

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTER OF SCIENTIFIC REASECH AND HIGHER EDUCTION
ECOLE SUPERIEUR DE COMMERCE -KOLEA-

**A dissertation submitted in partial fulfilment of the requirements for the Master's
Degree in Financial Sciences and Accounting**

Major: Money-Finance-Bank

Topic:

**The Determinants of the Exchange Rate: A Panel
Data Analysis of African Oil-Exporting Countries**

Submitted by:

Wisseem BOUZOURINE

Supervised by:

Mr. Abd EL Hafid DAHMANI

Internship location: Bank of Algeria, External Financial Relation Division, 07 Bd Che
Guevara 16000 Algiers

Internship duration: From 10/02/2025 to 13/05/2025

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Dedication

To my mother, whose unwavering love, strength, and prayers have guided and protected me through every challenge. Your presence has been my greatest support, and I dedicate all my achievements to you with deep gratitude.

To my grandmother, your kindness, your loving care, and your quiet understanding have been a shelter to my heart and soul. You have been by my side since infancy, present in every step of my life, and for that, I am deeply grateful.

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To my little sister, you are more than just family, you are the greatest gift I've ever received.

To my father's family and my friends.

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List of abbreviations

Abbreviation	Signification
FOREX	Foreign Exchange
USB	Union Bank of Switzerland
HSBC	Hongkong and Shanghai Banking Corporation
BNP	Banque Nationale de Paris
USD	United States Dollar
GPB	Great Britain Pound
CHF	Swiss Franc (Confederation Helvetica Franc)
CAD	Canadian Dollar
DZD	Algerian Dinar
FEER	Fundamental Equilibrium Exchange Rate
REER	Real Effective Exchange Rate
IMS	International Monetary System
BIRD	The Bank for International Reconstruction and Development
IFM	International Monetary Fund
SDRs	Special Drawing Rights
OCA	Optimum Currency Area
PPP	Purchasing Power Parity
US	United States
GDP	Gross Domestic Product
VAR	Vector Autoregressive
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
STAR	Smooth Transition Autoregressive Model
MENA	Middle East and North Africa
OPEC	Organization of the Petroleum Exporting Countries
CFA	Communauté Financière Africaine
SECO	State Secretariat for Economic Affairs
CBE	Central Bank Egypt
Kz/USD	Kwanza per United States Dollar
CPI	Consumer Price Index
CEMAC	Communauté Économique et Monétaire de l'Afrique Centrale
CFAF	Franc de la Communauté Financière Africaine
BEAC	Banque des États de l'Afrique Centrale
FRED	Federal Reserve Economic Data
OLS	The Ordinary Least Squares
VIF	Variance Inflated Factor
PCSE	Panel Corrected Standard Error
GMM	General Method of Moment

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Abstract

Exchange rate plays a crucial role in the international market. Its fluctuations, whether appreciation or depreciation, are strongly linked to a country's economic performance. In African oil-exporting countries, exchange rate volatility is high due to internal and external shocks, leading to reduced trade flows, lower foreign investment, and instability in interest and inflation rates. Several studies have mostly focused on nominal exchange rates more than REER in these economies. Therefore, this research aims to investigate the common determinants of real effective exchange rate fluctuations in African oil-exporting countries, using a sample of five (5) oil-economies in Africa, namely Algeria, Egypt, Nigeria, Angola, and Gabon. The panel data regression method is employed, using annual data covering the period from 1995 to 2020 to analyse the influence of several macroeconomic variables on the real effective exchange rate of the selected countries. The empirical results obtained using the PCSE approach show the presence of a statistically significant relationship between the REER and six macroeconomic determinants, namely oil prices, foreign exchange reserves, inflation, interest lending rate, gross domestic product, and the trade balance. Specifically, oil prices, foreign exchange reserves, inflation, and lending rate have a negative relationship with the REER of the selected countries, while GDP and the trade balance have a positive relationship with the REER.

Keywords: Real effective exchange rate; African oil-exporting countries; Macroeconomic fundamentals; Panel data.

Résumé

Le taux de change joue un rôle crucial sur le marché international. Ses fluctuations, qu'il s'agisse d'une appréciation ou d'une dépréciation, sont fortement liées à la performance économique d'un pays. Dans les pays africains exportateurs de pétrole, la volatilité de taux de change est élevée en raison des chocs internes et externes, ce qui entraîne une baisse des échanges commerciaux, une diminution des investissements étrangers ainsi qu'une instabilité des taux d'intérêt et d'inflation. Plusieurs études se sont principalement concentrées sur les taux de change nominaux, au détriment du taux de change effectif réel (REER) dans ces économies. Par conséquent, cette recherche vise à examiner les déterminants communs des fluctuations du taux de change effectif réel dans les pays africains exportateurs de pétrole, en utilisant un échantillon de cinq (5) économies pétrolières du continent, à savoir l'Algérie, l'Égypte, le Nigeria, l'Angola et le Gabon. La méthode de régression sur données de panel est utilisée, à partir des données annuelles couvrant la période de 1995 à 2020 pour analyser l'influence de plusieurs variables macroéconomiques sur le taux de change réel des pays sélectionnés. Les résultats empiriques obtenus à l'aide de l'approche PCSE montrent l'existence d'une relation statistiquement significative entre le taux de change réel effectif et six déterminants macroéconomiques, à savoir les prix du pétrole, les réserves de change, l'inflation, le taux d'intérêt débiteurs, le produit intérieur brut (PIB) et la balance commerciale. Plus précisément, les prix du pétrole, les réserves de change, l'inflation et le taux d'intérêt débiteur ont une relation négative avec le taux de change effectif réel des pays étudiés, tandis que le PIB et la balance commerciale présentent une relation positive avec ce dernier.

Mots-clés : Taux de change effectif réel ; Pays africains exportateurs de pétrole ; Fondamentaux macroéconomiques ; Données de panel.

ملخص

يلعب سعر الصرف دورا حاسما في السوق الدولية. اذ ان تقلباته، سواء من حيث الارتفاع او الانخفاض، ترتبط ارتباطا وثيقا بأداء الاقتصاد الوطني لدولة. في البلدان الافريقية المصدرة للنفط، تشهد أسعار الصرف تقلبا كبيرا نتيجة للصدمات الداخلية والخارجية، مما يؤدي الى انخفاض في تدفقات التجارة ، وتراجع الاستثمارات الأجنبية، وعدم استقرار في معدلات الفائدة والتضخم. وقد ركزت العديد من الدراسات على أسعار الصرف الاسمية أكثر من أسعار الصرف الحقيقية الفعالة في هذه الاقتصادات. ومن ثم، تهدف هذه الدراسة الى تحليل المحددات المشتركة لسعر الصرف الحقيقي الفعال في الدول الافريقية المصدرة للنفط، من خلال عينة تشمل خمس دول نفطية افريقية وهي الجزائر، مصر، نيجيريا، اونغولا، والغابون. تم استخدام منهج بيانات (Panel Data) بالاعتماد على بيانات سنوية تغطي الفترة الممتدة من 1995 الى 2020، لتحليل تأثير مجموعة من المتغيرات الاقتصادية الكلية على سعر الصرف الحقيقي الفعال في هذه الدول. وتظهر النتائج التجريبية، التي تم التوصل اليها باستخدام طريقة تصحيح الخطأ المعياري (PCSE)، وجود علاقة ذات دلالة إحصائية بين سعر الصرف الحقيقي الفعال وستة محددات اقتصادية كلية، وهي أسعار النفط، احتياطات النقد الأجنبي، معدل التضخم، معدل الفائدة على الإقراض، الناتج المحلي الإجمالي، و الميزان التجاري. وبشكل خاص ، تبين ان أسعار النفط، واحتياطات النقد الأجنبي والتضخم، ومعدل الفائدة على الإقراض لها علاقة عكسية مع سعر الصرف الحقيقي الفعال، وفي حين ان الناتج المحلي الإجمالي والميزان التجاري يرتبطان به ارتباطا إيجابيا.

الكلمات المفتاحية: سعر الصرف الحقيقي الفعال؛ الدول الافريقية المصدرة للنفط؛ المحددات الاقتصادية الكلية؛ بيانات Panel.

GENERAL INTRODUCTION

The geographical and historical specificities of countries have led to economic differences worldwide. Trade arises from the complementarity and competition of goods and services across regions, forming the basis of international economics. The value of a national currency relative to foreign currencies is influenced not only by the intrinsic value of exchanged goods but also by various complex factors that affect currency values and terms of trade.

The objective of every country, through its economic agents, is to benefit from international trade. The relationship between countries, once determined and influenced by multiple factors, is neither fixed nor neutral. It is undeniably a tool that can act upon and influence other economic variables. In this regard, the exchange rate lies at the heart of international economic relations. Within a comprehensive and coherent economic policy framework, exchange rate policy is one of the main concerns of public decision makers, on par with monetary and fiscal policy.

Unlike monetary policy, which focuses on the internal value of money, namely, the purchasing power of a currency unit in terms of goods and services within the national territory, exchange rate policy is concerned with the external value of the currency, defined as the purchasing power of a currency unit in terms of foreign currencies. According to Dominique Plihon (1994), the strategic importance of the exchange rate is linked to the fact that it is at the center of relations between countries, by measuring the price of currencies against one another. In a fully globalized and deregulated world, economists strive to understand the growing volatility in exchange rate movements and to identify their multiple and interdependent determinants.

The real exchange rate, defined as the relative price of foreign goods in terms of domestic goods, plays a crucial role in international economics. It serves not only as a measure of international competitiveness but also as a key signal for the long-term allocation of resources between tradable and non-tradable sectors within an economy. By influencing production and consumption choices between domestic and foreign goods, the real exchange rate becomes a fundamental variable in guiding macroeconomic outcomes. International trade has long been recognized as a critical driver of economic development, expanding production capabilities and consumer options (Adewuyi, 2005).

Despite its importance, research on the determinants of the real exchange rate in oil-exporting countries remains limited. Most existing studies have focused on the nominal exchange rate, while fewer have addressed the real exchange rate. Some relevant studies include the work of Karim Eslamloueyan et al. (2015) on the determinants of the real exchange rate in oil-producing countries of Middle East and North Africa from 1985 to 2009, the study of Likka Korhonen et al. (2009) on the equilibrium exchange rate in oil-dependent countries from 1975 to 2005, and the research of Odeyemi Gbenga A. (2014) on the real exchange rate of oil-exporting countries in Africa using a panel of three countries from 1980 to 2012. These studies often show divergent results, suggesting that the determinants of the real exchange rate may vary significantly across countries depending on economic structure, fiscal policy, and external vulnerabilities.

Among the key determinants is oil prices, which are particularly relevant for oil-exporting economies. The currencies of African oil-producing countries, for instance, have experienced substantial depreciation, notably during periods of sharp US dollar appreciation such as in 2015 and 2022. These depreciations raise concerns about exchange rate volatility and its broader implication for macroeconomic indicators such as inflation, interest rates, growth, trade flows, and foreign exchange reserves. Oil-dependent economies are particularly vulnerable because fluctuations in global oil prices directly affect their trade balance, currency stability, and economic performance.

Oil price volatility also acts as a transmission mechanism through the terms of trade. A fall in oil prices typically leads to currency depreciation and macroeconomic instability in oil-exporting nations, while oil-importing countries may experience different, sometimes opposite, effects (Fratzscher et al., 2015). The extent of impact depends on each country's degree of dependency on oil exports and the structure of its economy.

Given the critical role of the real exchange rate in reflecting a country's competitiveness and guiding economic policy, it is crucial to deepen the understanding of its determinants, particularly for African oil-exporting countries.

The purpose of this research is to investigate the determinants of real effective exchange rate fluctuations in African oil exporting countries from 1995 to 2019.

The main question which should be arisen in this regard and which this modest research is trying to answer, is:

« What are the common determinants of real effective exchange rate fluctuations in African oil-exporting countries? »

To obtain an adequate answer to the research question, it is essential to examine the following secondary questions:

- What are the main theories of exchange rate determination?
- How do oil prices influence fluctuations in the real effective exchange rate in African oil-exporting countries?
- What is the impact of foreign exchange reserves on the real effective exchange rate in the selected countries?
- Are there other factors that influence fluctuations in the real effective exchange rate in African oil-exporting countries?

To address the issue, a set of hypotheses can be formulated as follows:

- H 1: Oil prices significantly impact real effective exchange rate fluctuations in African oil-exporting countries.
- H 2: Foreign exchange reserves play a significant role in influencing real effective exchange rate fluctuations in African oil-exporting countries.
- H 3: Macroeconomic fundamentals, such as inflation, lending interest rate, GDP and the trade balance significantly affect real effective exchange rate fluctuations in African oil-exporting countries.

The choice of this topic was made for both personal and objective reasons. These are summed up as follows:

- The relevance of the research theme to our academic major;
- The opportunity to strengthen my econometric knowledge;
- The crucial role of the real effective exchange rate in national economies, particularly those heavily reliant on oil exports;
- The limited empirical research on real effective exchange rate determinants in African oil-exporting countries.

To address the main question and each of the secondary questions, as well as to test the formulated hypotheses, two methodological approaches will be employed: the descriptive approach and the analytical approach. We carried out documentary research, allowing us to consult a wide range of sources, such as articles, books, and websites, to gather extensive information for this study. The empirical component of the study will focus a panel data analysis covering five African oil-exporting countries (Algeria, Egypt, Nigeria, Angola, and Gabon) over the period from 1995 to 2020.

This dissertation will be divided into two parts. The initial part will consist of two theoretical chapters and the second parts will be devoted to the empirical analysis.

Chapter I: Theoretical concepts related to Exchange Rate and its Regimes

The first chapter will review the main concepts and definitions related to foreign exchange market and exchange rates, explores the evolution of international monetary system, and examines the different types exchange rate regimes, and the factors influencing the choice of exchange rates regimes.

Chapter II: Determinants of Exchange Rate: A Literature Review

The second chapter aims to explore both the theoretical and empirical determinants of exchange rates. It presents an overview of major theories explaining exchange rate behaviour, followed by a review of earlier empirical studies that investigated the key factors influencing exchange rates. Finally, it highlights real exchange rate variability and convergence toward equilibrium.

Chapter III: An empirical Analysis of the common determinants of real effective exchange rate in African oil-exporting countries

The third chapter will be devoted to examine the impact of common macroeconomic factors on the real effective exchange rate in African oil exporting counties from 1995 to 2020. The first section outlines the methodology used, introduces the selected sample, details variables and data sources. The second section provides a descriptive analysis of the data. Finally, the third section estimates the panel model and interprets the empirical results.

CHAPTER I: THEORITICAL CONCEPTS RELATED TO EXCHANGE RATE AND ITS REGIMES

Introduction

Each country has its own currency, which is used to determine the prices of goods and services and facilitate domestic transactions. All economic agents involved in international economic transactions, such as import, export, lending or borrowing in foreign currencies, traveling abroad, or exchanges goods and services in different currencies necessitate money conversion. This conversion requires conducting foreign exchange transactions in foreign exchange market.

The development of trade in goods and services, as well as the increase in capital flows between countries, and the reliance on foreign exchange transactions, implies the existence of an international monetary system, which regulates monetary transactions between nations and ensures the stability of international economic relations. Industrial development and the expansion of international trade have made it essential to establish an organized IMS. Since the 19th century, this system has undergone several transformations due to global economic and political tension.

The instability of exchange rates and the need for a reliable monetary framework have led to the emergence of various exchange rate regimes. These regimes directly influence a country's economic policies and its monetary stabilization strategies. The choice of an exchange rate regime is a central issue in international macroeconomics, particularly since the works of Friedman and Mundell. This choice depends on various factors, including a county's economic structure, its levels of trade openness, its objectives regarding monetary stability and competitiveness. Since the collapse of the Bretton Woods system in the 1970s and of the IMF reforms, countries can freely select their regime, either adopting a floating exchange rate or pegging their currency to one or more foreign currencies.

This chapter is organized as follows:

- **Section 01:** The fundamental concepts related to the Exchange Rate
- **Section 02:** The International Monetary System
- **Section 03:** Typology and the choice of the Exchange Rate Regimes

Section 01: The fundamental concepts related to the Exchange Rate

The exchange rate is essential in international trade, as it enables the conversion of national currencies in the absence of a single international currency. It influences foreign trade by defining a country's economic integration conditions and facilitating price comparisons of goods and services between different nations.

This section will focus on the fundamental concepts of the exchange rate and the foreign exchange market.

1.The Foreign Exchange Rate Market

International transactions generally involve monetary transfers between residents of different countries. Most of these transactions require currency conversion, justifying the existence of the foreign exchange (FOREX) market, a key component of financial markets.

The foreign exchange rate market (FOREX) facilitates the exchange of currencies and determinants their value relative to national currencies.

The forex market is the largest in the world, with daily transactions exceeding 4\$ trillion. It operates globally, with no geographical limits, functioning 24 hours a day through telecommunications networks.

1.1. Structure of the Foreign Exchange Market

The foreign exchange rate market consists of the wholesale market and the retail market.

1.1.1. The Wholesale Market (Interbank Market)

A wholesale market, often called the inter-bank, is an informal network that involves large-scale currency transactions primarily between commercial banks, investment institutions, non-financial corporations, and the central banks. Transactions are significantly larger, often averaging millions of dollars. In another word, the wholesale market is a market in which banks and currency brokerages deal with each other and with large corporations.

The primary price makers, or the market makers, quote two-way prices, meaning they are willing to buy and sell a currency at any given time. They take positions to facilitates liquidity but bear the risk of price movements. The bid-offer spread, also known as the bid-ask spread, provides a cushion against losses and ensures profitability. Price takers engage in the forex transactions purely for business needs, while some multinationals actively speculate for financial gains.

1.1.2. The Retail Market (Client Market)

A retail market, where individuals (such as tourists and travellers) exchange one currency for another through banks, involves small transaction sizes, typically with a large spread between buying and selling prices, reflecting lower liquidity and higher transaction costs.

CHAPTER I: TEORITICAL CONCEPTS RELATED TO EXCHANGE RATE AND IT REGIMES

1.2. Market participants

Commercial banks, central banks, brokers, Nonfinancial businesses, and non-Banking financial institutions are the main participants in the market.

1.2.1. Commercial Banks

The foreign exchange market can be considered an interbank market, where large commercial banks play a key role. They act as intermediaries for corporate clients, facilitate trade financing, hedge exchange rate risks, manage cash flow, and sometimes trade for their own profit.

Table 1.1: Market share of the most active Banks in the Foreign Exchange Market

Banks	2006	2007	2008	2010	2011	2012	2013	2014
Deutsche Bank	19,3	9,3	20,96	18,1	15,65	14,57	15,18	15,67
UBS	11,9	14,9	14,58	11,3	10,60	10,48	10,11	10,88
Citigroup	10,4	9,0	7,32	7,7	8,86	12,26	14,90	16,04
Royal Bank of Scotland	6,4	8,9	8,19	6,5	6,20	5,48	5,62	3,25
Barclays	6,6	8,8	10,45	11,1	10,76	10,95	10,24	10,91
JP Morgan-Chase			5,43	6,4	6,44	6,60	6,07	5,55
HSBC			4,09	4,6	6,27	6,72	6,93	7,12
Credit Suisse			3,05		4,80	4,68	3,70	2,07
Goldman Sachs			3,35		4,13	3,12	2,75	2,53
Morgan Stanley			1,95		3,65	3,52	3,15	2,28
Bank of America							3,08	4,38
Merrill							2,52	3,10
BNP Paribas								

Source: Simon, Y., Morel, C., (2015), « Finance Internationale », 11th edition, p. 12

1.2.2. Nonfinancial Business

Businesses participate in the foreign exchange market primarily due to international trade and direct investment. They aim to secure favourable exchange rates, hedge currency risks, and protect assets and liabilities abroad. Companies also engage in foreign currency borrowing and deposits to optimize their financial conditions.

1.2.3. Brokers

Brokers act as intermediaries between market makers without trading on their own account. They provide market information and price discovery while maintaining anonymity for participants. They earn commissions instead of profiting from currency movements.

1.2.4. Central Banks

Central banks play a key role in managing currency value and maintaining stability in the foreign exchange market. Under a fixed exchange rate system, they intervene to keep currency values within a set range by buying or selling foreign reserves. In a floating exchange rate system, they may still intervene to maintain orderly markets or support economic objectives, such as protecting exports. Their actions impact foreign exchange reserves, domestic money supply, and inflation. Any intervention must be aligned with broader economic policies to ensure stability and balance between external and domestic economic conditions.

The table below presents the official Foreign Exchange Reserves.

Table 1.2: Official Foreign Exchange Reserves

China (Mars 2014)	4010
Japan (May 2014)	1284
Saudi Arabia (April 2014)	738
Switzerland (may 2014)	545
Russia (June 2014)	478
Taiwan (May 2014)	427
Brazil (May 2014)	369
South Korea (May 2014)	361
India (July 2014)	321
Hong Kong (June 2014)	321
Singapore (June 2014)	278
Germany (June 2014)	209
France (May 2014)	152

Source: Simon, Y., Morel, C., (2015), Op-Cit, p. 16

1.2.5. Non-Banking Financial Institutions

In recent years, market liberalization¹ has allowed non-banking financial institutions to offer their clients a wider variety of services. Some of these services are difficult to distinguish from those provided by banks, including those related to foreign exchange transactions. Institutional investors, such as insurance companies, pension funds, and hedge funds, are also highly active in the foreign exchange market (Paul Krugman, Maurice Obstfeld, Marc Melitz, 2015, p. 355).

¹ Market liberalisation means the process of reducing or removing government regulations, restrictions, and controls over a market to allow for more competition and free market forces to operate. The goal is to make the market more efficient, competitive, and dynamic.

1.3. The segments of the Foreign Exchange Market (Spot Exchange Rate and Forward Exchange Rate)

Until 1990, the foreign exchange market was decentralized and operated by phone. The rise of electronic brokers (1990-1995) led to centralized, which was further accelerated by trading platforms, although phone-based markers remain key for large transactions.

The interbank foreign exchange market is divided into two main segments: the spot exchange rate and the forward market. The spot exchange rate refers to the rate at which currencies are exchanged for immediate delivery, typically settled within 48 hours. In contrast, the forward exchange is the rate agreed upon today for a currency exchanged that will take place at a future date.

The relationship between the forward rates and the spot rate can be quantified and is commonly expressed as an annualized percentage, indicating whether the forward rate is at a premium or discount relative to the spot rate.

A foreign currency is at a forward premium against a given currency when the forward price of the foreign currency is higher than its spot price. The opposite is true in the case of a forward discount. The percentage per annum premium (+) or discount (-) in a forward quote in relation to the spot rate is computed by the following formula (Rita Rodrigues, E. Eugene Carter, 1984, p. 96-97):

$$\text{Forward premium/discount} = \frac{(\text{Forward rate} - \text{Spot rate})}{\text{Spot rate}} \times \frac{12}{\text{Number of months forward}}$$

1.4. The Exchange Rate Quotations

A foreign exchange quotation is the price of a currency expressed in another currency. Foreign exchange rates can be quoted as the number of units of the home or domestic currency per unit of the foreign currency, or as the number of the foreign currency units per domestic currency unit (Wang Peijie, 2005, p. 2).

The exchange rate quotation results from the interaction of supply and demand in the foreign exchange market. The demand for foreign currency primarily comes from buyers of goods and services priced in foreign currency (importers), borrowers in foreign currencies, tourists and residents traveling abroad, and investors in foreign markets. Meanwhile, the supply of foreign currency originates from sellers of goods and services priced in foreign currencies (exporters), tourists and residents coming from abroad, and foreign investors.

To facilitate foreign exchange transactions, all currencies are identified by common code used across financial markets. The internationally adopted standard is the IOS 4217 code (a list of currency and fund codes). This coding system follows a simple principle: the first two letters represent the country, while the third corresponds to the currency. Below are some of currencies code:

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- **USD:** United States Dollar
- **GBP:** Great Britain Pound
- **CHF:** Swiss Franc (Confederation Helvetica Franc)
- **CAD:** Canadian Dollar
- **DZD:** Algerian Dinar

A Quotation consists of two prices: The bid price is the price at which the dealer giving the quote is willing to buy one unit of the base currency against quoted one. The ask or offer rate is the price at which the dealer is prepared to sell one unit of the base currency against quoted currency.

The difference between the bid and ask price is called the spread.

For example, the USD/EUR exchange rate indicates the value of the US dollar, which called base currency in British Pound Sterling, which is the quoted currency. If a bank quotes **USD/EUR = 0.8674/0.8676**

- 0.8674 is the bid price, the bank will buy USD for 0.8674 EUR
- 0.8676 is the ask price, the bank will sell USD for 0.8676 EUR

There are two ways to quote the exchange rates: Direct Quotation also called the price quotation represents the number of units of foreign currency required to obtain one unit of national currency, or it is the price one unit of the domestic currency expressed in a foreign currency. Indirect Quotation or volume Quotation is the number of units of national currency required to obtain one unit of foreign currency, or it is the price of one unit of foreign currency expressed in the domestic currency.

$$\text{Indirect Quotation} = \frac{1}{\text{Direct Quotation}}$$

2. Measures of the Exchange Rate

Different measures of the exchange rate can be defined. The exchange rate can be determined in relation to a single currency or a basket of currencies from trading partners.

2.1. Nominal Bilateral Exchange Rate

The exchange rate represents the relative price of one currency against another one. In another words, it indicates the amount of domestic currency that must be exchanged to obtain one unit of a foreign currency. When referring to the exchange rate, we generally mean the nominal bilateral exchange rate, which is quoted on financial markets.

2.2. Real Bilateral Exchange Rate

The real bilateral exchange rate measures a currency's purchasing power in terms of foreign goods by adjusting the nominal exchange rate for price levels. It accounts for inflation differences between two countries and reflecting external purchasing power. The real exchange

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rate is crucial for assessing price competitiveness, as it incorporates both exchange rate movements and inflation dynamics between the economies being compared. The RER is calculated as follows:

$$RER = NER \times \frac{P^*}{P}$$

Where, NER is the nominal exchange rate. P^* represents the foreign price level. P represents the domestic price level.

When domestic prices rise faster than foreign prices (P^*/P decreases), and the nominal exchange rate remains fixed, the real exchange rate increases, meaning the domestic currency appreciates, leading to a loss in competitiveness. Conversely, when domestic prices fall relative to foreign prices (P^*/P increases), and the nominal exchange rate is fixed, the real exchange rate decreases, meaning the domestic currency depreciates improving competitiveness.

2.3. Nominal Effective Exchange Rate

The nominal effective exchange rate of a currency measures its overall value relative to the currencies of its main trading partners. It is calculated as a weighted geometric average of the bilateral exchange rates, where the weights reflect the importance of each partner based on their share in the country's total external trade. This provides a more accurate picture of a currency's international value than looking at individual exchange rates.

The nominal effective exchange rate (NEER) of a currency j is defined as:

$$EER_j = \pi(BER_i)^{\alpha_i}$$

Where, for each trading partner i , BER_i represents the exchange rate between the domestic currency j and the foreign currency i , expressed as the number of units of currency i per units of currency j . The bilateral exchange rate increases when currency j appreciates. α_i reflects the competitive importance of country i in the trade, with:

$$0 \leq \alpha_i \leq 1$$

2.4. The Real Effective Exchange Rate (REER)

Similar to the nominal effective exchange rate, which combines bilateral nominal exchange rates, the real effective exchange rates (REER) aggregates bilateral real exchange rates. Although its calculation is more complex, the REER provides a more comprehensive measure of a currency's value by accounting for price level differences between countries.

Section 02: The International Monetary System

International trade requires a connection between national monetary systems, ensured by a stable international monetary system. This system helps avoid bartering, corrects balance of payments imbalances, provides the global economy with a means of payment, and limits excessive speculation.

This section will first present the international monetary system and the evolution of its rules and practices. Then, we will examine the different types of exchange rate regimes.

1. The Evolution of the International Monetary System

The international monetary system « I.M.S » refers to a set of practices and institutions that govern the settlement of transactions between countries as well as the money creation internationally (FARID YAICI, 2015, p. 15). Supporting stable and high global growth, while enhancing price and financial stability are the main objectives of the IMS.

The IMS provides the structure through which countries conduct borrowing, lending, trade, and financial transactions across borders. It also sets the rules for addressing imbalances in the balance of payments. Over time, various versions of this of this system have been implemented, each offering different mechanisms for managing these economic interactions. The IMS is the institutional framework of international exchange. It serves to:

- Provide a settlement currency for international transactions
- Establish a link between the value of each national currency and the international currency
- Trigger adjustment or rebalancing mechanisms

The international monetary system has been through many stages of evolution over time. It is transferred from a fixed exchange rate regime to a floating exchange rate regime:

1.1. The Gold Standard (1870-1914)

Gold has long been used as a monetary reference and a store of value. By the late 19th century, major economic powers (Europe, the United States) adopted the gold standard ensuring convertibility² into gold. The gold standard is a fixed exchange rate system, in which each currency is defined by a specific weight of gold. The exchange rate of two currencies is determined by the ratio of their gold weights.

Table below presents the exchange rate parities of main currencies in the time with gold.

² The convertibility of a currency refers to the ability to be converted or exchanged into gold or another currency, without restrictions or government-imposed limitations. A convertible currency indicates a strong economy.

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Table 1.3: Currency exchange rate parities with gold

Date	Monetary unit	Exchange rate parity with gold
1803	Franc Geminal	0,29032 grams
1816	Pound Sterling	7,32 grams
1834	Dollar	1,5 grams
1873	German Reichsmark	0,3982 grams

Source : YAICI, Y., (2015), « Précis de finance internationale : avec exercices corrigés », Préface de D. Plihon, Paris : Ellipses, p. 17

The issuing authority must regulate the monetary circulation within the limits of gold reserves, thereby ensuring a stable relation between the currency in circulation and the gold reserves.

The currencies of different countries are freely convertible to gold. Currency convertibility into gold was restricted, it was allowed only for transactions involving gold bars (internal convertibility) or for international exchanges (external convertibility).

The gold standard system presented several advantages and disadvantages:

Advantages	Disadvantages
▪ The gold standard limited money creation by requiring gold reserves, reducing inflation risks and ensuring price stability. ▪ Pegging currencies to gold stabilized exchange rates, enhancing trade predictability. ▪ It also corrected trade imbalances through gold flows between countries.	▪ Economic growth relied on gold discoveries ▪ Large gold inflows could cause inflation ▪ Insufficient reserves led countries to abandon the system ▪ High interest rates reduced investment and growth

World War I disrupted international trade and stopped the free movement of gold. Due to the economic instability caused by the war, governments gave up the gold standard, bringing this system to an end.

