.

A positive relationship between the CFA franc depreciation and local food prices is expected because a devaluation of the CFA franc makes food imports more costly, increasing costs. It reduces the quantity of goods imported in overall consumption by raising import prices compared to domestic prices. Furthermore, across the research period, food prices react more strongly and significantly to CFA franc depreciation than appreciations.

WAEMU countries rely on imports, particularly on food supplies. Imports of the WAEMU zone have increased significantly compared to exports, resulting in trade balance deficits in most nations. Food imports have progressively climbed as a proportion of overall imports. Exports need help growing. Burkina has a high coefficient when compared to the others, followed by Mali, Niger, Togo, Benin, Cote d'Ivoire, Guinea-Bissau, and Senegal. On the one hand, this is explained by the geographical location of these countries. Indeed, Burkina Faso, Mali, and Niger are the three Sahelian countries of the union, these three nations are undergoing desert encroachment, and rainfall is inconsistent and frequently insufficient. Only these three nations, out of the union's eight, do not have access to the sea. These nations' agricultural production is predominantly rainfed and subject to climate risks that cause significant geographical and temporal variability. Irrigation production occurs on a modest scale and with limited development. They have difficulty carrying out practical agricultural activities, and the harvests are modest. With an expanding population, the countries are turning on food imports to fill the deficit. Even during abundant agricultural seasons, the lack of infrastructure for agrarian product storage and transportation to areas with low harvests results in food waste, particularly fresh items (tomatoes, onions, meats).

On the other side, insecurity in certain countries is causing internal displacement, with people abandoning farms and cattle. Terrorism began to develop in Mali in 2012, Burkina Faso in 2015, and Niger in 2017. Poverty has grown in these three member countries since then.

The CFA franc's appreciation negatively affects food prices in the long run in Benin, Cote d'Ivoire, and Niger. An appreciation leads to a fall in the price of imported goods and increased quantities of imported goods. However, the magnitude of this influence for Niger is relatively modest, at 10%. As previously stated, the country is experiencing production and security challenges, as well as a growing population, which increases demand for essential goods; thus, despite a drop in import prices and given that demand exceeds food supply, prices hardly fall.

Except for Côte d'Ivoire and Senegal, a currency devaluation positively impacts food prices in the short term. Actuality, Cote d'Ivoire, and Senegal are the WAEMU countries that stand out from the rest by their growth and degree of industrialization. These two countries have established food processing companies, food conservation techniques, and, most critically, substantial infrastructural development—the processing and storage of food help to alleviate the short-term pressures caused by exchange rate fluctuations. Stock destocking provides food on the market for a limited period.

The hypotheses (H_0^5) and (H_0^6) evaluating the absence of pass-through in both the short and long-run are rejected in **Table 5.5** As a result, there undoubtedly exists a pass-through between exchange rate movements and food prices. Therefore, we have concluded that there exists an incomplete pass-through between exchange rate changes and food prices in WAEMU nations. Indeed, hypotheses (H_0^3) and (H_0^4) assessing the presence of complete pass through in the short and long term, respectively, were rejected, to the prejudice of hypotheses (H_1^3) and (H_1^4) indicating the presence of incomplete pass-through among WAEMU nations. This is explained by the fact that changes in the currency rate impact food prices. Indeed, the degree of pass-through ranges from 0 to 1. The primary invoicing currency is the US dollar, influencing inflation in WAEMU members and exporters. The US dollar is felt in WAEMU countries and among its trade partners. It should also be emphasized that France and other eurozone countries are the WAEMU's major trading partners, and because the XOF currency has a fixed parity with the euro, these economies feel changes in the dollar partially.

5.7. Residual Diagnostics

The CUSUM and CUSUM square tests of each of the eight countries are presented below:

i. Benin

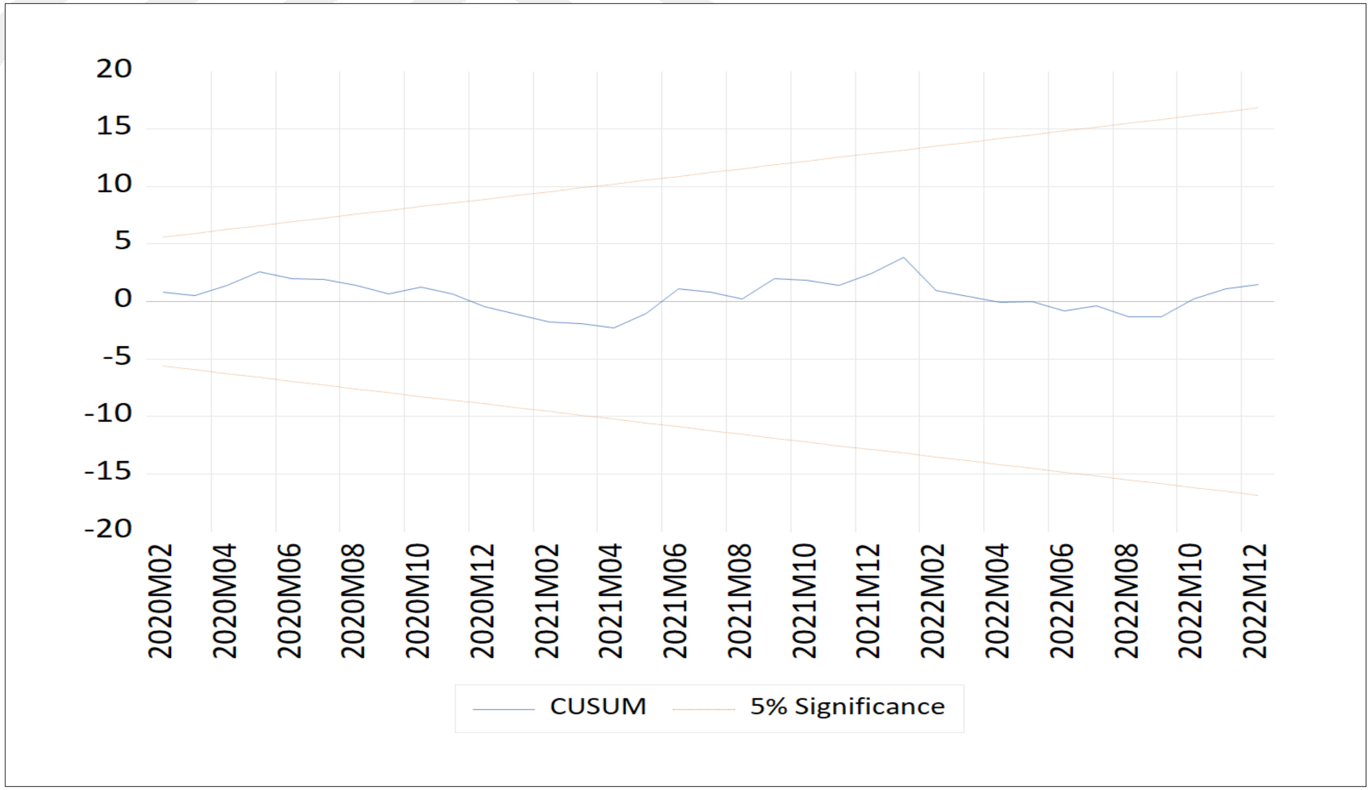


Figure 5.2. NARDL Residual Diagnostics Benin

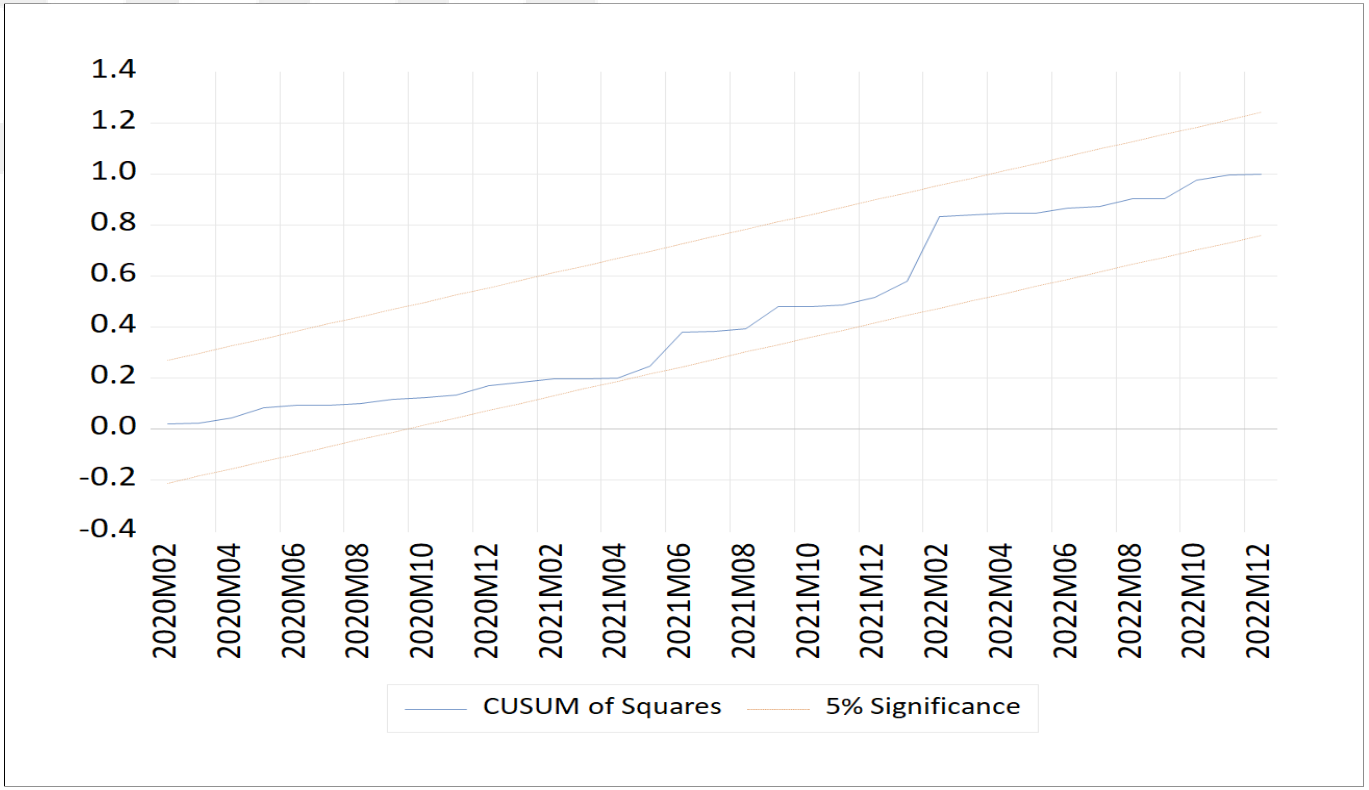


Figure 5.2. (cont.)

ii. Burkina Faso

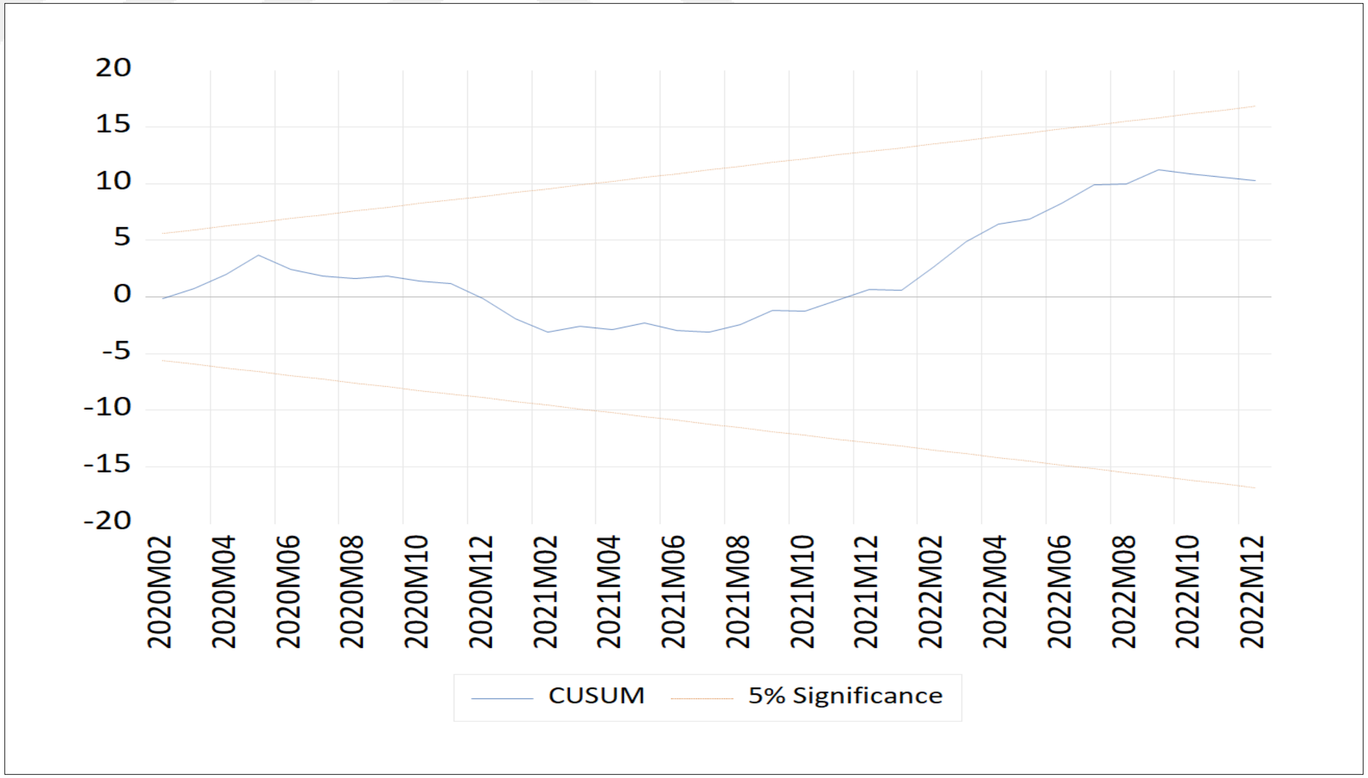


Figure 5.3. NARDL Residual Diagnostics Burkina Faso

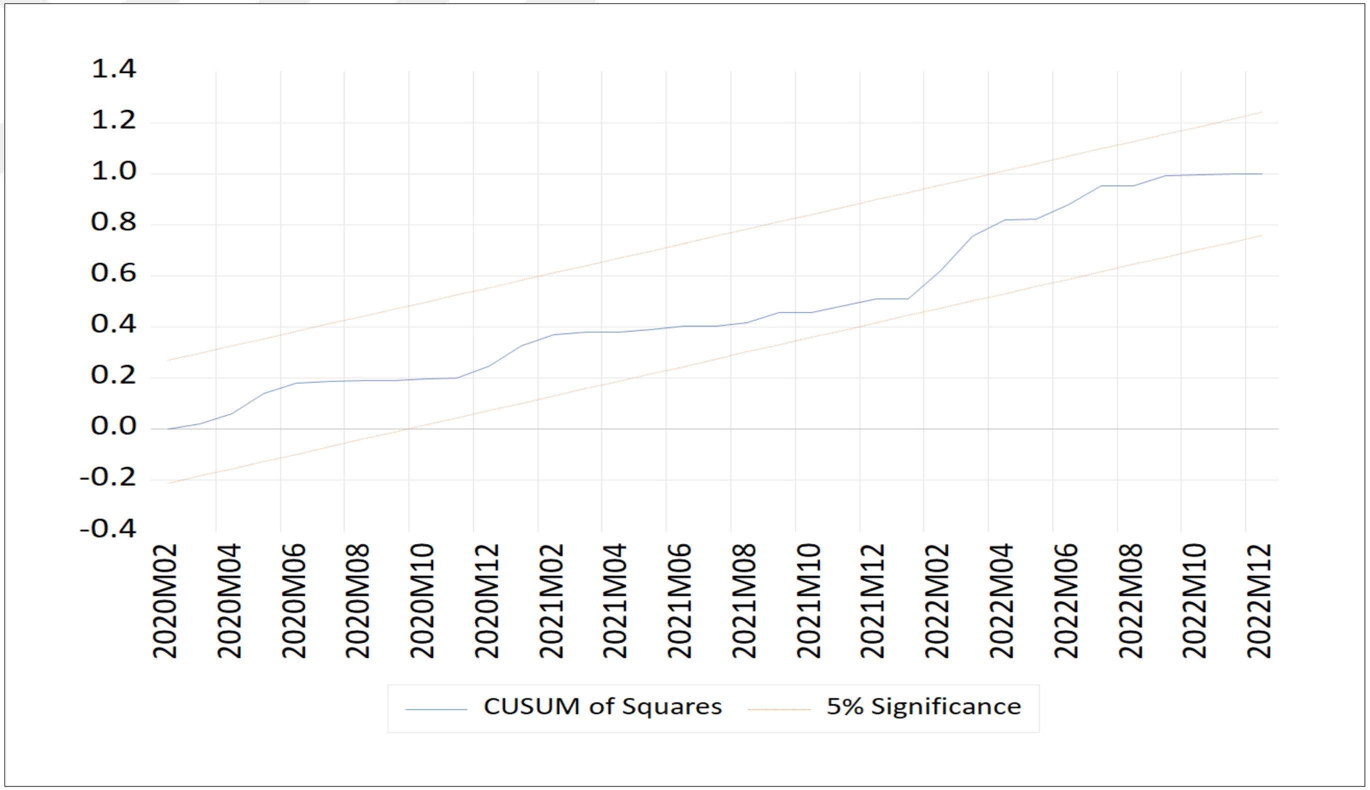


Figure 5.3. (cont.)

iii. Cote d’Ivoire

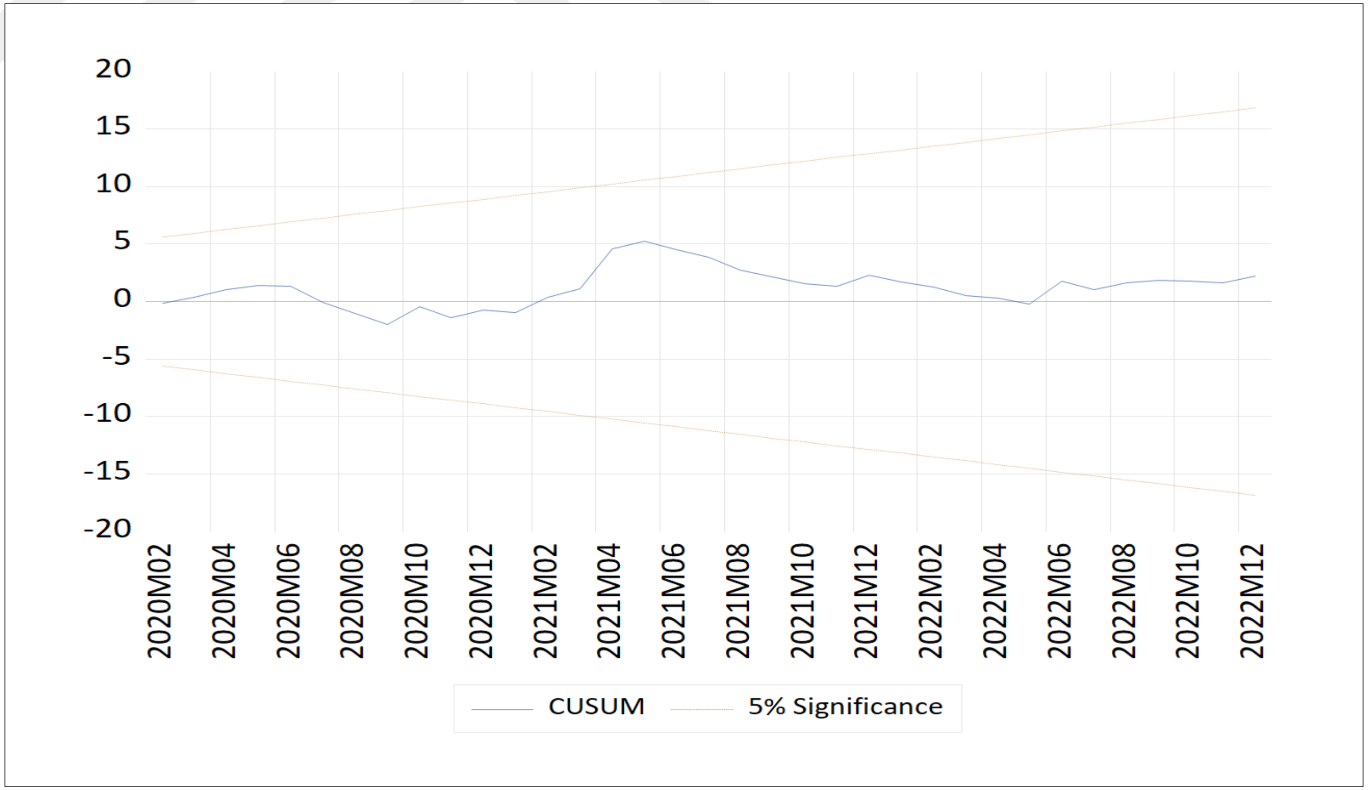


Figure 5.4. NARDL Residual Diagnostics Cote d’Ivoire

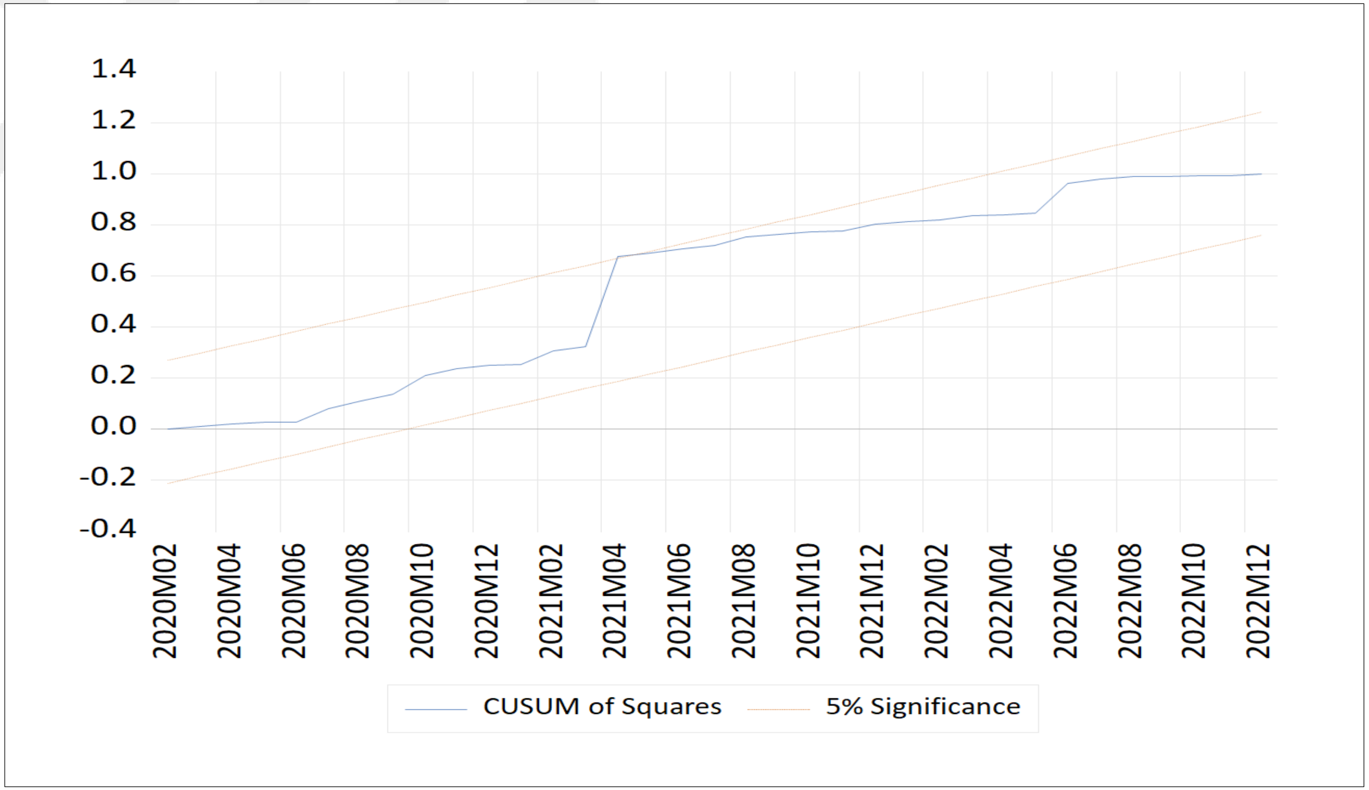


Figure 5.4. (cont.)

iv. Guinea Bissau

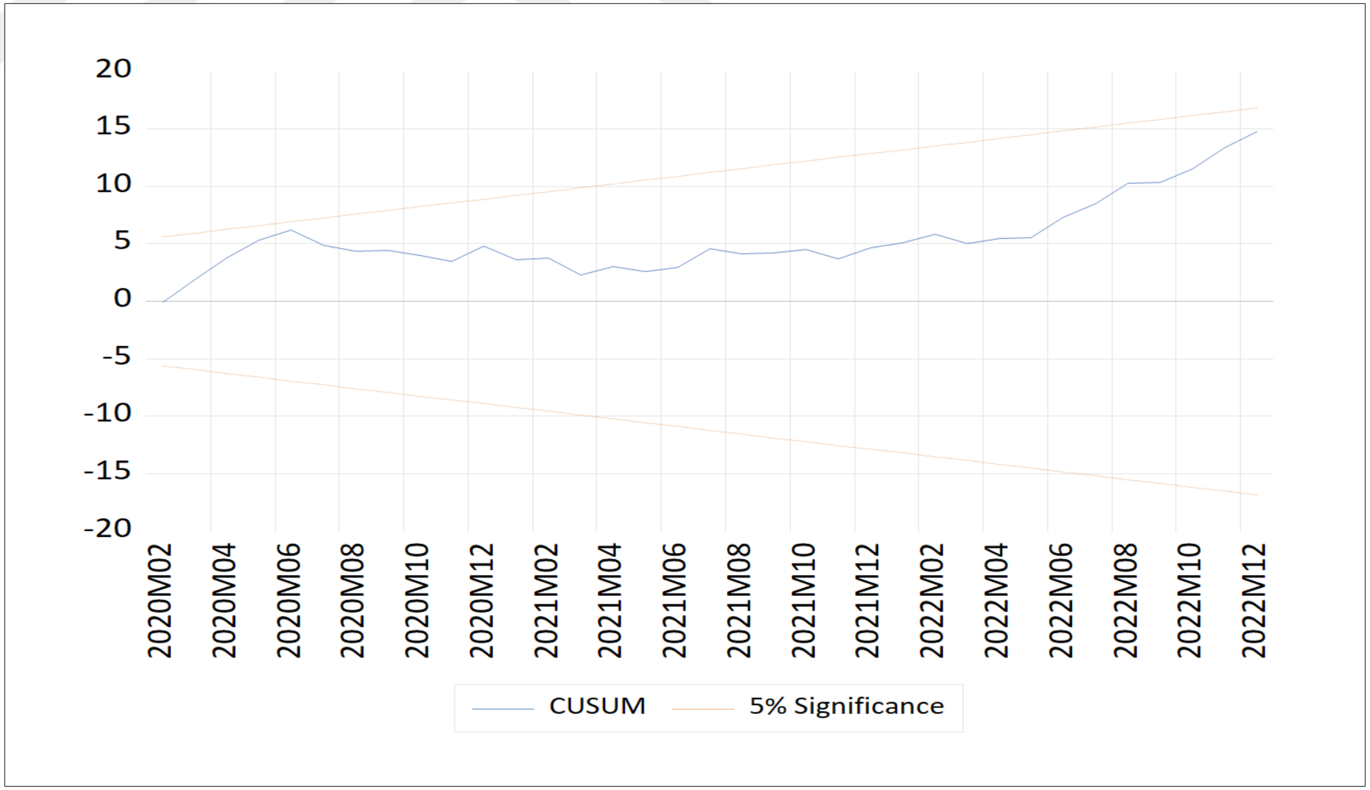


Figure 5.5. NARDL Residual Diagnostics Guinea Bissau

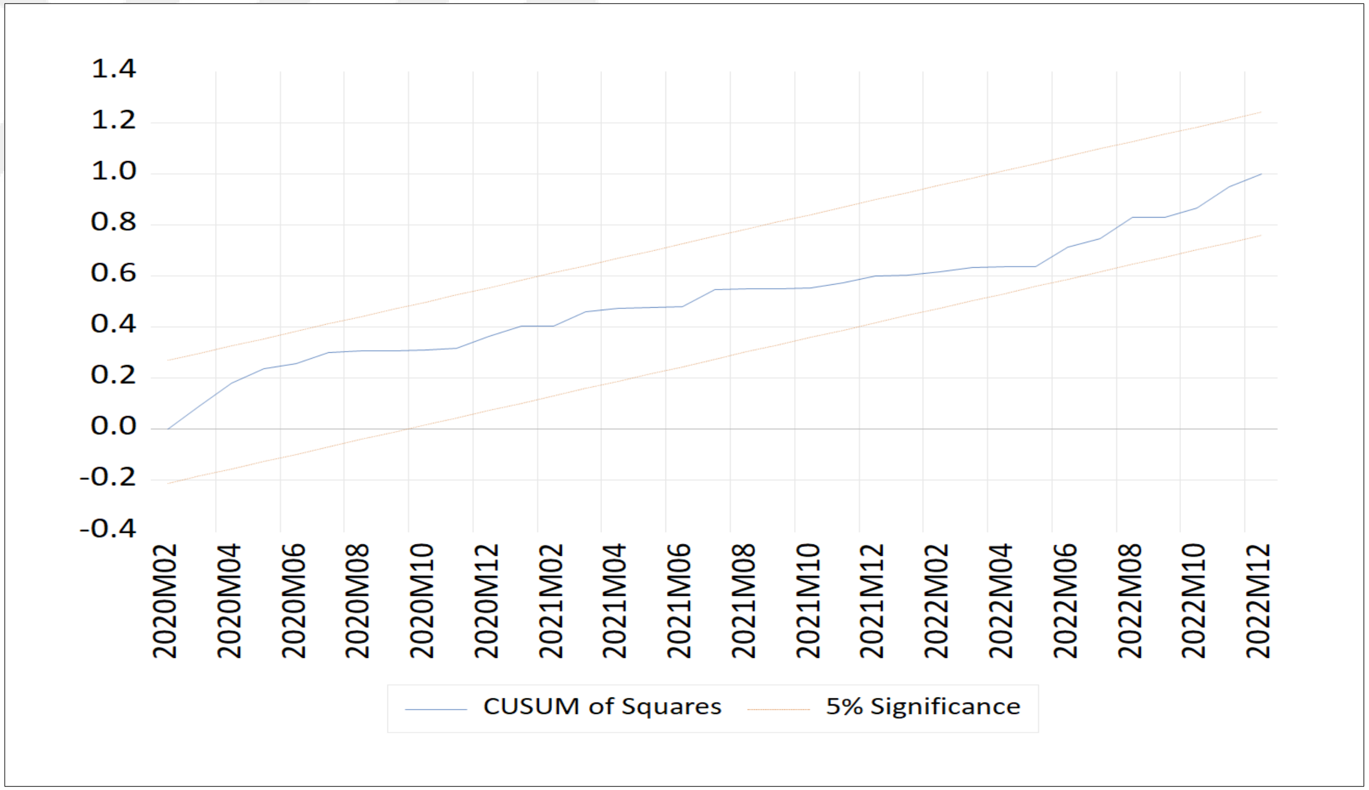


Figure 5.5. (cont.)

v. **Mali**

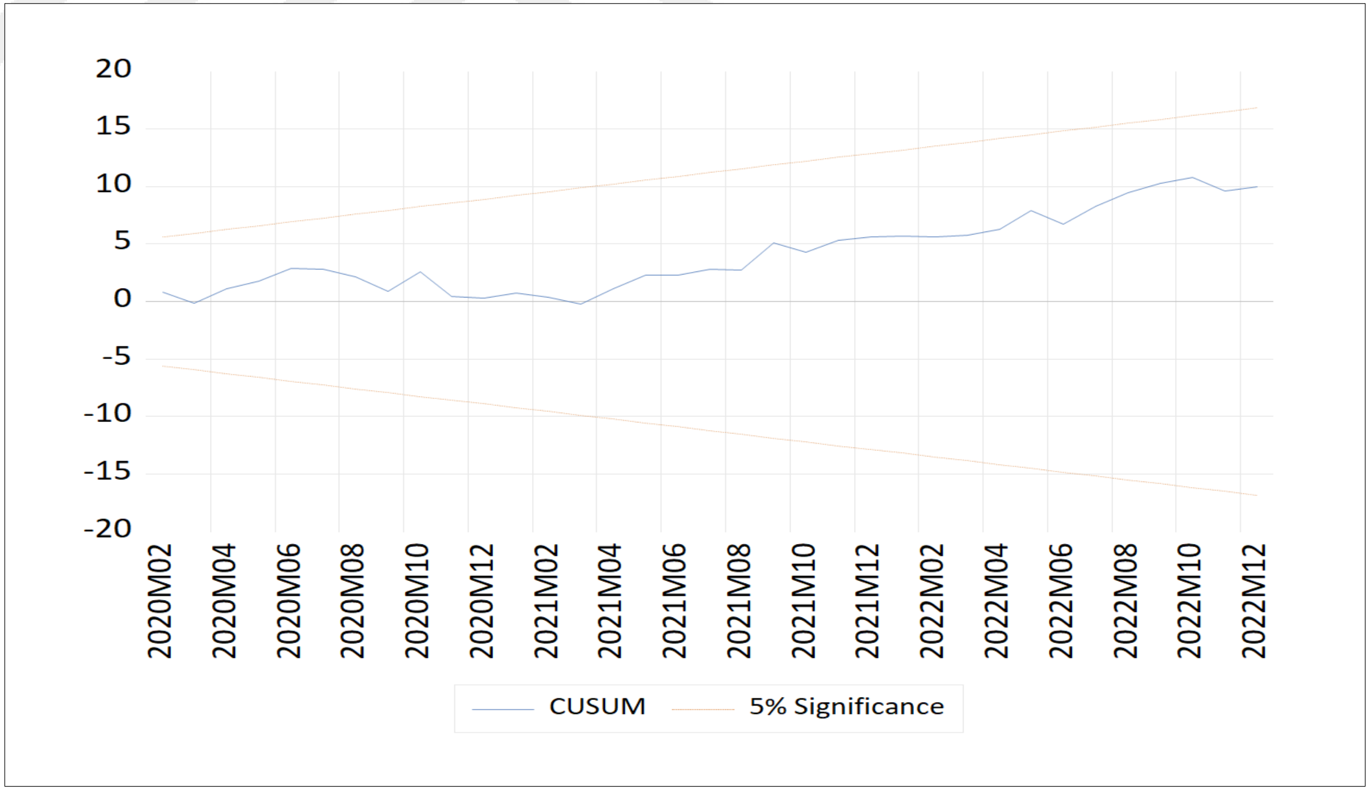


Figure 5.6. NARDL Residual Diagnostics Mali

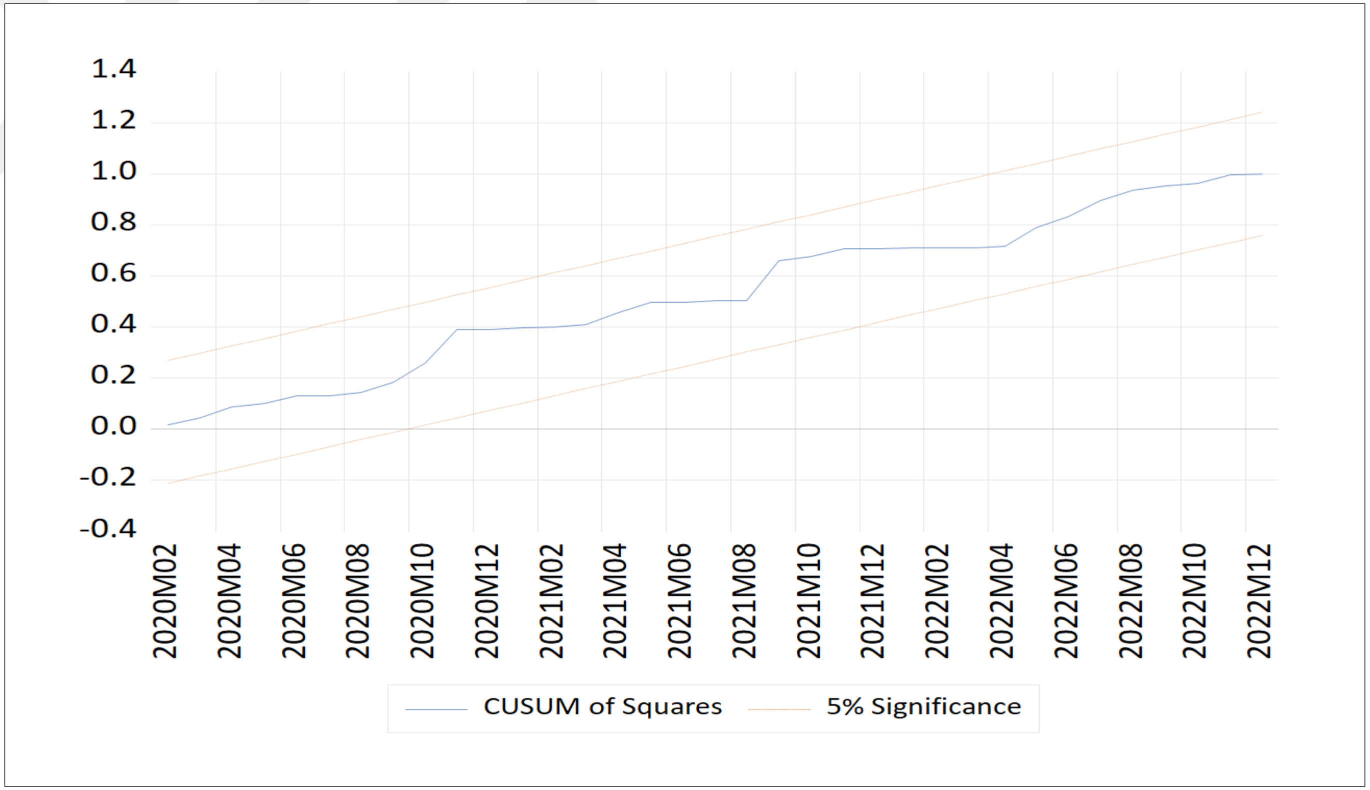


Figure 5.6. (cont.)