1.2. The Gold Exchange Standard (1914-1944)

The gold exchange standard was established in 1922 following the Genoa³ Agreements and was implemented between the two world wars. It was based on the convertibility of each currency into one or more currencies, that were freely convertible into gold fixed rate. The currency of a country is issued based on its gold reserves and currencies reserves convertible into gold, such as the British pound and the US Dollar. This mechanism facilitated money

³ Conference of Genoa, (April 10–May 19, 1922). post-World War I meeting at Genoa, Italy, to discuss the economic reconstruction of central and eastern Europe and to explore ways to improve relations between Soviet Russia and European capitalist regimes.

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creation and reducing the dependence on gold. However, several countries introduced exchange rate controls in 1931, leading to the collapse of the system after the abandonment of the convertibility of the pound sterling. The United States suspended the convertibility of the US Dollar in 1933 but restored in 1944.

The gold exchange standard had several limitations but offered two major advantages:

Advantages	Limitations
▪ Provided a stable monetary benchmark for international transactions ▪ Countries maintained their official exchange rates, ensuring balanced trade and financial stability	▪ Reserve currency vulnerability ▪ Excess liquidity creation ▪ Monetary instability ▪ Restore global trade and rebuild war-torn economies

1.3. The Bretton Woods System (1944-1971)

The Bretton Woods system was adopted by 44⁴ countries during the Bretton Woods conference in July 1944. Its objectives were to stabilize exchange rates, prevent the disorders of the interwar period, and create favourable conditions for trade development and growth.

Two opposing theories emerged: the United Kingdom, represented by J.M. Keynes and the United States represented by H. White. White advocated for the U.S dollar as the only currency convertible into gold, while Keynes supported the Bancor, a currency defined in relation to other currencies (ABADIE, MERCIER Suissa, 2011, p. 14). It was based on the following fundamental principles:

- The Bretton Woods System aimed to prevent competitive devaluation and promote economic competitiveness. It established a fixed exchange rate regime where only the U.S dollar was convertible into gold at 35 USD per ounce, while other currencies were pegged to the dollar
- Countries could hold their reserves in gold, U.S dollar, or trusted foreign currencies such as the British pound, the German mark, or the Japanese yen.
- Exchange rates were fixed but adjustable within a margin of more or less than 1%, requiring central bank intervention.
- The U.S dollar was the only currency directly convertible into gold, relieving the U.S of the need to defend its currency.
- Trade transactions were free, but capital movements remained controlled.
- The IMF was created to oversee the system, assist countries in financial difficulty, and ensure balance of payments stability. Each country contributed based on a quota, partly in gold and the rest its national currency.

⁴ Four African countries were presented at the BW conference: Egypt, Libya, South Africa and Ethiopia.

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- The creation of the international Bank for reconstruction and Development (BIRD): this international institution was initially established to facilitate the recontraction of European economics but gradually shifted its mission toward financing developing countries (FARID YAICI, 2015, p. 26).

The international monetary system established by the Bretton Woods agreements initially functioned well due to Marshall plan and the inflow of American capital. However, starting in 1950, the rising demand for dollar led to economic instability, which deteriorated in 1960's owing to the U.S balance of payment deficit and the decline in U.S gold reserves.

Table below presents U.S gold reserves.

Table 1.4: Evolution of the U.S gold Reserves

Period	U.S gold reserves	U.S Dollar held abroad
End of 1955	21,80	11,70
End of 1960	17,80	18,70
End of May 1968	10,70	31,50

Source : Ouamar, Z., (2016), « Les déterminants du choix du régime de change en Algérie ». Mémoire de Magistère en Sciences Économiques, Option : Monnaie-Finance-Banque, Université Mouloud Mammeri de Tizi-Ouzou, p. 39

In 1969, the IMF created Special Drawing Rights (SDRs) to meet the need for international liquidity. In 1976, NIXON ended the U.S dollar's convertibility into gold, marking the end the Bretton Woods System. In 1973, the system officially shifted to floating exchange rates.

1.4. The Current International Monetary System

The current IMS is based on Jamaica Accords⁵ of 1976, which established a floating exchange rate regime, where exchange rates are determined by supply and demand in foreign exchange markets and demonetized gold. The exchange rate can either be purely floating without central bank intervention or managed with monetary authority interventions. Certain countries peg the value of their currencies to a single currency or a basket of currencies, depending on their trade partners or special drawing rights. The system is characterized by the crucial role of the IMF.

⁵ The Jamaica Accords were concluded in 1976. They eliminated any reference to gold, abandoned the fixed adjustable exchange rate system, adopted a floating exchange rate regime and strengthened the oversight of the economic policy of countries of the IMF members

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The IMF was created in July 1944 at the United Nations conference in Bretton Woods (United States), where representatives of governments established a frame work for economic cooperation to prevent a return to the disastrous policies to the Great depression. The IMF is responsible for ensuring the stability of the international financial system and for maintaining an optimal balance between macroeconomic adjustment and financing. The IMF works to achieve sustainable growth and prosperity for all of its 191 member countries (Eiteman, Stonehill, & Moffett, Year, p. 34). The IMF is governed by and accountable to its member countries. Additionally, it aims to (Varma Lakshmi, 2019, p. 31):

- Promote international monetary cooperation;
- Support balanced growth of international trade;
- Encourage the stability of the exchange rate;
- Correct disequilibrium of the Balance of payment.

The IMF offers financial assistance to members to resolve balance of payments issues, conditioned on economic adjustment programs. It also provides technical assistance and training in fiscal policy, exchange rates, financial regulation, legislation, and statistics.

Its funds come from member quotas, credit arrangements, and bilateral borrowing agreements. It also created Special Drawing Rights (SDRs), an international reserve asset designed to complement the official reserves of the members countries. The SDR is not a currency but rather a potential claim on the freely usable currencies of the IMF members. it can be exchanged for the currencies of the IMF members. The SDRs is defined by a basket of currencies: the US dollar, Euro, Chinese Yuan, Japanese Yen, and the British pound.

2. The Exchange Rates Regimes

An exchange rate regime refers to a set of rules, employed by a country to determine the value of its currency relative to foreign currencies.

The international monetary system classifies the exchange rate regimes into three categories: a fixed exchange rates, a freely floating exchange rates regime, and a managed exchange rates regime.

2.1. Fixed Exchange Rates Regime

A fixed or pegged exchange rate is a regime in which monetary authorities set a reference exchange rate, linking the national currency to a single foreign currency or a basket of currencies based on trade relationships. The decision to peg a currency to a single foreign currency or a basket depends on the country's trade relationships. If a country has a dominant trading partners (over 50% of trade with one country, as per Williamson, 1996), it may opt a single-currency peg. Conversely, pegging to a basket of currencies helps stabilize the effective exchange rate when trade is diversified. However, currency basket often lack transparency, as their composition and weighting are not always disclosed, whereas as single currency peg is simpler and more transparent. Pegging to special drawing rights, which are based on a basket

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of five major currencies is one possible approach. However, some countries choose not to adopt this option because the value of SDRs has been decreasing.

A fixed exchange rate does not imply an irrevocable commitment to fixed value, central banks intervene in the foreign exchange market to maintain the exchange rate close to its fixed parity. This requires accumulating foreign exchange reserves to defend the currency.

- If the national currency appreciates too much, the central bank sells domestic currency and buys foreign reserves.
- If the national currency depreciates significantly, the central bank buys domestic currency using its foreign exchange reserves.

If the central bank's reserves become insufficient, it may adjust the official exchange rate through devaluation or revaluation.

- Devaluation increases the number of local currency units needed to obtain a unit of foreign currency, making exports cheaper and imports more expensive.
- Revaluation strengthens the national currency, meaning fewer local currency units are needed to buy foreign currency, making imports cheaper but exports less competitive.

Finally, a fixed exchange rate system requires the central bank to align its monetary policy with that of the country to which it is pegged even if it is not necessarily suitable for domestic economic conditions.

2.2. Floating exchange rate regimes

Floating exchange rate regimes are those in which a currency's value is determined by the forces of supply and demand in the foreign exchange market. The exchange rate fluctuates continuously based on market dynamics.

- A currency appreciates when its value increases due to higher demand than supply.
- A currency depreciates when its value decreases due to higher supply than demand.

According to Friedman (1953), a pure, independent, free, or perfect floating exchange rate occurs when there is no intervention by the central bank or monetary authorities. This theoretical model aligns with an ultra-liberal perspective where the state does not interfere in the foreign exchange market through buying or selling currencies. The country does not need any adjustment that is often required in a fixed-rate regime and so it does not have to bear the cost of adjustment (International Business Finance, p.14).

In reality, central banks may still intervene in the foreign exchange market or use monetary policy to influence exchange rate movements. This intervention is not meant to defend a predetermined exchange rate level but to smooth excessive exchange rate fluctuations, this system is referred to as "dirty floating" or managed floating.

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In the floating exchange rate system, foreign exchange reserves remain unchanged, as the exchange rate adjusts naturally, and monetary policy focuses on domestic economic objectives such as price stability and employment, rather than maintaining a specific exchange rate. Most advanced economies today operate under a floating exchange rate system, including Japan, Canada, South Africa, the United States....

2.3. Managed Floating Exchange Rate Regimes

From considering a fixed rate with fluctuation bands, it is easy to envisage a system, or rather a non-system, where the authorities manipulate the exchange rate to suit their own (usually unannounced) objectives, sometimes intervening to fix the rate, sometimes staying on the sidelines (Laurence S. Copeland, 1994, p.19).

Manages floating or dirty floating system is a compromise between fixed and floating exchange rates. The exchange rates are determined by supply and demand and the central banks intervene in the foreign exchange market to limit excessive fluctuations while allowing some flexibility. Supporters of intermediate regimes argue that they combine the advantages of both fixed and floating systems. However, critics believe they inherit the disadvantages of both rather than benefits.

2.4. Advantages and disadvantages of Exchange Rate Regimes

Exchange rate regimes have several advantages and disadvantages:

	Advantages	Disadvantages
Fixed Regime	▪ A fixed exchange rate helps control inflation by enforcing monetary discipline and aligning policies with the anchor country. ▪ It reduces inflation expectations, boosts investor confidence, lowers risk premiums. ▪ It facilitates trade and investment by minimizing exchange rate uncertainty.	▪ A fixed exchange rate restricts monetary policy autonomy. ▪ It exposes the currency to speculative attacks, and lead to real appreciation. ▪ It reduces export competitiveness and slowing growth.
Floating Regime	▪ A floating exchange rate allows automatic current account adjustment, monetary policy independence, and no mandatory central bank intervention, with speculation helping stabilize rates naturally.	▪ A floating exchange rate can lead to high volatility, discouraging trade and investment, and may be inflationary. ▪ Global financial cycles limit monetary policy independence, and the currency may be seen as less stable than under a fixed regime.

Section 03: Typology and the choice of the exchange rate regimes

Exchange rate regimes, ranging from free floating to fixed, are classified into several categories, based on their degree of monetary autonomy. Their selection, crucial for open economies, relies on a cost-benefit analysis and goes beyond the fixed vs. floating dichotomy.

This section explores the typology of exchange rate regimes, their classification, and the criteria a country uses to determine its optimal exchange rate regime.

1. The typology of the Exchange Rate Regimes

Following Frankel (1999), exchange rate regimes can be viewed as a spectrum ranging from fixed to floating.

Monetary Union	A monetary union is the most rigid regime, as it leads to the disappearance of the concept of exchange rates in favour of conversion rates (Jean Pierre Allegret, 2005, P. 12). It is formed when multiple countries adopt a single currency and establish a shared central bank. The central bank implements a common monetary policy, manages the union's foreign exchange reserves and guarantees the irrevocability of the adopted conversion rates.
Currency Board	A currency board regime is a fixed exchange rate system in which a country legally commits to maintaining a nearly absolute stability of its national currency against a specific foreign currency. The strong commitment by the authorities makes the regime highly rigid. It establishes a legal link between the domestic currency and one foreign currency or a basket of currencies. This system ensures that the amount of central money in circulation is fully backed by the central bank's foreign exchange reserves held by the central bank.
Dollarization:	Dollarization occurs when a country adopts another country's currency, losing control over its own monetary policy. The issuing country retains control over its currency. While the U.S dollar is the most common, other currencies like the euro can also be adopted. The expected advantage of dollarization is reducing the spread between the domestic exchange rate and the foreign interest rate, thereby eliminating exchange rate.
Adjustable peg (fixed but adjustable exchange rate system)	The adjustable peg system is a fixed exchange rate regime allowing periodic adjustments. A country links its currency to another or a basket of currencies at a fixed rate, with limited fluctuation margins. The parity can be adjusted in response to balance of payment imbalances. Similar to the Bretton Woods system, had fluctuation margins of more or less than 1% (1944-1971) and more or less than 2% (1971-1973). Its rigidity depends on the frequency of adjustments and stability measures during market pressures.

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Crawling peg	Crawling peg is a hybrid of fixed exchange rate and flexible exchange rate, in which the value of currency is pegged to the value of another currency but it allowed to fluctuate within a certain limit. Therefore, this system avoids too much of instability and too much of rigidity. This system is less rigid because the exchange rate bands are periodically adjusted and the central rate are modified by the authorities. The parity is adjusted regularly based on predetermined parameters to account for financial and economic changes, such as inflation differentials between countries.
Crawling Bands	Crawling bands is a system in which the exchange rate floats within a predefined band, with the central bank intervention to adjust and prevent the exchange rate from exceeding the floating band barriers. These bands can be classified as horizontal or adjustable. ▪ In a horizontal band system, the exchange rate moves around a fixed central parity, a regime previously adopted by European countries before the introduction of the euro. ▪ In an adjustable band system, the central parity follows a trend, either appreciating or depreciating over time. Adjustable bands have been widely used in economies experiencing high inflation, such as Brazil in the 1980s and 1990s. in such cases, the exchange rate is adjusted to align with inflation, preventing excessive appreciate of the real exchange rate.
Conventional pegged arrangement	A conventional pegged arrangement fixes a country's currency to another currency or a basket of currencies, with public disclosure of the composition. The country maintains the peg through direct or indirect interventions, ensuring the exchange rate fluctuation within narrow margins (typically less than $\pm 1\%$ around central rate or within a 2% fluctuation range for at least six months).
Stabilized arrangement	A stabilized arrangement involves a spot market exchange rate remaining within a 2% margin for at least six months, without floating, expect for a few outliers or step adjustments. The stability can be measured against a single currency or a basket of currencies, with confirmation through statistical methods.

2. The choice of Exchange Rate Regimes

The choice of an exchange rate regime is a crucial decision in macroeconomic and monetary policy, impacting trade, financial stability, and economic growth. This choice depends on a country's specific needs and global economic and financial conditions.

The analysis of the determinants of exchange rate regime choice is based on several theoretical approaches that consider economic, structural, and political factors. These approaches help explain why some countries adopt a fixed exchange rate regime, while others opt for a floating or intermediate regime.

2.1. The theory of Optimum Currency Areas (OCA)

The OCA theory, introduced in 1961 by Mundell, and later developed by Mc. Kinnon and Keen. this approach seeks to determine the conditions under which a group of countries would benefit from forming a monetary union by adopting a single currency. In return, these countries give up the exchange rate as a tool of economic policy.

2.1.1. Definition of an OCA

An optimal currency area (OCA) is a geographical region where a fixed exchange rate system is adopted for internal transactions, while exchange rates remain flexible with external economies. Within an OCA, transactions can take place using either a single currency or multiple currencies with fixed exchange values, while their exchange rates fluctuate relative to third-party currencies.

A currency area is considered “optimal” if it allows for efficient adjustment to economic shocks while ensuring internal stability (low inflation and unemployment) and external stability (balance of payments equilibrium). The formation of a monetary union can result either from third countries adopting the currency of another country (dollarization, euroization), or from the creation of a single currency within a region.

Eurozone (European Monetary Union), Dollar zone (Countries using the U.S dollar) and CFA franc zone (West and Central African countries) are examples of optimal currency area.

2.1.2. Criteria of an OCA

Optimal currency area theorists have identified key criteria for monetary areas: Mundell emphasized factor mobility, McKinnon openness, Kenen diversification, financial integration, and Cooper and Kindleberger preference.

2.1.2.1. The labour Mobility

Mundell’s criterion (1961) highlights factor mobility, particularly, labour mobility as a key adjustment mechanism to asymmetric shocks⁶ in a monetary union. Without a flexible exchange rate, a country facing negative shock can no longer devalue its currency to regain competitiveness. Instead, adjustment must occur through the mobility of labour and capital among member countries.

If a country A experiencing a crisis and its workers can easily migrate to country B, where economic conditions are better, this helps reduce unemployment and mitigate the shock. Thus, labour mobility is crucial to offset asymmetric shocks between member countries.

Wage flexibility also plays a role, if mobility is low, the affected country must rely on internal adjustments like wage cuts, which can help maintain employment, while higher wages in expanding economies absorb demand. Factor mobility is thus an indicator of the degree of

⁶ Asymmetric shocks are common shocks that affect the countries in the zone but with varying magnitudes.

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economic integration among member states. The higher it is, the more viable the monetary union becomes.

In an ideal OCA, these mechanisms ensure economic stability without needing exchange rate adjustments. If labour mobility and wage flexibility are insufficient, floating exchange rates remain a better option to absorb shocks.

2.1.2.2. Degree of Trade integration (McKinnon, 1963)

In 1963, McKinnon expanded the optimum currency area theory by introducing the openness criterion, which links a country's trade integration to its exchange rate regime choice. He argued that highly open economies are more exposed to global price fluctuation, making fixed exchange rates preferable for stability. Conversely, closed economies benefit from flexible exchange rates, allowing better adjustment to economic shocks. He provided two main justifications for this view:

- Exchange rate fluctuations significantly impact domestic prices in open economies, making fixed exchange rates preferable to ensure price stability.
- Exchange rate policy loses effectiveness in highly open economies, as the expected benefits of devaluation (such as increased exports and reduced imports) become limited when trade dependency is high.

According to McKinnon, the level of trade integration determines the choice of exchange rate regime. In high open economy, a fixed exchange rate enhances stability by reducing transactions costs and uncertainty. Conversely, in a less open economy, a flexible exchange rate allows for better economic adjustments. Countries in an optimal currency area benefit most from fixed exchange rates due to strong trade integration and limited external exposure.

2.1.2.3. Production Diversification

In 1969, Kenen expanded optimum currency area theory by introducing production diversification, he argued that highly diversified economies are less reliant on exchange rate adjustments to absorb asymmetric shocks.

A diversified economy can mitigate the negative effects of demand shocks (such as inflation or unemployment) because it has multiple sectors that can compensate for fluctuation in any single industry. Instead of relying on international labour mobility to restore equilibrium, a well-diversified economy can adjust internally through sectoral shifts.

Diversified economies are better suited for fixed exchange rates and monetary unions due to fewer interventions needs, while specialized economies benefit from floating rates to adjust to demand shocks. Greater diversification reduces reliance on exchange rate policies and lowers the cost of adopting a monetary union.

2.1.2.4. Financial Integration criterion

Ingram and Johnson (1969) expanded the optimum currency area theory by highlighting the critical role of financial integration in determining the viability of a monetary union. They argued that previous models overlooked how financial markets contribute to exchange rate stability.

According to their view, full capital mobility and liberalized financial markets allow capital to move faster than labour, serving as an automatic balance of payment adjustment mechanism. In a highly integrated financial system, even small interest rate changes can lead to capital flows that naturally correct economic imbalances without the need for exchange rate adjustments. Thus, stronger financial and monetary integration diminishes the necessity of exchange rate fluctuations for economic stability.

2.1.2.5. Homogeneity of Preferences criterion

Cooper and Kindleberger (1977, 1986) introduced homogeneity of preferences as a key criterion for an optimum currency area. They argued that a monetary union functions effectively when member states share common economic objectives, such as inflation control and employment policies. For a successful union, policies and economic priorities must align, ensuring policy convergence among countries. If trade is strong and public preference are similar, nations are more likely to benefit from a common currency. The European Monetary union exemplifies this principle, as its creation was based on policy alignment formalized in the Maastricht treaty.

2.2. The Impossible Trinity and Choice of Exchange Rate Regime

The impossible trinity, or trilemma was first introduced by R. Mundell (1972) and later updated by T. Padoa Schioppa in in the context of European monetary unification. It highlights the difficulty for a country to simultaneously achieve three key objectives of the international monetary system:

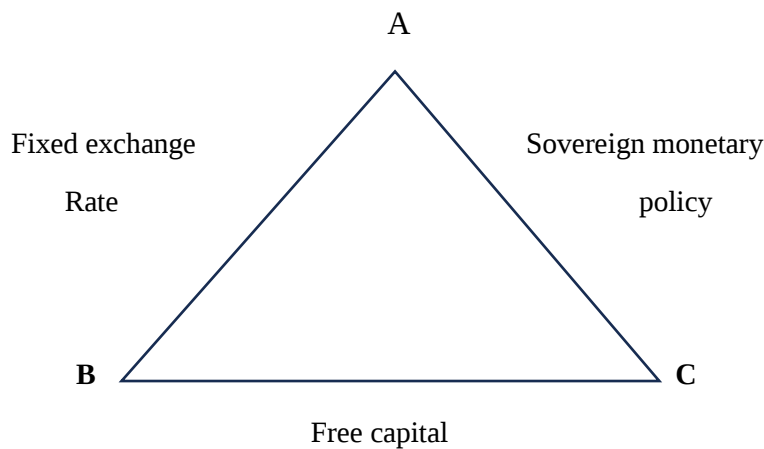
- Exchange rate stability
- Capital mobility
- Monetary policy autonomy

Since these three goals are mutually exclusive, a country must sacrifice one to maintain the other two. The three extreme monetary regimes are represented at the vertices of the triangle:

- A (Full bilateralism): fixed exchange rates and capital controls, preserving monetary policy autonomy.
- B (Monetary union): fixed exchange rates and free capital movement, but no monetary policy autonomy.
- C (Pure flexibility): floating exchange rates and capital mobility, ensuring monetary autonomy.

The figure below presents the impossible trinity.

Figure 1.1: The Impossible Trinity



Source : Allegret, J. P. (2005), « Les régimes de change dans les marchés émergents : Quelles perspectives pour le XXI^e siècle ? », *Revue d'économie financière*, p. 13

This frame work illustrates the trade-offs that countries face designing their monetary and capital flow policies.

2.3. The nature of Economic Shocks and the Choice of Exchange Rate Regime

Economic shocks are unexpected changes affecting demand and supply. They can be supply or demand shocks, permanent or temporary, and monetary or real. The nature of economic shocks plays a crucial role in determining whether a country should adopt a fixed or flexible exchange rate regimes.

- Flexible exchange rates preferable when external nominal shocks (such as sudden exchanges in foreign interest rates, exchange rate speculation) dominate, as they allow the economy to adjust quickly and absorb macroeconomic fluctuations.
- Fixed exchange rates are more suitable when internal nominal shocks (such as changes in domestic inflation expectation, wage increases, or shifts in monetary policy) are predominant.
- Flexible regimes are also favoured in the presence of real shocks, whether external or domestic, as they provide better economic stability.

Conclusion

International trade and financial transactions require currency exchanges, as each country has its own national currency. These exchanges take place in the foreign exchange market (FOREX), a continuously operating global market where currencies are traded based on supply and demand, determining the exchange rate.

This market is structured around major banks and central banks, which intervene to regulate exchange rate fluctuations. The rapid globalization of economies and the advancement of information and communication technologies have significantly increased its dynamism.

A stable international monetary system is essential for smooth economic transactions. Historically, it has undergone major transformations, from the gold standard to the Bretton Wood system, and finally to today's hybrid system, where floating and managed exchange rates coexist. Countries now have the flexibility to choose their exchange rate regime, whether fixed, floating, or intermediate (managed floating). However, with increasing capital mobility, the trend has shifted towards greater exchange rate flexibility to adapt to financial dynamics.

Ultimately, the choice of an exchange rate regime remains a crucial decision for economic stability, trade competitiveness, and monetary policy. As financial markets continue to evolve, countries must adopt exchange rate policies that balance monetary independent, exchange rate stability, and economic resilience in an international world.

CHAPTER II: DETERMINANTS OF EXCHANGE RATE: A LITERATURE REVIEW

Introduction

The determination of exchange rates is a central issue in international macroeconomics, as it directly influences a country's monetary and trade policies. Since the early 20th century, various theories have been developed to explain exchange rate fluctuations and predict their equilibrium levels. Initial approaches focused on the exchange of goods and services and general price levels. However, with the 1970s, contemporary models emphasize the predominant role of financial variables in explaining exchange rate variations. Several fundamental factors, such as inflation, the current account balance, and interest rates, significantly influence these fluctuations.

Understanding real exchange rate variability involves distinguishing between short-term volatility and long-term misalignment. While short-term volatility can prevent and discourage trade and investment, particularly in developing economies, long-term misalignment may lead to economic distortions such as resource misallocation, reduced competitiveness and lower growth. These misalignments often result from inconsistent macroeconomic policies, requiring corrective measures to restore equilibrium.

This chapter is structured as follows:

- **Section 01:** Theories of Exchange Rate Determination: A Literature Review
- **Section 02:** Empirical Literature Review on the Determinants of Exchange Rates
- **Section 03:** Real Exchange Rate Variability and Convergence toward Equilibrium

Section 01: Theories of Exchange Rate Determination: A Literature Review

Several theories attempt to explain exchange rate levels and fluctuations. Among them, the purchasing power parity theory and the balance of payments approach emphasize arbitrage in goods and services markets, linking exchange rates to anticipated inflation and trade flows.

In contrast, other approaches focus on the financial sphere rather than the real economy to explain exchange rate variations. These theories emerged in a context where financial transactions vastly exceed trade in goods, significantly influencing exchange rate dynamics.

1. Real Exchange Rate Approach

Theories explaining exchange rate variations include purchasing power parity (PPP) and the balance of payment approach. PPP establishes a link between the exchange rate and expected inflation, while the balance of payment approach considers economic flows between countries.

1.1. Purchasing Power Parity (PPP)

The purchasing power parity links exchange rates to the relative prices of goods and services between countries. Formalized by Cassel in the 1910s, PPP traces its origins back to Navarro in the 15th century, followed by Hume and Ricardo in the 18th century.

1.1.1. Presentation the Purchasing Power theory

According to Dornbusch (1985): « Purchasing Power Parity (PPP) is a theory of exchange rate determination. It asserts that the exchange rate change between two currencies over any period of time is determined by the change in the two countries' relative price levels. Because the theory singles out price level changes as the overriding determinant of exchange rate movements it has also been called the inflation theory of exchange rates ».

The purchasing power of a currency refers to the value of a currency within a country, which is determined by the quantity of goods and services that can be purchased with a unit of the currency.

The PPP theory therefore predicts that a fall in a currency's domestic purchasing power (as indicated by an increase in the domestic price level) will be associated with a proportional currency depreciation in the foreign exchange market. Symmetrically, PPP predicts that an increase in the currency's domestic purchasing power will be associated with a proportional currency appreciation (Krugman, P. R., Obstfeld, M., Melitz, M. J., 2015, p. 386).

The PPP theory is based on three hypotheses:

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- The foreign exchange market is perfect, meaning there are no administrative exchange controls, information costs, or transaction fees.
- The goods markets are perfect, implying the absence of tariffs, transportation costs, administrative controls, or indirect regulation (such as health controls or requirements to comply with country-specific standards).
- The structure of consumption is identical across different countries, meaning that economic agents consume the same basket of goods.

1.1.2. The two versions of the Purchasing Power Parity

In 1922, Gustave Cassel proposed defining the equilibrium nominal exchange rate as the rate that ensures the purchasing power parity between two countries. This principle is divided into two version: Absolute PPP and Relative PPP.

1.1.2.1. Absolute Purchasing Power Parity

The absolute purchasing power parity is based on the assumption that the law of one price applies to all goods and services. This law states that in competitive markets free of transportation costs and official barriers to trade (such as tariffs), identical goods sold in different countries must sell for the same price when their prices are expressed in terms of the same currency. The absolute PPP is obtained by applying the law of one price to a basket of goods in the context of international comparisons.

According to Macdonald Ronald (2007), this theory posits that the nominal exchange rate of a country is established by comparing the overall price levels between the domestic and foreign countries. In other words, there is an equilibrium exchange rate between two currencies that ensures equal purchasing power in different countries. This rate adjusted to reflect differences in prices level, which forms the basis of absolute purchasing power parity:

$$S_t = P_t^* / P_t$$

Where S_t is the spot rate expressed as number of units of home currency per unit of foreign currency, P_t is the price index in the home country, and P_t^* is the price index in foreign country.

In practice, if prices are lower in one country than another, arbitrage opportunities arise, leading to increased demand for the cheaper goods. This demand drives up prices and appreciates the local currency until price levels and exchange rates stabilize, ensuring equal purchasing power between the two currencies. However, absolute PPP does not always hold due to trade barriers, transportation costs, and structural economic differences (market structure, competition intensity, non-tradable goods like services, etc...). because price levels do not equalize perfectly, the relative PPP concept introduced, which accounts for gradual price adjustments over time.

1.1.2.2. The relative PPP

The relative purchasing power parity derives from the absolute version, but is less restrictive. It abandons absolute analysis in favour of reasoning based on differentials or variations. Indeed, the relative PPP theory predicts that the exchange rate evolves to reflect changes in price levels over time, but does not necessarily bring them to equality. The exchange rate between two countries will adjust to offset the impact of differences in their inflation over time. According to this theory, the percentage change in exchange rate between the currencies of two countries over a given period approximately equals the difference in the inflation rates in the two countries over the same time interval. The purchasing power parity is giving by the following formula:

$$\Delta E_t = \Delta P_t - \Delta P^*_t$$

Where ΔE_t is the relative change in exchange rate, ΔP_t is the relative change in domestic prices, and ΔP^*_t is the relative change in foreign prices.

Purchasing power parity considers that over a medium-term period, changes in the price ratio between two countries influence the exchange rate. The country (A) with higher inflation experiences a greater depreciation of its currency to reflect the loss of purchasing power due to the price differential. In other word, country (B) experiences its own currency appreciate relatively.

1.1.3. Limits of purchasing power parity

The purchasing power parity (PPP) theory of exchange rates presents several problems:

Contrary to the assumption underlying the Law of One Price, trade barriers such as transport costs and restrictions on trade exist, and may be significant enough to prevent certain goods and services from being exchanged between countries.

Since inflation data in different countries are based on distinct baskets of goods and services, exchange rate fluctuations do not necessarily offset official inflation differences. This remains true even in the absence of trade barriers and when all products are freely tradable.