vi. Niger

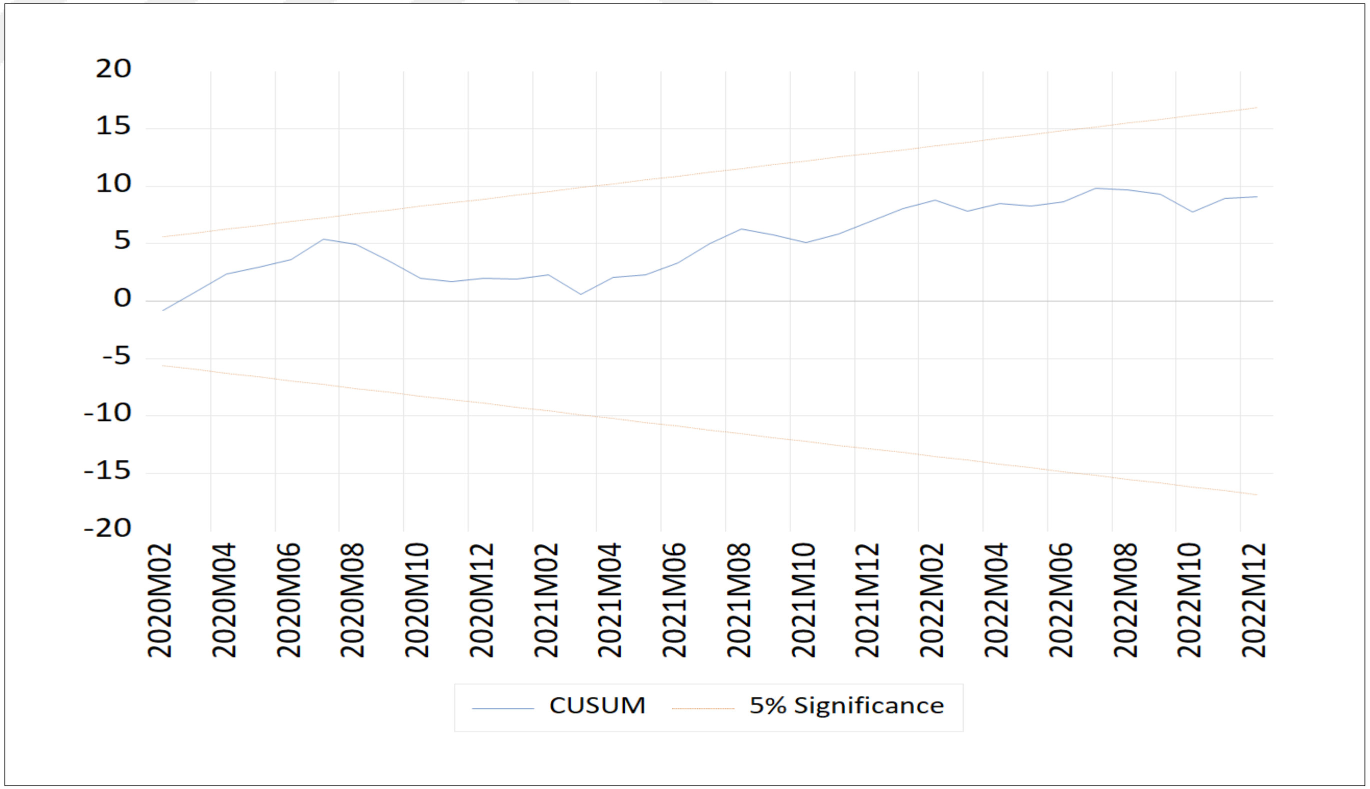


Figure 5.7. NARDL Residual Diagnostics Niger

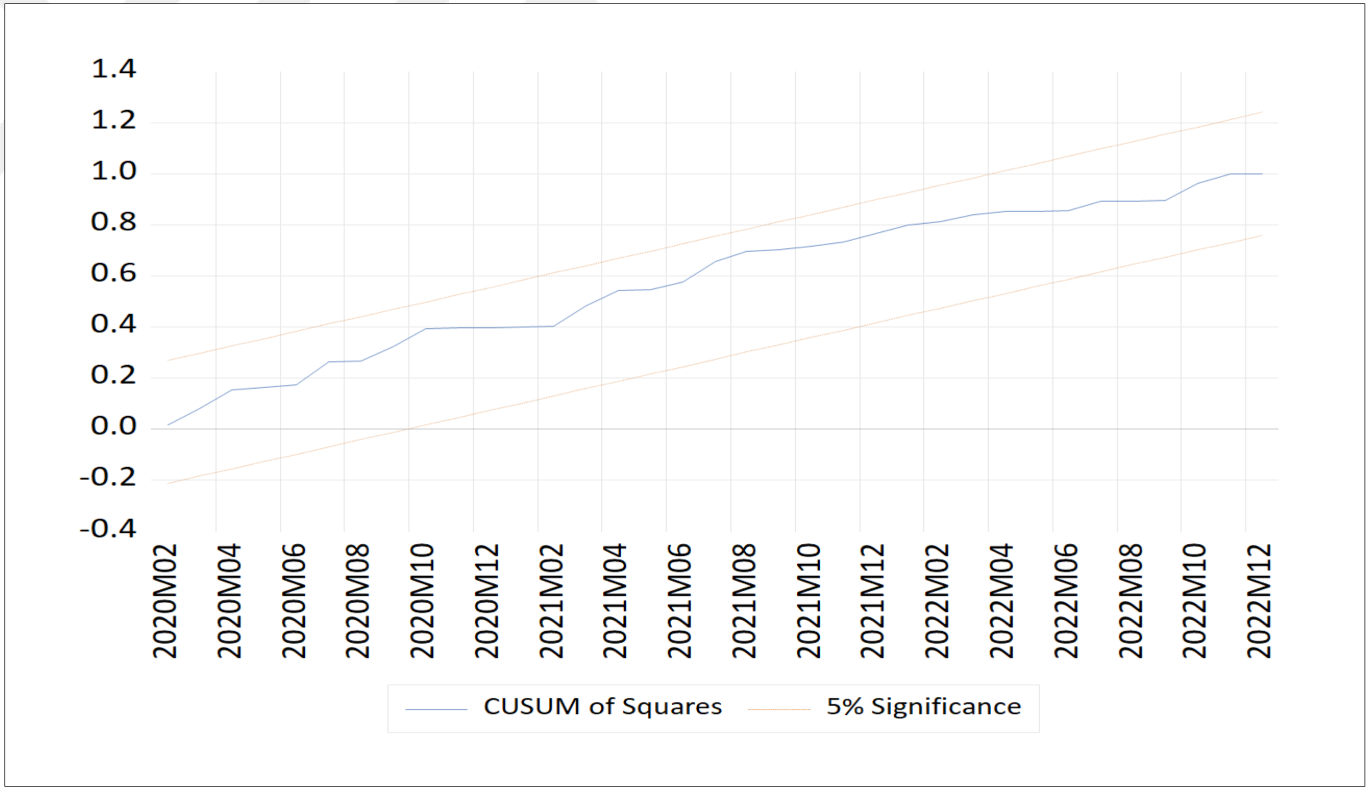


Figure 5.7. (cont.)

vii. Senegal

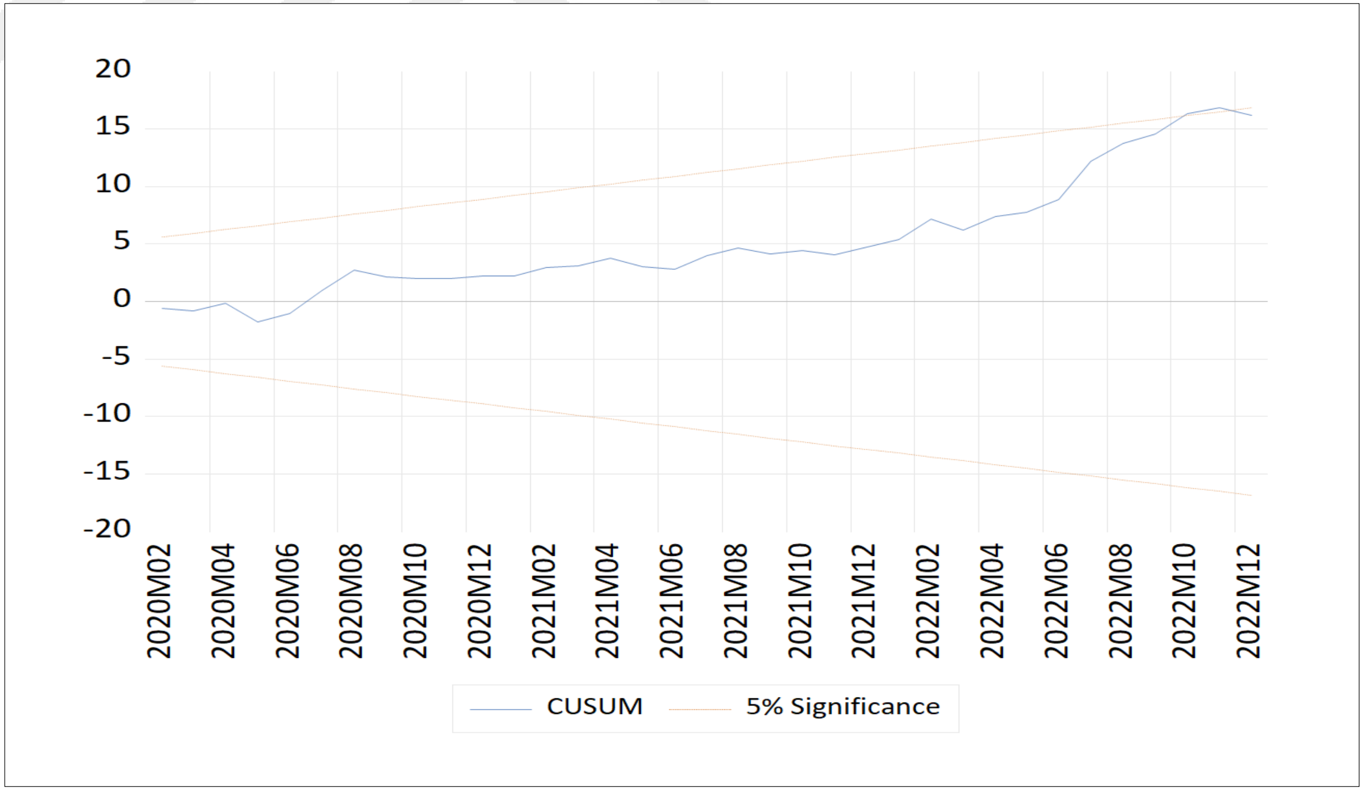


Figure 5.8. NARDL Residual Diagnostics Senegal

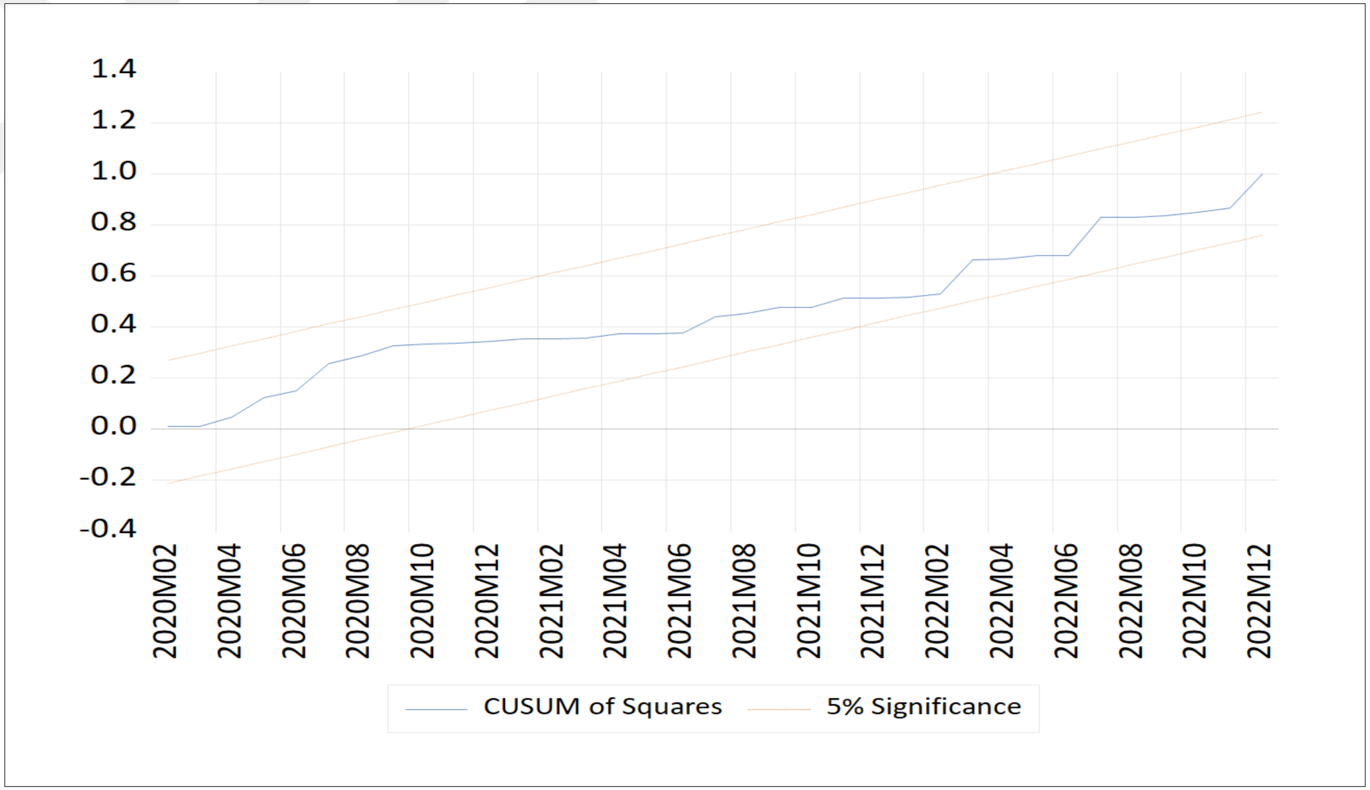


Figure 5.8. (cont.)

viii. Togo

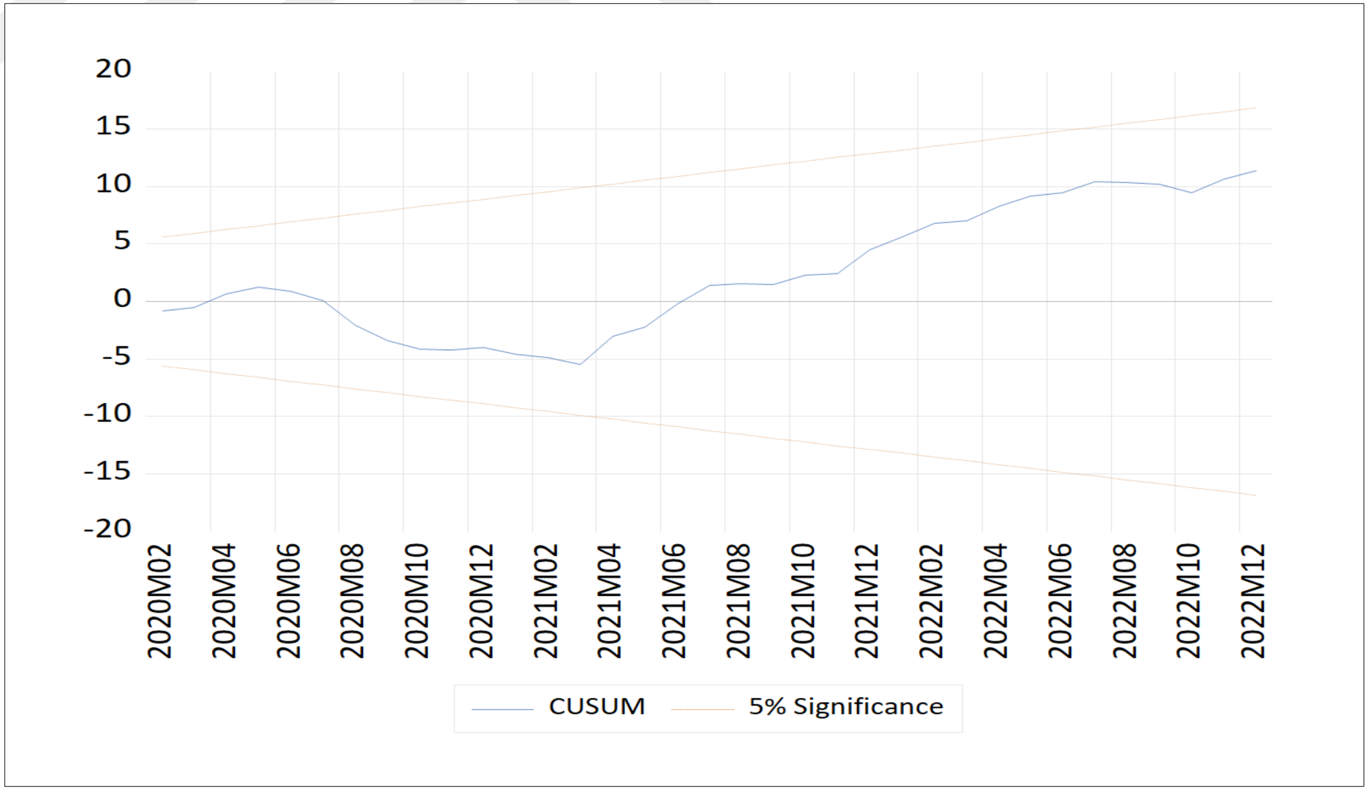


Figure 5.9. NARDL Residual Diagnostics Togo

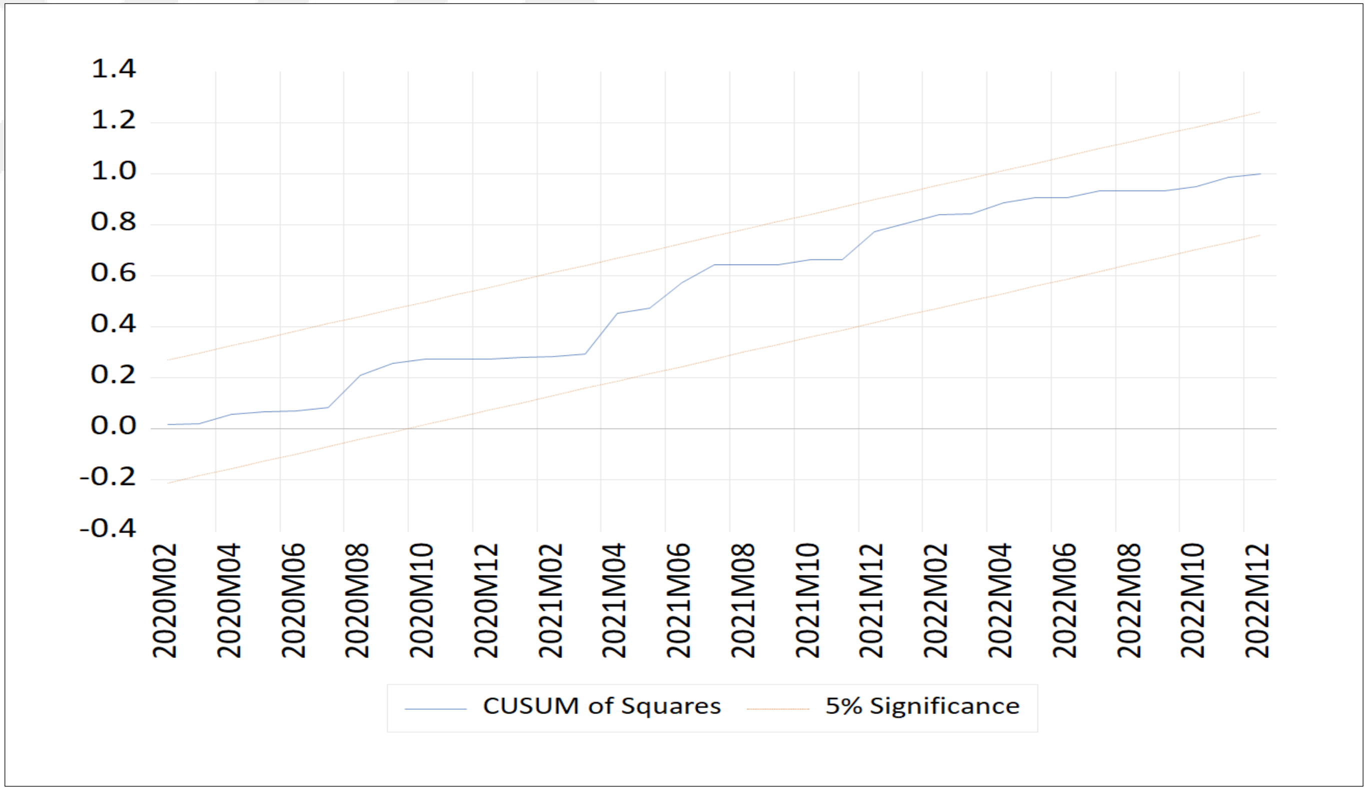


Figure 5.9. (cont.)

CHAPTER VI

CONCLUSION AND POLICY RECOMMENDATIONS

Food insecurity and the rising poverty in the WAEMU countries prompted us to conduct this study. The WAEMU members, like many other African and worldwide countries, have faced food crises characterized by an increase in the cost of cereals. Among the crises, the 2007-2008 food crisis coincided with the global financial crisis and paralyzed the global economy, severely affecting developing economies. Yet again, the world is a victim of a food crisis even more significant than in 2007-2008. The advent of COVID-19 and the war opposing Ukraine to Russia generated serious repercussions for developing economies.

The study objective is to determine the existing relationship between the exchange rate and food prices in the CFA zone. To do so, we have adopted an innovative approach that enables us to assess the asymmetrical relationship between exchange rate movements and food prices. In other words, we have decided to investigate the relationship between the depreciation (appreciation) of the common currency with that of food prices. We have also pushed the research to determine if there is a long-term relationship between the changes in the exchange rate and food costs and the type of pass-through between the two variables. Given the study's coverage span, we have included two variable dummies to represent the shocks of the GFC and COVID-19 extended to the current conflict. Indeed, the analysis is based on monthly data from January 2004 to December 2022.

The NARDL model was chosen as the most suitable model for the investigation. The choice was made on this model for several reasons. Firstly, it is a modified version of the linear ARDL proposed by Shin et al. (2011), which allows us to capture the asymmetry of the exchange rate (appreciations and depreciations). Second, the NARDL model is a model that employs a mixture of variables integrated at different orders without exceeding integration at the first difference. Third, it captures the relationship between the variables in the short and long term, which is the goal of our study. Five variables were considered to carry out the research: food prices, nominal exchange rate, international oil price, money supply, and output gap.

The approach has been implemented in each of WAEMU's eight member countries. The NARDL results reveal an asymmetrical relationship between the exchange rate and food prices. Appreciations and depreciations affect food prices differently in all WAEMU countries. In the short term, an appreciation of the exchange rate has no substantial effect on food costs in the CFA area; however, a depreciation of the local currency has a positive influence on food prices in six countries: Benin, Burkina Faso, Guinea Bissau, Mali, Niger, and Togo. As for Cote d'Ivoire and Senegal, no significance has been recorded in the short term. The Bound test also shows a long-term relationship between the two variables. In the long run, a depreciation of the CFA franc has a positive impact and different magnitude in all CFA zone nations. Food prices rise by 0.581% in Benin, 0.973% in Burkina Faso, 0.335% in Cote d'Ivoire, 0.241% in Guinea-Bissau, 0.617% in Mali, 0.615 in Niger, 0.222% in Senegal, and 0.594% in Togo when the CFA franc depreciates by 1%. However, an appreciation of the XOF has a negative impact only in Benin, Côte d'Ivoire, and Niger. A 1% increase in the local currency leads to a 0.462% decline in long-term food costs in Benin, 0.222% in Côte d'Ivoire, and 0.268% in Niger.

In sum, changes in the exchange rate have a varied influence on the price of food when the local currency appreciates or depreciates. Almost all WAEMU member countries endure the short and long-run effects. However, the CFA franc's depreciation impact is more significant than its appreciation. Even if changes in the currency rate contribute to inflation in the economies of the eight nations, the effect is partial because WAEMU members and their trade partners share it. Furthermore, the dollar represents the invoicing currency. Thus, exporters and importers who use currencies other than the dollar share the shock of its changes. This research implies that food imports constitute a channel that contributes to increasing inflation within the countries of the WAEMU. To reduce inflation through the channel of imports impacting the price of products on the local WAEMU market, the promotion and better development of the community's common market to facilitate trade, adopt transparency of exchanges, and opt for genuine free movement of goods and services can be recommended. Adopt monetary policies that enable the financing of food processing and storage firms. Improving irrigation and expanding WAEMU's areas will allow for improved product distribution coverage.

In future studies, the magnitude of the exchange rate fluctuation might be addressed to determine whether the pass-through into food prices depends on the size of an appreciation or depreciation.

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APPENDIXES

APPENDIX A

Table A.1. ARDL Bound Test

Countries	F-statistic	T-statistic
Benin	2.451	-3.205
Burkina Faso	3.242	-3.933
Cote d'Ivoire	5.992	-4.759
Guinea Bissau	4.424	-4.470
Mali	3.101	-3.614
Niger	3.534	-3.940
Senegal	7.279	-5.835
Togo	3.790	-4.268

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
			F-Statistic			
Asymptotic	3.03	4.06	3.47	4.57	4.4	5.72
			t-Statistic			
Asymptotic	-3.13	-4.04	-3.41	-4.36	-3.96	-4.96

* I(0) and I(1) are respectively the stationary and non-stationary bounds.

Table A.2. Error Correction Coefficients

Country	Variable	Coefficient	Std. Error	t-Statistic	Prob.
Benin	**LER(-1)**	**-0.36971**	**0.380761**	**-0.97097**	**0.332629**
	LOIL(-1)	0.024751	0.065585	0.377385	0.706252
	LM2(-1)	0.290342	0.164116	1.769121	0.078259
	GAP(-1)	-0.02133	0.013794	-1.54636	0.123456
Burkina Faso	**LER(-1)**	**0.457007**	**0.336244**	**1.359154**	**0.17549**
	LOIL(-1)	0.30483	0.082432	3.69796	0.000275
	LM2(-1)	0.517428	0.35906	1.441062	0.150989
	GAP(-1)	-0.01045	0.011269	-0.92727	0.3548
Cote d'Ivoire	**LER(-1)**	**0.08937**	**0.197079**	**0.453472**	**0.650656**
	LOIL(-1)	0.080093	0.032574	2.458767	0.014714
	LM2(-1)	0.42523	0.113163	3.757689	0.00022
	GAP(-1)	0.008213	0.004364	1.881953	0.061163
Guinea Bissau	**LER(-1)**	**0.157367**	**0.153861**	**1.022789**	**0.307531**
	LOIL(-1)	0.116438	0.028939	4.023532	7.89E-05
	LM2(-1)	0.17053	0.054713	3.116813	0.002072
	GAP(-1)	0.00255	0.00356	0.716234	0.474606
Mali	**LER(-1)**	**0.022631**	**0.349432**	**0.064765**	**0.94842**
	LOIL(-1)	0.10978	0.067568	1.624729	0.105652
	LM2(-1)	-0.30022	0.255919	-1.17309	0.242029
	GAP(-1)	-0.00896	0.011794	-0.75975	0.44822
Niger	**LER(-1)**	**0.028726**	**0.333677**	**0.086089**	**0.931474**
	LOIL(-1)	0.103993	0.061275	1.69717	0.091079
	LM2(-1)	0.395858	0.132397	2.989942	0.003108
	GAP(-1)	0.00758	0.012613	0.60101	0.548452
Senegal	**LER(-1)**	**0.071923**	**0.148501**	**0.484323**	**0.628639**
	LOIL(-1)	0.094305	0.037219	2.53375	0.011981
	LM2(-1)	-0.00864	0.268971	-0.03211	0.974417
	GAP(-1)	-0.00619	0.006311	-0.98074	0.327797
Togo	**LER(-1)**	**0.130863**	**0.298636**	**0.438202**	**0.66167**
	LOIL(-1)	0.028965	0.060957	0.475177	0.635132
	LM2(-1)	0.41553	0.143942	2.88678	0.00428
	GAP(-1)	-0.00051	0.012186	-0.04224	0.966346

Note: * Coefficients derived from the CEC regression.

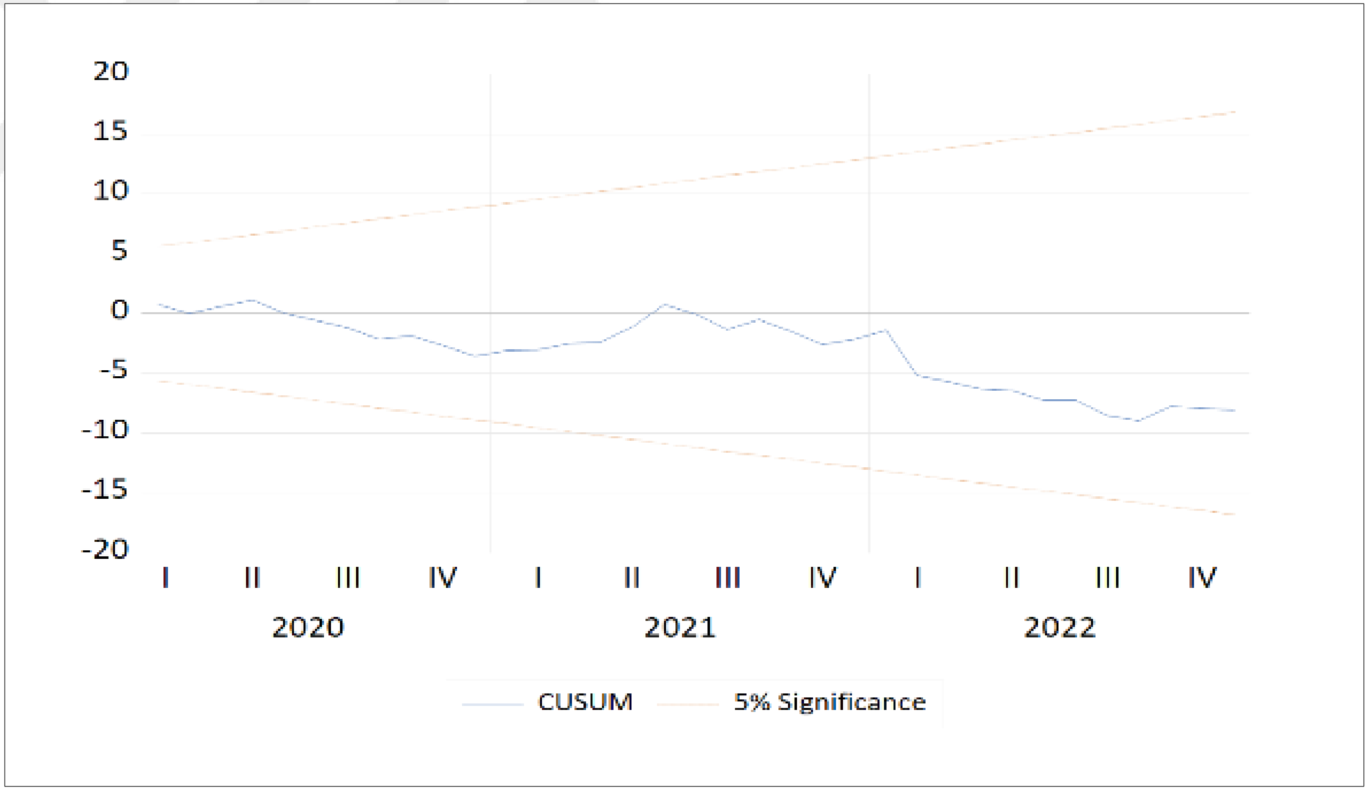


Figure A.1. ARDL Residual Diagnostics Benin

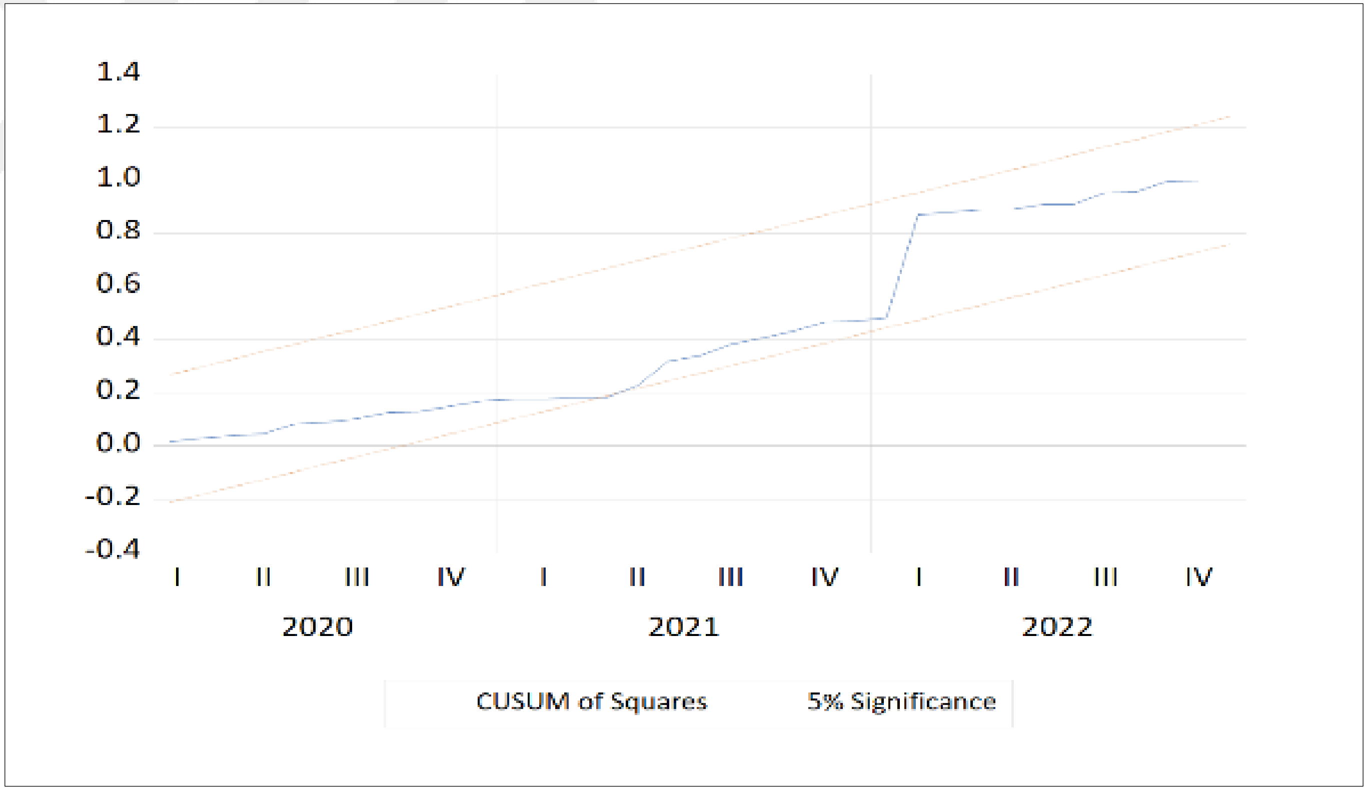


Figure A.1. (cont.)