Some goods and services are not perfect substitutes and cannot be compared solely on price. Quality differences limit the arbitrage opportunities needed for convergence. Additionally, consumer preferences vary across countries, and firms set rigid, market-specific prices to maximize profits.

1.2. The Balassa-Samuelson effect

The persistent deviation of the real exchange rate from the exchange rate predicted by the purchasing power parity (PPP) led to two separate studies: the first by Balassa (1964) and the other by Samuelson (1964).

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Balassa and Samuelson argued that empirically, when all countries' price levels are converted to dollars (common currency) at prevailing nominal exchange rate, rich countries tend to have higher price levels than poor countries (Kenneth Rogoff, 1996, p. 658). This phenomenon is not merely due to higher absolute productivity levels in rich countries compared to poor countries but rather their relative productivity advantage in tradable goods sector.

The Balassa-Samuelson effect explains the distortion in purchasing power parity due to international differences in relative productivity between the tradable goods sector (manufacturing and agriculture) and the non-tradable goods sector (services).

According to Asea and Mendoza (1994), differences in labour productivity between tradable and non-tradable sectors affect relative prices, which in turn cause fluctuations in the real exchange rate.

These authors show that when a country is catching up with the income levels in the more economically advanced economies, it will face a continuous real appreciation of its exchange rate. Since traded goods prices are determined in the global market, relatively faster productivity growth in the tradables sector will translate into rising wages in this sector that will also bid up wages in the non-tradable sector (Couharde, C. et al., 2019, p.1).

1.3. The determination of the Exchange Rate through the Balance of Payment approach

The exchange rate and the balance of payment are closely linked, influencing economic policy in an open economy.

1.3.1. Balance of Payments concepts

According to Richard Ward, the Balance of Payments Accounts are "a systematic accounting of a nation's economic transactions with the rest of the world, over a given time period " (Pereira, J. A., 1998, p.7).

The main objective of balance of payments is to record, in accounting form, all real, financial, and monetary flows between a country and the rest of the world, providing a precise overview of a country's international economic relations. It serves as a key tool for managing exchange rate policy, economic policy, and monetary policy.

The balance of payments accounts only record transactions between domestic and foreign entities. Internal transactions among residents do not appear, though they may indirectly affect the balance of payments (for example, changes in domestic interest rates influencing foreign investment). It can be compiled monthly, quarterly, or annually. Seasonal adjustments are crucial to avoid misinterpreting regular fluctuations as long-term trends.

1.3.2. The structure of the Balance of Payment

All economic and financial transactions carried out between residents⁷ and non-residents during a given period are recorded in the balance of payments.

The balance of payments follows the principles of double-entry accounting, requiring each transaction to be recorded twice: once as a credit (+) and once as a debit (-). Barring errors and omissions, the sum of all credits must always equal the sum of all debits, ensuring that the balance of payments remains balanced. It is traditionally divided into three major components: the current account, the capital account, and official reserves.

1.3.2.1. The Current Account

The current account in the balance of payments is a statement of actual receipts and payments over a short period. It includes the value of exports and imports of both visible and invisible goods and can show either a surplus or a deficit. It is divided into two intermediary balances: the balance of trade (merchandise) and the balance of invisible transactions.

➤ Merchandise (Balance of Trade)

The balance of trade records exports and imports of physical goods and non-monetary gold movement. The difference between the value of exports (credit) and imports (debit) determines the trade balance, which can be either deficit (negative balance) or surplus (positive balance).

The trade balance is crucial because it measures both a country's competitiveness and its level of dependence on foreign goods.

➤ The Balance of Invisibles

The balance of invisibles differs from the trade balance in that it does not cover the exchange of tangible goods but instead records the balance of services, the income balance, and unilateral transfers.

1) Balance of Services includes all exports and imports of services such as freight and transportation, international trips (tourism), insurance, banking, film rentals, royalties, etc.

2) Income Balance records net investment income (profits, dividends, interest on foreign investment), and net compensation of Employees (wages paid by non-residents employers to their resident employees, and vice versa).

⁷ Residents would be those individuals or institutions that have a permanent association with the territory of a country, together with the government authorities of the mentioned country, in all levels. In that concept are included, therefore, all individuals and economic units that are subordinated to the national authorities, although they can be foreign.

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3) Unilateral Transfers cover changes in Gifts among countries (contributions, charitable donations, war repair, immigrant' transfers, etc).

The sum between trade balance and balance of invisibles creates the current account.

1.3.2.2. The Capital Account (Balance of Capitals)

The capital account records two main categories of capital-related transactions: The first involves capital transfers, where one party has transferred ownership of something to another party without receiving anything in return. Capital transfers include conditional grants for specific capital projects (e.g., foreign aid project to build roads) and forgiveness of debt. The second of transaction involves non-financial, and non-produced assets. This includes intangible assets (e.g., brand names) as well as rights to use land or water (e.g., for mining or fishing).

1.3.2.3. The Financial Account

The financial account records transactions that involve financial assets and liabilities between residents and non-residents. The financial account indicates the functional categories, sectors, instruments, and maturities used for net international financing transactions. The financial account is classified according to the instrument and functional categories (SNA, 2008, p. 133). The financial account is divided into five categories based on the nature of financial flows (Foreign direct investment, portfolio investment, financial derivatives, other investments).

1.3.2.4. Reserves Account

Official reserves accounts measure the changes in international reserves owned by the country's monetary authorities, usually the central bank, during the given period. International reserves are composed mainly of gold and convertible foreign exchange. Foreign exchange reserves are financial assets denominated in such currencies as the U.S dollar, which are freely and easily convertible into another currencies (Rita Rodrigues, E. Eugene Carter, 1984, p. 16). The reserves account also includes transactions with the IMF, such as purchases (credit) and repurchases (debits) from international monetary fund, and the special drawing rights.

1.3.2.5. Errors & Omissions

The errors and omissions account is an adjustment account used to record transactions that are misreported or unaccounted for, either intentionally or unintentionally. It also accounts for discrepancies between different data sources.

1.3.3. Importance of the Balance of payments in determining the Exchange Rate

The information contained in the balance of payments and the analysis of certain balances (deficits or surplus) can help explain exchange rate levels. This approach highlights how the

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balance of payments influences the supply and demand for foreign currencies, consequently the movement of exchange rates.

Indeed, the balance of payments can be either deficit or surplus depending on the movement of goods and services. If imports exceed exports, the current account balance is in deficit. Conversely, if exports exceed imports, the current account balance is in surplus. A deficit increases the demand for foreign currencies in exchange for the national currency in the foreign market. As a result, all the value of the national currency decreases, leading to a depreciation. Conversely, a surplus reduces the demand for foreign currencies and consequently increases the value of the national currency in the foreign market.

Regarding the financial account, capital flows influence exchange rate movements. Foreign capital inflows appreciate the domestic currency, while outflows lead to depreciation.

1.3.4. Adjustment of the Balance of Payments in a Fixed and Floating Exchange Rate System

In a fixed exchange rate system, the central bank intervenes to maintain currency parity by adjusting foreign exchange reserves. It sells reserves during a deficit to stabilize the exchange rate and buys reserves during a surplus to prevent appreciation. Persistent imbalances may lead to devaluation or revaluation.

In a floating exchange rate system, the exchange rate adjusts automatically based on supply and demand. A deficit leads to currency depreciation, while a surplus causes appreciation, ensuring external balance without central bank intervention.

2. The Financial Exchange Rate determinations

Alongside theories explaining exchange rate variations through arbitrage in goods and services markets, alternative approaches focus on the financial sphere rather than the real economy to explain exchange rate fluctuations.

2.1. The Interest Rate Parity theory

The interest rate theory, introduced by J.M. Keynes (1923), explains exchange rate determination through international capital movements. Unlike the purchasing power parity (PPP) theory, it is based on arbitrage between financial investments and establishes a link between interest rates and both spot and forward exchange markets.

According to this theory, exchange rates are influenced by differences in real interest rates across financial markets. A higher interest rate attracts foreign capital and supports the national currency, while a lower interest rate differential between two currencies is reflected in forward and expected future exchange rates.

The theory is based on the following assumptions:

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- National and foreign securities are equivalent in terms of risk and maturity.
- Perfect capital mobility, implying no capital controls, no transaction costs, and no market imperfections.

The interest rate parity (IRP) theory can be interpreted through two distinct approaches: uncovered interest rate parity and covered interest rate parity.

2.1.1. Uncovered Interest Rate Parity Theory

The Uncovered Interest Rate Parity theory states that investors do not hedge against the risk caused by unexpected exchange rate fluctuations. In the absence of capital flow restrictions and if capital markets are perfectly competitive, any difference in nominal interest rates between two countries will be offset by expected changes in the exchange rate.

The expected parity equation is written as:

$$i - i^* = \frac{S^e - S}{S}$$

where i is the domestic interest rate, i^* is the foreign interest rate, S^e is the expected future exchange rate, and S is the nominal exchange rate.

According to uncovered interest rate parity theory, a lower domestic interest rate compared to the foreign rate encourages residents to invest abroad, increasing the supply of domestic currency and the demand for foreign currency, leading to a depreciation of the domestic currency.

2.1.2. Covered Interest Rate Parity

Covered exchange rate parity states that an investment in foreign currency, fully hedged against exchange rate risk using forward contract, should generate the same return as a domestic currency investment. This is based on the idea that, in the absence of arbitrage, the difference between the forward exchange rate and the spot exchange rate, known as the forward discount must equal the interest rate differential between the two countries. If this condition is not met, arbitrage opportunities arise, encouraging investors to transfer funds between currencies until market equilibrium is restored.

Thus, if the forward discount is lower than the interest rate differential, investors will be incentivized to buy foreign assets and sell domestic ones. Conversely, if the forward discount exceeds this differential, the opposite incentives will occur. The covered interest rate parity can be expressed as follows:

$$i - i^* = \frac{F - S}{S}$$

where i and i^* are respectively the domestic and the foreign interest rates, S is the spot exchange rate and F is the forward exchange rate.

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According to the covered interest rate parity, an agent holding a sum of money in domestic currency can place this amount either in domestic currency at the nominal interest rate or in foreign currency at the foreign interest rate, in the same bank (CAMARA. Y, 2008).

2.2. The relationship between PPP and Fisher Effect

The theory proposed by Fisher establishes a relationship between interest rates and inflation rates.

According to Fisher (The theory of interest, 1930), the nominal interest rate, which links the money held today to the money that will be held tomorrow, consists of two elements: the expected real interest rate, representing the rate at which current goods and services are transformed into future goods and services, plus an inflation premium, corresponding to the expected inflation (SIMON Yves, 2012, p. 200). This relationship is expressed as follows:

$$I_{\text{nominal}} = I_{\text{real}} + \pi^e$$

$$\text{Nominal interest rate} = \text{Real interest rate} + \text{Expected inflation rate}$$

The Fisher effect is the foundation of the monetary approach, which suggests that when the interest rate rises, the exchange rate depreciates. In the long term, an increase in the interest rate differential between countries occurs only when expected inflation differs between them.

2.3. The Monetarist Approach to Exchange Rates

The monetarist approach to exchange rates, developed in the 1970s by Johenson and Frankel, Mussa, Dornbusch, and Kouri, is based on the idea that exchange rates are determined by monetary equilibrium in a flexible exchange rate regime. It emphasizes the role of monetary supply and demand rather than trade flows. This approach is fundamentally based on money demand, considered a strong and stable macroeconomic relationship. This demand classically depends on income, prices, and interest rates:

$$(1) \quad M = P \cdot L(y, i)$$

$$(2) \quad M^* = P^* \cdot L(y^*, i^*)$$

Where M and M^* represent national and foreign money supplies, P and P^* represent national and foreign price levels, y and y^* represent national and foreign income, and i and i^* represent domestic and foreign real interest rate.

Equation (1) and (2) define monetary equilibrium based on supply, flexible prices, and similar income and interest rate functions across countries. The exchange rate is integrated using purchasing power parity (PPP), expressed as $P = E \cdot P^*$ (E represents the exchange rate). Combining between equation (1) and (3) and eliminating prices establishes a relationship between the exchange rate and money supply (ADOUKA Lakhdar, 2011, p. 57):

$$E = \frac{M}{M^*} \cdot \frac{L(y^*, i^*)}{L(y, i)}$$

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An increase in the money supply leads to higher prices and a depreciation of the national currency. Conversely, a restrictive monetary policy reduces money supply, resulting in currency appreciation.

The monetary approach views the balance of payments as a monetary phenomenon, where external equilibrium depends on changes in money supply and demand. An excess money supply leads to a balance of payments deficit, while monetary tightening can restore equilibrium.

2.4. The Balanced Portfolio Model

The origins of portfolio balance literature date back to the 1950s, with the works of Markowitz, Sharpe, and Tobin. However, these models were expanded in the second half of the 1970s by several economists, such as Ronald McKinnon, Paul Masson, Willem Branson, and Pentti Kouri.

This model assumes that the exchange rate is determined by the interaction of supply and demand forces in financial asset markets. Domestic and foreign are considered imperfect substitutes, meaning investors take into account relative returns and potential risks of both domestic and foreign assets. As result, investors prefer to diversify their portfolios.

The portfolio balance model explains that changes in trade balance leads to a redistribution of wealth, shifting from deficit countries to surplus countries.

According to this model, the determinant of the exchange rate is based on the short term, where the exchange rate is determined by the interaction of supply and demand in financial asset markets, and the long term, where it is influenced by the interaction between financial asset markets and real economic flows.

3. Macroeconomic approaches

This part will discuss the main theories of the real equilibrium exchange rate, including the FEER, DEER, and BEER approaches.

3.1. Fundamental Equilibrium Exchange Rate (FEER)

Williamson (1985) proposed the FEER model as a benchmark macroeconomic approach. He emphasized the medium term as the most important horizon for assessing the effects of the real exchange rate, whether in terms of internal equilibrium (full employment) or external equilibrium (trade balance). Thus, the FEER represents the real exchange rate that ensures, over the medium term, internal balance, defined as a trade-off between inflation and employment, and external balance for an economy engaged in international trade (MEZENE, M., 2018, p. 378).

However, one of the main challenges with the FEER is its practical feasibility. Williamson himself acknowledged that the model is difficult to implement in operational terms. Although the model is based on economic fundamentals (such as the current account balance,

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inflation, and production levels), it is complex to calculate due to methodological issues and the variance in macroeconomic objectives between countries depending on their level of development. For this reason, Williamson suggested calculating the FEER using multinational macroeconomic models.

3.2. Desired Equilibrium Exchange Rate

Several authors have conducted combined studies in recent years within the IMF (Artis & Taylor, 1993) and (Bayoumi, Peter, Steve & Mark, 1993) to determine the FEER. These studies led to the development of a new concept: the DEER, or Desired Equilibrium Exchange Rate, which also aims to ensure internal and external equilibrium of an economy in the medium term. This new concept emphasizes the desired equilibrium exchange rate as synonym of real equilibrium exchange rate, promoting consistency between macroeconomic equilibrium and the underlying policy objectives.

The DEER introduces a normative aspect in defining the REER, hence the term desired with the goal of achieving a targeted level of balance in both the current account and employment. The IMF, in this context, presents the pursuit of the DEER as an objective in itself.

3.3. Econometric approach: Behavioural Equilibrium Exchange Rate (BEER)

Clark and McDonald (1997) developed a composite model called BEER. This approach is more pragmatic than the REER/DEER models, as it focuses more on empirically explaining the determination and evolution of the exchange rate rather than providing purely theoretical framework. Their approach involves selecting a set of fundamental variables that can influence the long-term real exchange rate, such as terms of trade, inflation, oil prices, foreign exchange reserves, and unemployment rates. The next step is to identify cointegration relationship between the exchange rate and these fundamentals: $Q = Af$, where f represents the vector of long-term fundamentals (MEZENE, M., 2018).

According to Clark and McDonald, the gap between the actual exchange rate and its estimated long-term value, based on the cointegration relationship, allows for the assessment of exchange rate misalignment.

Section 02: Empirical Literature Review on the Determinants of Exchange Rate

This section aims to present a review of previous research on the determinants of exchange rates worldwide.

Numerous studies have explored the determinants of exchange rates. The initial efforts to analyse exchange rate behaviour were undertaken by Budiger Dornbusch (1973), Richard Meese (1979), and Kenneth Rogoff (1983). Later, Philippe Lan (1999) examined both nominal and real exchange rates over the long term. His findings indicated that certain variables, such as openness, economic growth, and terms of trade, play a crucial role in explaining both real and nominal exchange rate fluctuations.

The study conducted by Drine Imed and Chistophe Rault, using panel unit root tests, panel cointegration tests, and estimated method confirms that real exchange rates in developing countries (45 developing countries) do not follow a fixed or general norm. instead, their trajectory depends on several country-specific economic factors. They found that the key determinants influencing the real exchange rate in the long run are terms of trade, trade openness, foreign direct investment inflows, public spending, domestic investment and GDP per capita (Balassa-Samuelson effect).

Cerrato M and Sarantis N (2003) examined the purchasing power parity hypothesis using monthly data on black market exchange rates from twenty emerging market economies from January 1973 to December 1993. The study applied a unique panel of black-market exchange rates, advanced heterogeneous panel unit root and cointegration tests to evaluate whether the real black market exchange rate follows a mean-reverting process. They found that panel unit root does not support mean reversion in the real black market exchange rate, while panel cointegration tests provide evidence in favour of a long-run relationship between exchange rates and relative prices.

Bouri Sara and Chahinez Badraoui employed the cointegration techniques to study the main determinants of Algeria's real exchange rate over the period 1970-2016. They found that investment, the development of the banking systems, and trade openness play a crucial role in explaining Algeria's real exchange rate dynamics. The study findings suggest that economic diversification and a well-functioning financial system are essential for exchange rate stability.

The study of Mohamed Achouche and Hamid Kherbach (2006) employs a dynamic stochastic general equilibrium model and vector error correction model to analyse Algeria's real exchange rate determinations. The empirical results indicate that Algeria's real exchange rate is influenced by economic fundamentals.

The study conducted by Mussa Michael L (1984) developed an integrated model of exchange rate behaviour, synthetizing a monetary approach where the exchange rate is treated

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as an asset price. It incorporates rational expectations and reduced-form conditions for equilibrium in both money markets and balance of payments. The study finds that exchange rate movements are largely unpredictable and influenced by both monetary factors (money supply and demand) and real factors (current account). It discusses the phenomenon of exchange rate overshooting, where monetary disturbances create short-term deviations from purchasing power parity. It highlights the limited ability of simple monetary models to explain exchange rate fluctuations, suggesting that both monetary and real economic forces play a role.

Edwards (1989) developed a theoretical model of the real exchange rate and estimated its equilibrium value for a panel of developing countries. He identified key factors influencing the real exchange rate, including terms of trade, public spending, capital flows, exchange and trade controls, the chronological progress and capital accumulation.

Achy Lahcen (2001) examined the real equilibrium exchange rate for five MENA countries, including Algeria, Morocco, Tunisia, Egypt and Turkey from 1985 to 1997 to analyse the long-term relationship between the real effective exchange rate and key economic fundamentals, using the Edwards model (1989-1994) and Elbadawi's approach (1994), applying a cointegration method to assess the long-term. The findings show a long-term relationship between the REER and these key economic fundamentals.

Similarly, Joseph and Linda Joyce Kamas (2003) analysed the factors influencing the real exchange rate in Argentina, Colombia and Mexico over the long term. Though cointegration analysis, they established a relationship between the real exchange rate and real economic variables, including terms of trade, capital flows, productivity, and the government's share of GDP. Their results confirmed the significance of terms of trade and productivity in determining the real exchange rate.

Some Yirlier Hyacinthe (2008) examined the determinants of the exchange rate between the Canadian dollar and the Japanese yen using macroeconomic models (Monetary and portfolio model) and microstructural models (order flows and market liquidity models) and estimating a VAR model to identify key influencing factors. The study results show that aggregate demand shocks drive most of the exchange rate fluctuations, oil prices indirectly influence CAD/JPY despite low direct trade, monetary shocks have a short-term effect but no long-term impact, the exchange rate exhibits overshooting behaviour after monetary shocks, and no strong long-term cointegration exists between exchange rates and macroeconomic fundamentals

Another study conducted by Achouche Mohamed and Hamid Kherbach (2006), applying the purchasing power parity theory to analyse the real exchange rate of the Algerian dinar from 1970 to 2003, employing unit root tests to examine the stationarity of the real exchange rate, cointegration analysis (Johanson test) to determine long-term equilibrium relationship, and least squares regression to estimate the relationship between the nominal rate, domestic price levels, and foreign price levels. Their analysis found that there is a long-term equilibrium relationship between the exchange rate and price levels, validating the relative PPP hypothesis for Algeria.

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Dufrénot and Yehoun (2005) analysed the determinants of the real exchange rate across 64 developing countries, applying panel cointegration techniques. The study considered variables such as productivity, terms of trade, openness, and government expenditures. The results indicate that factors like openness and terms of trade significantly influence the real exchange rate in low-income countries.

Hasanov. F (2009) estimated the equilibrium real exchange rate through multiple approaches, including the Purchasing Power Parity, macroeconomics Balance, Behavioural Equilibrium Real Exchange Rate and Permanent Real Exchange Rate. His findings identified key determinants of the real exchange rate, namely relative productivity, trade openness, net foreign assets, government expenditure, and oil prices.

Si Mohammed k (2015) conducted an empirical test of purchasing power parity of the Algerian exchange rate. The study covered the period January 2003-May 2015 (149 monthly observations), applying panel cointegration tests, panel error correction model and unit root tests to check stationarity. They found that the purchasing power parity holds in the long run for Algeria and its nine main trading partners (Canada, China, Japan, Switzerland, Sweden, Turkey, UK, US and Eurozone). Panel cointegration tests confirmed a long-run relationship between exchange rates and relative prices. The error correction model indicates that exchange rate deviations from PPP adjust at a rate of 30% per month. The study provides strong empirical support for PPP in Algeria, confirming a long-term equilibrium between the exchange rate and relative prices, despite short-term fluctuations.

Alioui Fatima Zahra (2018) studied the key determinants of the Algerian real effective exchange rate from 1974 to 2013, using Elbadawi's model (1998) and vector autoregressive model (VAR). The study results indicate that trade openness and foreign exchange reserves have a negative impact on the real effective exchange rate, but terms of trade (oil price) have a positive impact on the stability of the REER.

Several empirical studies have been conducted to examine whether higher exchange reserves reduce exchange rate volatility and ensure its stability. Hviding Ketil, Michael Nowak et al. (2004), using panel data regression analysis and the system generalized method of moment (GMM), found that higher reserves reduce exchange rate volatility. Their study suggests that holding sufficient reserves lowers real exchange rate fluctuations in emerging markets, and countries with flexible exchange rate regimes benefit more from higher reserves in terms of exchange rate stability. The study indicates that reserves accumulation is crucial tool for stabilizing exchange rates.

Empirical studies on developed countries by McDonald (1996), Oh (1996), Papell (2002), using Unit Root tests, as well as studies by Zumaquero & Urrea (2002), Pedroni (2001) using the cointegration approach, generally confirm the validity of the PPP. Their results indicate that the exchange rate adjusts to changes in relative prices, supporting the PPP hypothesis. However, Drine & Rault (2003) et Mami (2004) studies, who distinguished developed countries and developing countries, show that the PPP holds for developed countries

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but not for developing countries. Additionally, the study of Brasher & Mohsin (2004), applying panel cointegration approach to a sample of 10 Asian countries, lead to a rejection of the PPP hypothesis (Kazadi.J, 2020). High exchange rate volatility and excessive monetary growth in developing countries further challenge PPP's applicability (Phylaktis & Kassimatis, 1994; Luintel, 2000).

The study conducted by Urbanovsky Tomas (2017) examined the relationship between the exchange rate, current account and financial account in the Czech Republic using cointegration analysis and vector error correction model. The study results show that the current and financial accounts are closely linked and influence each other, exchange rate changes do not significantly impact the balance of payments components, capital inflows can deepen current deficits, posing risks to economic stability and policymakers should be cautious about financial market liberalization to avoid balance of payments crises.

Sarno Lucio and Taylor Mark P. (2002) studied the purchasing power parity and the real exchange rate, using unit root tests for real exchange rate stationarity, cointegration models to test long-run PPP validity, threshold and STAR models to capture nonlinear reversion and panel data methods for stronger statistical evidence to major industrialized countries. The study concludes that while PPP is a useful long-run exchange rate anchor, short-term deviations are significant due to nonlinearities, market frictions and real economic shocks.

Satour Rachid, Sadallah Amine, Boucha Mohamed and Fekarcha Sofian (2020) analysed the determinants of the exchange rate in Algeria from 1990 to 2017, using stationarity tests, structural change test and ordinary least squared (OLS) method. The study shows that the exchange rate is positively linked to gross domestic product and trade openness, but negatively to terms of trade and exports.

Boucheta Yahia studies the determinants of the real equilibrium exchange rate of the Algerian dinar from 1986 to 2010 using cointegration techniques and the ECM model based on Edwards. His analysis found that external debt and Net foreign Assets have a significant impact on the long-term real exchange rate. Similarly, Achouche Mohamed developed an econometric model of the real equilibrium exchange rate of the Algeria from 1970 to 2003. His empirical study, validated through variance analysis and impulse response functions, identified the key determinants of the real exchange rate in Algeria (Zidat Rafika, Nasri Amia, 2021).

Likka Korhonen and Tui Juurikkala (2009) analysed the determinants of equilibrium real exchange rates in a sample of oil-dependent countries. Their findings revealed that oil prices have a statistically significant impact on real exchange rates in these oil-producing nations. Specifically, an increase in oil prices leads to an appreciation of the real exchange rate.

Pechding Bunditsakulchai et al. (2024) investigated the relationship between crude oil prices and the real effective exchange rate in Thailand, using Johanson cointegration test. The

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study results shows that there is a significant negative relationship between real crude oil prices and Thailand's REER, a 1% increase in the real oil price leads to a 0.31% decrease in the REER.

Kazadi Joel (2020) examined the validity of the purchasing power parity hypothesis between South Africa and China over the period 1986-2019, using unit root process and cointegration test. The study results indicate that PPP is not valid for South Africa and China from 1986 to 2019, the real exchange rate does not revert to its mean, contradicting the PPP hypothesis, structural breaks and market frictions play a crucial role in exchange rate behaviour and finally, the study suggests that PPP is more applicable to developed economies than to emerging markets. The study finds that long-run equilibrium between the nominal exchange rate and relative price levels. The unit root test results show that the real exchange rate follows a unit root process, implying that deviations from PPP are persistent. The cointegration test shows that the nominal exchange rate and price indices are not cointegrated meaning they do not move together in the long run.

Ito, Isard, and Sxmansky (1999) observed a pronounced effect in high-growth Asian countries (Japan, Korea, and Taiwan), suggesting that the validity of the hypothesis depends on the stage of economic development. The hypothesis is particularly suited for a rapidly expanding under resourced open economy. The expansion must entail a move from an industrial structure and export composition. However, a growing economy does not imply applicability of the Balassa-Samuelson if the economy has recently emerged from the primary goods exporter or planned economy phase.

Macdonald and Ricci (2001) analysed the impact of the distribution sector on the real exchange rate, including the Balassa-Samuelson effect and other macroeconomic variables such interest rates, size of net foreign assets to GDP ratios for ten developed countries (Belgium, Denmark, Finland, France, Italy, Japan, Norway, Sweden, Germany and USA), employing panel dynamic ordinary least squares estimator to estimate long-run coefficients, finding that increased productivity and competitiveness of the distribution sector led to exchange rate appreciation.

Studies on Central and Eastern European countries by Egert et al. (2002), using Panel cointegration techniques showed that productivity growth leads to real exchange rate appreciation, though some effects were mitigated by the structure of the Consumer Price Index (CPI). Analyses in Asia by Kakkr and Yan (2012), Drine and Bault (2002) produced mixed results, with some tests failing to confirm a positive relationship between productivity differentials and relative prices.

After the collapse of the Bretton Woods system in 1973, the monetary approach to exchange rate determination gained prominence. However, the high volatility of exchange rates in the 1980s led to difficulties in empirical validation. Meese and Rogoff (1983) found that the random walk model outperformed monetary models in short-term forecasts, attributing this to issues such as the failure of uncovered interest parity. Despite this, later studies by Mark (1995),

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Groen (2000), Mark and Sul (2001), and Rapach and Wohar (2001) provided evidence supporting the monetary model in the long run. Shidong Zhang, Thomas C. Lowinger and Jie Tang investigate the monetary model of exchange rate determination by applying a multivariate time series model of the US dollar exchange rates to the Canadian dollar, Japanese Yen, and United Kingdom's pound.

Dornbusch and Fischer (1980) examined the relationship between nominal exchange rate and the current account, suggesting a causal link where the current account influences exchange rate determination. However, Martin (2016) found evidence of a reversed relationship, particularly in non-industrial countries, where flexible exchange rate regimes facilitate faster current account adjustments. Larrain (2003) argues for a two-way causality between the current account and the exchange rates.

Vanessa Orellana et al. (2021) investigated the validity of uncovered interest rate parity (UIRP), which established a proportional relationship interest rate differentials and expected changes in nominal exchange rates. Unlike traditional approaches, this study employs a gravity panel framework, modelling interest rate differentials as a function of expected changes in nominal exchange rates. By utilizing all available nominal exchange rate pairings within the sample (contains 45 countries, classified into two groups according to income-level criteria used by the World Bank). The results confirm the validity of uncovered interest rate parity among high-income countries, whereas the hypothesis is not supported for medium-income countries.

Section 03: Real Exchange Rate Variability and Convergence toward Equilibrium

Although the real equilibrium exchange rate depends solely on real variables, the observed real exchange rate is influenced by both real and monetary factors. The existence of an equilibrium value does not imply that the observed rate will always match it. In reality, the observed RER often deviates from its equilibrium path, leading to various macroeconomic imbalances.

This section aims to analyse the exchange rate volatility and misalignment, including their impact on growth and stability. It also reviews empirical studies on real exchange rate misalignment and volatility.

1. Analysis of the cost of Exchange Rate Instability

Highlighting the benefits of exchange rate stabilisation requires first examining the costs associated with exchange rate instability. To effectively analyse these consequences, it is important to distinguish between volatility and misalignment (distortion).

According to Dornbush (1976), volatility refers to short-term fluctuations in the exchange rate, typically measured using the coefficient of variation⁸. This measure is usually applied to the nominal exchange rate due to the lack of short-term inflation, and more importantly, because its primary purpose is to reflect short-term flexibility in current markets.