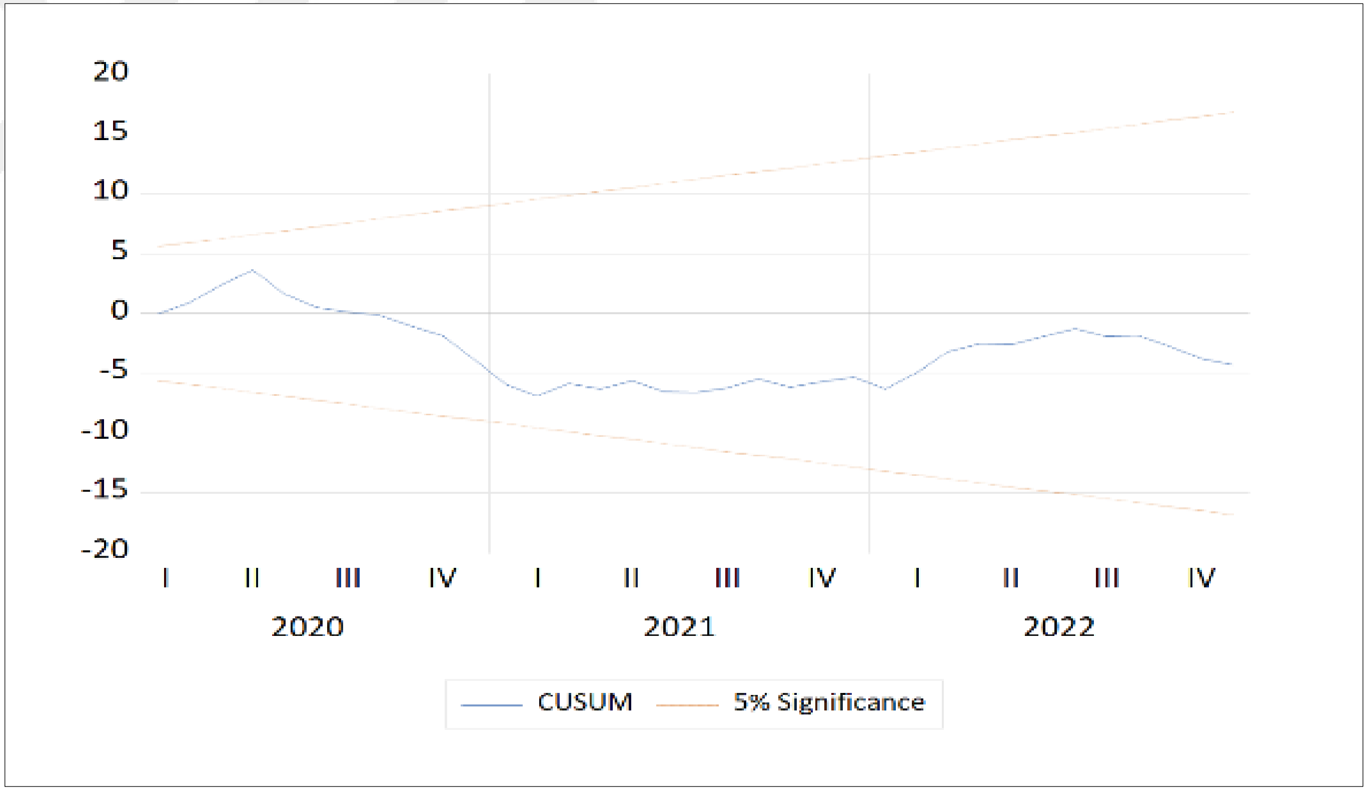
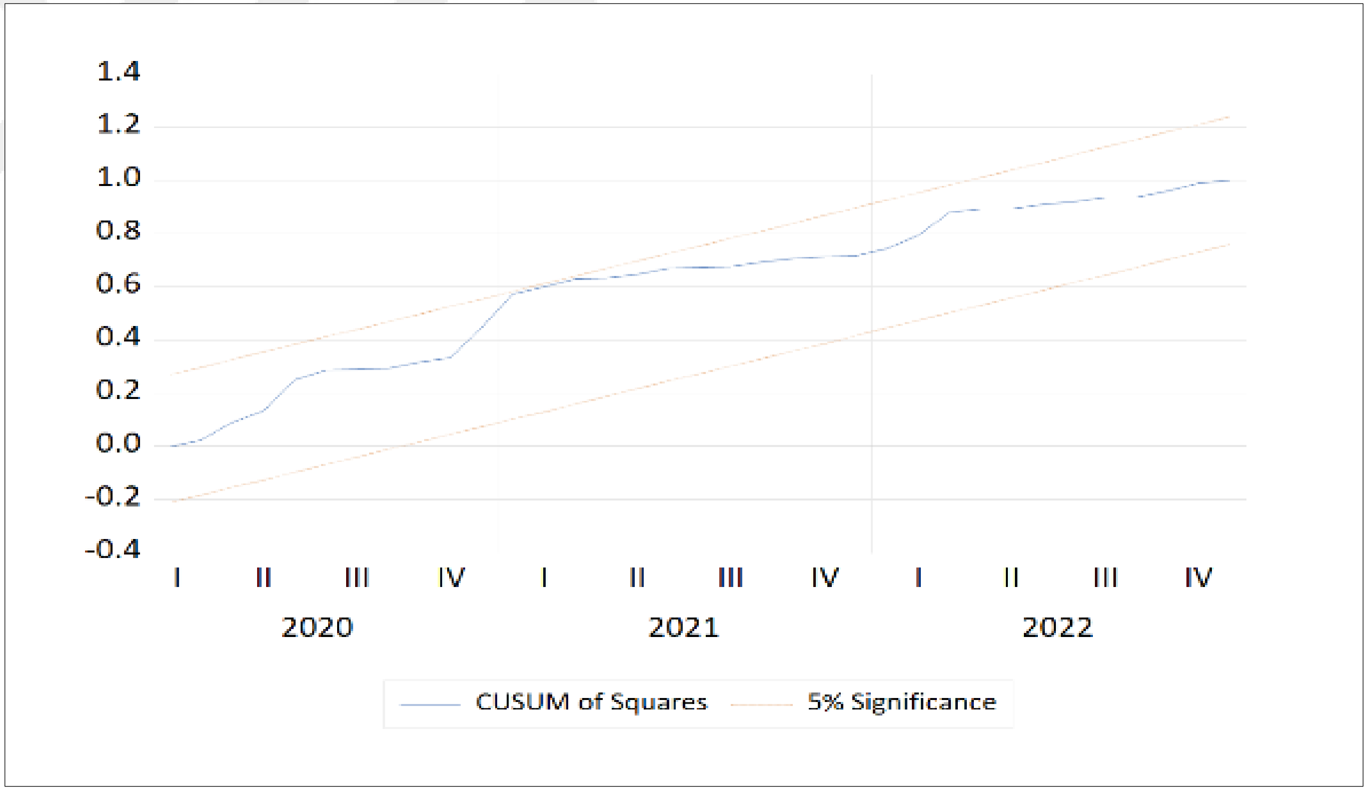


Figure A.2. ARDL Residual Diagnostics Burkina Faso



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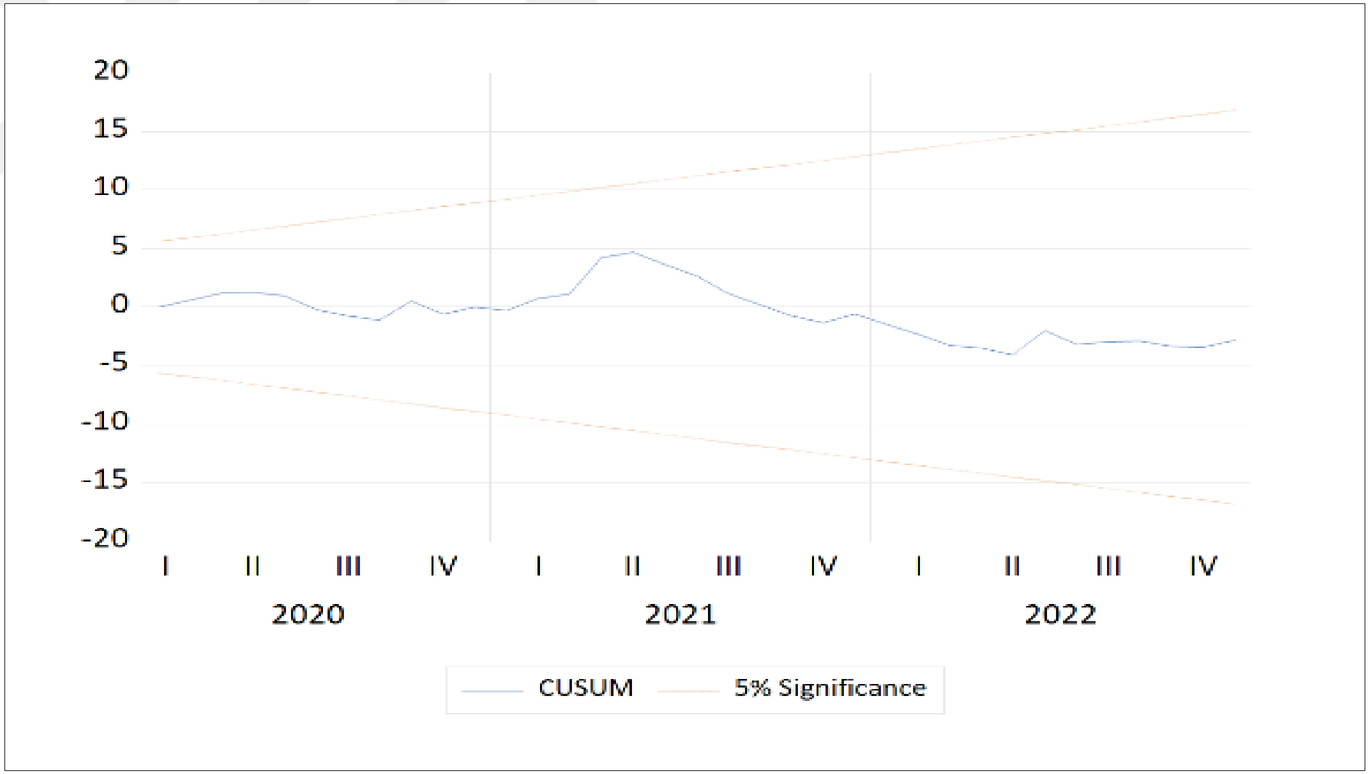
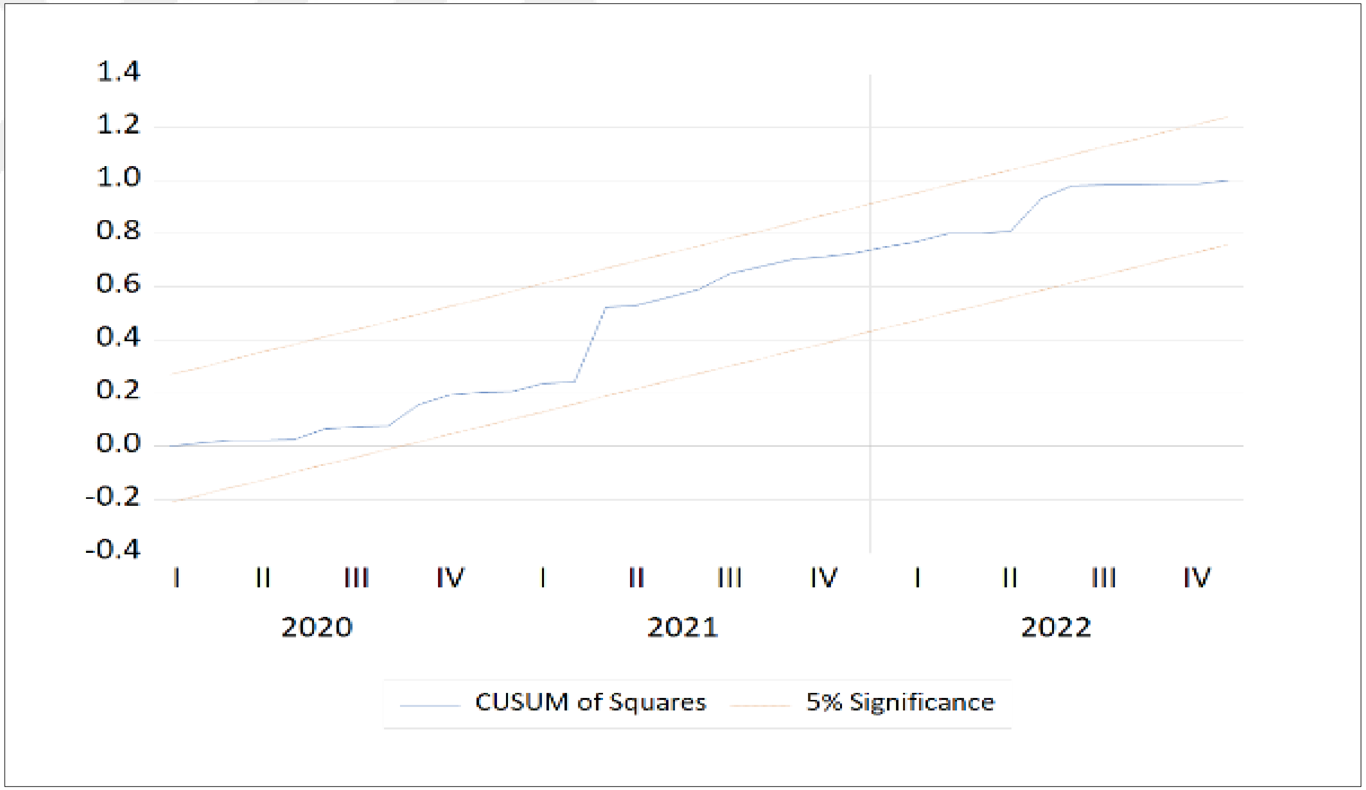


Figure A.3. ARDL Residual Diagnostics Cote d'Ivoire



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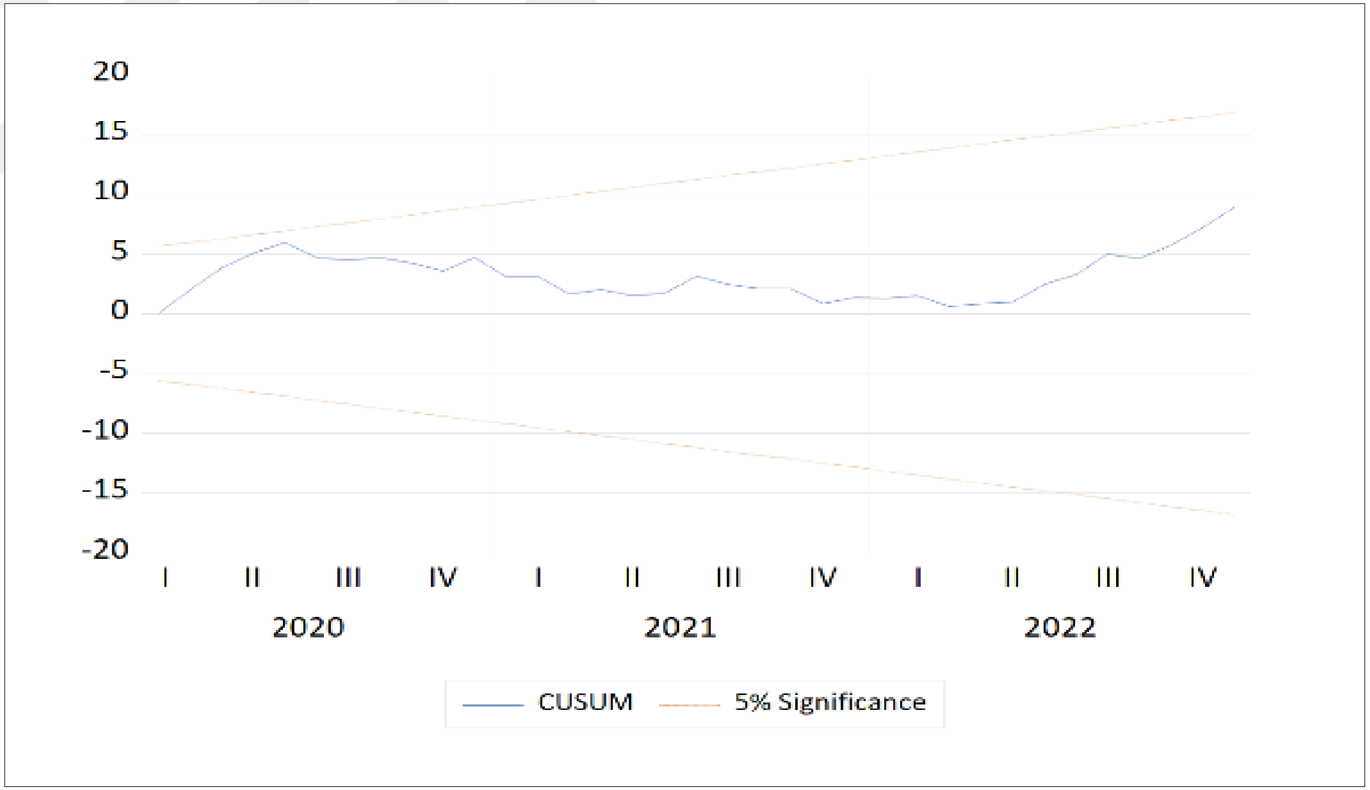

Figure A.4. ARDL Residual Diagnostics Guinea Bissau

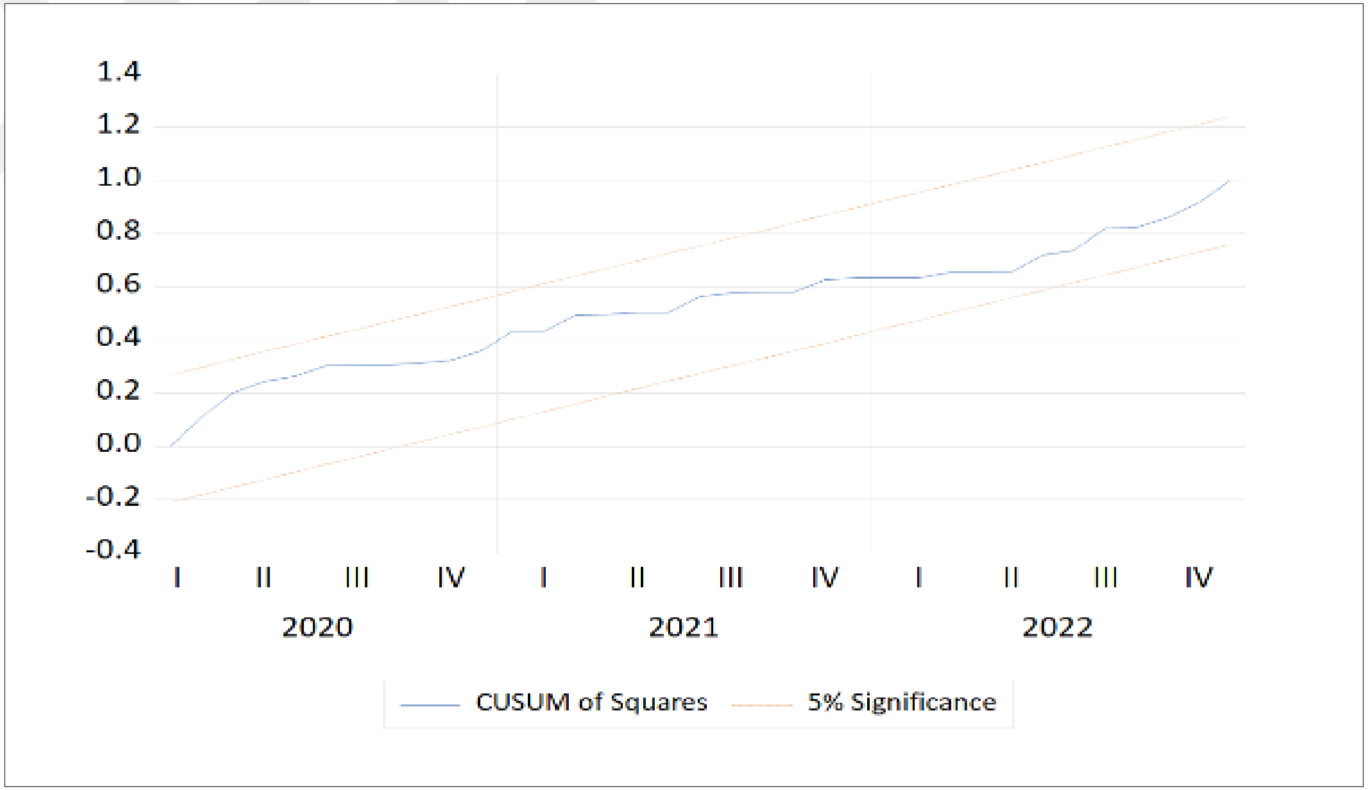

Figure A.4. (cont.)

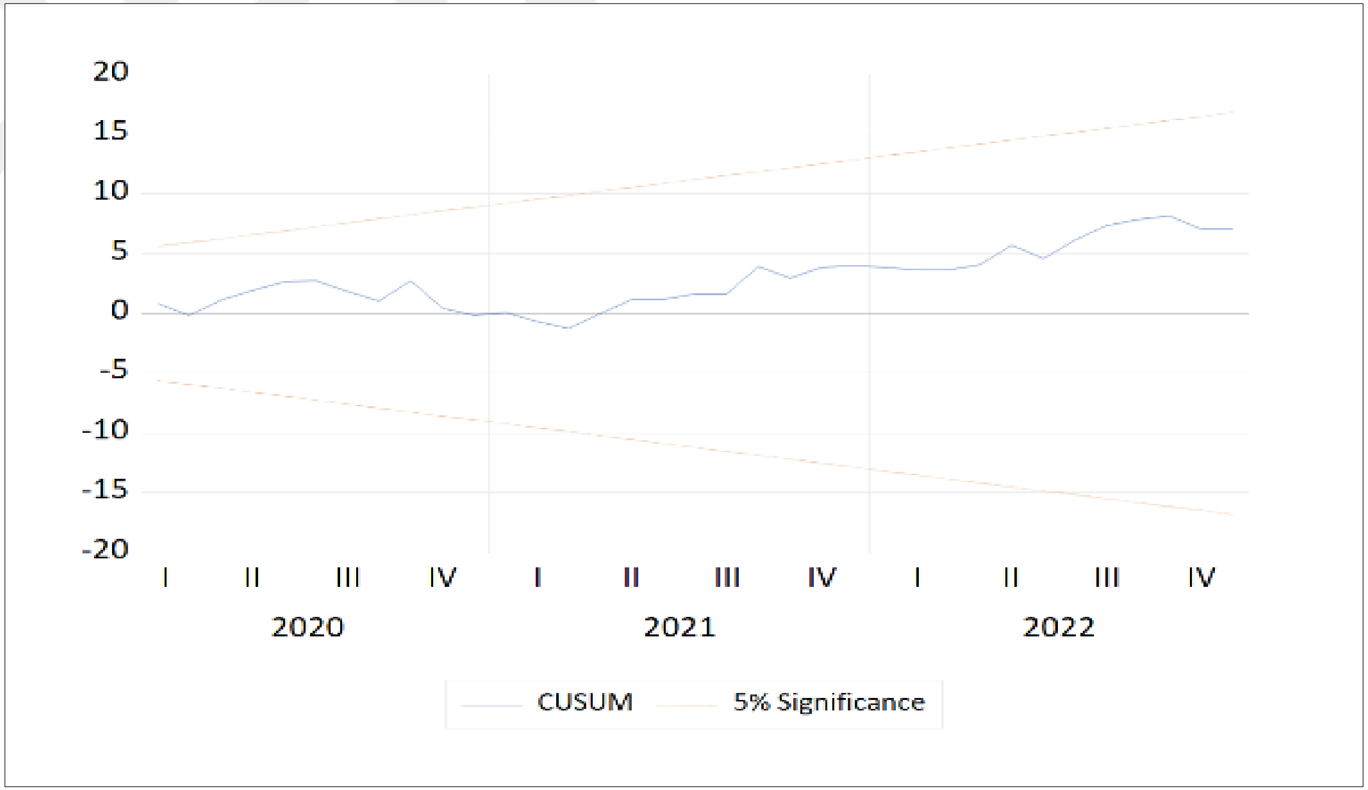

Figure A.5. ARDL Residual Diagnostics Mali

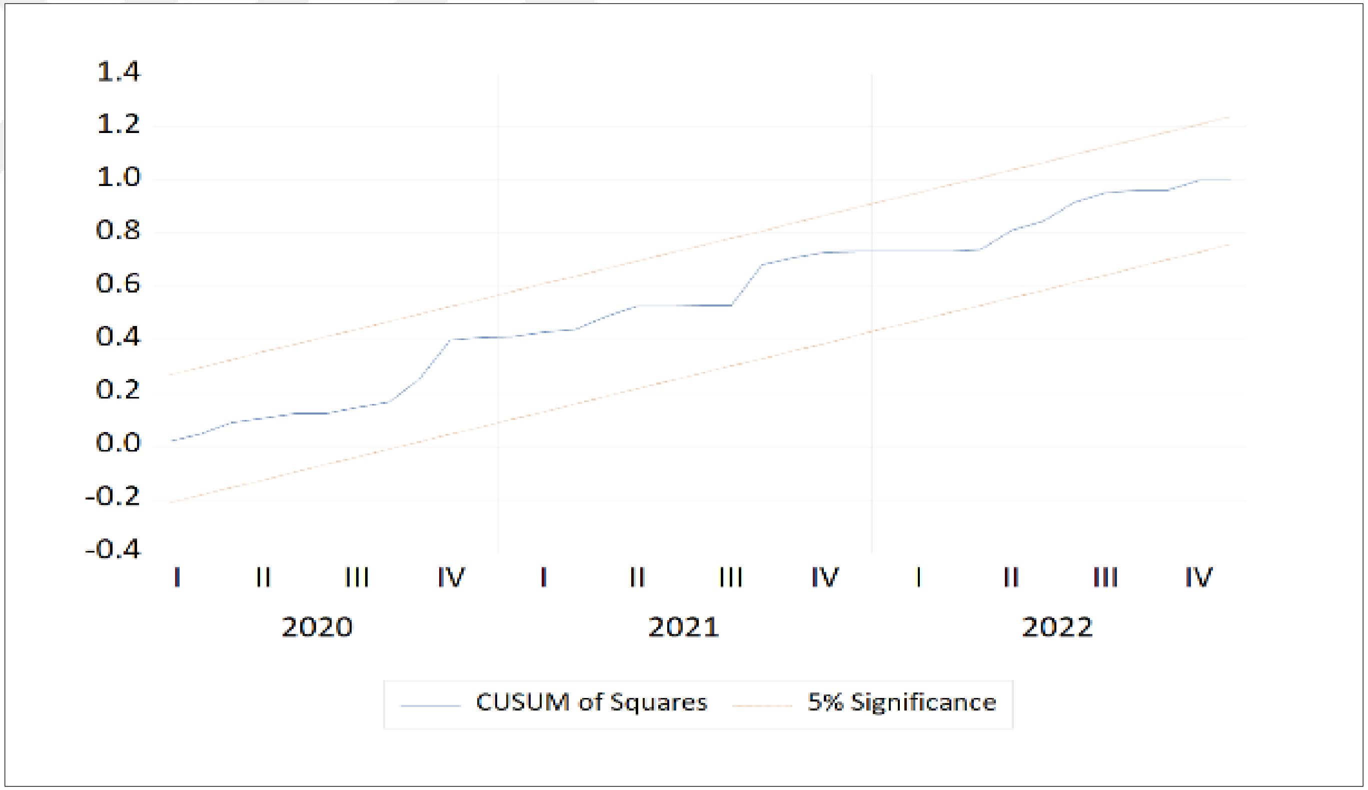

Figure A.5. (cont.)

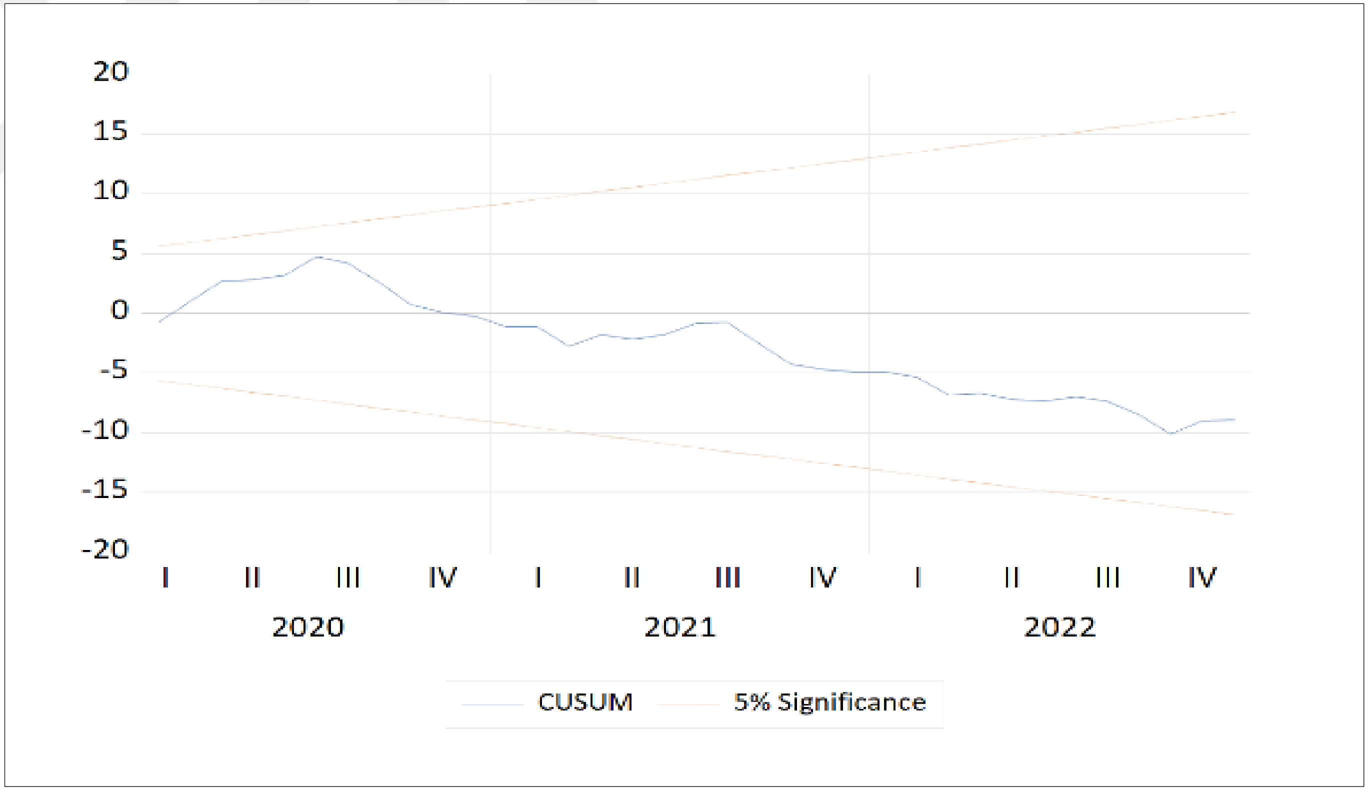

Figure A.6. ARDL Residual Diagnostics Niger

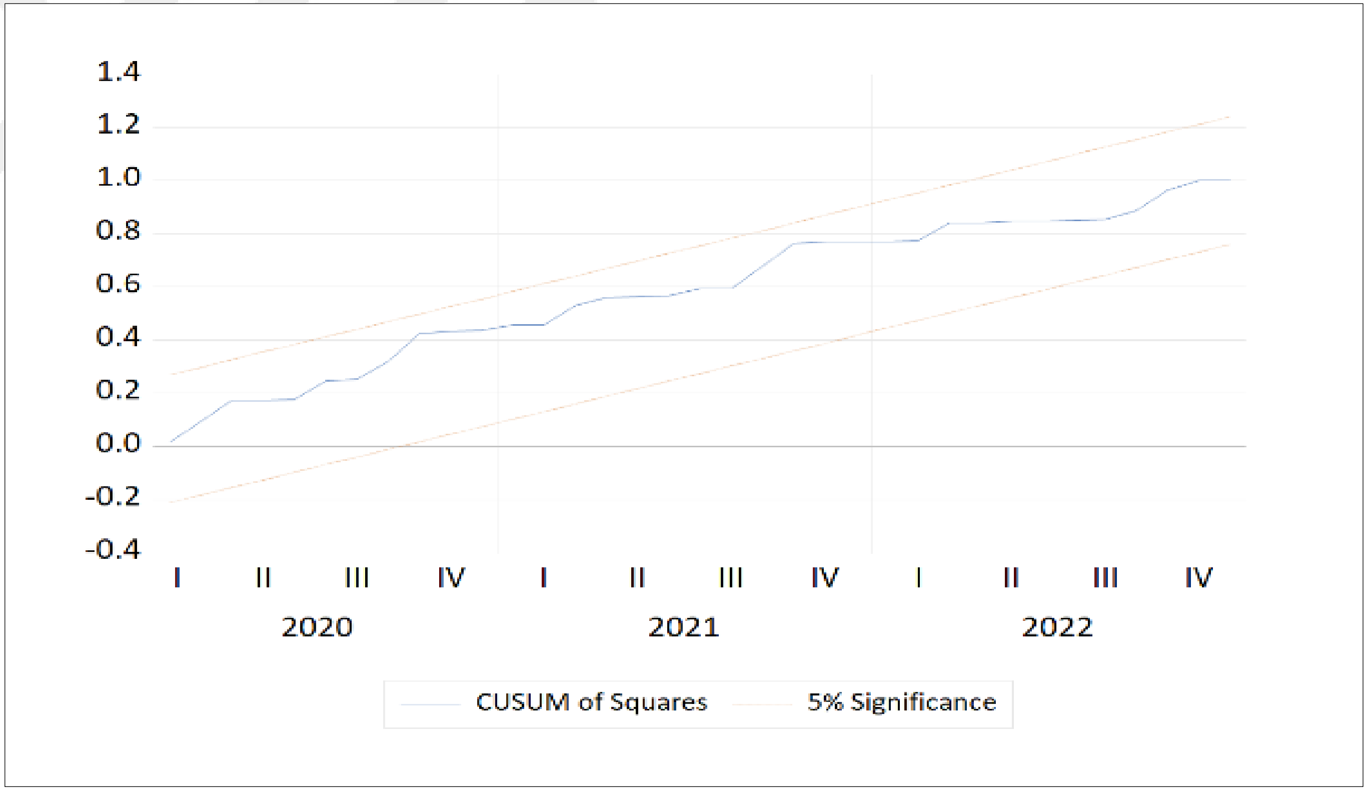

Figure A.6. (cont.)