In contrast, misalignment refers to a persistent deviation of the exchange rate from its long-term equilibrium level (S. Edwards (1987), Elbadawi (1994), Baffes et al. (1997), Montiel (1999, 2003) et Razin et Colins (1999)). Such deviations in the real exchange rate can create significant and lasting differences between the observed rate and its theoretical equilibrium. At any given time, the real exchange rate is influenced not only by economic fundamentals (such as taxes, international prices, real interest rates, terms of trade, etc.) but also by macroeconomic pressures like excess money supply or fiscal deficits.

Short-term deviations are generally inconsistent and stem from temporary fluctuations in real variables, making their adjustment costs often negligible. In this sense, volatility is more of a nuisance than a major obstacle to international trade.

It is often argued that heightened exchange rate volatility increases price uncertainty, which may lead to two main outcomes:

- A slowdown in the growth of international trade
- A rise in foreign direct investment (FDI) as firms seek to mitigate price uncertainty

⁸ Standard deviation divided by the mean of the period.

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However, the relationship between exchange rate volatility and trade growth remains debated. Some empirical studies conducted in developed countries find no significant relationship, while others report a negative correlation between exchange rate volatility and trade growth.

Conversely, studies focused on developing countries clearly demonstrate a negative impact of exchange rate volatility on trade expansion. This discrepancy is not surprising, as developed economies typically have more advanced financial markets and widespread access to hedging instruments, which help mitigate currency risk-tools that are largely unavailable in developing countries.

In an open economy, achieving sustainable macroeconomic balance requires consistency between monetary and fiscal policies and the adopted exchange rate regime. A misalignment between macroeconomic policy and the exchange rate system can generate significant economic imbalances, often reflected in real exchange rate misalignment.

Finally, two types of real exchange rate misalignment are generally identified:

- Macroeconomic misalignment occurs when there is an inconsistency between macroeconomic policies and the established exchange rate system.
- Structural misalignment, on the other hand, arises when long-term sustainable changes in the fundamentals determining the equilibrium real exchange rate are not reflected in the short-term movements of the actual real exchange rate.

Unless the observed real exchange rate adjusts to reflect these changes in the equilibrium rate, the currency is said to be structurally misaligned, often due to shocks such as changes in the terms of trade.

Unlike volatility, misalignments can cause much more serious disruptions to the economy. Persistent deviations from equilibrium distort market signals, after relative domestic prices, and lead to significant adjustment costs that could be avoided if the exchange rate remained close to its equilibrium level.

The costs of such persistent distortions are relatively easy to identify: Overvaluation of the currency may lead to higher unemployment, and undervaluation tends to result in inflationary pressures. These effects often offset each other across countries, more unemployment in one country typically translates into less unemployment in another.

2. Real Exchange Rate Misalignment and Convergence Mechanisms toward Equilibrium

Real exchange rate misalignment can also encourage speculation behaviour, which may result in massive capital outflows and decline in social welfare within the country. Such misalignments place a significant burden on policymakers, as they must manage the associated economy consequences.

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The key to restoring equilibrium lies in eliminating the root cause of the imbalance. In this regard, Peter Montiel, based on the simple definition of the real exchange rate ($RER = E \times P^* / P_n$), proposes two main mechanisms to bring the real exchange rate back to its equilibrium level: By adjusting the domestic price of non-tradable goods (P_n), or by devaluating the nominal exchange rate (E) (P presents the price of tradable goods abroad).

This leads to a distinction between two types of policy responses:

- A disinflation policy (automatic adjustment)
- A devaluation policy

There are also several other policies aimed at realigning the real exchange rate. These include income policies, which involve controlling the rise in prices and wages through certain forms of direct intervention, as well as export subsidy policies and import taxation policies.

All of these are alternative options for correcting distortions. However, they generally less effective than a straightforward nominal devaluation, which remains the most appropriate solution for developing countries.

2.1. Disinflation Policy

In case of macroeconomic misalignment, restoring real exchange rate (RER) equilibrium may rely on correcting inconsistencies between monetary and fiscal policies and the existing exchange rate regime. Authorities may anticipate an automatic adjustment of the observed RER. However, under a fixed nominal exchange rate regime, this adjustment tends to be slow and difficult, primarily due to price stickiness, especially when the economy suffers from a loss of competitiveness due to an overvalued RER. Consequently, relying solely on automatic correction may lead to prolonged adjustment periods, undermining macroeconomic stability and delaying external balances restoring.

2.2. Devaluation

As an alternative, nominal devaluation aims to restore equilibrium by adjusting the domestic price of tradable goods. By increasing the nominal exchange rate (E), it effectively raises the RER, improving external competitiveness. When implemented at the right time, particularly in situations of clear overvaluation, and supported by coherent macroeconomic policies, devaluation can help rebalance the external sector in the medium and long-term. However, if the RER is already close to its equilibrium level, devaluation may simply raise non-tradable prices (P_n), thus having little to no effect on the real exchange rate.

3. An empirical literature review on real exchange rate misalignment and volatility

Zouheir Abida (2010) examined the role of real exchange rate (RER) misalignment on long-run economic growth in three countries of the Maghreb countries over the period 1980-

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2008. He estimated equilibrium RER relying on the Fundamental Equilibrium Exchange Rate (FEER) approach, from which misalignment derived, and a dynamic panel growth model. The findings show that the coefficient for RER misalignment is negative, which means that a more depreciated (appreciated) RER helps (harms) long-run growth.

Benkaddouri Ali and Bouali Hicham (2019) estimated the behaviour equilibrium exchange rate (BEER) in Algeria during the period from 1980 to 2016 and assessed the degree of misalignment. They used the autoregressive distributed lag model (ARDL) methodology to study the long run relationship between REER and a set of determinants. The results show that, in the long-run, government spending, trade openness and net capital flows have a negative relationship with the real exchange rate of the Algerian dinar, while terms of trade and productivity differentials have a positive relationship with the REER. They also found that REER was always deviating from its equilibrium level, between overvaluation and undervaluation.

Getaneh Mihret Ayele (2022) examined the main drivers of real effective exchange rate (REER) misalignment and its effect on the economic growth of East African least developed countries (LDCs). The study applied Pooled Mean Group (PMG) and dynamic OLS estimators for panel and ARDL Bound testing for time series data over the period 1980–2019. The panel results revealed that the REER of LDCs were significantly misaligned for the study period. The REER appreciates for an improved terms of trade and net foreign asset position, while it depreciates for an increased trade openness and broad money supply in the long-run. The panel results also confirmed that the GDP per capita would improve for an increase in real investment and human capital, while it declines for an increase in openness, net foreign aid inflows and REER misalignment in the long-run. The ARDL bound testing results generally support the panel estimation results. In the short-run, the REER misalignment would obstruct growth of Ethiopia while it promotes growth of Kenya.

Ajao Mayowa G. (2015) examined the determinants of real exchange rate volatility in Nigeria from 1981 to 2008, using GARCH (1,1) model to estimate exchange rate volatility, and error correction model (ECM) and co-integration analysis revealed a long-term equilibrium relationship between real and exchange rate volatility and its determinants. The study indicates that openness of the economy and lagged exchange rate has a negative effect, and government expenditures and lagged exchange rate have a positive effect.

Boussaha N, Hamid F and Souam S (2018) proposed a multivariate periodic stochastic volatility (PVAR-SV) model to capture periodicity in stochastic conditional variance of financial time series, model forecast the volatility of oil prices and exchange rate in Algeria and analyse the interactions between oil prices and Algerian exchange rate and improve the accuracy of volatility forecasts using advanced estimation methods, specifically the Periodic Kalman Filter and Particle Filters combined with the expectation maximization algorithm over the period from January 3, 2005 to December 31, 2015 with 2836 observations each analysed times series. The study results indicates that the proposed approach provides accurate and effective volatility forecasting results.

Conclusion

Exchange rates are subject to significant fluctuations, influenced by a combination of real and financial factors. Various theories attempt to explain these variations, some emphasizing trade and price movements, while others focus on capital flows and financial markets. These approaches are not mutually exclusive but rather complementary, helping to capture the complexity of exchange rate dynamics in an integrated global economy. The value of a currency is both a strategic and symbolic asset for nations, reflecting their economic and financial strength.

moreover, the real exchange rate equilibrium is determined by its underlying fundamentals. However, in the short and medium term, the actual real exchange rate also responds to changes in monetary and fiscal policies. When the real exchange rate deviates significantly from its equilibrium level, it is referred to as a misalignment. Regardless of their origin, such deviations from the equilibrium path are likely to generate several macroeconomic problems, including reduced competitiveness, trade imbalances, and economic instability.

**CHAPTER III: AN EMPIRICAL
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Introduction

Effective exchange rates serve as a crucial measure of how a country's exchange rate changes in relationship to its trading partners, providing insight into its overall price competitiveness. This competitiveness plays a central role in enhancing productivity, encouraging innovation, and driving economic growth. In developing countries, the real exchange rate is a key variable for the conduct of economic policy. It not only represents a key instrument in the conduct and implementation of monetary and exchange rate policies but also reflects the stance of the economy (growth, external balance, etc.).

Following the presentation of a theoretical and empirical literature review on the determinants of the exchange rate, this chapter aims to examine the common determinants of real effective exchange rate fluctuations in African oil-exporting countries. It begins with a presentation of the research methodology. Subsequently, the chapter provides a descriptive analysis of the data before proceeding to the empirical investigation using panel data regression techniques.

This chapter is organized as follows:

- **Section 01:** Research methodology
- **Section 02:** Descriptive Analysis
- **Section 03:** Model estimation and results interpretation

Section 01: Research methodology

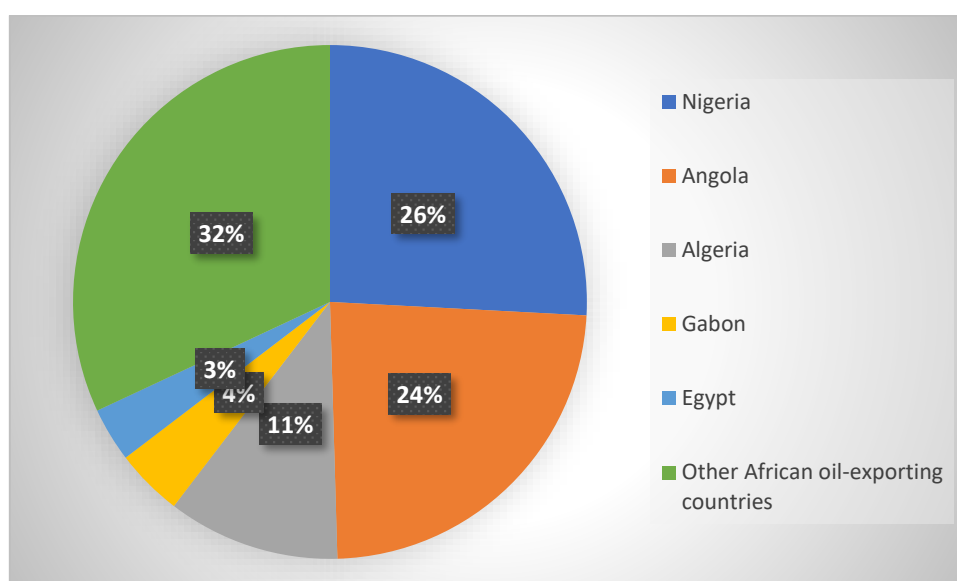
This section will present the sample of our study, the data sources the data collected and the variables related to the model to be estimated, following by a presentation of the research methodology.

1. The sample presentation of the study

The sample of countries constituting the Panel—Algeria, Angola, Egypt, Gabon, and Nigeria—was selected due to their significant weight oil production and exports within Africa. This selection is inspired by the previous studies, such as the work of Thobeka Mdluli (2021) and Da-Wariboko Yvonne Asikiye et al. (2022), which also included libya. However, libya was excluded from this study due to insufficient data availability.

The figure below shows the share of oil exports for each selected country in Africa.

Figure 3.2: The share of oil exports for each selected country in Africa



Source: Personal conception using Excel

1.1. Algeria

Algeria, a major producer of hydrocarbons (oil and natural gas), is the 16th largest oil-producing country in the world and the 3rd in Africa. The importance of the hydrocarbon sector in the Algeria economy makes the international oil price the main adjustment variable for its economy. This exogenous variable is uncontrollable, which explains the extreme vulnerability of the Algeria economy, constantly exposed to the fluctuation in oil prices.

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The main challenge for the Algeria economy remains its heavy reliance on hydrocarbon revenues and public spending. The hydrocarbon sector accounted for 14% of GDP, 86% of exports, and 47% of budget revenues between 2019 and 2023 (World Bank, 2024).

After the negative shock of the pandemic and the decline in oil prices in 2020, the Algerian economy began to recover in 2021. Growth was supported by the recovery in external demand, mainly for oil, whose production increased and prices rebounded. This improvement in oil revenues partially offset the rise in investment spending.

Algeria's hydrocarbon export revenues reached 50\$ billion in 2023, making a 16% decrease compared to 2022, according to data presented the Minister of Energy and Mines in 2024. However, the hydrocarbon sector is expected to maintain its growth, with oil and natural gas exports growing at around 5% in 2024 and 2025. (African Development Bank, 2024). Between January and October 2024, Algeria's oil exports saw a significant increase. They averaged 410000 barrels per day over 10 months, compared to 378000 barrels per day during the same period in 2023.

The country's economic growth rate accelerated from 3.6% in 2022 to 4.2% in 2023, driven by the hydrocarbon sector, industry, construction, and services. Inflation remained high (9.3% versus 9.2% in 2022) due to rising food prices. Real GDP growth is projected to continue at around 4% in 2024 and then slow to 3.7% in 2025. The upward trend in inflation is projected to reverse in 2024, falling to 6.8% in 2024 and 5.7% in 2025 as agricultural production increases (African Development Bank, 2024).

Algeria an oil-exporting country, naturally builds its foreign exchange reserves by exporting hydrocarbons. The rise in global oil prices during the 2000s allowed it to accumulate significant reserves, which peaked at 194.01\$ billion in 2014 (Bank of Algeria, 2023). The drop in oil prices in mid-2014 had a negative impact, causing these reserves to fall to 45.30 billion in 2021. Following the rebound in oil prices in 2022, these reserves slightly recovered (IMF, 2023). The significant overall balance of payments surplus recorded in 2022, along with the smaller surplus in 2023, contributed to rebuilding the stock of official foreign exchange reserves (excluding monetary gold). These reserves reached 60.944\$ billion at the end of 2022 and 68.988 billion at the end of 2023 (Bank of Algeria, annual report, 2023).

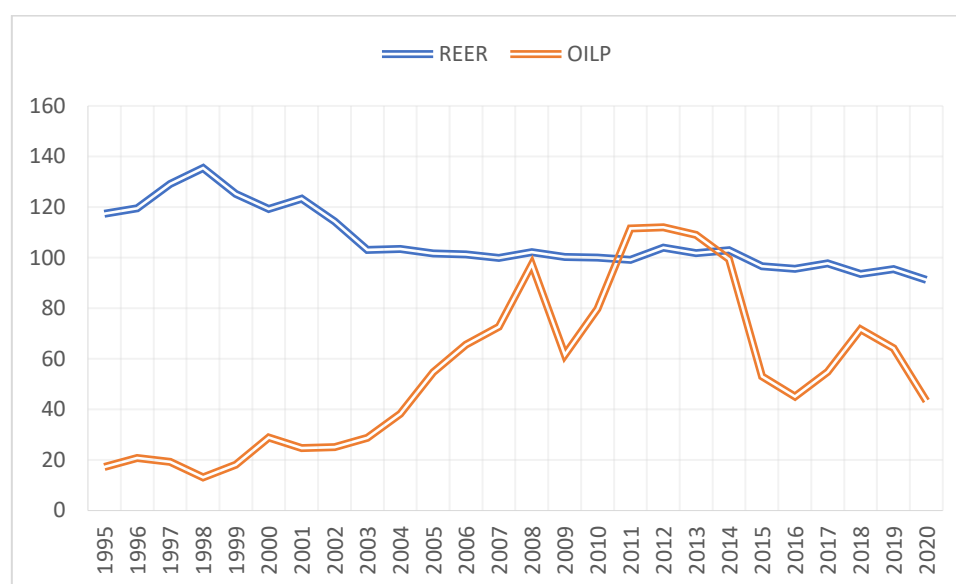
In 2023, the overall balance of payments recorded its second consecutive surplus after eight years of continuous deficits (2014-2012). However, this surplus shrank significantly, dropping from 18.468\$ billion in 2022 to 6.347\$ billion in 2023. This development is explained by the deterioration of the current and capital account balance over the period, despite a relative improvement in the financial account balance. The decline in the current and capital account surplus in 2022 was mainly due to increase in goods exports, particularly hydrocarbons, and, to lesser extent, an increase in imports of goods and services (Bank of Algeria, annual report, 2023).

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The Improvements in the fundamental of the national economy have created room for an appreciation of the dinar. Consequently, the Bank of Algeria appreciated the exchange rate of the dinar against the currencies of the country's trading partners in 2022 and 2023, significantly mitigating the impact of imported inflation (Bank of Algeria, annual report, 2023).

The chart below illustrates the evolution of oil price and the real effective exchange rate of the Algerian Dinar.

Figure 3.3: The evolution of oil prices and the real effective exchange rate of the Algerian Dinar



Source: Personal conception using Excel

In April 1994, Algeria transitioned from a fixed exchange rate regime to a managed floating system under IMF supervision.

1.2. Egypt

The Egyptian government focuses its economic policy on growth through modernization and diversification of the economy. Along with South Africa, Egypt is one of the most diversified economies on the African continent (SECO, 2024, P. 4). However, its economy is rentier in nature, as it relies on tourism, revenues from Suez Canal, remittances from emigrants, and hydrocarbon revenues (Marc Lavergne, 2010, p. 50).

Foreign direct investment inflows into North Africa increased in 2022, reaching 15 billion USD, up from 10 billion USD in 2021. This increase is mainly due to Egypt, which saw its foreign direct investment inflows more than double, amounting to 11 billion USD. As a result, Egypt is the second-largest recipient of foreign direct investment in African behind

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South Africa. The majority of foreign investments have been made in the oil and gas industries (SECO, 2024, p. 3).

Crude Oil Production in Egypt increased to 526000 Barrels per Day in November from 516000 Barrels per Day in October of 2024. Crude Oil Production in Egypt averaged 679970 Barrels per Day from 1994 until 2024, reaching an all-time high of 930000 Barrels per Day in November of 1996 and a record low of 516000 Barrels per Day in October of 2024 (U.S energy information administration, 2024). In 2023, Egypt exported \$2.37B in Crude Petroleum, making it the 34th largest exporter of Crude Petroleum in the world. At the same year, Crude Petroleum was the 4th most exported product in Egypt.

Real GDP growth at market prices recorded 4.2 percent during H1 (July/Dec.) of fiscal year 2022/2023, against 9.0 percent in the corresponding period a year earlier (CBE, 2023, p. 45). CPI inflation rate (urban) rose by 35.7 percent at end of fiscal year 2022/2023 (June/June) against a rise of 13.2 percent at end of the preceding fiscal year (CBE, annual report, 2023, p. 47).

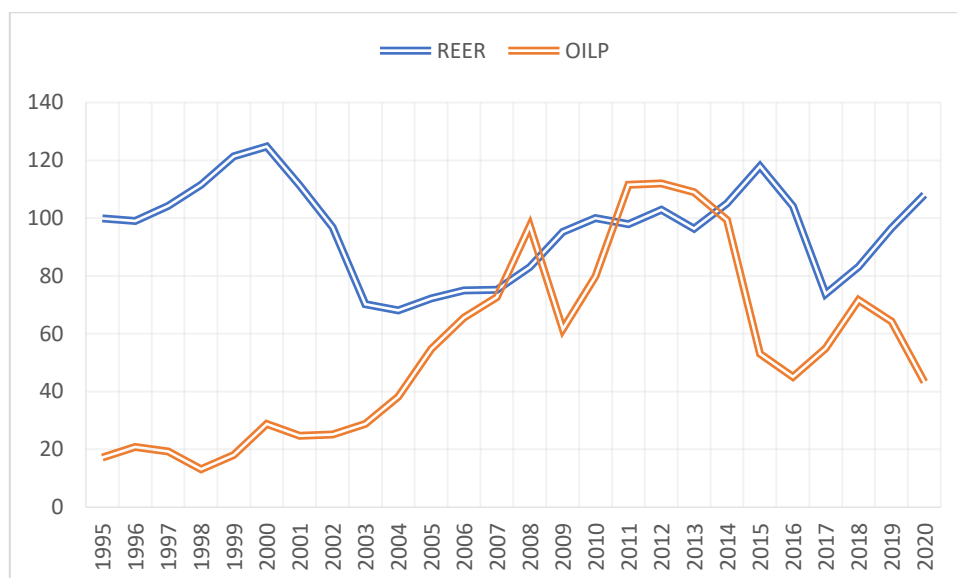
Merchandise exports decreased by 23.5 percent to reach US\$ 16.4 billion, due to the decrease in oil exports by 62.7 percent to US\$ 3.2 billion (19.6 percent of total exports) and the increase in nonoil exports by 2.7 percent to US\$ 13.2 billion (80.4 percent of total exports). As a result, the exports/ imports ratio decreased to 46.9 percent from 58.0 percent. Merchandise imports decreased by 5.3 percent to reach US\$ 35.1 billion, reflecting the decrease in both non-oil imports by 4.7 percent to reach US\$ 28.8 billion (82.0 percent of total imports) and oil imports by 7.8 percent to reach US\$ 6.3 billion (18.0 percent of total imports). (CBE, annual report, 2024, p. 1).

During July/December 2023/2024, net international reserves increased by US\$ 0.4 billion (against an increase of US\$ 0.6 billion in the corresponding period a year earlier) to reach US\$ 35.2 billion, thus covering 6.0 months of merchandise imports at end of December 2023. The increase was an outcome of the pickup in gold by US\$ 0.7 billion and the decline in foreign currencies by US\$ 0.3 billion (CBE, annual report, 2024, p. 9).

The chart below illustrates the evolution of oil price and the real effective exchange rate of the Egyptian Pound.

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Figure 3.4: The evolution of oil prices and the real effective exchange rate of the Egyptian Pound



Source: Personal conception using Excel

By early 2003, the Egyptian central bank announced a shift from a fixed exchange rate regime to a managed float regime. In October 2022, the CBE started to apply a durably flexible exchange rate and decided to gradually repeal letters of credits for import finance, resulting in the appreciation of all currencies against the Egyptian pound. During July/December 2023, the weighted average of the US dollar in the Egyptian inter-bank market approximately stabilized at EGP 30.8931 by the end of December 2023 (compared with the end of June 2023). At end of December 2023, according to the foreign exchange market (buying price), most foreign currencies appreciated against the Egyptian pound (CBE, annual report, 2024, p. 15).

1.3. Nigeria

The most important themes that emerge in the discussion of exchange rates and their management in Nigeria include the high volatility, real exchange rate overvaluation albeit in the context of continuous nominal depreciation, and the search for mechanism for market-determined rate where government is the dominant supplier of foreign exchange. Exchange rate stability is one of the goals of monetary policy in Nigeria, and over the years exchange rate policy has been driven mostly by an obsession to keep the nominal exchange rate 'stable'. For the general public, the health of the economy is gauged by the nominal exchange rate where a depreciating rate is synonymous with a weakening economy (AJAO, Mayowa G., 2015, p. 48).

Nigeria produced more than 1.4 million barrels of oil per day in 2023 to rank as the 16th-largest oil producer in the world. The country produced around 2 million barrels per day

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between 2015 and 2019, and an annual average of about 1.5 million barrels per day from 2016 through 2023. Nigeria continues to dominate as Africa's largest producer of Crude Oil, boasting proven reserves of 37.50 billion barrels (Nigeria Upstream Petroleum Regulatory commission, 2024).

The Nigeria economy is highly dependent on oil and is therefore very vulnerable to fluctuations in oil prices and production. Over the past decade, economic growth has averaged 2.5%. However, the COVID-19 pandemic and the drop in oil prices caused the economy to contract by -1.8% in 2020 (IFM). Economic growth rebounded to 2.6% in 2020, supported by government policy measures, rising oil prices, and international financial aid (BNP Paribas, 2023).

Nigeria 's export value in 2023 amounted to 55.7\$ billion, representing a 12.0% decline compared to 2022 (63.3\$ billion). This decrease follows significant export growth in 2022 (+33.7%) and 2021 (+34.9%). The decline is primarily attributed to the drop in crude oil prices in 2023, as oil accounted for 78.2% of the West African giant's exports between 2018 and 2023. Consequently, the value of crude oil exports fell by 9.9% in 2023, despite a 16.4% increase in export volume, reaching an average of 0.81 mbpd compared to 0.69 mbpd in 2022 (Direction Générale du Trésor français, 2024).

The Nigerian economy experienced a gradual recovery in 2023, following the disruptions caused by the COVID-19 pandemic. The performance of the external sector is expected to improve in 2024, driven by a favourable trade balance, increased domestic oil production, high crude oil prices, and the operationalisation of the Dangote and Port Harcourt refineries. Inflation though elevated, is expected to moderate in 2024. It is projected at 21.40 per cent (within a range of 19.84% and 25.35%) from 28.90 per cent in 2023 (Central Bank of Nigeria, annual report, 2024).

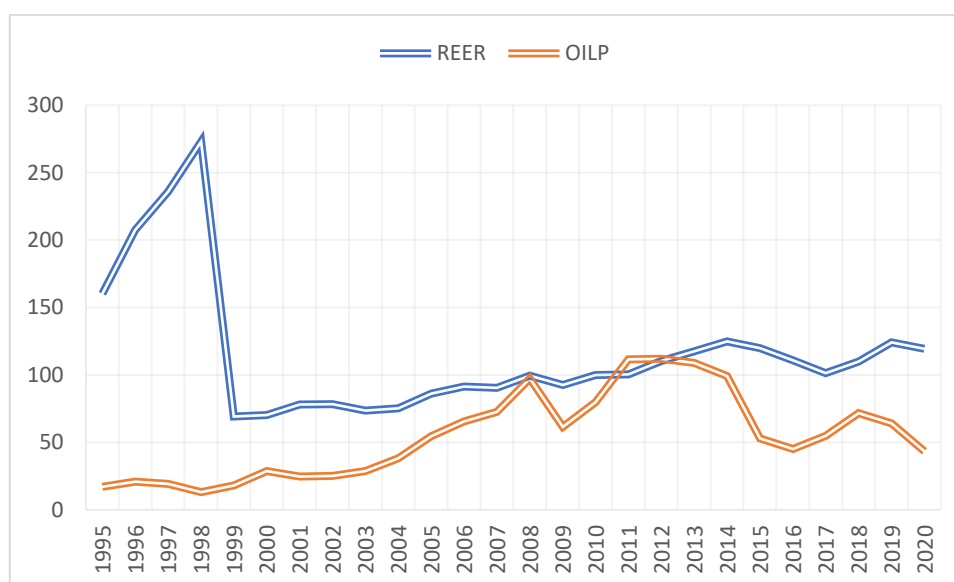
The external reserves which stood at US\$33.09 billion in 2023 could reduce slightly in 2024. This is on the assumption of continued payments of outstanding foreign exchange forward obligations, matured foreign exchange swaps, and debt service. The expected improvement in crude oil earnings together with recent reforms in the foreign exchange market and energy sector, however, would cushion the drop in external reserves. the reforms in the foreign exchange market, are expected to help stabilise the exchange rate. The expected rise in crude oil export receipts would provide further impetus to the market, moderate depreciation pressures and strengthen the naira (Central Bank of Nigeria, annual report, 2024).

In 2023, Nigeria was the number 41 economy in the world in terms of GDP (current US\$), the number 52 in total exports, the number 50 in total imports, the number 164 economy in terms of GDP per capita (current US\$) and the number 129 most complex economy according to the Economic Complexity Index.

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The chart below illustrates the evolution of oil prices and the real effective exchange rate of the Nigerian Naira.

Figure 3.5: The evolution of oil prices and the real effective exchange rate of the Nigerian Naira



Source: Personal conception using Excel

Nigeria, following structural reforms, has adopted a managed floating exchange rate regime since the 1990s.

1.4. Angola

Angola is one of the most oil-dependent African countries, with oil accounting for 28.9% of GDP and 95% of exports. GDP grew an estimated 0.9% in 2023, much lower than the 3.5% projected at the beginning of the year and the 3% growth in 2022. The first half of 2023 was marked by falling oil production and prices, higher external debt amortizations as the debt service moratorium ended, and a 60% currency devaluation. Driven mostly by the devaluation and the high share of dollar-denominated debt, the public debt-to-GDP ratio rose to 84% at the end of 2023 after falling to 69.2% in 2022. On the positive side, the ratio of debt service to total income declined from 279% in 2022 to 100% in 2023, reflecting the efficacy of the authorities' strategy to reduce financing costs. Inflation dropped from 21.7% in 2022 to 13.6% in 2023. The decline in imports compensated for the 28% drop in exports in 2023, leaving international reserves basically unchanged at the end of 2023 (\$14.7 billion) from the end of 2022 (\$14.6 billion), equivalent to 7.5 months of import cover (African Development Bank, 2024).

The average crude oil barrel price exported by the country in fiscal year 2023 stood at \$80,40, down 20% from the average export crude oil barrel price recorded in fiscal year 2022,

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but 7,2% higher than the \$75,0 crude oil barrel price forecast published in the Government's General State Budget for 2023 (IMF, annual report, 2024).

In 2023, Angola's Kwanza sharply depreciated due to limited oil revenues being used to repay foreign debt, mainly to China. The exchange rate rose from 503 KZ/USD in early 2023 to round 828 KZ/USD by year-end, making a 65% annual drop.

Angola's economy recovered in 2024 but the country is facing headwinds. Growth improved to 3.8 percent in 2024 from one percent in 2023. However, inflation remained elevated following a 44 percent exchange rate depreciation in June 2023 and import substitution measures, which have increased food production costs. The monetary policy framework improved, exchange rate flexibility increased, and debt management strengthened—helping to mitigate liquidity pressures from elevated external debt service and capital spending overruns (IMF, annual report, 2025).