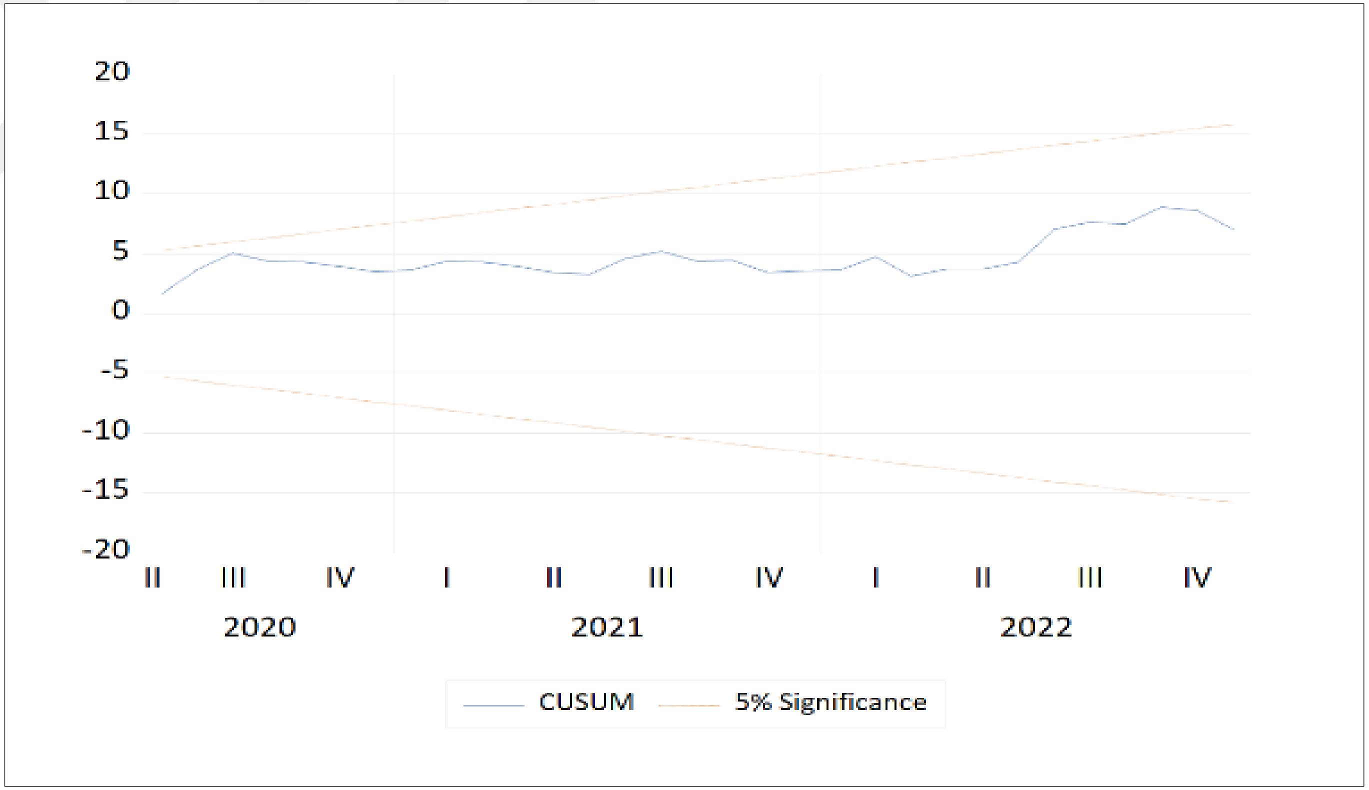

Figure A.7. ARDL Residual Diagnostics Senegal

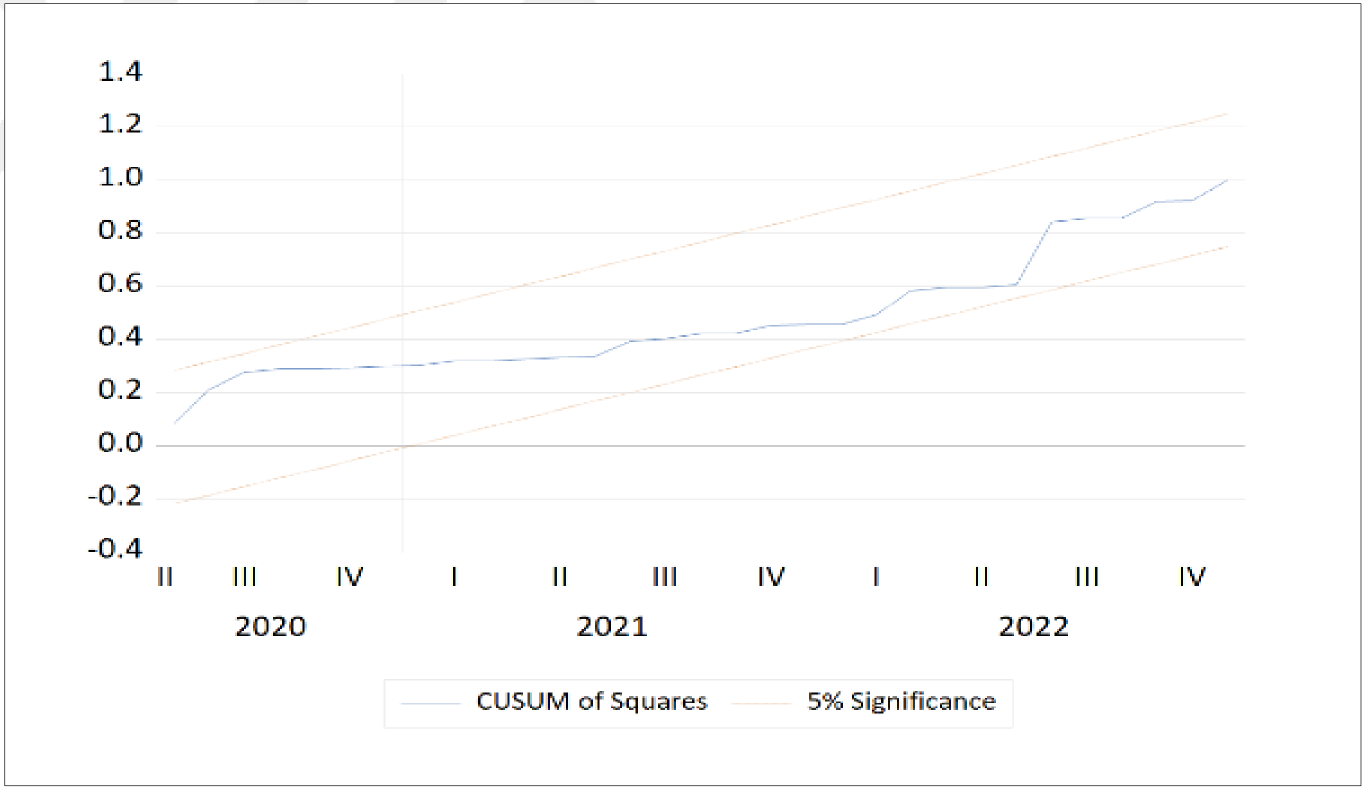

Figure A.7. (cont.)

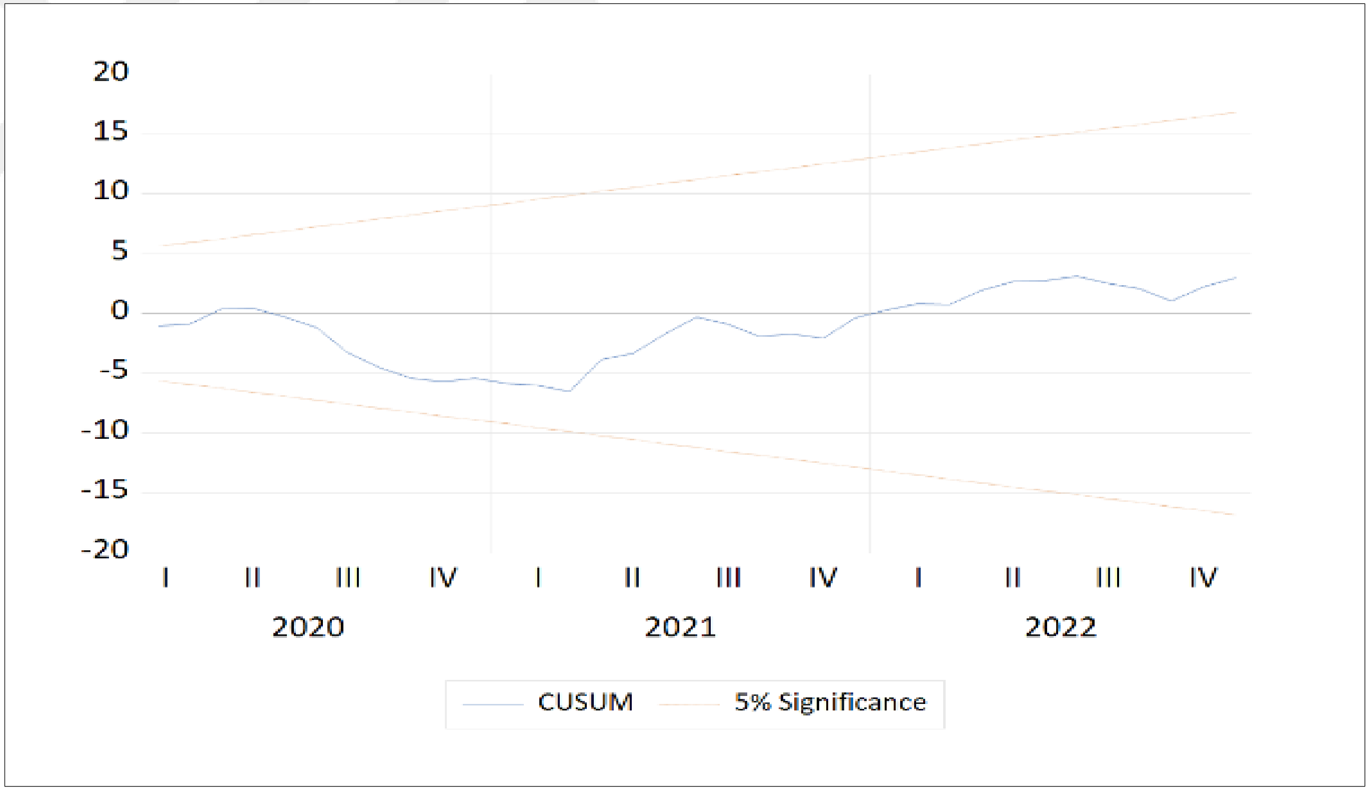

Figure A.8. ARDL Residual Diagnostics Togo

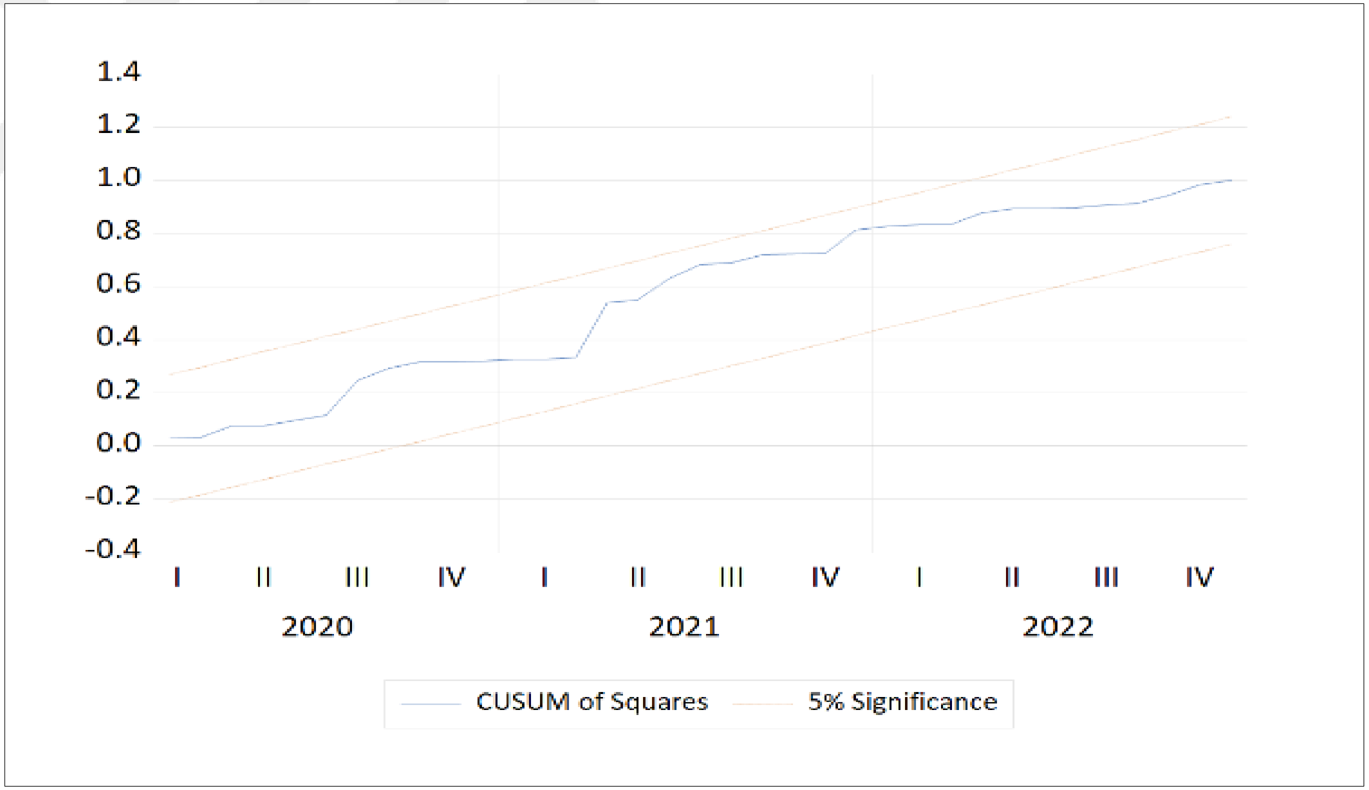

Figure A.8. (cont.)

APPENDIX B

Table B.1. Unit Root Benin

	UNIT ROOT TEST TABLE (PP)					
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.5657	-1.8345	-2.8584	-3.0606	-2.6338
	Prob.	0.4985	0.3631	0.052	0.031	0.0877
		n0	n0	*	**	*
With Constant & Trend	t-Statistic	-2.71	-2.8504	-2.8372	-1.941	-2.5839
	Prob.	0.2336	0.181	0.1856	0.6296	0.2882
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	2.4187	0.3909	0.2579	2.7142	-2.6732
	Prob.	0.9964	0.7959	0.7601	0.9985	0.0076
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-20.1511	-10.4519	-9.6566	-7.729	-10.7053
	Prob.	0	0	0	0	0
		***	***	***	***	***
With Constant & Trend	t-Statistic	-21.529	-10.4244	-9.6488	-8.5776	-10.7526
	Prob.	0	0	0	0	0
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-17.4778	-10.4716	-9.6821	-6.4419	-10.6531
	Prob.	0	0	0	0	0
		***	***	***	***	***
	UNIT ROOT TEST TABLE (ADF)					
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.7874	-2.1068	-3.468	-3.0689	-3.3699
	Prob.	0.3862	0.2423	0.0097	0.0305	0.0131
		n0	n0	***	**	**
With Constant & Trend	t-Statistic	-2.3326	-3.0911	-3.4531	-2.7064	-3.2581
	Prob.	0.4142	0.1109	0.0471	0.2351	0.0762
		n0	n0	**	n0	*
Without Constant & Trend	t-Statistic	1.7461	0.2902	0.1514	1.0936	-3.3925
	Prob.	0.9806	0.7691	0.7291	0.9286	0.0008
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-11.4056	-10.5511	-9.2564	-3.1352	-4.302
	Prob.	0	0	0	0.0255	0.0006
		***	***	***	**	***
With Constant & Trend	t-Statistic	-11.4331	-10.5295	-9.2548	-3.709	-4.29
	Prob.	0	0	0	0.0238	0.0039
		***	***	***	**	***
Without Constant & Trend	t-Statistic	-11.2037	-10.5698	-9.2658	-2.4535	-4.2926
	Prob.	0	0	0	0.014	0
		***	***	***	**	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.1. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)

Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.724237	1.16434	0.202349	1.610811	0.033037
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.42042	0.20895	0.209653	0.359567	0.033037
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.195719	0.063668	0.088684	0.51188	0.113029
	Prob.	n0	n0	n0	**	n0
With Constant & Trend	t-Statistic	0.085819	0.029684	0.055466	0.106065	0.07699
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:

a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant

b: Lag Length based on AIC

c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.2. Unit Root Burkina Faso

				UNIT ROOT TEST TABLE (PP)		
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.4878	-1.8345	-2.8584	0.3618	-3.0637
	Prob.	0.5382	0.3631	0.052	0.9809	0.0308
		n0	n0	*	n0	**
With Constant & Trend	t-Statistic	-2.7589	-2.8504	-2.8372	-4.9238	-2.9847
	Prob.	0.2143	0.181	0.1856	0.0004	0.1388
		n0	n0	n0	***	n0
Without Constant & Trend	t-Statistic	1.9258	0.3909	0.2579	2.3724	-3.0711
	Prob.	0.9872	0.7959	0.7601	0.9959	0.0022
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-13.3114	-10.4519	-9.6566	-8.5756	-11.2593
	Prob.	0	0	0	0	0
		***	***	***	***	***
With Constant & Trend	t-Statistic	-13.2905	-10.4244	-9.6488	-8.742	-11.3808
	Prob.	0	0	0	0	0
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-13.2122	-10.4716	-9.6821	-7.9311	-11.2674
	Prob.	0	0	0	0	0
		***	***	***	***	***
				UNIT ROOT TEST TABLE (ADF)		
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic					
	Prob.	0.6597	0.2423	0.0097	0.7845	0.008
		n0	n0	***	n0	***
With Constant & Trend	t-Statistic	-3.2978	-3.0911	-3.4531	-2.5606	-3.5219
	Prob.	0.0694	0.1109	0.0471	0.299	0.0396
		*	n0	**	n0	**
Without Constant & Trend	t-Statistic	1.4577	0.2902	0.1514	2.6993	-3.5628
	Prob.	0.9641	0.7691	0.7291	0.9984	0.0004
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-3.4473	-10.5511	-9.2564	-4.0303	-5.0319
	Prob.	0.0104	0	0	0.0015	0
		**	***	***	***	***
With Constant & Trend	t-Statistic	-3.3963	-10.5295	-9.2548	-3.5917	-5.0821
	Prob.	0.0546	0	0	0.0329	0.0002
		*	***	***	**	***
Without Constant & Trend	t-Statistic	-3.0771	-10.5698	-9.2658	-2.587	-5.0491
	Prob.	0.0022	0	0	0.0097	0
		***	***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.2. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)
Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.667764	1.164341	0.202349	1.940756	0.030478
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.273146	0.20895	0.209653	0.132412	0.030478
	Prob.	***	**	**	*	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.081483	0.063667	0.088684	0.300738	0.134087
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.069091	0.029684	0.055466	0.183667	0.049248
	Prob.	n0	n0	n0	**	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.3. Unit Root Cote d'Ivoire