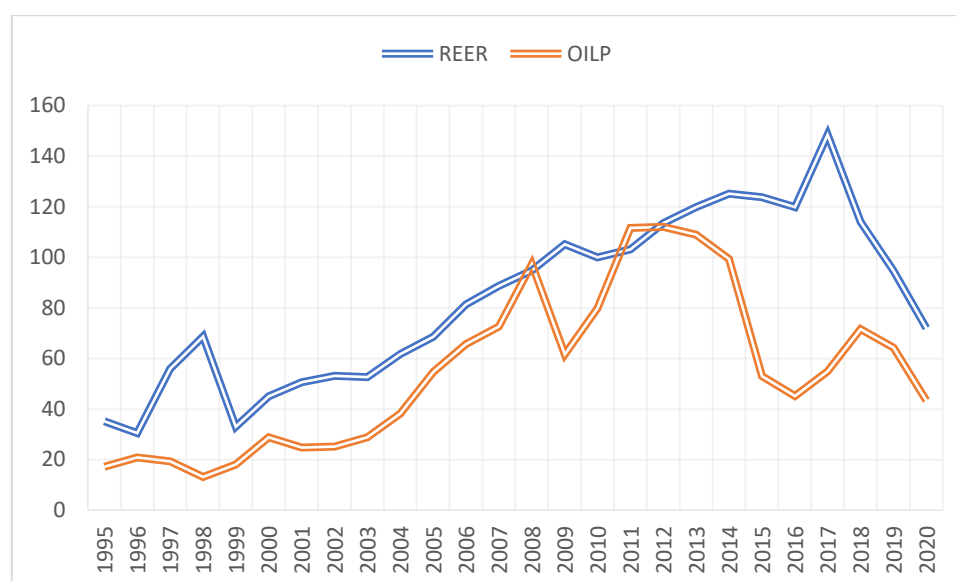
Both the oil and non-oil sectors lifted GDP. Oil production was better than expected, averaging over 1.1 million barrels per day in 2024. Economic recovery broadened to the non-oil sector, which grew by 4.8 percent in the first three quarters of 2024. Inflation continued to increase, driven by supply side factors. Annual CPI inflation remained high at 27.5 percent in December 2024 with food and non-alcoholic beverages contributing over 13 percentage points to the overall rate. The external position strengthened. Improved oil revenues in the first half of 2024 led to a 7.4 percent year-on-year increase in exports, while imports continued contracting. The current account surplus reached 4.1 percent of GDP in 2024, with gross international reserves remaining above 7 months of imports (IMF, annual report, 2025).

The REER has markedly appreciated since its decline in 2023 driven by rising inflation and despite the continued depreciation of the nominal effective exchange rate (NEER). The REER is returning to pre-shock levels, retracing the depreciation observed in 2023, when oil production was disrupted by maintenance operations and debt servicing pressures increased following the end of pandemic-related moratoriums. As of November 2024, the NEER depreciated by 16 percent year-on-year while the REER appreciated 8 percent during the same period (IMF, annual report, 2025).

The chart below illustrates the evolution of oil prices and the real effective exchange rate of the Angola's Kwanza.

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Figure 3.6: The evolution of oil prices and the real effective exchange rate of the Angola's Kwanza



Source: Personal conception using Excel

As of December 2024, Angola allowed greater exchange rate flexibility and reduced foreign exchange interventions, leading to Kwanza depreciation of over 10% since the start of the year—helping preserve foreign exchange reserves, which rose to \$15.2 billion, covering 7.3 months of imports. The depreciation has been mainly driven by fiscal pressures, including external debt repayments. Despite adequate reserves, Angola remains vulnerable due to its reliance on oil exports. Continued exchange rate flexibility and strong liquidity buffers are essential to manage external shocks (IMF, annual report, 2025).

1.5. Gabon

The de jure and de facto exchange rate arrangement of CEMAC is a conventional peg. Gabon participates in CEMAC and has no separate legal tender. The regional currency is the CFA franc⁹, which is pegged to the euro at a fixed rate of CFAF 655.957 per euro (IMF, annual report, 2024).

⁹ The franc of the Communauté Financière Africaine (CFA), called the “céfa,” was established by France in the aftermath of World War II as a currency for its African colonies. The CFA is an African currency tied to the euro. In 2020, France modified its monetary agreement with the eight member states of the West African Economic and Monetary Union (UEMOA), which includes Gabon. As a result, the Central Bank of West African States (BEAC) is no longer required to deposit half of its foreign exchange reserves with the Bank of France. The law also mandates France’s withdrawal from the monetary bloc’s governance bodies, such as the BEAC. This has increased the independence of the bank and the monetary zone from French influence. Only the BEAC central bank is now responsible for issuing and managing Gabon’s currency.

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The Gabonese economy is highly dependent on the hydrocarbon sector, which makes it vulnerable to terms of trade shocks and the energy transition. Oil accounts for about $\frac{1}{3}$ of nominal GDP and 40 percent of government revenues, and more than $\frac{2}{3}$ of merchandise exports (oil accounted for 67% of Gabon's exports in 2023). Gabon's dependence on hydrocarbons extends beyond its impact on the fiscal and external balances (IMF 2024). Declining oil revenues and the impact of the COVID-19 pandemic have reinforced the urgent need to consolidate economic resilience and pursue structural reforms for sustainable and inclusive growth (African Development Bank Group, 2024).

Gabon's oil industry has been the cornerstone of its economy since the 1970s. At its peak, the nation produced approximately 240,000 barrels of oil per day, making it one of the top oil producers in Africa.

The macroeconomic situation in 2022-2023 was characterized by a slowdown in growth from 3.0 percent in 2022 to 2.3 percent in 2023 due to disruptions on the rail network which limited manganese and wood exports. However, growth should accelerate to 2.9 percent in 2024 as railway transportation normalizes and public demand remains strong (IMF, annual report, 2024).

Inflation, for its part, continued to fall, standing at 3.7% in December 2023. This fall in inflation is the joint result of the introduction of additional measures aimed at containing the cost of living and the implementation of a more restrictive monetary policy by the BEAC (World Bank, 2024).

The current account surplus more than halved to 4.4 percent of GDP in 2023 due to lower oil prices and commodity exports and is expected to gradually decline over the medium-term with projected lower oil prices and production. Foreign currency reserves attributed to Gabon increased in 2022-2023 with higher oil prices but the external position could weaken considering large external debt obligations scheduled in 2025-2030 (IMF, annual report, 2024).

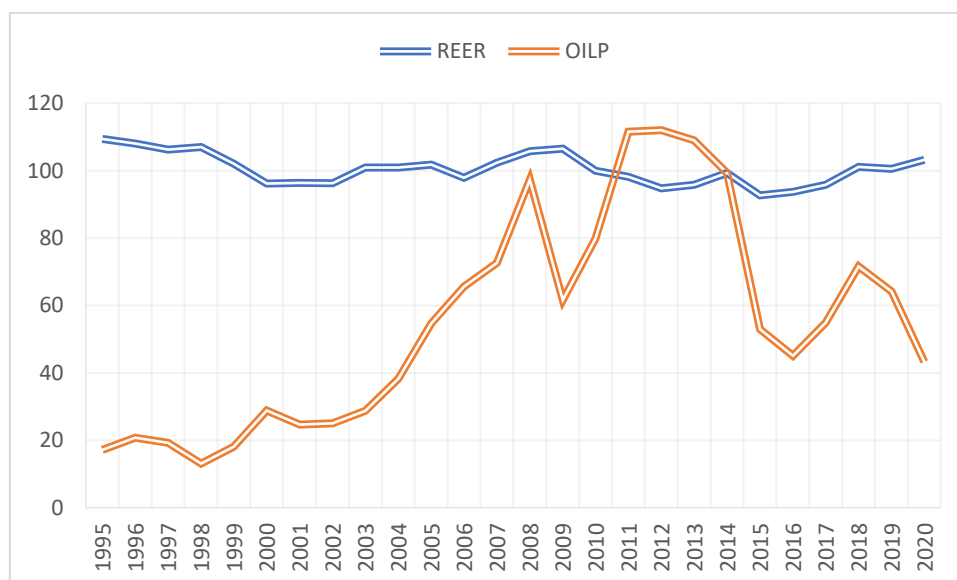
Public debt, estimated at 70 percent of GDP at end-2023, is elevated and above the sub-Saharan African average of about 60 percent. Compared to its peers, Gabon's fiscal revenues are relatively low primarily due to weak nonoil revenue mobilization and a decline in oil revenues on the back of weaker oil production—while saving from oil wealth over the years has been limited by procyclical spending (IMF, annual report, 2024).

Foreign currency reserves—indicatively attributed to Gabon from the currency union pool—increased moderately over the past two years in response to higher oil inflows, reaching 2.7 months of imports. The improvement reflected stronger oil exports but was held back by buoyant imports (likely associated with expansionary fiscal policies) and by capital outflows (potentially related to the accumulation of oil receipts abroad). The current account surplus is estimated by staff at 7.5 percent of GDP on average in 2022-23 (IMF, annual report, 2024).

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The chart below illustrates the evolution of oil prices and the real effective exchange rate of the CFA franc.

Figure 3.7: The evolution of oil prices and the real effective exchange rate of the CFA franc



Source: Personal conception using Excel

Over time, the limitations of oil dependency have become apparent. While oil wealth has facilitated some degree of development, it has also fostered a lopsided economy with limited growth in other sectors. This lack of diversification has stymied job creation and innovation, leaving the economy vulnerable to external shocks (World Bank, 2024).

Recognizing the risks of oil dependency, Gabon's government has launched a multifaceted strategy to diversify its economy. The plan encompasses investments in agriculture, mining, tourism, and infrastructure, aiming to create a more balanced and resilient economic framework (IMF eLibrary, 2024).

2. Data sources and selection of model variables

The data used in this study were collected from multiple reputable sources. The table below summarizes the selected variables, their respective sources, descriptions, and the relevant empirical studies that support their inclusion as determinants of real effective exchange rate fluctuations.

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Table 3.5: List of model variables

Variable	Abbreviation	Description	Data source	Earlier studies	Sub-hypotheses
Oil Prices	OILP	Global price of Brent Crude, U.S. Dollars per Barrel, Annual.	FRED	(Baimaganbetov et al., 2019), (Karim Eslamloueyan et al., 2015)	H1 : +
Foreign Exchange reserves	EXC_RESV	International Liquidity, Total Reserves excluding Gold, US Dollars (Millions).	IFM	(Flávio Vilela Viera et al., 2022), (Alioui Fatima Zahra, 2018)	H2 : -
Inflation	INF	Inflation rate, average consumer prices (Annual percent change)	IMF	(Armél Mbiapep Peuwo Djouaka et al., 2023), (Dilesha Rathnayake et al., 2017)	H3a : -
Lending Rate	INR_LEND	Percent per annum	Word Bank, IMF	Adeleye et al. (2024)	H3b : -
Gross Domestic Product	GDP	GDP (Current US\$)	World Bank	Adeleye et al. (2024)	H3c: +
Trade balance	TB	U.S. dollars (Billions)	World Bank IMF	(Dilesha Rathnayake, 2017)	H3d: +

Source: Personal conception

2.1. The variable to be explained

The dependent variable chosen for this study is the real effective exchange rate. According to the IMF, the real effective exchange rate (REER) is a measure of the value of a currency against a weighted average of several foreign currencies, divided by a price deflator or index of costs. The REER commonly used as a measure of the exchange rate of a currency adjusted for inflation and trade partners. An increase in REER implies that exports become more expensive and imports become cheaper; therefore, an increase indicates a loss in trade competitiveness. Several studies have been investigated the determinants of real effective exchange rate in oil exporting and producing countries, such as Karim Eslamloueyan et al. (2015), Dilesha Rathnayake (2017), and Adeleye et al. (2024).

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2.2. Explanatory Variables

A set of variables has been selected in order to investigate the key determinants of real effective exchange rate fluctuations in Africa oil-exporting countries.

2.2.1. Oil Price

Hydrocarbon are a national resource that can be used to finance development, balance the balance of payments, and maintain adequate employment levels. Oil and Gaz serve as raw materials for petrochemicals and as an energy source for all sectors of economic life.

crude oil brent price value represents the benchmark prices which are representative of the global market. They are determined by the largest exporter of a given commodity. Prices are period averages in nominal U.S. dollars.

H1: Oil prices significantly impact real effective exchange rate fluctuations in African oil-exporting countries.

2.2.2. Foreign Exchange Reserves

According to the IMF (2001), a country's international reserves refer to "those external assets that are readily available to and controlled by monetary authorities for direct financing of payments imbalances, for indirectly regulating the magnitudes of such imbalances through intervention in exchange markets to affect the currency exchange rate, and/or for other purposes".

The accumulation of foreign exchange reserves by economies is one of the key elements in ensuring exchange rate stability in international markets, as well as a measure of national wealth. The holding of reserves by central banks is driven by the need to safeguard against and respond to potential economic fluctuation shocks in a context increasingly marked by globalization and market liberalization (Gbandi, 2016).

Foreign exchange reserves play a crucial role in the economy by enabling monetary policymakers and government authorities to manage and adjust the value of the national currency in the line with economic goals or response to external shocks. An increase in reserves, often resulting from strong demand for the domestic currency, tends to strengthen the currency. However, if reserves are used to intervene in the market, it can also result in a weaker currency. So, reserves can be used to either support or adjust the exchange rate depending on policy goals and external conditions.

H2: Foreign exchange reserves play a significant role in influencing the real effective exchange rate fluctuations in African oil-exporting countries.

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2.2.3. Inflation

Inflation is an increase in the level of prices of the goods and services that households buy. It is measured as the rate of change of those prices. Typically, prices rise over time, but prices can also fall (a situation called deflation). The most well-known indicator of inflation is the Consumer Price Index (CPI), which measures the percentage change in the price of a basket of goods and services consumed by households (Reserve Bank of Australia, 2024).

According to IFM, inflation is the rate of increase in prices over a given period of time. Inflation is typically a broad measure, such as the overall increase in prices or the increase in the cost of living in a country.

H3a: Inflation significantly affects real effective exchange rate fluctuations in African oil-exporting countries.

2.2.4. Lending Interest Rate

According to the world bank, lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to creditworthiness of borrowers and objectives of financing. The terms and conditions attached to these rates differ by country, however, limiting their comparability.

H3b: Lending interest rate significantly impacts real effective exchange rate fluctuations in African oil-exporting countries.

2.2.5. Gross Domestic Product

According to the world bank, GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Gross domestic product (GDP) is the most common measure for the size of an economy, and it measures the value of total final output of goods and services produced by that economy in a certain period of time. The aim is to quantify the additional value coming from goods and services newly produced, the so-called value added, not taking into consideration the value of goods and services used to produce them (intermediate consumption) (Eurostat, 2024, P.2).

H3c: GDP has a significant influence on real effective exchange rate fluctuations in African oil-exporting countries.

2.2.6. Trade of Balance

According to the world bank, net trade in goods and services is derived by offsetting imports of goods and services against exports of goods and services. Exports and imports of goods and services comprise all transactions involving a change of ownership of goods and services between residents of one country and the rest of the world.

H3d: The trade balance significantly affects real effective exchange rate fluctuations in African oil-exporting countries.

3. Analysis method

The study employed panel data analysis as the primary statistical tool to examine the common determinants of real effective exchange rate (REER) fluctuations in Africa oil-exporting countries.

3.1. Choice of Panel Data method

The nature of data to be analysed requires the use of statistical tools to examine the relationship between variables. while cross-sectional data generally requires a large sample size (typically more than 30 subjects), our study focuses on only five African oil-exporting economies, which limits the suitability of a solely cross-sectional approach. Similarly, time series analysis demands a long, continuous time span of data; although the selected countries have data going back over 30 years, the limited availability of data for certain countries makes time series methods less applicable.

Therefore, our research employs panel data analysis, which allows us to account for both individual effects of the countries and the time dimensions of the study. This approach is considered more appropriate, as it combines cross-sectional and time-series dimensions, while also allowing for the analysis of multiple explanatory variables. This combination increases the number of observations and improves sample diversity, thereby enhancing the precision and reliability of the results.

3.2. Presentation of Panel Data Model

According to Wang Peijie (2008), a Longitudinal or Panel data refers to data sets consisting of cross-sectional observations over time, or pooled cross section and time series data. They have two dimensions, one for time and one for the cross-section entity, the entity can be individuals, firms, regions or countries.

An important advantage of panel data compared with time series or cross-sectional data sets is that they allow identification of certain parameters or questions, without the need to make restrictive assumptions.

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The panel data model can be written for N individual ($i = 1, \dots, N$) and T time period ($t = 1, \dots, T$), resulting in $n = N \times T$ total observations. It is expressed as follows (Bourbonnais, R, 2015, p. 348):

$$y_{it} = \alpha_i + \beta_i' X_{it} + \varepsilon_{it}$$

Where, y_{it} is the dependent variable observed for individual i at time t . X_{it} is the vector. K exogenous variables. α_i is the individual-specific constant term. β' is the vector of K coefficients for the K exogenous variables. ε_{it} is the error term.

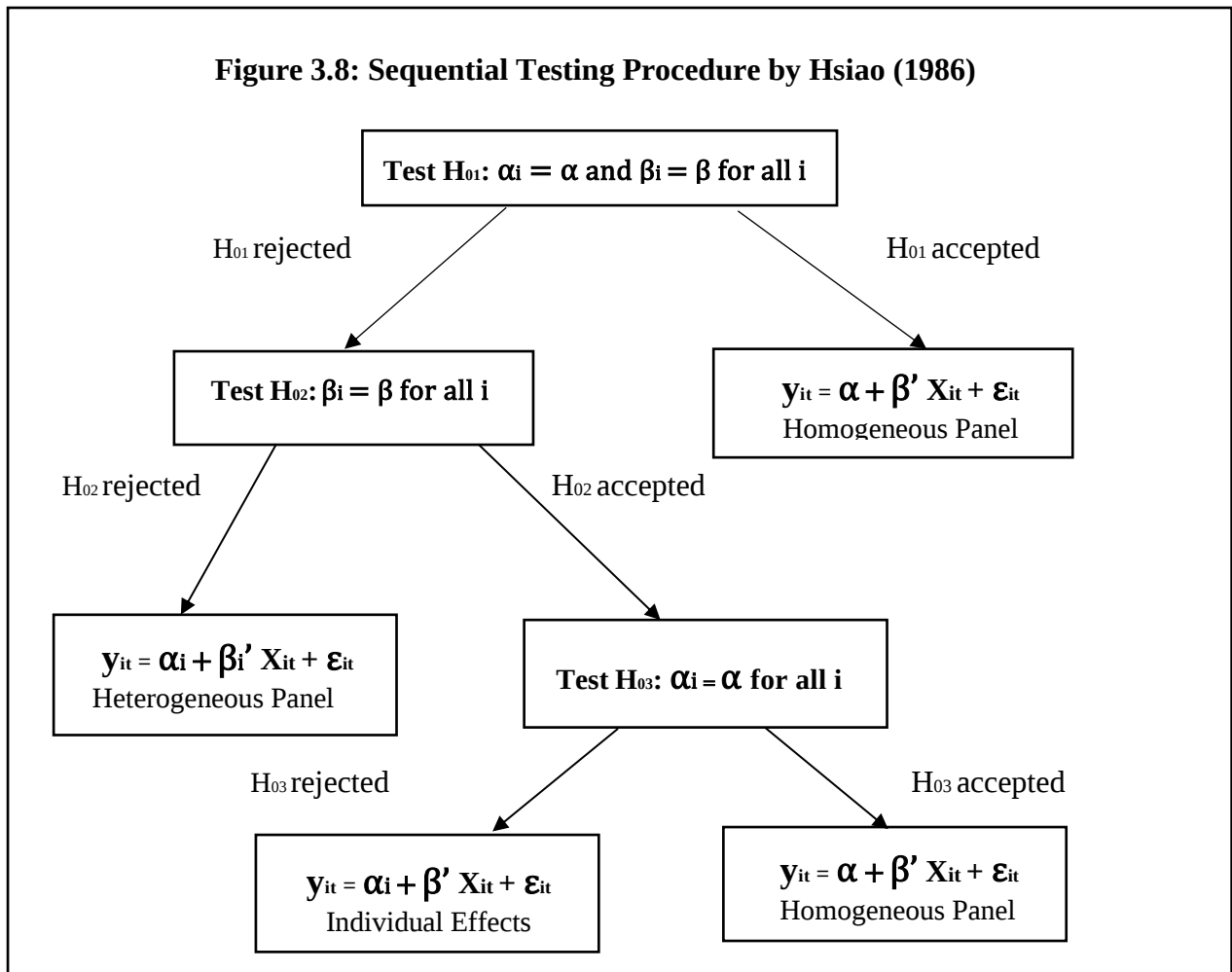
According to R. Zulfikar (2023), a panel is referred to as a balanced panel if each subject has the same number of observations. It is called an unbalanced panel if each subject has a different number of observations. Usually, the unbalanced panel dataset results from missing observations for some variables during data collection.

3.3. Specificities of the Panel Data Model

Before proceeding with panel data modelling, it is necessary to determine whether the coefficients of given model remain identical for each individual over time. The objective of this test is to distinguish between the global effect, which encompasses characteristics common to all individuals, and the individual-specific effect, which captures variations unique to each entity.

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Figure 3.8: Sequential Testing Procedure by Hsiao (1986)



Source: Bourbonnais. R, Op-cit, p.349

Hypothesis tests are constructed based on Fisher statistics (test of restrictions on the coefficients):

- First step: Testing the hypothesis of a perfect and homogeneous structure.
- Second step: Testing the equality of the β_{ik} coefficients for all individuals.
- Third step: Testing the equality of individual constant α_i under the assumption that the coefficients β_{ik} are common to all individuals.

3.4. Methods and models used for estimating Panel Data

There are several estimation methods, but we focused on three main approaches.

3.4.1. The Ordinary Least Squares (OLS) Method

According to Andrianady, Ravahiny Josué (2024), the Ordinary Least Squares (OLS) regression method is employed to estimate the linear relationship between a dependent variable and one or more independent variables. The objective is to reduce the sum of squared residuals, which are the discrepancies between the observed and predicted values.

The pooled model functions like a traditional regression model. It treats all observations as independent, without accounting for differences across panels or over time. It does not incorporate any panel-specific information.

3.4.2. Fixed Effects Model

According to Zulfikar Rizka (2018), the fixed effects model considers that differences across individual units can be represented by assigning each a unique intercept. To estimate this model, dummy variables are introduced for each individual, enabling the model to account for these specific intercepts. This method is commonly referred to as the Least Squares Dummy Variables (LSDV) approach.

3.4.3. Random Effects Model

According to Boulabbas Mokhtar et al. (2023), the random effects, also referred to as the component error model or composite error model, assumes that the individual-specific characteristics are random. In this framework, the constant term for each individual is treated as a random variable. This term is divided into two parts: a fixed component and a random component unique to each individual. Together, these elements form a composite error structure.

4. Model specification

The objective of this study is to examine the influence of explanatory variables (INF, INR_LEND, OILP, GDP, EXC_RESRV, and TB) on real effective exchange rate fluctuations of five (5) African oil exporting countries from 1995 to 2020.

Before estimating the parameters of every factor under consideration, it is essential to specify the model to be analysed and interpreted, as presented below:

$$\ln_REER_{it} = f(\ln_OILP, \ln_EXC_RESRV, \ln_INF, \ln_INR_LEND, \ln_GDP, TB)$$

The full formulation of our model is as follows:

$$\ln_REER_{it} = \beta_0 + \beta_1 \ln_OILP_{it} + \beta_2 \ln_EXC_RESRV_{it} + \beta_3 \ln_INF_{it} + \beta_4 \ln_INR_LEND_{it} + \beta_5 \ln_GDP_{it} + \beta_6 TB_{it} + \varepsilon_{it}$$

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Where:

$\ln_REER_{it}$: the logarithm of real effective exchange rate;

$\ln_OILP_{it}$: the logarithm of oil prices;

$\ln_EXC_RESRV_{it}$: the logarithm of foreign exchange reserves;

$\ln_INF_{it}$: the logarithm of inflation;

$\ln_INR_LEND_{it}$: the logarithm of interest lending rate;

$\ln_GDP_{it}$: the logarithm of gross domestic product;

TB_{it} : the trade balance;

i : index of countries, where $i = [1,5]$;

t : index of periods, where $t = [1,26]$;

β_0 : the intercept;

β_k : coefficient of the explanatory variables, where $k = [1,6]$;

ε : term of error.

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Section 02: Descriptive Analysis

Before estimating the parameters of the panel data regression model, it is essential to perform a descriptive analysis of both the dependent variable and the independent variables.

The third section aims to conduct a descriptive analysis of the variables. First, we present the descriptive statistics, followed by the correlation matrix, and then the Variance Inflation Factor (VIF).

1. Descriptive statistics of variables

Descriptive statistics provide an initial overview of the variables included in the regression model by summarizing key information. The table below aims to presents the mean, standard deviation, and lowest and greatest observation of each variables in the sample (see appendix No. 02).

Table 3.6: Descriptive analysis of variables

Code		Mean	SD	Min	Max
1	ln_REER	4.664	0.108	4.513	4.909
	ln_OILP	3.822	0.651	2.575	4.719
	ln_EXC_RESRV	10.725	1.373	7.603	12.179
	ln_INF	1.359	0.85	-1.204	3.395
	ln_INR_LEND	2.215	0.263	2.079	2.944
	ln_GDP	25.459	0.616	24.455	26.199
	TB	3.663	16.946	-27.449	32.476
2	ln_REER	4.549	0.176	4.221	4.827
	ln_OILP	3.822	0.651	2.575	4.719
	ln_EXC_RESRV	9.888	0.417	9.361	10.614
	ln_INF	2.032	0.627	0.833	3.157
	ln_INR_LEND	2.587	0.139	2.399	2.908
	ln_GDP	25.748	0.611	24.820	26.673
	TB	-13.458	10.883	-34.677	0.398
3	ln_REER	4.687	0.355	4.237	5.61
	ln_OILP	3.822	0.651	2.575	4.719
	ln_EXC_RESRV	9.869	0.964	7.275	10.878
	ln_INF	2.515	0.517	1.686	4.288
	ln_INR_LEND	2.891	0.134	2.613	3.21
	ln_GDP	26.203	0.688	24.803	27.076
	TB	3.994	15.451	-32.241	24.367

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4	ln_REER	4.33	0.45	3.317	5
	ln_OILP	3.822	0.651	2.575	4.719
	ln_EXC_RESRV	9.103	1.314	5.928	10.358
	ln_INF	3.799	1.705	1.988	8.33
	ln_INR_LEND	3.552	0.901	2.528	5.384
	ln_GDP	24.269	1.115	22.435	25.636
	TB	8.616	9.006	-1.050	22.882
5	ln_REER	4.609	0.046	4.529	4.695
	ln_OILP	3.822	0.651	2.575	4.719
	ln_EXC_RESRV	6.264	1.634	2.287	2.287
	ln_INF	0.514	0.935	-1.609	2.262
	ln_INR_LEND	3.552	0.901	2.528	5.384
	ln_GDP	23.024	0.525	22.224	23.625
	TB	3.468	1.839	0.813	7.003
Total	ln_REER	4.567825	0.2981046	3.41714	5.609526
	ln_OILP	3.821774	0.6411567	2.574612	4.718603
	ln_EXC_RESRV	9.169671	1.955572	2.2875	12.17928
	ln_INF	2.0924	1.482816	-1.609438	8.329899
	ln_INR_LEND	2.959438	0.7857855	2.079442	5.383922
	ln_GDP	24.94049	1.36751	22.22365	27.07622
	TB	1.256963	14.12312	-34.6771	32.47631

Source: Elaborated by the student using output of Stata/MP 17.0 software

Algeria (Code 1) demonstrates a relatively stable macroeconomic profile characterized by a predictable real effective exchange rate, with a moderately high mean value of ln_REER at 4.664 and low variability. Algeria appears to have the most stable real effective exchange rate. Inflation average at 1.359, indicating moderate price increases, though the presence of a negative minimum value suggest occasional deflationary episodes that could point to macroeconomic imbalances. Algeria also benefits from the lowest average lending rate at 2.215, which may reflect loose monetary policy or low perceived credit risk. With a fairly high GDP level (mean=25.459), the economy appears robust in terms of output. Most notably, Algeria holds the highest average level of foreign exchange reserves (10.725), serving as a strong external buffer against external shocks. Algeria shows a positive and strong trade balance with an average of 3.663 billion, reflecting a favorable trade position. Overall, these indicators portray Algeria as a macroeconomically stable country with controlled inflation, strong reserves, and accommodative monetary conditions.

Egypt (Code 2) presents a moderate yet stable economic profile. The real effective exchange rate (ln_REER) averages 4.549, slightly below that of Algeria, but still reflects relative stability in the currency's external value. Inflation remains moderate at 2.032, within a manageable range, pointing to effective control of price levels. The lending interest rate

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stands at a balanced level of 2.587, suggesting neither excessive monetary tightening nor looseness. With a gross domestic product (ln_GDP) average of 25.748, the economy shows solid overall performance and output capacity. Foreign exchange reserves are also healthy, averaging 9.888 with low volatility, indicating good management of external assets. The trade balance (TB) is negative, with an average of -13.458 billion, indicating a trade deficit. This trade imbalances may offset the positive aspects of Egypt's stable macroeconomic conditions, potentially contributing to external vulnerability despite solid GDP and healthy reserves. Altogether, Egypt displays sound macroeconomic fundamentals, with controlled inflation, stable reserves, and a resilient GDP, but a trade deficit that could affect its external stability.

Nigeria (Code 3) represents a large and dynamic economy characterized by the highest average real effective exchange rate (ln_REER) at 4.687, accompanied by the widest fluctuation (max=5.610), suggesting notable exchange rate volatility. Inflation stands at a relatively high mean of 2.515, though still manageable limits, possibly necessitating the use of higher lending rate (2.891) to contain price pressures. The country boasts the highest GDP among all selected countries (mean=26.203), reflecting strong economic output and scale, likely driven by substantial resources wealth. Its foreign exchange reserves are also relatively strong with average 9.869, but display more variability (SD=0.964), indicating exposure to external fluctuations. The trade balance for Nigeria averages 3.994 billion, indicating periods of trade surplus or deficit, suggesting that Nigeria may face external challenges despite its large and resource-rich economy. Overall, Nigeria portrays a large, resource-rich economy marked by robust output and reserves, yet facing some instability in its exchange rate and external buffers.