		UNIT ROOT TEST TABLE (PP)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-0.431	-1.8345	-2.8584	-0.721	-2.9084
	Prob.	0.9003	0.3631	0.052	0.838	0.0459
		n0	n0	*	n0	**
With Constant & Trend	t-Statistic	-2.2771	-2.8504	-2.8372	-1.8624	-2.8836
	Prob.	0.4443	0.181	0.1856	0.6707	0.1699
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	3.5897	0.3909	0.2579	2.9857	-2.9225
	Prob.	0.9999	0.7959	0.7601	0.9993	0.0036
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-14.3099	-10.4519	-9.6566	-10.7606	-11.5471
	Prob.	0	0	0	0	0
		***	***	***	***	***
With Constant & Trend	t-Statistic	-14.2632	-10.4244	-9.6488	-10.7413	-11.568
	Prob.	0	0	0	0	0
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-13.3185	-10.4716	-9.6821	-9.8551	-11.5392
	Prob.	0	0	0	0	0
		***	***	***	***	***
		UNIT ROOT TEST TABLE (ADF)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-0.7913	-2.1068	-3.468	-1.7527	-3.2405
	Prob.	0.8192	0.2423	0.0097	0.4033	0.0191
		n0	n0	***	n0	**
With Constant & Trend	t-Statistic	-1.8216	-3.0911	-3.4531	-2.3002	-3.2065
	Prob.	0.691	0.1109	0.0471	0.4316	0.0859
		n0	n0	**	n0	*
Without Constant & Trend	t-Statistic	2.7371	0.2902	0.1514	2.306	-3.2538
	Prob.	0.9986	0.7691	0.7291	0.9951	0.0012
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-4.1104	-10.5511	-9.2564	-3.125	-5.1061
	Prob.	0.0012	0	0	0.0262	0
		***	***	***	**	***
With Constant & Trend	t-Statistic	-4.1069	-10.5295	-9.2548	-3.2594	-5.1076
	Prob.	0.0072	0	0	0.076	0.0002
		***	***	***	*	***
Without Constant & Trend	t-Statistic	-2.9819	-10.5698	-9.2658	-2.1506	-5.1109
	Prob.	0.003	0	0	0.0306	0
		***	***	***	**	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.3. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)						
Null Hypothesis: the variable is stationary						
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.818809	1.164341	0.202349	1.820612	0.033234
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.334084	0.20895	0.209653	0.232677	0.033234
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.11472	0.063667	0.088684	0.076204	0.07375
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.118119	0.029684	0.055466	0.06677	0.048866
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.4. Unit Root Guinea Bissau

			UNIT ROOT TEST TABLE (PP)			
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-0.6502	-1.8345	-2.8584	-1.6145	-3.4026
	Prob.	0.8554	0.3631	0.052	0.4735	0.0119
		n0	n0	*	n0	**
With Constant & Trend	t-Statistic	-2.7414	-2.8504	-2.8372	-1.3658	-3.3855
	Prob.	0.2211	0.181	0.1856	0.8683	0.0559
		n0	n0	n0	n0	*
Without Constant & Trend	t-Statistic	2.3722	0.3909	0.2579	2.477	-3.4067
	Prob.	0.9959	0.7959	0.7601	0.997	0.0007
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-13.9835	-10.4519	-9.6566	-10.6576	-12.1644
	Prob.	0	0	0	0	0
		***	***	***	***	***
With Constant & Trend	t-Statistic	-13.9546	-10.4244	-9.6488	-10.8231	-12.1715
	Prob.	0	0	0	0	0
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-13.6281	-10.4716	-9.6821	-10.0609	-12.1839
	Prob.	0	0	0	0	0
		***	***	***	***	***
			UNIT ROOT TEST TABLE (ADF)			
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-0.2329	-2.1068	-3.468	-1.6559	-2.6324
	Prob.	0.9309	0.2423	0.0097	0.4522	0.0881
		n0	n0	***	n0	*
With Constant & Trend	t-Statistic	-1.823	-3.0911	-3.4531	-1.4711	-2.6259
	Prob.	0.6904	0.1109	0.0471	0.8366	0.2693
		n0	n0	**	n0	n0
Without Constant & Trend	t-Statistic	3.1076	0.2902	0.1514	1.6694	-2.6423
	Prob.	0.9996	0.7691	0.7291	0.977	0.0083
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-8.8463	-10.5511	-9.2564	-3.5022	-5.2592
	Prob.	0	0	0	0.0088	0
		***	***	***	***	***
With Constant & Trend	t-Statistic	-8.8306	-10.5295	-9.2548	-3.7165	-5.2569
	Prob.	0	0	0	0.0233	0.0001
		***	***	***	**	***
Without Constant & Trend	t-Statistic	-1.871	-10.5698	-9.2658	-2.9245	-5.2739
	Prob.	0.0586	0	0	0.0036	0
		*	***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.4. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)

Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.851538	1.164341	0.202349	1.851818	0.037911
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.263791	0.20895	0.209653	0.330069	0.037911
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.063436	0.063667	0.088684	0.212049	0.050631
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.06485	0.029684	0.055466	0.053922	0.028274
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:

a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant

b: Lag Length based on AIC

c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.5. Unit Root Mali

		UNIT ROOT TEST TABLE (PP)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.62859	-1.83451	-2.85844	-0.34023	-3.38258
	Prob.	0.466304	0.363132	0.051956	0.915401	0.012578
		n0	n0	*	n0	**
With Constant & Trend	t-Statistic	-2.74943	-2.85043	-2.83716	-2.22533	-3.33465
	Prob.	0.217959	0.180985	0.185579	0.472798	0.063332
		n0	n0	n0	n0	*
Without Constant & Trend	t-Statistic	1.773824	0.390946	0.257915	0.911365	-3.38735
	Prob.	0.981766	0.795887	0.760081	0.903112	0.000774
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-10.4109	-10.4519	-9.65656	-11.1951	-11.6261
	Prob.	2.27E-17	1.84E-17	1.23E-15	4.26E-19	5.26E-20
		***	***	***	***	***
With Constant & Trend	t-Statistic	-10.404	-10.4244	-9.64883	-11.3093	-11.6919
	Prob.	1.27E-16	1.14E-16	8.94E-15	9.06E-19	1.21E-19
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-10.2345	-10.4716	-9.68207	-11.1429	-11.6414
	Prob.	5.26E-19	1.35E-19	1.26E-17	3.00E-21	1.86E-22
		***	***	***	***	***
		UNIT ROOT TEST TABLE (ADF)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.26203	-2.10678	-3.46798	-0.27092	-3.5046
	Prob.	0.647213	0.242291	0.009738	0.925607	0.008757
		n0	n0	***	n0	***
With Constant & Trend	t-Statistic	-2.38589	-3.09115	-3.45312	-2.35411	-3.49938
	Prob.	0.38585	0.110941	0.047123	0.402629	0.041971
		n0	n0	**	n0	**
Without Constant & Trend	t-Statistic	1.698107	0.290215	0.151373	1.008925	-3.52553
	Prob.	0.978372	0.769074	0.729072	0.917476	0.000479
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-3.33204	-10.5511	-9.25638	-3.85721	-5.89117
	Prob.	0.014657	1.10E-17	1.08E-14	0.002809	5.98E-07
		**	***	***	***	***
With Constant & Trend	t-Statistic	-3.29782	-10.5295	-9.25485	-4.04924	-5.91865
	Prob.	0.069379	6.34E-17	8.60E-14	0.008618	5.30E-06
		*	***	***	***	***
Without Constant & Trend	t-Statistic	-2.82766	-10.5698	-9.2658	-3.71839	-5.90877
	Prob.	0.004796	7.73E-20	1.40E-16	0.000237	1.51E-08
		***	***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.5. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)
Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.663006	1.164341	0.202349	1.408339	0.031736
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.369496	0.20895	0.209653	0.255141	0.031736
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.079951	0.063667	0.088684	0.210684	0.095296
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.056421	0.029684	0.055466	0.044439	0.037252
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.6. Unit Root Niger

		UNIT ROOT TEST TABLE (PP)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.98716	-1.83451	-2.85844	-0.98394	-3.76177
	Prob.	0.292437	0.363132	0.051956	0.759187	0.003831
		n0	n0	*	n0	***
With Constant & Trend	t-Statistic	-2.23386	-2.85043	-2.83716	-1.79871	-3.72444
	Prob.	0.468081	0.180985	0.185579	0.702403	0.022636
		n0	n0	n0	n0	**
Without Constant & Trend	t-Statistic	2.27052	0.390946	0.257915	1.215318	-3.76741
	Prob.	0.994652	0.795887	0.760081	0.942639	0.000195
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-10.7299	-10.4519	-9.65656	-10.9627	-12.2741
	Prob.	4.40E-18	1.84E-17	1.23E-15	1.35E-18	2.65E-21
		***	***	***	***	***
With Constant & Trend	t-Statistic	-10.9173	-10.4244	-9.64883	-10.9398	-12.2963
	Prob.	7.51E-18	1.14E-16	8.94E-15	6.64E-18	5.60E-21
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-10.5615	-10.4716	-9.68207	-10.8272	-12.2931
	Prob.	8.10E-20	1.35E-19	1.26E-17	1.79E-20	5.33E-24
		***	***	***	***	***
		UNIT ROOT TEST TABLE (ADF)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.72327	-2.10678	-3.46798	-1.88939	-2.57768
	Prob.	0.418102	0.242291	0.009738	0.336914	0.099209
		n0	n0	***	n0	*
With Constant & Trend	t-Statistic	-2.56304	-3.09115	-3.45312	-1.65803	-2.51334
	Prob.	0.297824	0.110941	0.047123	0.766342	0.321447
		n0	n0	**	n0	n0
Without Constant & Trend	t-Statistic	1.432404	0.290215	0.151373	1.639956	-2.61512
	Prob.	0.962164	0.769074	0.729072	0.975443	0.008948
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-3.2818	-10.5511	-9.25638	-3.50527	-4.32751
	Prob.	0.016936	1.10E-17	1.08E-14	0.008743	0.00052
		**	***	***	***	***
With Constant & Trend	t-Statistic	-3.32694	-10.5295	-9.25485	-3.69548	-4.39255
	Prob.	0.064676	6.34E-17	8.60E-14	0.02471	0.002771
		*	***	***	**	***
Without Constant & Trend	t-Statistic	-2.9129	-10.5698	-9.2658	-3.04797	-4.33458
	Prob.	0.003694	7.73E-20	1.40E-16	0.002419	2.10E-05
		***	***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.6. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)

Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.665832	1.164341	0.202349	1.646817	0.028811
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.375883	0.20895	0.209653	0.334996	0.028811
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.202287	0.063667	0.088684	0.090628	0.069295
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.065039	0.029684	0.055466	0.080042	0.029556
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.7. Unit Root Senegal

		UNIT ROOT TEST TABLE (PP)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-0.30608	-1.83451	-2.85844	0.094574	-3.08349
	Prob.	0.920595	0.363132	0.051956	0.964726	0.029216
		n0	n0	*	n0	**
With Constant & Trend	t-Statistic	-3.45898	-2.85043	-2.83716	-3.05586	-2.97777
	Prob.	0.04641	0.180985	0.185579	0.119663	0.140818
		**	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	2.33865	0.390946	0.257915	4.080623	-3.09799
	Prob.	0.995547	0.795887	0.760081	0.999988	0.002049
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-9.94539	-10.4519	-9.65656	-10.739	-10.9011
	Prob.	2.62E-16	1.84E-17	1.23E-15	4.20E-18	1.85E-18
		***	***	***	***	***
With Constant & Trend	t-Statistic	-9.92165	-10.4244	-9.64883	-10.7434	-11.0494
	Prob.	1.91E-15	1.14E-16	8.94E-15	1.95E-17	3.66E-18
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-9.77227	-10.4716	-9.68207	-9.47316	-10.8997
	Prob.	7.50E-18	1.35E-19	1.26E-17	4.21E-17	1.18E-20
		***	***	***	***	***
		UNIT ROOT TEST TABLE (ADF)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	0.152028	-2.10678	-3.46798	-0.37789	-5.20857
	Prob.	0.968895	0.242291	0.009738	0.90929	1.39E-05
		n0	n0	***	n0	***
With Constant & Trend	t-Statistic	-2.51712	-3.09115	-3.45312	-2.5527	-5.13772
	Prob.	0.319612	0.110941	0.047123	0.302663	0.000164
		n0	n0	**	n0	***
Without Constant & Trend	t-Statistic	2.224054	0.290215	0.151373	2.985223	-5.24949
	Prob.	0.993934	0.769074	0.729072	0.999341	3.67E-07
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-3.22692	-10.5511	-9.25638	-3.95418	-4.89363
	Prob.	0.019783	1.10E-17	1.08E-14	0.002015	5.39E-05
		**	***	***	***	***
With Constant & Trend	t-Statistic	-3.25031	-10.5295	-9.25485	-3.86127	-4.93529
	Prob.	0.077615	6.34E-17	8.60E-14	0.015313	0.000369
		*	***	***	**	***
Without Constant & Trend	t-Statistic	-1.38052	-10.5698	-9.2658	-2.16428	-4.90861
	Prob.	0.155321	7.73E-20	1.40E-16	0.02961	1.75E-06
		n0	***	***	**	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.7. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)						
Null Hypothesis: the variable is stationary						
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.869564	1.164341	0.202349	1.965118	0.020666
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.22787	0.20895	0.209653	0.23194	0.020666
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.089357	0.063667	0.088684	0.110352	0.149224
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.078279	0.029684	0.055466	0.077091	0.05521
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table B.8. Unit Root Togo

		UNIT ROOT TEST TABLE (PP)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.25773	-1.83451	-2.85844	-1.81993	-3.98913
	Prob.	0.649291	0.363132	0.051956	0.370212	0.001764
		n0	n0	*	n0	***
With Constant & Trend	t-Statistic	-2.71096	-2.85043	-2.83716	-1.51854	-3.98555
	Prob.	0.233217	0.180985	0.185579	0.820658	0.010427
		n0	n0	n0	n0	**
Without Constant & Trend	t-Statistic	2.433406	0.390946	0.257915	1.52047	-4.02812
	Prob.	0.996563	0.795887	0.760081	0.968409	7.13E-05
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-13.7084	-10.4519	-9.65656	-11.5189	-10.8757
	Prob.	7.77E-24	1.84E-17	1.23E-15	8.79E-20	2.10E-18
		***	***	***	***	***
With Constant & Trend	t-Statistic	-13.7186	-10.4244	-9.64883	-11.5725	-10.8486
	Prob.	8.15E-24	1.14E-16	8.94E-15	2.25E-19	1.09E-17
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-12.7835	-10.4716	-9.68207	-11.3535	-10.8119
	Prob.	3.96E-25	1.35E-19	1.26E-17	9.22E-22	1.95E-20
		***	***	***	***	***
		UNIT ROOT TEST TABLE (ADF)				
	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	-1.15843	-2.10678	-3.46798	-3.20546	-4.45527
	Prob.	0.692348	0.242291	0.009738	0.021019	0.000318
		n0	n0	***	**	***
With Constant & Trend	t-Statistic	-2.6119	-3.09115	-3.45312	-2.17849	-4.31785
	Prob.	0.275512	0.110941	0.047123	0.498679	0.003577
		n0	n0	**	n0	***
Without Constant & Trend	t-Statistic	1.455505	0.290215	0.151373	1.830306	-4.46852
	Prob.	0.963889	0.769074	0.729072	0.983958	1.20E-05
		n0	n0	n0	n0	***
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	-2.9801	-10.5511	-9.25638	-3.50183	-5.52614
	Prob.	0.038397	1.10E-17	1.08E-14	0.008836	3.31E-06
		**	***	***	***	***
With Constant & Trend	t-Statistic	-2.95842	-10.5295	-9.25485	-4.14516	-5.493
	Prob.	0.146599	6.34E-17	8.60E-14	0.00635	3.62E-05
		n0	***	***	***	***
Without Constant & Trend	t-Statistic	-2.5656	-10.5698	-9.2658	-3.01822	-5.51265
	Prob.	0.010291	7.73E-20	1.40E-16	0.002658	1.05E-07
		**	***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table B.8. (cont.)

UNIT ROOT TEST RESULTS TABLE (KPSS)
Null Hypothesis: the variable is stationary

	At Level					
		LFPI	LER	LOIL	LM2	GAP
With Constant	t-Statistic	1.651674	1.164341	0.202349	1.433788	0.022082
	Prob.	***	***	n0	***	n0
With Constant & Trend	t-Statistic	0.285486	0.20895	0.209653	0.407664	0.022082
	Prob.	***	**	**	***	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					
	At First Difference					
		d(LFPI)	d(LER)	d(LOIL)	d(LM2)	d(GAP)
With Constant	t-Statistic	0.11795	0.063667	0.088684	0.211511	0.079384
	Prob.	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.095609	0.029684	0.055466	0.055736	0.078218
	Prob.	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	=======	=======	=======	=======	=======
	Prob.					

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on AIC
c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

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