Angola exhibits clear signs of macroeconomic instability, with the lowest average real effective exchange rate (ln_REER) at 4.330 and a wide range of fluctuation, suggesting a trend of real depreciation or volatility in currency value. Inflation is the highest among all countries, averaging 3.799 and peaking at 8.33, which reflects significant price likely driven by policy shortcoming or structural weaknesses. The lending rate is also elevated at 3.552, potentially implemented to counter inflation, though it may come at the cost of reduced economic growth. GDP is the lowest among the top four countries with average of 24.269 and exhibits notable variability, indicating inconsistent economic performance. Foreign exchange reserves are relatively low (mean=9.103) and highly volatile (SD=1.314), highlighting external sector vulnerability. The trade balance (TB) for Angola averages 8.616 billion, suggesting trade surplus. Despite positive trade balances, Angola faces macroeconomic challenges, including high inflation, weak currency performance, and unstable reserves, but somewhat supported by trade surplus.

Gabon (Code 5) reflects the profile of a small and vulnerable economy. The real effective exchange rate (ln_REER) is relatively stable and moderate, with a mean of 4.609 and minimal volatility, indicating exchange rate stability. It records the lowest average inflation (0.524), which could suggest either weak domestic demand or successful inflation control through monetary policy. However, this is coupled with relatively high lending rate (3.553), potentially inconsistent with the low inflation environment and possibly restrictive for economic growth

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scale. Foreign exchange reserves are also the weakest (mean=6.364) and highly volatile, highlighting significant exposure to external shocks. The trade balance for Gabon averages 3.468 billion, indicating a modest trade surplus. This positive trade balance offers some buffer against the small size of Gabon's economy, but it remains vulnerable due to low reserves and high financing costs.

Overall, the mean $\ln_REER$ is 4.567, indicating relative consistency across countries, with moderate standard deviations (0.298), reflecting some within-countries variability. Inflation ($\ln_INF$) varies considerably across countries, suggesting differing price stability conditions. The lending rate ($\ln_INR_LEND$) shows substantial variation, with a mean of 2.959. Oil prices ($\ln_OILP$) is constant across all countries in each period with average of 3.821 and standard deviation of 0.641, as expected for a global commodity. Gross domestic product ($\ln_GDP$) ranges widely across countries. Foreign exchange reserves ($\ln_EXC_RESRV$) exhibit considerable variance. The trade balance (TB) also shows notable variability across countries.

It is worth noting that the dataset includes 26 annual observations for each of the five African oil-exporting countries, resulting in a total of 130 observations. However, after applying the natural logarithm transformation to the variables, four observations were excluded due to negative inflation values, which are undefined in logarithm terms. As a result, the final dataset for inflation consists of 126 observations.

2. Correlation matrix

Studying the correlation between different variables is crucial as it helps to understand the possible relationship between the components, which in turn facilitate and guide the subsequent analysis and interpretations.

The table below represents the correlation between the dependent variable ($\ln_REER$) and the other explanatory factors, as well as the correlation among the explanatory variables (see appendix No. 03).

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Table 3.7: Correlation Matric between model variables

variables	ln_REER	Ln_OILP	ln_EXC_R ESRV	ln_INF	ln_INR_ LEND	ln_GDP	TB
ln_REER	1.0000						
Ln_OILP	0.0723	1.0000					
ln_EXC_RES RV	0.0896	0.4774*	1.0000				
ln_INF	-0.5152*	-0.1681	0.0749	1.0000			
ln_INR_LEND	-0.4575*	-0.4334*	0.6977*	0.3433*	1.0000		
ln_GDP	0.3641*	0.4446*	0.8355*	0.0100	-0.7025*	1.000	
TB	-0.0013	0.1363	-0.0239	-0.0616	0.0645	-0.1903*	1.000

(*) Significant at the 5% threshold

Source: Elaborated by the student using output of Stata/MP 17.0

The correlation matrix reveals interesting relationships among the variables influencing the real effective exchange rate (ln_REER). Notably, ln_REER is significantly and negatively correlated with inflation (ln_INF) and lending interest rate (ln_INR_LEND), suggesting that as inflation and lending rate increases, the real effective exchange rate tends to decline, indicating a real depreciation. In contrast, ln_REER shows a positive and significant correlation with gross domestic product (ln_GDP), indicating that stronger economic growth is mildly linked to an appreciation of the real effective exchange rate. Oil prices (ln_OILP) and foreign exchange reserves (ln_EXC_RESRV) show a positive and insignificant correlation with ln_REER, while the trade balance shows a negative and insignificant correlation with ln_REER.

Moreover, oil prices show a positive and significant relationship with both foreign exchange reserves and gross domestic product. Oil prices also have a negative and significant correlation with lending rate. Additionally, GDP shares a strong positive and significant correlation with foreign exchange reserves, while it has a negative and significant correlation with lending rate and the trade balance. Inflation has a positive and insignificant correlation with both gross domestic product and foreign exchange reserves, and a positive and significant correlation with lending rate, while it has a negative and insignificant correlation with the trade balance and oil prices.

According to Gujarati (2010), when examining the correlation among explanatory variables, high pairwise correlations (greater than 0.8) can indicate potential multicollinearity. However, this criterion is not completely reliable.

Based on these results, we can conclude that, apart from the correlation between ln_GDP and ln_EXC_RESRV which reaches 83.55% that indicates a potential multicollinearity risk

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between them, no other variables exhibit a correlation exceeding 0.8 threshold. This generally suggests that aside from this pair, there are no major multicollinearity concerns within the model. Therefore, to confirm the absence of significant multicollinearity issues, a complementary analysis was conducted using the Variance Inflation Factor (VIF).

3. Multicollinearity Test

The presence of multicollinearity in a regression model can increase the variance of the regression coefficients, making them unstable and difficult to interpret. This issue often arises when certain predictor variables in the model are measuring the same phenomenon. To assess the multicollinearity among the explanatory variables mentioned above, a variance inflation factor (VIF) test is conducted. The VIF test measures how much the variance of a regression coefficient is inflated due to a linear relationship with other variables, potentially reducing the reliability of the model.

To indicate the absence of the multicollinearity, any variable with a VIF value exceeding 10 should be carefully examined. Therefore, the variance inflation factor for each variable should remain below this critical threshold. Additionally, tolerance, defined as $1/VIF$ and commonly used by researchers to the degree of collinearity, should be greater than 0.1.

The multicollinearity test is used to assess whether the explanatory variables in a model are correlated with each other. To do this, we use the variance inflation factor (VIF). A VIF value below 10 indicates the absence of problematic multicollinearity among the variables.

The table below presents the VIF test results for the explanatory variables of the economic model (see the appendix No. 04).

Table 3.8: The VIF test result for the explanatory variables

Variable	VIF	1/VIF
Ln_EXC_RESRV	4.23	0.236590
Ln_GDP	4.04	0.247471
Ln_INR_LEND	3.20	0.312619
Ln_INF	1.54	0.647696
Ln_OILP	1.46	0.686480
TOB	1.16	0.859271
Mean VIF	2.61	

Source: Elaborated by the student using output of Stata /MP 17.0 software

The test results show an average VIF of 2.61 and a maximum VIF of 4.23, both well below the threshold of 10 established by the authors. This indicates a low level of collinearity among the variables used in the model, suggesting that each variable offers distinct information not captured by the others.

Section 03: Model estimation and results interpretation

This section aims to present the results of the estimated model and to test the hypotheses using Stata/MP 17.0. First, we will outline the different statistical tests and the outcomes of the panel data regression. Then, we will interpret the results to explain the impact of common macroeconomic factors on real effective exchange rate fluctuations in African oil-exporting countries.

1. Presentation of the tests

The application of a panel data regression is required with an individual dimension of five (5) oil-exporting countries and a temporal dimension of years. A set of econometric procedures was undertaken to develop this specific approach. It should be noted that the multicollinearity test performed on the selected explanatory variables (such as inflation, lending interest rates, oil prices, foreign exchange reserves, gross domestic product, and balance of trade) does not reveal any correlation issues; therefore, no variable was eliminated. The following tests were conducted using the Stata/MP 17.0 software, and their interpretation are provided accordingly.

1.1 Model specification test

Model specification tests aim to determine the most appropriate model to use, typically between pooled OLS, fixed effects, and random effects model. The process generally involves applying the F-test (testparm) to decide between pooled OLS and fixed effects, the Hausman test to decide between fixed effects and random effects models, and finally, the Breusch-Pagan Lagrange Multiplier test to determine the presence or the absence of random effects.

1.1.1. Testparm

This test is widely used in Stata to determine which model is more appropriate between pooled OLS model and the fixed effects model. If the Prob > F is less than 0.05, we reject the null that the coefficients for the years are jointly equal to zero. In this case, time fixed effects are needed.

H0: The coefficients of the time variables are jointly equal to zero

H1: At least one of the coefficients of time variables is not equal to zero

The table below represents the testparm results (see appendix No. 05).

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Table 3.9: Result of the Testparm test

<i>Testparm</i>	
F(4,4)	29.71
Prob > F	0.0031

Source: Elaborated by the student using output of Stata/MP 17.0 software

Since the p-value is equal 0.0031, which is less than 0.05, we reject the null hypothesis that all individual effects are jointly equal to zero. Therefore, we concluded that the fixed effects model is more appropriate than the pooled OLS model.

1.1.2. The Hausman Test

The Hausman test is used to determine whether a fixed effects model or random effects is more suitable for panel data analysis. This test compares the estimates from both models to check for significant differences between them, which would indicate the presence of correlation between unobserved individual effects and the explanatory variables. The decision rule involves testing the following hypotheses:

H0: Presence of random effects

H1: Presence of fixed effects

The decision to accept or reject the null hypothesis is based on the p-value obtained from the test. If the p-value is less than the conventional 5% threshold, it suggests that the individual effects are correlated with the explanatory variables, making the fixed effects model the more appropriate choice.

The test result is represented in the following table (See Appendix No. 06).

Table 3.10: Hausman test result

<i>Hausman Test</i>	
Chi-square test value	154.61
P-value	0.0000

Source: Elaborated by the student using output of Stata/MP 17.0 software

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The p-value is less than the conventional 5% threshold. This suggests that the individual effects are correlated with the explanatory variables, making the fixed effects model the more appropriate choice than the random effects model.

1.1.3. Breusch-Pagan Test

The Breusch-Pagan test is used to decide between two hypotheses regarding the presence of random effects in a panel regression model. The hypotheses tested are as follows:

H0: Absence of random effects

H1: Presence of random effects

The decision to reject or not the null hypothesis depends on the p-value associated with the test. If the p-value is less than the 5% significance level, this suggests that random effects are significant, and the null hypothesis is rejected in favour of the alternative.

The table below represents the Breusch-Pagan Lagrange Multiplier test results (see appendix No. 07).

Table 3.11: Result of the Breusch-Pagan Lagrange Multiplier test

<i>Breusch-Pagan Lagrange Multiplier test results</i>	
Chibar2 (01)	0.00
Prob > chibar2	1.0000

Source: Elaborated by the student using output of Stata/MP 17.0 software

The Chi-square statistic is not significant, with a p-value of 1.0000, which is greater than 5% threshold. As result, we fail to reject the null hypothesis H0 and confirm the absence of random effects.

1.2. Validity Tests of the Econometric Model

The validity tests applied to the econometric model include the autocorrelation test and the heteroskedasticity test.

1.2.1. Autocorrelation Test

According to M. Drukker (2003), serial correlation in linear panel-data models distorts standard error estimates and reduces the efficiency of results.

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In order to identify whether there is autocorrelation in the residuals, the Wooldridge test is applied. The decision to accept or reject the null hypothesis relies on the p-value obtained from the test. If the p-value is less than standard threshold of 5%, it indicates enough evidence to reject the null hypothesis and confirm that the residuals exhibit significant autocorrelation. This test evaluates the following hypotheses:

H0: No autocorrelation is present

H1: Autocorrelation is present

The result of the test is as follows (see appendix No. 08).

Table 3.12: Result of the Autocorrelation test

<i>Wooldridge test for autocorrelation in panel data</i>	
F (1,4)	25.162
Prob > F	0.0074

Source: Elaborated by the student using output of Stata/MP 17.0 software

Given that the p-value is equal to 0.0074, which is less than 5% significant threshold, the null hypothesis H0 is rejected. This indicates the presence of autocorrelation in the model.

1.2.2. Heteroscedasticity test

Heteroscedasticity refers to a situation where the standard deviation of a dependent variable is not consistent across the range of an independent variable or over time. To determine whether a model exhibits homoscedasticity (constant variance) or heteroscedasticity (non-constant variance), the modified Wald test for groupwise heteroskedasticity is performed. The modified Wald test examines whether each unit in the panel has a different variance of the error term in a fixed effects model.

H0: Homoscedasticity of residuals

H1: Heteroscedasticity of residuals

The test results are presented in the following table (see appendix No. 09).

Table 3.13: Result of Heteroskedasticity test

<i>Wald test for groupwise heteroskedasticity in fixed effect regression model</i>	
Chi2 (5)	11.60
Prob > chi2	0.0406

Source: Elaborated by the student using output of Stata/MP 17.0 software

Since the p-value is 0.0406, which is below the 5% significant threshold, we reject the null hypothesis H_0 of homoscedasticity of residuals, confirming the presence of heteroscedasticity in the model.

2. Presentation and interpretation of estimation results

Based on the results of the two previous tests, the estimated model exhibits two key issues: autocorrelation and heteroscedasticity. To address these problems, we will employ the Panel-Corrected Standard Errors (PCSEs) estimation method, which is specifically designed to correct for both and provide more reliable results.

The main objective of this study is to identify and analyse the key macroeconomic factors influencing real effective exchange rate (REER) fluctuations within a group of countries that share a common economic characteristic: a reliance on hydrocarbons. This methodological approach treats the countries as a structural homogenous group, focusing on the average effects of the explanatory variables on the REER rather than on individual country comparisons. Consequently, the use of the panel-corrected standard errors (PCSEs) model is appropriate, without introducing country-specific fixed effects.

According to Katz and Beck (1995), the panel-corrected standard errors method works well with small samples, making it good choice when we have a limited of cross-sectional units, as the case in this study. Other method like feasible generalized least squares (FGLS) may not perform as reliably in such small panels.

2.1. Model estimation

The results of the regression analysis using the PCSEs approach are as follows (see appendix No. 10).

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Table 3.14: Results of the regression analysis using the PCSEs approach

Linear regression, correlated panels corrected standard errors (PCSEs)				
Variables	Coefficient	Std. Error	Z	P-value
ln_OILP	-0.0964041	0.0345585	-2.79	0.005***
ln_EXP_RESRV	-0.1146862	0.0176188	-2.51	0.000***
ln_INF	-0.0804918	0.0134903	-5.97	0.000***
ln_INR_LEND	-0.1120758	0.03478	-3.22	0.001***
ln_GDP	0.2022075	0.0307949	6.57	0.000***
TB	0.0037567	0.001442	2.61	0.009***
_cons	1.437025	0.6736296	2.13	0.033**
R-squared		0.5938		
Wald chi2 (6)		150.59		
Prob > chi2		0.0000***		
Number of observations		126		
Number of groups		5		

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Elaborated by the student using output of Stata/MP 17.0 software

In the table above, the relationship between the dependent and independent variables in the model analysing the common determinants of real effective exchange rate (REER) fluctuations in African oil-exporting countries is based on 126 observations. The R-squared value is 0.5938, indicating that approximately 59.38% of the variation in the REER is explained by the selected explanatory variables. This suggests a relatively strong explanatory power of the model. Additionally, the wald chi2 test for overall model significance is statistically significant at the 1% level (Prob > chi2 = 0.0000), implying that the model fits the data well and the independent variables collectively have strong explanatory potential.

2.2. Estimated model equation

The equation of the econometric model can be formulated as follows:

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$$\ln_REER_{it} = 1.4370 - 0.0964 \ln_OILP_{it} - 0.1146 \ln_EXP_RESRV_{it} - 0.0804 \ln_INF_{it} - 0.1120 \ln_INR_LEND_{it} + 0.2022 \ln_GDP_{it} + 0.0037 Tb_{it} + \epsilon_{it}$$

Where:

i: index of countries;

t: index of periods;

β_0 : the intercept;

β_k : coefficient of the explanatory variables;

ϵ_{it} : term of error.

2.3. Results interpretation

The following presents an analysis of the impact of key determinants on real effective exchange rate (REER) fluctuations of African oil-exporting countries.

✓ Oil Prices

The findings show a negative and statistically significant effect of oil prices on real effective exchange rate fluctuations of African oil-exporting countries at the 1% threshold (coefficient = -0.0964041). This implies that an increase in oil prices leads to a decrease in the real effective exchange rate in these countries, indicating a real depreciation.

This result contradicts both theoretical expectations and the findings of Baimaganbetov et al. (2019), but aligns with the result of Karim Eslamloueyan & Amir Kia (2015), who found a negative relationship between oil prices and the REER in oil-producing countries of the Middle East and North Africa. They note that the sign of the estimated coefficient of oil price does not justify the theoretical model. However, it is only statistically significant at the 1% level. According to their interpretation, higher oil prices increase the relative demand for currency of oil producing and exporting countries. This in turn increases the value of the domestic currency relative to the U.S. dollar in foreign exchange markets and hence leads to a lower nominal exchange rate. Consequently, a higher oil price might result in a lower real exchange rate (Karim Eslamloueyan & Amir Kia, 2015). This finding rejects the hypothesis H1.

This result can be justified by the complexity of the relationship between oil prices and the real effective exchange rate (REER), which is influenced by various intervening factors. While higher oil prices are expected to lead to REER appreciation, since increased export revenues raise demand for the local currency, this effect can be offset or reversed by several

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dynamics. Government may intervene through sterilized foreign exchange operations or impose capital controls to avoid excessive appreciation and protect non-oil sectors, a strategy often aimed at preventing Dutch disease.

Dutch disease refers to the negative impact of increased foreign income—particularly, from natural resource exports that generate high state revenues—on economic development, which often affects relatively small, resource-rich countries. The resulting appreciation of the real exchange rate can harm the export competitiveness potential (Zurane Brincikova, 2016). A country can handle the negative consequences of the Dutch disease in several ways, depending on whether the income increase is permanent or temporary. One approach through foreign exchange interventions. However, such intervention increases foreign exchange reserves and may lead to inflation and lower interest rates, which can reduce private investment. These factors explain why the empirical relationship between oil prices and REER is not always positive.

✓ **Foreign exchange reserves**

The regression results indicate a significant negative correlation at the 1% threshold between foreign exchange reserves and real the effective exchange rate in African oil-exporting countries (coefficient = -0.1146862). Specifically, an increase in foreign exchange reserves is associated with a decrease in real effective exchange rate. This finding corresponds with the results of earlier studies, such as Flávio Vilela Viera et al. (2022), and Alioui Fatima Zahra (2018). This result validates the hypothesis H2.

This result can be explained by the fact when foreign reserves are increased, monetary authorities would depreciate the real exchange rate since more foreign currencies are purchased by the country (Dilesha Rathnayake, 2017). In other words, when a country accumulates more reserves, it sells domestic currency, which increases the supply on the domestic currency, thereby depreciating its real value, which low the REER. This result is expected for many oil-exporting countries, especially those are heavily dependent on hydrocarbons. In such cases, the authorities accumulate reserves to stabilize the real effective exchange rate in response to economic shocks and to protect the non-oil sector from becoming less competitive. As a result, they tend to depreciate their REER.

✓ **Inflation**

Study reveals that inflation has a statistically significant and negative effect on real effective exchange rate fluctuations of African oil-exporting countries at the 1% threshold (coefficient = -0.0804918). The findings indicate that an increase (decrease) in inflation leads to a depreciation (appreciation) of the real effective exchange rate in the selected countries. A decrease in the REER reflects a real depreciation of the domestic currency. This mean that, after adjusting for inflation, the purchasing power of the currency declines in terms of foreign goods and services. In other words, the domestic currency buys less abroad. As result, domestic goods and services because relatively cheaper and more attractive on international markets, boosting export competitiveness. Meanwhile, imports become more expensive for consumers,

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which may reduce foreign consumption and shift demand toward locally produced goods. It is worth to note that this finding is consistent with theoretical expectation and aligns with the results of other studies, such as Armel Mbiapep Peuwo Djouaka et al. (2023) and Dilesha Nawadali et al. (2017). This result validates the sub-hypothesis H3a.

The inflation rate or overall price level in an economy significantly affects the value of its currency. Countries that maintain low and stable inflation generally see their currencies appreciate, as their purchasing power strengthens relative to other currencies. In contrast, nations with high inflation often experience depreciation of their domestic currency.

✓ **Interest Rate**

The regression findings show that the interest lending rate has a negative and statistically significant impact on real effective exchange rate fluctuations of the selected countries at the 1% threshold (coefficient = -0.1120758), indicating that an increase (decrease) in the interest lending rate is associated with a depreciation (appreciation) of the real effective exchange rate. This result is consistent with the theoretical expectations and aligns with the findings of Adeleye et al. (2024) on the real effective exchange rate of African producing countries, and the findings of Dilesha Rathnayake (2017), who theoretically expected this result because a high interest rate could cause an inflation in the long run which results from a lower real exchange rate. This finding confirms the sub-hypothesis H3b.

A higher lending rate increases the cost of borrowing, which discourages individuals and businesses from taking out loans. As result, demand for credit declines. With reduced access to affordable financing, investment activity, particularly in productive sector such as industry, infrastructure, and innovation slows down. This decline in investment weakens overall economic performance by reducing output and productivity growth. In turn, a weaker economy can lead to a deteriorate in the country's trade balance and investor confidence, potentially causing a depreciation of the real effective exchange rate (REER).

✓ **Gross domestic product**

The findings show that gross domestic product has a positive and statistically significant effect on REER fluctuations of the selected countries at the 1% threshold (coefficient = 0.2022075). This implies that an increase in GDP leads to an increase in REER. An increase in the real effective exchange rate (REER) indicates a real appreciation of the domestic currency. This means that, after adjusting for inflation, the domestic currency can buy more foreign goods and services relative to a basket of the other currencies. In other words, the purchasing power of the domestic currency increases on international market. As a result, exports become less competitive on international markets due to higher relative prices, while imports become more attractive and cheaper for domestic consumers. This result is consistent with theoretical expectations and earlier studies, such as the work of Adeleye et al. (2024). This result validates the sub-hypothesis H3c.

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GDP growth can lead to an appreciation of the domestic currency by enhancing productivity, boosting exports, and reducing the general price level. In effect, it helps limit the depreciation of the domestic currency by stabilizing exchange rate movements.

✓ Trade Balance

The regression results indicate that the trade balance has a positive and statistically significant impact on real effective exchange rate fluctuations of the selected countries at the 1% threshold. An increase in trade balance is associated with an increase in the real effective exchange rate (REER), which reflects a real appreciation of the domestic currency. As a result, exports become less competitive on international markets due to higher relative prices, while imports become more attractive and cheaper for domestic consumers. This finding aligns with theoretical expectations and previous empirical findings, such as Dilesha Rathnayake (2017). The finding confirms the sub-hypothesis H3d.

The trade balance is another variable that influences exchange rates through the foreign exchange supply and demand. Trade is associated with foreign currencies and makes adjustments in the supply and demand of domestic currency. If the trade balance is deficit, domestic currency demand may decrease and local currency will depreciate. On the other hand, a trade surplus increases the demand for domestic goods and currency having as a consequence the appreciation of the national currency.

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Note

To better understand the sensitivity of each country's real effective exchange rate (REER) to oil prices fluctuations, we conducted separate regression (see appendix No. 11) for each of the five oil-exporting countries: Algeria, Egypt, Nigeria, Angola, and Gabon. This approach allowed us to assess the individual significant and impact of oil prices on REER within each national context. The results indicate that oil prices have a statistically significant effect on the REER in all the selected countries. This reinforces the hypothesis of the significant impact of oil prices movements on REER fluctuations of African oil-exporting countries.

For the other economic variables, by conducting separate regression for each of the five selected countries, we found that the results for foreign exchange reserves reveal a mostly negative and statistically significant effect on the REER in several of the countries analysed (Algeria, Egypt, Nigerian, and Angola), while the effect is not significant for Gabon. The negative relationship observed may reflect the policy choices of oil-exporting countries that accumulate reserves as a precautionary measure and to prevent excessive currency appreciation. This is particularly relevant in economies with management exchange rate regimes, such a case for Algeria. Thus, the accumulation of reserves may act more as buffer than a direct signal of external strength, leading to REER depreciation or limited appreciation despite strong foreign exchange earnings.

We observe similar findings for inflation, which was included to capture internal price dynamics influencing the REER. The results indicate a negative and significant relationship in most countries, confirming the classical economic theory that inflation leads to real depreciation of the exchange rate.

The analysis also included lending interest rate, the results show a significant negative relationship between lending rate and REER in several countries, with the exception of Gabon, where the relationship is not statistically significant.

To evaluate the role of economic growth in determining the REER, we included the GDP as an explanatory variable in each country-specific regression. The results show a positive and statistically significant relationship between GDP and REER across all selected countries.

Lastly, the trade balance was included to assess the direct contribution to REER dynamics. The results point to a generally positive and significant relationship, particularly in countries with more consistent trade surplus, except Egypt, which has experienced a persistent trade deficit. This indicates that improvement in the current account tend to support REER appreciation as net exports contribute positively to foreign currency inflows and reduce depreciation pressure.

CHAPTER III : AN EMPIRICAL ANALYSIS OF THE COMMON DETERMINANTS OF REAL EFFECTIVE EXCHANGE RATE IN AFRICAN OIL-EXPORTING COUNTRIES

Conclusion

This study aimed to investigate the common macroeconomic factors influencing real effective exchange rate (REER) fluctuations in a sample of five (5) African oil-exporting countries (Algeria, Egypt, Nigeria, Angola, and Gabon) over the period 1995-2020.

The first section presented the study sample, the variables selected, and the statistical methodology used to estimate the model and test the research hypotheses. The second section provided a description analysis of the data. Finally, the third section presented and discussed the results of the estimated model, which examines the relationship between selected macroeconomic variables and REER in the studied countries.

The findings reveal that all the selected macroeconomic variables significantly influence REER fluctuations. Using panel data regression, the results show that inflation, lending interest rates, foreign exchange reserves, and oil prices have a negative impact on the REER fluctuations. In contrast, GDP and the trade balance have a positive effect on the REER fluctuations of the selected countries. These results confirm H2 and H3, and invalidate H1. However, the county-specific regressions highlight that in Algeria, Egypt, Nigeria, and Angola most variables, particularly oil prices, inflation, and foreign reserves, show a statistically significant effect on REER fluctuations. In contrast, Gabon stands out as an exception, where most variables are not significant, suggesting a weaker transmission of macroeconomic fundamentals to the REER, possibly due to policy buffers or structural differences. These findings emphasize the importance of considering national contexts when analysing exchange rate dynamics in oil-exporting African countries.

GENERAL CONCLUSION

GENERAL CONCLUSION

A key condition for any sound exchange rate policy is the ability to define a real exchange rate that is close to its equilibrium value and does not show major deviations, a rate that ensures both internal and external balance. However, the equilibrium value of the exchange rate is not directly observable. Over time, several theories have emerged in an attempt to address this issue.

The primary objective of our research is to examine the impact of common macroeconomic factors on real effective exchange rate fluctuations in African oil-exporting countries. To achieve this objective, the study employed a panel data regression approach, covering five (5) African oil-exporting countries (Algeria, Egypt, Nigeria, Angola, and Gabon) over the period from 1995 to 2020. The significance of this study lies in its contribution to a deeper understanding of the relationship between the common macroeconomic fundamentals and the real effective exchange rate.

In the theoretical part, we first provided a general overview of the fundamental concepts related the exchange rate, the international monetary system, and the typology and the choice of the exchange rate regimes. This overview is essential for establishing a solid theoretical foundation for this research. Following this, we presented both theoretical and an empirical literature review on the determinants of the exchange rates, in order to understand the principal theories of exchange rate determination and to examine the previous studies on the key factors influencing exchange rate behaviour. This review helps clarify the link between economic fundamentals and the exchange rate dynamics. However, the results of these earlier studies vary across samples countries. More precisely, any explanatory variable may have a positive or negative association with the REER, depending on the specific economic context of each country and each sample. Finally, we explored the concept of real exchange rate misalignment and volatility to highlight their macroeconomic implications.

Regarding the empirical part, our research investigated the impact of common macroeconomic factors on real effective exchange rate fluctuations in African oil-exporting countries. The empirical analysis aimed to model the relationship between real effective exchange rate and several explanatory variables, namely oil prices, foreign exchange reserves, inflation, gross domestic product (GDP), interest lending rate, and the trade balance. This was accomplished by employing an econometric model, specifically a panel multiple linear regression model.

Based on the results obtained from the previous chapter, we identified a significant negative relationship between oil prices and REER fluctuations in the selected countries. This outcome invalidates the initial hypothesis H1, which posited that oil prices would have a positive influence on real effective exchange rate (REER) fluctuations. The results also indicate that foreign exchange reserves have a significant negative impact on real effective exchange rate fluctuations, which aligns with earlier studies and confirms the hypothesis H2. Furthermore, the findings reveal that inflation and the interest lending rate have a significant negative impact on real effective exchange rate fluctuations, while gross domestic product

(GDP) and the trade balance show a significant positive effect. These findings confirm the hypothesis H3.

However, the county-specific regressions show that in Algeria, Egypt, Nigeria, and Angola most variables, particularly oil prices, inflation, and foreign reserves, have a statistically significant effect on REER fluctuations. In Gabon most variables are not significant, suggesting a weaker transmission of macroeconomic fundamentals to the REER. These findings emphasize the importance of considering national contexts when analysing exchange rate dynamics in oil-exporting African countries.

This study provides contributions along two main axes: the methodological approach and policy relevance.

From a methodological perspective, the study adopts a rigorous panel data approach that allows for the analysis of both temporal and cross-country variations. This method facilitates a more nuanced examination of the influence of each determinant on the REER and enhances the robustness and credibility of the findings. It reveals context-specific relationships, such as the unexpected negative effect of oil prices on REER, offering insights that challenge some conventional expectations. The use of panel data is particularly appropriate for capturing the heterogeneity among countries and for assessing dynamic relationships over time.

In terms of policy relevance, this research highlights the importance of understanding the factors influencing real exchange rate fluctuations in resource-dependent economies. By identifying key macroeconomic and structural variables that significantly affect the REER, the study provides policymakers and central banks with evidence-based insights to inform exchange rate management strategies. These findings can also support efforts to enhance economic stability, competitiveness, and long-term sustainable growth.

Despite the contributions outlined above, it is important to acknowledge the limitations and obstacles that may restrict broader expansion of this research. These limitations include:

- A long research period would have allowed us to conduct a more detailed analysis and to explore more deeply the theoretical implications of the results obtained.
- Due to limited data availability for African countries, we had to limit both the number of variables and the number of countries included in the panel.
- The number of countries included in the panel remains relatively unrepresentative and limited. Indeed, applying the dynamic panel model using GMM requires a large number of cross-sectional (N) relatively to the time dimension (T).
- Data obtained from secondary sources (such as the World Bank and the IMF) sometimes diverge from those reported by the monetary authorities of the countries themselves, which introduces a risk of bias and potential inaccuracies in the results.

For future research on the subject, we suggest expanding the panel to include additional oil-exporting countries with diverse economic profiles. It would also be relevant to examine the issue by dividing the period into two parts: before the 2014 oil shock and the period from

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that point until the COVID-19 pandemic. Furthermore, selecting a broader set of oil-exporting countries and classifying them into developing and developed economies could provide deeper insights into the differentiated impacts of external shocks on exchange rate dynamics. Moreover, we recommend the use of alternative econometric methods, particularly with a large panel, to enable their effective application, such as GMM method to address endogeneity and dynamic relationship in such contexts. We also suggest employing the panel ARDL approach for the selected sample in this study, commonly used in previous studies on exchange rates in African oil-exporting countries, could allow a more robust comparative analysis. Additionally, incorporating other explanatory variables and grouping them into macroeconomic, financial, and political categories could provide a deeper understanding of the multiple dimensions influencing real exchange rate dynamics.

Based on the empirical evidence presented, we can conclude that the real effective exchange rate (REER) in African oil-exporting countries is significantly influenced by a common set of determinants: oil prices, foreign exchange reserves, inflation, interest lending rate, GDP, and the trade balance. This finding highlights the critical importance of these macroeconomic fundamentals for formulating exchange rate policies.

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APPENDICES

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➤ Appendix N° 01: Data model variables

Years	Code	Ln_REER	ln_INF	Ln_INR	ln_OILP	ln_GDP	Ln_EXC	TB
1995	1	4.765144	3.394508	2.913256	2.844837	24.45531	7.603483	0.16
1996	1	4.783933	2.928524	2.944439	3.035363	24.57217	8.35114	4.16
1997	1	4.860459	1.740466	2.754191	2.96064	24.59816	8.993023	5.21
1998	1	4.908647	1.609438	2.442347	2.574612	24.59837	8.831352	0.81
1999	1	4.830131	0.955512	2.374906	2.896366	24.60773	8.417521	3.36
2000	1	4.78189	-1.20397	2.302585	3.361946	24.72678	9.394652	12.86
2001	1	4.814452	1.435085	2.251292	3.20736	24.80779	9.80264	9.19
2002	1	4.738834	0.336472	2.149822	3.223469	24.84257	10.05352	6.83
2003	1	4.634846	1.458615	2.094946	3.359649	25.02031	10.40805	10.78
2004	1	4.639048	1.386294	2.079442	3.643714	25.24412	10.67467	13.13
2005	1	4.62172	0.336472	2.079442	4.001568	25.39653	10.9385	24.20
2006	1	4.617519	0.832909	2.079442	4.183648	25.53613	11.26336	31.95
2007	1	4.603841	1.308333	2.079442	4.285692	25.68249	11.61112	30.13
2008	1	4.627233	1.589235	2.079442	4.578109	25.91835	11.8723	32.48
2009	1	4.607785	1.740466	2.079442	4.120354	25.73601	11.91197	-0.91
2010	1	4.60517	1.360977	2.079442	4.379611	25.90384	11.99914	9.94
2011	1	4.596364	1.504077	2.079442	4.714376	26.10928	12.11627	17.00
2012	1	4.643525	2.186051	2.079442	4.718603	26.14885	12.16158	12.81
2013	1	4.622995	1.193923	2.079442	4.690997	26.16005	12.17928	2.92
2014	1	4.633997	1.064711	2.079442	4.598603	26.19949	12.09859	-7.68
2015	1	4.570305	1.568616	2.079442	3.97072	25.95701	11.88226	-25.38
2016	1	4.560025	1.856298	2.079442	3.808418	25.92046	11.64738	-27.45
2017	1	4.582974	1.722767	2.079442	4.005275	25.96966	11.48878	-22.40
2018	1	4.538141	1.458615	2.079442	4.271271	25.99398	11.29262	-15.70
2019	1	4.558587	0.693147	2.079442	4.16198	25.98833	11.0556	-15.71
2020	1	4.513282	0.875469	2.079442	3.768934	25.82844	10.79717	-17.45
1995	2	4.603768	2.24071	2.801591	2.844837	24.82026	9.691607	-3.88
1996	2	4.595765	1.960095	2.746202	3.035363	24.93731	9.764131	-4.20
1997	2	4.646937	1.824549	2.624064	2.96064	25.08556	9.834393	-6.02
1998	2	4.714701	1.609438	2.566231	2.574612	25.1639	9.804988	-8.57
1999	2	4.798949	1.308333	2.562253	2.896366	25.23094	9.580805	-6.89

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2000	2	4.826538	1.029619	2.581416	3.361946	25.32682	9.481709	-6.03
2001	2	4.712842	0.875469	2.587137	3.20736	25.29472	9.46698	-4.93
2002	2	4.572672	0.832909	2.624064	3.223469	25.16763	9.491179	-3.07
2003	2	4.252127	1.223775	2.605156	3.359649	25.10889	9.516996	0.40
2004	2	4.220779	2.104134	2.593387	3.643714	25.08996	9.566139	-0.40
2005	2	4.279846	2.163323	2.575788	4.001568	25.21863	9.933486	-3.61
2006	2	4.31664	1.458615	2.533697	4.183648	25.40007	10.10486	-3.87
2007	2	4.32044	2.388763	2.526395	4.285692	25.59416	10.31519	-9.30
2008	2	4.419964	2.459589	2.51163	4.578109	25.8159	10.38022	-12.46
2009	2	4.556469	2.785011	2.482821	4.120354	25.96579	10.38136	-9.23
2010	2	4.60517	2.459589	2.398653	4.379611	26.11226	10.42263	-11.03
2011	2	4.584215	2.406945	2.400921	4.714376	26.18705	9.610168	-14.33
2012	2	4.634123	2.163323	2.484907	4.718603	26.3549	9.361132	-20.20
2013	2	4.5676	1.931521	2.508922	4.690997	26.38773	9.51842	-20.53
2014	2	4.655497	2.312536	2.460301	4.598603	26.44553	9.392262	-26.83
2015	2	4.770356	2.397895	2.453158	3.97072	26.52044	9.494167	-30.37
2016	2	4.645703	2.322388	2.61007	3.808418	26.52973	9.9455	-34.68
2017	2	4.301343	3.157	2.900047	4.005275	26.23816	10.41072	-27.35
2018	2	4.420407	3.039749	2.907811	4.271271	26.29385	10.56125	-24.71
2019	2	4.570603	2.631889	2.779854	4.16198	26.48745	10.61362	-25.43
2020	2	4.683148	1.740466	2.430685	3.768934	26.67343	10.4369	-32.38
1995	3	5.076302	4.288204	3.007331	2.844837	25.67146	7.274768	-0.16
1996	3	5.335199	3.377588	2.987532	3.035363	25.94756	8.312802	1.75
1997	3	5.463984	2.370244	2.878917	2.96064	26.02583	8.933517	0.54
1998	3	5.609526	2.066863	2.900551	2.574612	26.10967	8.867967	-1.00
1999	3	4.23698	1.88707	3.010128	2.896366	24.80326	8.603431	1.79
2000	3	4.250815	1.931521	3.057493	3.361946	24.95985	9.20139	8.95
2001	3	4.359062	2.939162	3.154373	3.20736	25.02134	9.254992	3.91
2002	3	4.362093	2.557227	3.209667	3.223469	25.27771	8.899913	2.34
2003	3	4.299644	2.639057	3.030818	3.359649	25.37474	8.871847	5.58
2004	3	4.321714	2.70805	2.953912	3.643714	25.63419	9.738356	17.12
2005	3	4.457453	2.884801	2.887497	4.001568	25.89188	10.2499	24.37
2006	3	4.515691	2.104134	2.826919	4.183648	26.19745	10.6525	23.32
2007	3	4.505682	1.686399	2.829628	4.285692	26.35183	10.8461	20.85

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2008	3	4.600777	2.451005	2.717065	4.578109	26.55067	10.87806	23.81
2009	3	4.528744	2.525729	2.943956	4.120354	26.41027	10.6545	8.91
2010	3	4.60517	2.617396	2.867046	4.379611	26.6286	10.38404	11.85
2011	3	4.610197	2.379546	2.773838	4.714376	26.75026	10.39329	11.64
2012	3	4.705001	2.501436	2.820883	4.718603	26.86309	10.68809	17.65
2013	3	4.766834	2.140066	2.816755	4.690997	26.97732	10.6654	22.77
2014	3	4.827036	2.079442	2.806285	4.598603	27.07622	10.4412	-1.86
2015	3	4.786342	2.197225	2.824301	3.97072	26.92383	10.25002	-22.90
2016	3	4.708271	2.753661	2.825419	3.808418	26.72629	10.21218	-8.55
2017	3	4.619539	2.80336	2.865244	4.005275	26.65218	10.5868	-0.09
2018	3	4.699594	2.493206	2.827544	4.271271	26.76765	10.6652	-5.60
2019	3	4.821806	2.433613	2.732846	4.16198	26.88556	10.55414	-30.89
2020	3	4.783444	2.580217	2.613155	3.768934	26.79215	10.51134	-32.24
1995	4	3.558863	7.890657	5.329089	2.844837	22.43503	7.088586	0.32
1996	4	3.41714	8.329899	5.383922	3.035363	22.74169	6.595598	0.90
1997	4	4.024135	5.400423	3.630985	2.96064	22.75776	5.928381	-0.06
1998	4	4.228751	4.67656	3.806663	2.574612	22.59603	6.452363	-1.05
1999	4	3.495391	5.514235	4.385728	2.896366	22.54019	7.22954	-0.39
2000	4	3.807888	5.783825	4.636283	3.361946	22.93479	8.069921	2.45
2001	4	3.923228	5.02782	4.564	3.20736	22.91336	9.00566	0.04
2002	4	3.97169	4.69043	4.578167	3.223469	23.45018	9.323383	1.45
2003	4	3.963674	4.587006	4.565546	3.359649	23.60318	9.790846	0.91
2004	4	4.123659	3.772761	4.410786	3.643714	23.88248	9.522527	3.16
2005	4	4.22731	3.135494	4.215354	4.001568	24.3334	9.88729	9.14
2006	4	4.397992	2.587764	2.970969	4.183648	24.68181	10.20506	17.06
2007	4	4.484398	2.501436	2.873499	4.285692	24.90174	10.34695	18.40
2008	4	4.550991	2.525729	2.528414	4.578109	25.20671	10.35777	21.12
2009	4	4.655517	2.617396	2.752518	4.120354	24.97614	10.20479	-0.38
2010	4	4.60517	2.674149	3.11545	4.379611	25.15169	10.07704	7.55
2011	4	4.635341	2.60269	2.93158	4.714376	25.43989	10.07206	22.19
2012	4	4.731949	2.332144	2.812795	4.718603	25.57571	9.7674	22.48
2013	4	4.786064	2.174752	2.760556	4.690997	25.60863	9.642798	16.02
2014	4	4.829938	1.987874	2.7962	4.598603	25.63568	9.701056	22.88
2015	4	4.81783	2.219203	2.82624	3.97072	25.22858	9.531117	8.78

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2016	4	4.785913	3.424263	2.758775	3.808418	24.68905	9.579702	0.04
2017	4	5.000413	3.394508	2.760396	4.005275	25.02313	9.52184	9.71
2018	4	4.735777	2.97553	3.029022	4.271271	25.0984	9.542669	19.09
2019	4	4.549593	2.839078	2.959865	4.16198	24.98451	9.701056	20.03
2020	4	4.276953	3.104587	2.978377	3.768934	24.60486	9.531117	2.16
1995	5	4.695043	2.261763	5.329089	2.844837	22.32444	4.997794	1.83
1996	5	4.68271	-0.35667	5.383922	3.035363	22.46269	5.51631	2.23
1997	5	4.665796	1.386294	3.630985	2.96064	22.39602	5.644038	1.92
1998	5	4.673223	0.336472	3.806663	2.574612	22.22365	2.734886	0.81
1999	5	4.625414		4.385728	2.896366	22.26292	2.88741	1.55
2000	5	4.566669	-0.69315	4.636283	3.361946	22.34867	5.247501	1.65
2001	5	4.567957	0.741937	4.564	3.20736	22.33735	2.2875	1.52
2002	5	4.566981	-1.60944	4.578167	3.223469	22.39764	4.939154	1.27
2003	5	4.614353	0.741937	4.565546	3.359649	22.5969	5.281025	1.86
2004	5	4.614103	-0.91629	4.410786	3.643714	22.77356	6.094525	2.38
2005	5	4.622629	0.182322	4.215354	4.001568	22.98323	6.505133	3.59
2006	5	4.584028		2.970969	4.183648	23.05809	7.015203	3.72
2007	5	4.62808		2.873499	4.285692	23.24542	7.112525	4.15
2008	5	4.66119	1.667707	2.528414	4.578109	23.4687	7.561897	7.00
2009	5	4.66861	0.641854	2.752518	4.120354	23.2176	7.597517	2.86
2010	5	4.60517	0.336472	3.11545	4.379611	23.38859	7.459271	5.70
2011	5	4.586611	0.262364	2.93158	4.714376	23.62525	7.67662	6.10
2012	5	4.55154	0.993252	2.812795	4.718603	23.56646	7.762835	6.59
2013	5	4.562428	-0.69315	2.760556	4.690997	23.59092	8.007558	6.50
2014	5	4.597948	1.504077	2.7962	4.598603	23.6249	7.815401	4.35
2015	5	4.529153		2.82624	3.97072	23.38932	7.530008	4.53
2016	5	4.540478	0.741937	2.758775	3.808418	23.36403	6.671206	3.33
2017	5	4.56255	0.993252	2.760396	4.005275	23.4266	6.872184	1.93
2018	5	4.616665	1.568616	3.029022	4.271271	23.54865	7.186183	5.09
2019	5	4.610994	0.693147	2.959865	4.16198	23.54906	7.224006	3.84
2020	5	4.636971	0.530628	2.978377	3.768934	23.45387	7.234534	3.86

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➤ Appendix N° 02: Descriptive analysis of variables by country (Code)

```
. tabstat ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB, statistics(mean sd min max) by( Code)
```

Summary statistics: Mean, SD, Min, Max
Group variable: Code (Code)

Code	ln_REER	ln_OILP	ln_EXP~V	ln_INF	ln_INR~D	ln_GDP	TB
1	4.663879	3.821774	10.72485	1.358962	2.21455	25.45855	3.663082
	.1082971	.6513345	1.373231	.8499786	.2628811	.6160409	16.94573
	4.513282	2.574612	7.603483	-1.203973	2.079442	24.45531	-27.44949
	4.908647	4.718603	12.17928	3.394508	2.944439	26.19949	32.47631
2	4.5491	3.821774	9.887724	2.031832	2.586814	25.74812	-13.45754
	.1764535	.6513345	.4172307	.6270393	.1389134	.6113	10.88341
	4.220779	2.574612	9.361132	.8329091	2.398653	24.82026	-34.6771
	4.826538	4.718603	10.61362	3.157	2.907811	26.67343	.3979
3	4.686804	3.821774	9.868913	2.515239	2.891119	26.20273	3.994486
	.3546626	.6513345	.9637349	.5171959	.1338536	.6882694	15.45096
	4.23698	2.574612	7.274768	1.686399	2.613155	24.80326	-32.24126
	5.609526	4.718603	10.87806	4.288204	3.209667	27.07622	24.36747
4	4.330214	3.821774	9.102943	3.798854	3.552353	24.26902	8.616328
	.4501019	.6513345	1.314493	1.70493	.9006215	1.115375	9.005621
	3.41714	2.574612	5.928381	1.987874	2.528414	22.43503	-1.04983
	5.000413	4.718603	10.35777	8.329899	5.383922	25.63568	22.88247
5	4.609127	3.821774	6.263932	.5143334	3.552353	23.02402	3.468462
	.0462106	.6513345	1.634306	.9352003	.9006215	.5249303	1.839025
	4.529153	2.574612	2.2875	-1.609438	2.528414	22.22365	.813
	4.695043	4.718603	8.007558	2.261763	5.383922	23.62525	7.003
Total	4.567825	3.821774	9.169671	2.0924	2.959438	24.94049	1.256963
	.2981046	.6411567	1.955572	1.482816	.7857855	1.36751	14.12312
	3.41714	2.574612	2.2875	-1.609438	2.079442	22.22365	-34.6771
	5.609526	4.718603	12.17928	8.329899	5.383922	27.07622	32.47631

```
. summarize ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB
```

Variable	Obs	Mean	Std. dev.	Min	Max
ln_REER	130	4.567825	.2981046	3.41714	5.609526
ln_OILP	130	3.821774	.6411567	2.574612	4.718603
ln_EXP_RESRV	130	9.169671	1.955572	2.2875	12.17928
ln_INF	126	2.0924	1.482816	-1.609438	8.329899
ln_INR_LEND	130	2.959438	.7857855	2.079442	5.383922
ln_GDP	130	24.94049	1.36751	22.22365	27.07622
TB	130	1.256963	14.12312	-34.6771	32.47631

➤ **Appendix N° 03: Correlation matrix between model variables**

. pwcorr ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB, star (5)

	ln_REER	ln_OILP	ln_EXP~V	ln_INF	ln_INR~D	ln_GDP	TB
ln_REER	1.0000						
ln_OILP	0.0723	1.0000					
ln_EXP_RESRV	0.0896	0.4774*	1.0000				
ln_INF	-0.5152*	-0.1681	0.0749	1.0000			
ln_INR_LEND	-0.4575*	-0.4334*	-0.6977*	0.3433*	1.0000		
ln_GDP	0.3641*	0.4446*	0.8355*	0.0100	-0.7025*	1.0000	
TB	-0.0013	0.1363	-0.0239	-0.0616	0.0645	-0.1903*	1.0000

➤ **Appendix N° 04: Result of the VIF test**

. reg ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB

Source	SS	df	MS	Number of obs	=	126
Model	6.80158408	6	1.13359735	F(6, 119)	=	28.99
Residual	4.65339768	119	.039104182	Prob > F	=	0.0000
				R-squared	=	0.5938
				Adj R-squared	=	0.5733
Total	11.4549818	125	.091639854	Root MSE	=	.19775

ln_REER	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
ln_OILP	-.0964041	.0331599	-2.91	0.004	-.162064	-.0307443
ln_EXP_RESRV	-.1146862	.0193566	-5.92	0.000	-.1530142	-.0763582
ln_INF	-.0804918	.0148212	-5.43	0.000	-.1098393	-.0511443
ln_INR_LEND	-.1120758	.0401538	-2.79	0.006	-.1915843	-.0325673
ln_GDP	.2022075	.0265146	7.63	0.000	.1497059	.2547091
TB	.0037567	.0013306	2.82	0.006	.001122	.0063914
_cons	1.437025	.6223039	2.31	0.023	.2048015	2.669249

. vif

Variable	VIF	1/VIF
ln_EXP_RESRV	4.23	0.236590
ln_GDP	4.04	0.247471
ln_INR_LEND	3.20	0.312619
ln_INF	1.54	0.647696
ln_OILP	1.46	0.686480
TB	1.16	0.859271
Mean VIF	2.61	

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➤ Appendix N° 05: Result of the Testparm Test

```
. xtreg ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB i.years, fe robust
note: 2020.years omitted because of collinearity.
```

```
Fixed-effects (within) regression      Number of obs   =      126
Group variable: Code                  Number of groups =       5

R-squared:                            Obs per group:
    Within = 0.8576                      min =      22
    Between = 0.1967                     avg =     25.2
    Overall = 0.2288                     max =      26
```

```
corr(u_i, Xb) = -0.9257                F(4,4)          =      .
                                         Prob > F        =      .
```

(Std. err. adjusted for 5 clusters in Code)

ln_REER	Coefficient	Robust std. err.	t	P> t	[95% conf. interval]	
ln_OILP	-.1155892	.1676425	-6.89	0.002	-1.621343	-.6904423
ln_EXP_RESRV	-.0513734	.0329106	-1.56	0.194	-.1427479	.0400011
ln_INF	-.0331754	.0279894	-1.19	0.302	-.1108863	.0445356
ln_INR_LEND	-.1391118	.0261659	-5.32	0.006	-.2117599	-.0664636
ln_GDP	.6395562	.1372545	4.66	0.010	.2584767	1.020636
TB	-.0000644	.0023817	-0.03	0.980	-.0066771	.0065482
years						
1996	.1170194	.112376	1.04	0.357	-.1949863	.4290251
1997	.0496503	.1069307	0.46	0.667	-.247237	.3465375
1998	-.3231516	.1226517	-2.63	0.058	-.6636874	.0173843
1999	-.1848884	.1208385	-1.53	0.201	-.5203899	.1506131
2000	.3300676	.1189291	2.78	0.050	-.0001325	.6602677
2001	.1789452	.0839303	2.13	0.100	-.0540828	.4119731
2002	.0694097	.095392	0.73	0.507	-.1954411	.3342604
2003	.0944424	.0680749	1.39	0.238	-.0945637	.2834485
2004	.331865	.0957171	3.47	0.026	.0661118	.5976183
2005	.654469	.1743353	3.75	0.020	.1704365	1.138501
2006	.7037144	.2217144	3.17	0.034	.0881366	1.319292
2007	.7392828	.1994532	3.71	0.021	.185512	1.293054
2008	.9992414	.2204831	4.53	0.011	.3870822	1.611401
2009	.5966868	.1057337	5.64	0.005	.3031229	.8902507
2010	.7917456	.1386574	5.71	0.005	.4067708	1.17672
2011	1.038199	.1846651	5.62	0.005	.5254863	1.550911
2012	1.045407	.1771932	5.90	0.004	.5534394	1.537374
2013	.9714141	.1700743	5.71	0.005	.4992122	1.443616
2014	.8880881	.1233053	7.20	0.002	.5457377	1.230438
2015	.2695823	.0458761	5.88	0.004	.14221	.3969547
2016	.1398716	.1039163	1.35	0.250	-.1486461	.4283894
2017	.347011	.0850819	4.08	0.015	.1107858	.5832362
2018	.6075351	.0633597	9.59	0.001	.4316204	.7834498
2019	.4504993	.0597988	7.53	0.002	.2844712	.6165274
2020	0 (omitted)					
_cons	-6.471084	2.968336	-2.18	0.095	-14.71251	1.770337
sigma_u	.74612916					
sigma_e	.1208144					
rho	.97445126	(fraction of variance due to u_i)				

```
. testparm i.years

( 1) 1996.years = 0
( 2) 1997.years = 0
( 3) 1998.years = 0
( 4) 1999.years = 0
( 5) 2000.years = 0
( 6) 2001.years = 0
( 7) 2002.years = 0
( 8) 2003.years = 0
( 9) 2004.years = 0
(10) 2005.years = 0
(11) 2006.years = 0
(12) 2007.years = 0
(13) 2008.years = 0
(14) 2009.years = 0
(15) 2010.years = 0
(16) 2011.years = 0
(17) 2012.years = 0
(18) 2013.years = 0
(19) 2014.years = 0
(20) 2015.years = 0
(21) 2016.years = 0
(22) 2017.years = 0
(23) 2018.years = 0
(24) 2019.years = 0
    Constraint 1 dropped
    Constraint 2 dropped
    Constraint 5 dropped
    Constraint 6 dropped
    Constraint 7 dropped
    Constraint 8 dropped
    Constraint 9 dropped
    Constraint 10 dropped
    Constraint 12 dropped
    Constraint 13 dropped
    Constraint 14 dropped
    Constraint 15 dropped
    Constraint 16 dropped
    Constraint 17 dropped
    Constraint 18 dropped
    Constraint 19 dropped
    Constraint 21 dropped
    Constraint 22 dropped
    Constraint 23 dropped
    Constraint 24 dropped

F( 4, 4) = 29.71
    Prob > F = 0.0031
```

➤ Appendix N° 06: Hausman Test Result

. xtreg ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB, fe

Fixed-effects (within) regression
 Group variable: Code

Number of obs = 126
 Number of groups = 5

R-squared:
 Within = 0.7387
 Between = 0.2272
 Overall = 0.2780

Obs per group:
 min = 22
 avg = 25.2
 max = 26

F(6,115) = 54.20
 Prob > F = 0.0000

corr(u_i, Xb) = -0.8786

ln_REER	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
ln_OILP	-.4310158	.0451583	-9.54	0.000	-.5204657	-.3415659
ln_EXP_RESRV	-.0847157	.0188788	-4.49	0.000	-.1221109	-.0473204
ln_INF	-.0337757	.0160629	-2.10	0.038	-.0655932	-.0019581
ln_INR_LEND	-.0769706	.0333989	-2.30	0.023	-.1431273	-.0108138
ln_GDP	.5396299	.0426688	12.65	0.000	.4551112	.6241487
TB	.0059673	.0012982	4.60	0.000	.0033959	.0085388
_cons	-6.202309	.9962357	-6.23	0.000	-8.17566	-4.228957
sigma_u	.52174107					
sigma_e	.14555961					
rho	.92778629	(fraction of variance due to u_i)				

F test that all u_i=0: F(4, 115) = 26.16 Prob > F = 0.0000

. estimates store fixed

. xtreg ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB, re

Random-effects GLS regression
 Group variable: Code

Number of obs = 126
 Number of groups = 5

R-squared:
 Within = 0.5660
 Between = 0.8988
 Overall = 0.5938

Obs per group:
 min = 22
 avg = 25.2
 max = 26

Wald chi2(6) = 173.93
 Prob > chi2 = 0.0000

corr(u_i, X) = 0 (assumed)

ln_REER	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
ln_OILP	-.0964041	.0331599	-2.91	0.004	-.1613963	-.031412
ln_EXP_RESRV	-.1146862	.0193566	-5.92	0.000	-.1526244	-.0767479
ln_INF	-.0804918	.0148212	-5.43	0.000	-.1095409	-.0514428
ln_INR_LEND	-.1120758	.0401538	-2.79	0.005	-.1907757	-.0333758
ln_GDP	.2022075	.0265146	7.63	0.000	.1502398	.2541752
TB	.0037567	.0013306	2.82	0.005	.0011488	.0063646
_cons	1.437025	.6223039	2.31	0.021	.2173321	2.656719
sigma_u	0					
sigma_e	.14555961					
rho	0	(fraction of variance due to u_i)				

. estimate store random

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. hausman fixed random

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
ln_OILP	-.4310158	-.0964041	-.3346117	.0306545
ln_EXP_RESRV	-.0847157	-.1146862	.0299705	.
ln_INF	-.0337757	-.0804918	.0467162	.0061927
ln_INR_LEND	-.0769706	-.1120758	.0351052	.
ln_GDP	.5396299	.2022075	.3374224	.0334306
TB	.0059673	.0037567	.0022106	.

b = Consistent under H0 and Ha; obtained from **xtreg**.

B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

$$\begin{aligned}\text{chi2}(6) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 154.61\end{aligned}$$

Prob > chi2 = 0.0000

(V_b-V_B is not positive definite)

➤ Appendix N° 07: Result of the Breusch-Pagan Test

```
. xtreg ln_REER ln_OILP ln_EXP RESRV ln_INF ln_INR LEND ln_GDP TB, re
```

Random-effects GLS regression	Number of obs	=	126
Group variable: Code	Number of groups	=	5

R-squared:	Obs per group:
Within = 0.5660	min = 22
Between = 0.8988	avg = 25.2
Overall = 0.5938	max = 26

	Wald chi2(6)	=	173.93
corr(u_i, X) = 0 (assumed)	Prob > chi2	=	0.0000

ln_REER	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
ln_OILP	-.0964041	.0331599	-2.91	0.004	-.1613963	-.031412
ln_EXP_RESRV	-.1146862	.0193566	-5.92	0.000	-.1526244	-.0767479
ln_INF	-.0804918	.0148212	-5.43	0.000	-.1095409	-.0514428
ln_INR_LEND	-.1120758	.0401538	-2.79	0.005	-.1907757	-.0333758
ln_GDP	.2022075	.0265146	7.63	0.000	.1502398	.2541752
TB	.0000376	.0000133	2.82	0.005	.0000115	.0000636
_cons	1.437025	.6223039	2.31	0.021	.2173321	2.656719
sigma_u	0					
sigma_e	.14555961					
rho	0 (fraction of variance due to u_i)					

```
. xttest0
```

Breusch and Pagan Lagrangian multiplier test for random effects

$$\ln_REER[Code,t] = Xb + u[Code] + e[Code,t]$$

Estimated results:

	Var	SD = sqrt(Var)
ln_REER	.0916399	.3027208
e	.0211876	.1455596
u	0	0

Test: $\text{Var}(u) = 0$

```
chibar2(01) =      0.00
Prob > chibar2 =    1.0000
```

➤ Appendix N° 08: Result of the Autocorrelation Test

```
. xtserial ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB
```

Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

$$F(1, 4) = 25.162$$
$$\text{Prob} > F = 0.0074$$

➤ Appendix N° 09: Result of the Heteroscedasticity Test

```
. xtreg ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB, fe
```

Fixed-effects (within) regression

Group variable: Code

R-squared:

Within = 0.7387

Between = 0.2272

Overall = 0.2780

Number of obs = 126

Number of groups = 5

Obs per group:

min = 22

avg = 25.2

max = 26

F(6,115) = 54.20

Prob > F = 0.0000

corr(u_i, Xb) = -0.8786

ln_REER	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
ln_OILP	-.4310158	.0451583	-9.54	0.000	-.5204657	-.3415659
ln_EXP_RESRV	-.0847157	.0188788	-4.49	0.000	-.1221109	-.0473204
ln_INF	-.0337757	.0160629	-2.10	0.038	-.0655932	-.0019581
ln_INR_LEND	-.0769706	.0333989	-2.30	0.023	-.1431273	-.0108138
ln_GDP	.5396299	.0426688	12.65	0.000	.4551112	.6241487
TB	.0059673	.0012982	4.60	0.000	.0033959	.0085388
_cons	-6.202309	.9962357	-6.23	0.000	-8.17566	-4.228957
sigma_u	.52174107					
sigma_e	.14555961					
rho	.92778629	(fraction of variance due to u_i)				

F test that all u_i=0: F(4, 115) = 26.16 Prob > F = 0.0000

```
. xttest3
```

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: $\sigma^2(i) = \sigma^2$ for all i

chi2 (5) = 11.60

Prob > chi2 = 0.0406

➤ Appendix N° 10: Result of the PCSEs Approach

```
. xtpcse ln_REER ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                Number of obs   =       126
Time variable:   years                Number of groups =         5
Panels:          correlated (unbalanced)  Obs per group:
Autocorrelation: no autocorrelation      min =        22
Sigma computed by casewise selection      avg =       25.2
                                           max =         26
Estimated covariances   =        15      R-squared        =    0.5938
Estimated autocorrelations =         0      Wald chi2(6)       =   150.59
Estimated coefficients   =         7      Prob > chi2        =    0.0000
```

ln_REER	Panel-corrected					[95% conf. interval]
	Coefficient	std. err.	z	P> z		
ln_OILP	-.0964041	.0345585	-2.79	0.005	-.1641376	-.0286707
ln_EXP_RESRV	-.1146862	.0176188	-6.51	0.000	-.1492184	-.080154
ln_INF	-.0804918	.0134903	-5.97	0.000	-.1069324	-.0540513
ln_INR_LEND	-.1120758	.03478	-3.22	0.001	-.1802433	-.0439082
ln_GDP	.2022075	.0307949	6.57	0.000	.1418506	.2625643
TB	.0037567	.001442	2.61	0.009	.0009305	.0065829
_cons	1.437025	.6736296	2.13	0.033	.1167356	2.757315

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➤ Appendix N° 11: The results of the country-specific regressions

```
. xtpcse ln_REER OILP_Algeria OILP_Nigeria OILP_Egypt OILP_Angola OILP_Gabon ln_EXP_RESRV ln_INF ln_INR_LEND ln_GD
> P TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation                min =      22
Sigma computed by casewise selection                avg =     25.2
                                                    max =      26
Estimated covariances      =      15      R-squared        =     0.7939
Estimated autocorrelations =       0      Wald chi2(10)     =     417.00
Estimated coefficients      =      11      Prob > chi2      =     0.0000
```

ln_REER	Panel-corrected					
	Coefficient	std. err.	z	P> z	[95% conf. interval]	
OILP_Algeria	-.3748702	.0527548	-7.11	0.000	-.4782677	-.2714728
OILP_Nigeria	-.4336314	.0531989	-8.15	0.000	-.5378992	-.3293635
OILP_Egypt	-.4859572	.0611568	-7.95	0.000	-.6058223	-.3660922
OILP_Angola	-.3174073	.0465311	-6.82	0.000	-.4086065	-.226208
OILP_Gabon	-.1816942	.0336954	-5.39	0.000	-.247736	-.1156525
ln_EXP_RESRV	-.1116262	.0160191	-6.97	0.000	-.143023	-.0802294
ln_INF	-.0465649	.0143494	-3.25	0.001	-.0746891	-.0184407
ln_INR_LEND	.0031316	.029988	0.10	0.917	-.0556439	.0619071
ln_GDP	.5467419	.0463453	11.80	0.000	.4559068	.637577
TB	.0058192	.0013671	4.26	0.000	.0031398	.0084986
_cons	-6.594874	1.073456	-6.14	0.000	-8.69881	-4.490938

```
. xtpcse ln_REER ln_EXP_RESRV_Algeria ln_EXP_RESRV_Nigeria ln_EXP_RESRV_Egypt ln_EXP_RESRV_Angola ln_EXP_RESRV_Gab
> on ln_OILP ln_INF ln_INR_LEND ln_GDP TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation                min =      22
Sigma computed by casewise selection                avg =     25.2
                                                    max =      26
Estimated covariances      =      15      R-squared        =     0.8096
Estimated autocorrelations =       0      Wald chi2(10)     =     478.93
Estimated coefficients      =      11      Prob > chi2      =     0.0000
```

ln_REER	Panel-corrected					
	Coefficient	std. err.	z	P> z	[95% conf. interval]	
ln_EXP_RESRV_Algeria	-.1327761	.0133115	-9.97	0.000	-.1588662	-.106686
ln_EXP_RESRV_Nigeria	-.158286	.0147374	-10.74	0.000	-.1871709	-.1294012
ln_EXP_RESRV_Egypt	-.1786943	.0165068	-10.83	0.000	-.2110471	-.1463415
ln_EXP_RESRV_Angola	-.1063416	.0144621	-7.35	0.000	-.1346868	-.0779964
ln_EXP_RESRV_Gabon	-.0220546	.0192161	-1.15	0.251	-.0597174	.0156083
ln_OILP	-.3987335	.0457196	-8.72	0.000	-.4883422	-.3091247
ln_INF	-.0555714	.0134804	-4.12	0.000	-.0819925	-.0291504
ln_INR_LEND	-.0002506	.0294708	-0.01	0.993	-.0580124	.0575112
ln_GDP	.5713705	.0440463	12.97	0.000	.4850413	.6576998
TB	.0059255	.0012553	4.72	0.000	.0034651	.0083859
_cons	-6.88023	1.002859	-6.86	0.000	-8.845797	-4.914663

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```
. xtpcse ln_REER ln_INF_Algeria ln_INF_Nigeria ln_INF_Egypt ln_INF_Angola ln_INF_Gabon ln_OILP ln_EXP_RESRV ln_INR
> _LEND ln_GDP TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation                min =      22
Sigma computed by casewise selection                avg =     25.2
                                                    max =      26
Estimated covariances   =      15          R-squared      =     0.6633
Estimated autocorrelations =      0          Wald chi2(10)   =     263.14
Estimated coefficients   =     11          Prob > chi2    =     0.0000
```

ln_REER	Panel-corrected					[95% conf. interval]	
	Coefficient	std. err.	z	P> z			
ln_INF_Algeria	-.0790773	.0261681	-3.02	0.003	-.1303659	-.0277888	
ln_INF_Nigeria	-.1908366	.03035	-6.29	0.000	-.2503214	-.1313518	
ln_INF_Egypt	-.1705568	.0348118	-4.90	0.000	-.2387867	-.1023269	
ln_INF_Angola	-.0799476	.0142036	-5.63	0.000	-.1077862	-.0521091	
ln_INF_Gabon	.0223068	.0356152	0.63	0.531	-.0474978	.0921115	
ln_OILP	-.1389006	.0355359	-3.91	0.000	-.2085496	-.0692516	
ln_EXP_RESRV	-.1415293	.0186047	-7.61	0.000	-.1779938	-.1050647	
ln_INR_LEND	-.0519965	.0416443	-1.25	0.212	-.1336179	.0296249	
ln_GDP	.3277233	.0409206	8.01	0.000	.2475205	.4079262	
TB	.0026848	.0016642	1.61	0.107	-.000577	.0059466	
_cons	-1.383049	.9471447	-1.46	0.144	-3.239418	.473321	

```
. xtpcse ln_REER ln_INR_LEND_Algeria ln_INR_LEND_Nigeria ln_INR_LEND_Egypt ln_INR_LEND_Angola ln_INR_LEND_Gabon ln
> _OILP ln_EXP_RESRV ln_INF ln_GDP TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation                min =      22
Sigma computed by casewise selection                avg =     25.2
                                                    max =      26
Estimated covariances   =      15          R-squared      =     0.7722
Estimated autocorrelations =      0          Wald chi2(10)   =     473.23
Estimated coefficients   =     11          Prob > chi2    =     0.0000
```

ln_REER	Panel-corrected					[95% conf. interval]	
	Coefficient	std. err.	z	P> z			
ln_INR_LEND_Algeria	-.3363533	.0478185	-7.03	0.000	-.4300758	-.2426307	
ln_INR_LEND_Nigeria	-.3779704	.043246	-8.74	0.000	-.462731	-.2932099	
ln_INR_LEND_Egypt	-.3928782	.0441076	-8.91	0.000	-.4793275	-.3064288	
ln_INR_LEND_Angola	-.1946481	.0360888	-5.39	0.000	-.2653809	-.1239153	
ln_INR_LEND_Gabon	-.0291641	.0377486	-0.77	0.440	-.10315	.0448218	
ln_OILP	-.3821444	.0476184	-8.03	0.000	-.4754748	-.288814	
ln_EXP_RESRV	-.0865061	.0176239	-4.91	0.000	-.1210484	-.0519638	
ln_INF	-.0113024	.0203294	-0.56	0.578	-.0511473	.0285425	
ln_GDP	.4552911	.0371693	12.25	0.000	.3824407	.5281416	
TB	.0052997	.0015845	3.34	0.001	.0021941	.0084053	
_cons	-3.786195	.8261111	-4.58	0.000	-5.405343	-2.167047	

APPENDICES

```
. xtpcse ln_REER ln_GDP_Algeria ln_GDP_Nigeria ln_GDP_Egypt ln_GDP_Angola ln_GDP_Gabon ln_OILP ln_EXP_RESRV ln_INF
> ln_INR_LEND TB
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation          min =      22
Sigma computed by casewise selection          avg =     25.2
                                              max =      26
Estimated covariances   =      15          R-squared       =     0.7880
Estimated autocorrelations =      0          Wald chi2(10)    =     497.72
Estimated coefficients   =     11          Prob > chi2      =     0.0000
```

ln_REER	Panel-corrected					[95% conf. interval]
	Coefficient	std. err.	z	P> z		
ln_GDP_Algeria	.5429575	.0475378	11.42	0.000	.4497852	.6361298
ln_GDP_Nigeria	.5352186	.0470147	11.38	0.000	.4430716	.6273657
ln_GDP_Egypt	.5286666	.0455947	11.59	0.000	.4393026	.6180306
ln_GDP_Angola	.5557182	.0484601	11.47	0.000	.4607381	.6506983
ln_GDP_Gabon	.5835682	.0520604	11.21	0.000	.4815316	.6856048
ln_OILP	-.4282856	.0560884	-7.64	0.000	-.5382169	-.3183544
ln_EXP_RESRV	-.0876777	.0169124	-5.18	0.000	-.1208255	-.05453
ln_INF	-.034694	.0171207	-2.03	0.043	-.06825	-.0011381
ln_INR_LEND	-.061466	.0292747	-2.10	0.036	-.1188433	-.0040886
TB	.0057924	.0014258	4.06	0.000	.0029979	.0085869
_cons	-6.420919	1.099976	-5.84	0.000	-8.576831	-4.265006

```
. xtpcse ln_REER TB_Algeria TB_Nigeria TB_Egypt TB_Angola TB_Gabon ln_OILP ln_EXP_RESRV ln_INF ln_INR_LEND ln_GDP
```

Number of gaps in sample = 3

Linear regression, correlated panels corrected standard errors (PCSEs)

```
Group variable:   Code                      Number of obs   =      126
Time variable:   years                     Number of groups =       5
Panels:          correlated (unbalanced)    Obs per group:
Autocorrelation: no autocorrelation          min =      22
Sigma computed by casewise selection          avg =     25.2
                                              max =      26
Estimated covariances   =      15          R-squared       =     0.6781
Estimated autocorrelations =      0          Wald chi2(10)    =     213.24
Estimated coefficients   =     11          Prob > chi2      =     0.0000
```

ln_REER	Panel-corrected					[95% conf. interval]
	Coefficient	std. err.	z	P> z		
TB_Algeria	.0041906	.0013519	3.10	0.002	.001541	.0068403
TB_Nigeria	.0061826	.0020291	3.05	0.002	.0022056	.0101597
TB_Egypt	-.0025635	.0030221	-0.85	0.396	-.0084867	.0033597
TB_Angola	.0159018	.0040463	3.93	0.000	.0079712	.0238323
TB_Gabon	.0664184	.0171333	3.88	0.000	.0328377	.0999991
ln_OILP	-.2043792	.0485088	-4.21	0.000	-.2994547	-.1093037
ln_EXP_RESRV	-.0984107	.017473	-5.63	0.000	-.1326572	-.0641642
ln_INF	-.0763002	.0121896	-6.26	0.000	-.1001915	-.0524089
ln_INR_LEND	-.0721115	.0335406	-2.15	0.032	-.1378499	-.0063731
ln_GDP	.2654154	.0327137	8.11	0.000	.2012977	.3295332
_cons	-.0560558	.7422033	-0.08	0.940	-1.510748	1.398636

➤ **Appendix N° 12: The Evolution of the Selected Variables in African oil-exporting countries**

Figure: The evolution of the Real Effective Exchange Rate in African oil-exporting countries

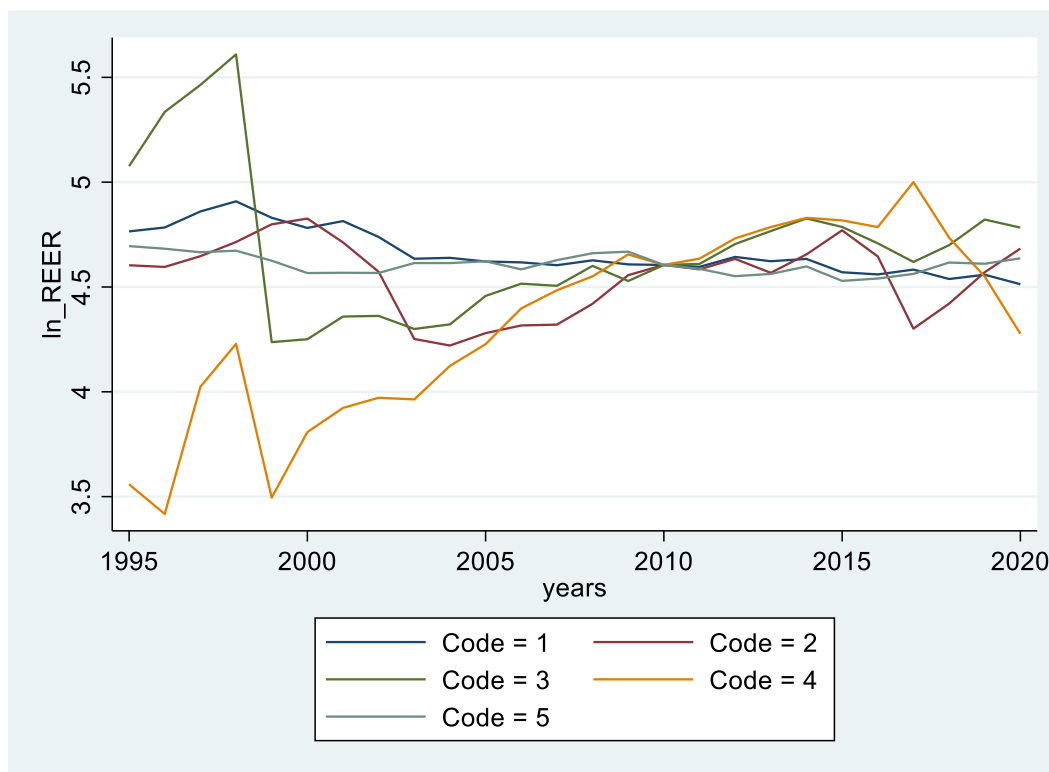


Figure: The evolution of oil prices in African oil-exporting countries

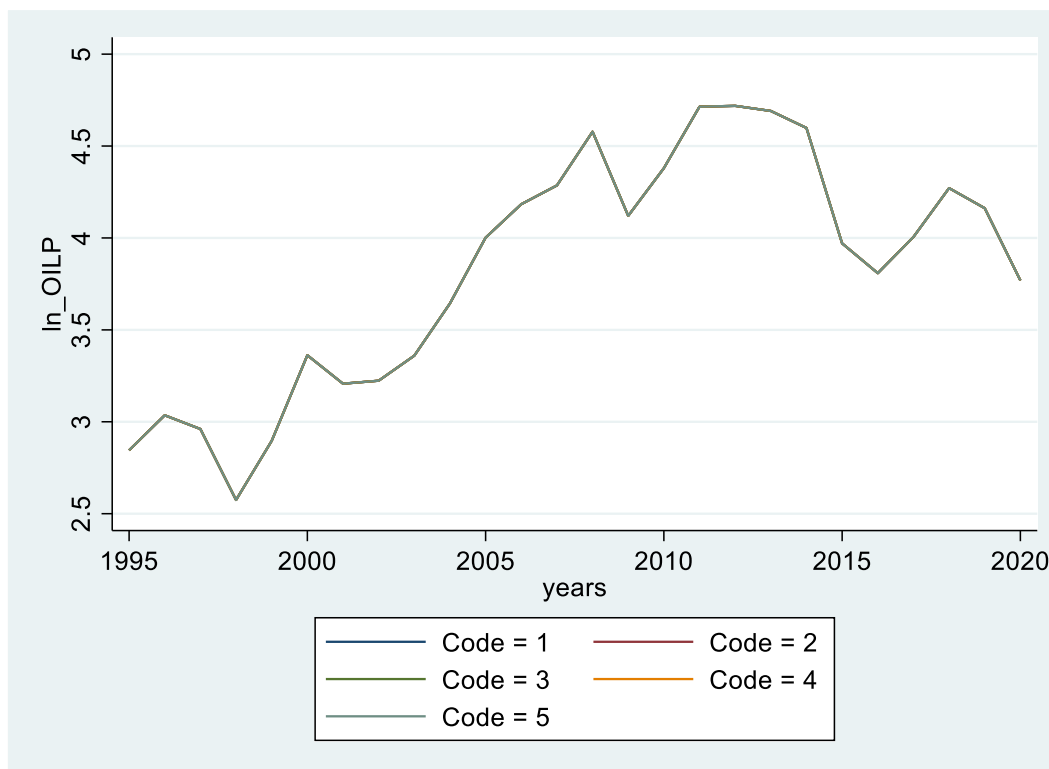


Figure: The evolution of foreign exchange reserves in African oil-exporting countries

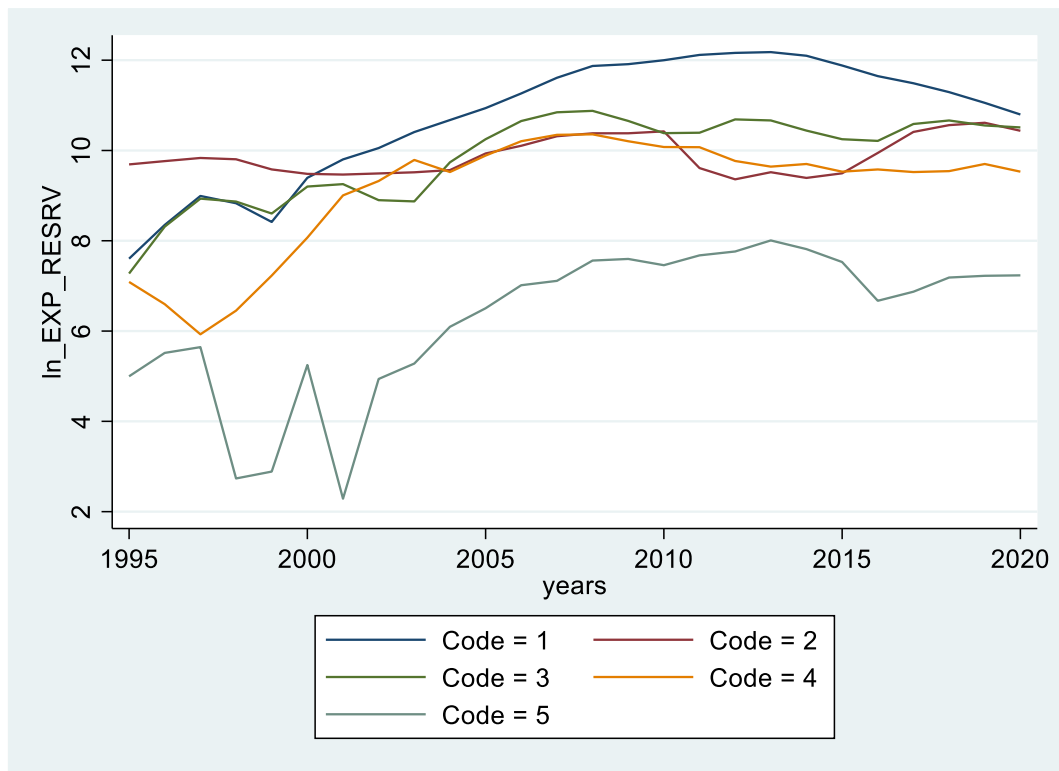


Figure: The evolution of Inflation in African oil-exporting countries

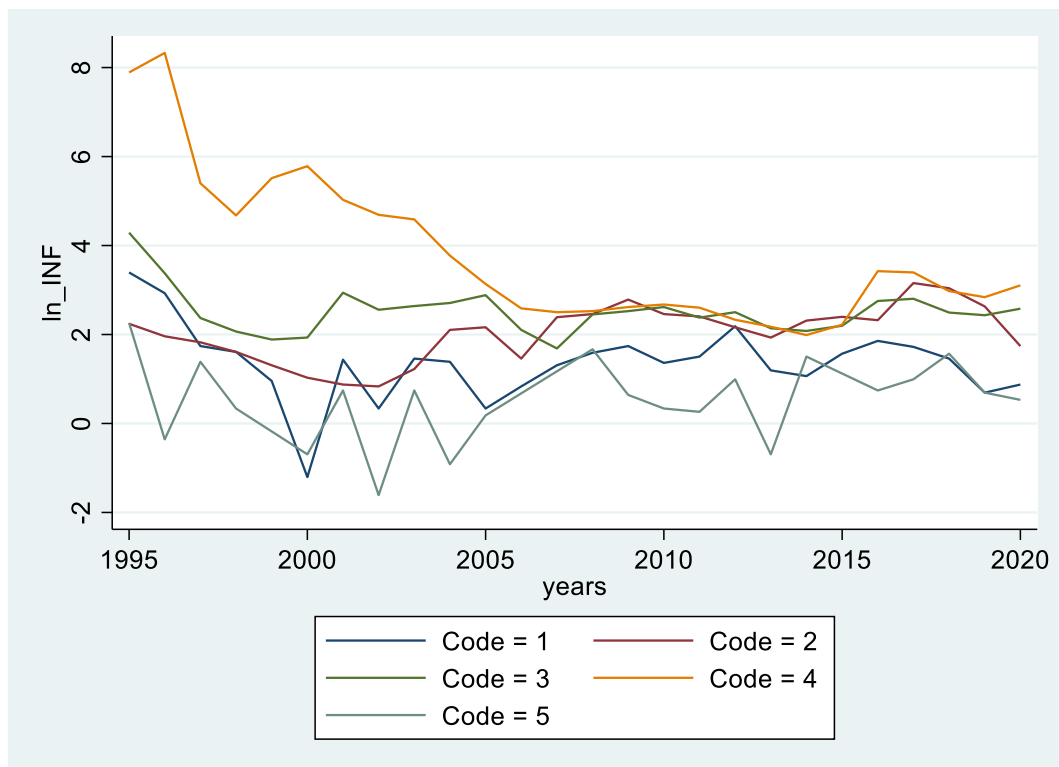


Figure: The evolution of Interest Lending Rate in African oil-exporting countries

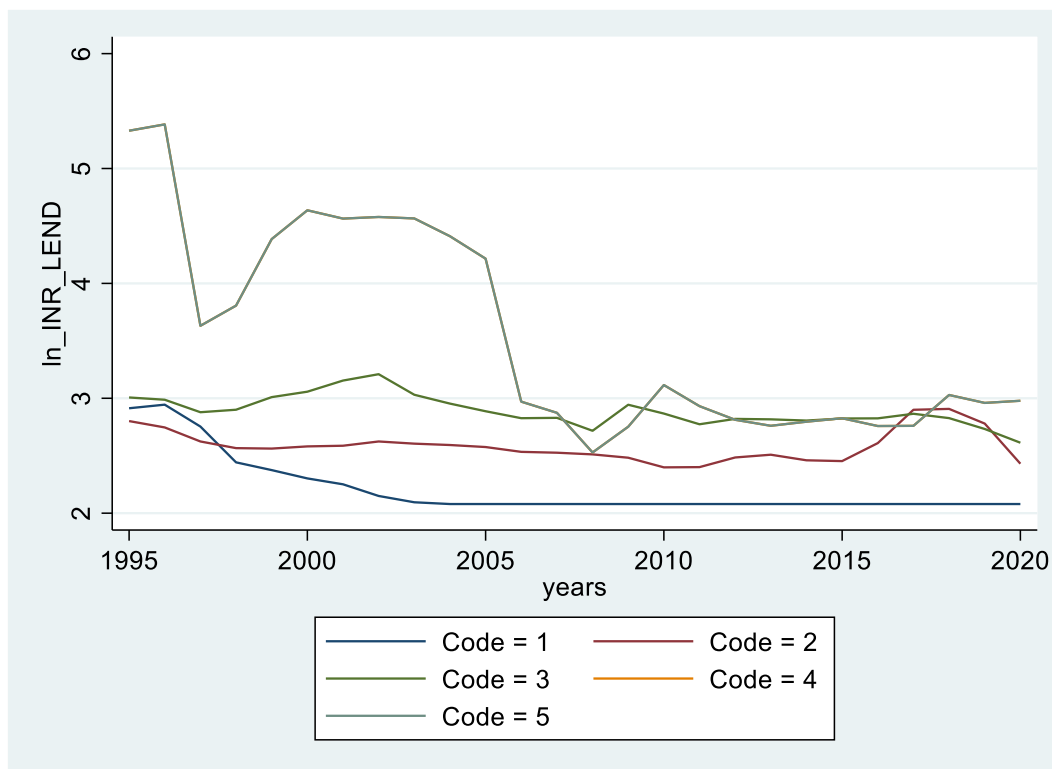


Figure: The evolution of Gross Domestic Product in African oil-exporting countries

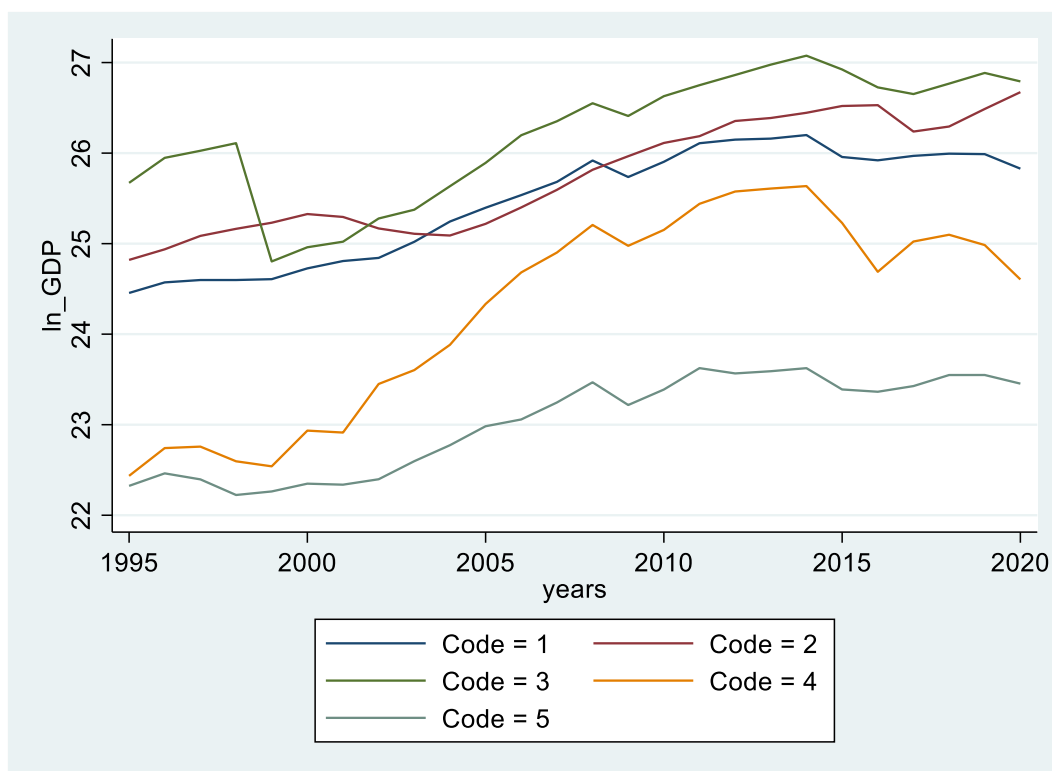
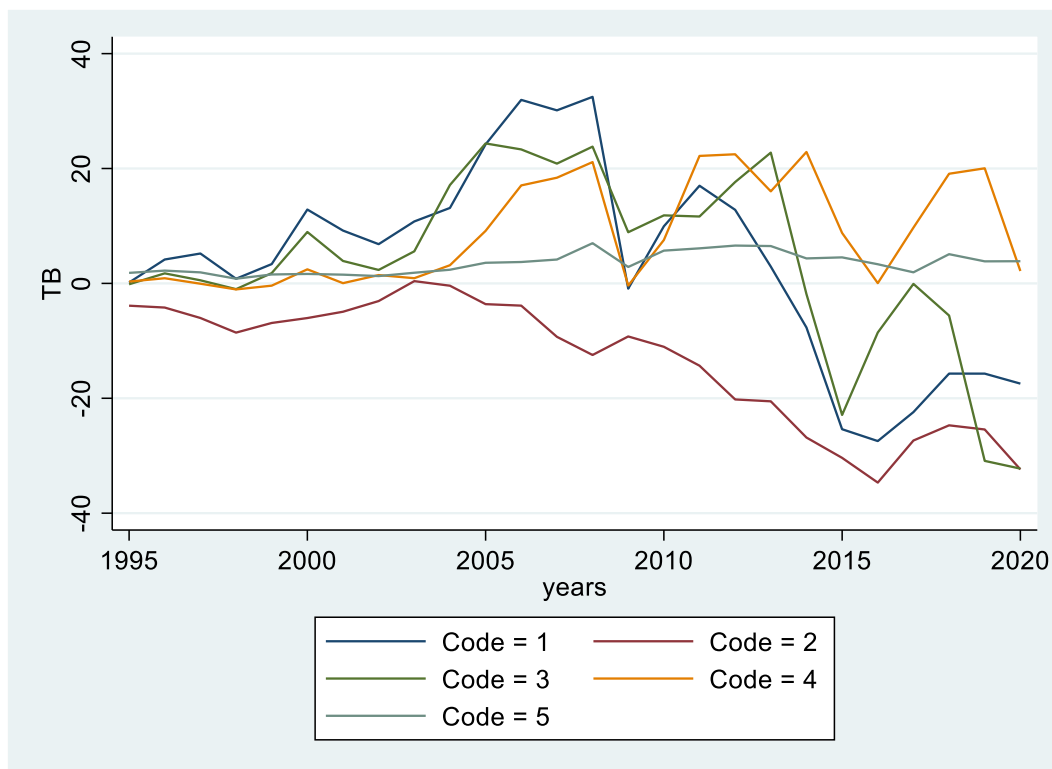


Figure: The evolution of the Trade Balance in African oil-exporting countries



Source: Output of Stata/MP 17.0

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