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End of Studies Project

Topic

Real exchange rate misalignments and Current-account: Evidence from Tunisia

A copula approach

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Dedication

I dedicate this work to my mother.

Rihab

Abstract

The need to explain the relationship between the real effective exchange rate and the current account balance is controversial and continues to attract the interest of economists from all over the world. Thus, modeling this dependence has a prominent position for investors and decision-makers

In this work, Tunisia's behavioral equilibrium exchange rate (BEER) is estimated to further investigate the possibility of exchange rate misalignment.

Then, the bivariate dependence structure between the estimated misalignment series and the current account is studied using a copula approach.

Keywords:

The Real effective exchange rate (REER), The behavioral equilibrium exchange rate (BEER), Exchange rate misalignment, The current account (CA), bivariate Copulas.

ACRONYMS

ADF: Augmented Dickey-fuller

AMU: Arab Maghreb Union

ARCH: Autoregressive Conditionally Heteroscedastic

BEER: The behavioral Equilibrium Exchange Rate

BOP: The balance of payments

CA: The current account

CBT: Central Bank of Tunisia

CML: The Canonical Maximum Likelihood

CPI: The consumer price index

ECM: Error Correction Models

EDF: The empirical distribution function

EER: The Effective Exchange Rate

FEER: The Fundamental Equilibrium Exchange Rate

GARCH: Generalized Autoregressive conditionally Heteroscedastic

GDP: Gross domestic Product

GFC: The Global Financial Crisis

KA: The capital account

KPSS: Kwiatkowski–Phillips–Schmidt–Shin

KS: Kolmogorov-Smirnov

LM: The Lagrange Multiplier

NATREX: The Natural Real Exchange Rate

NEER: The Nominal Effective Exchange Rate

NER: Nominal exchange rate

OER: The official exchange rate

PPP: The purchasing power parity

REER: The Real effective exchange rate

RER: The Real Exchange Rate

SAP: The structural adjustment program

SEMC: Southern and Eastern Mediterranean countries

TB: The trade balance

VAR: Vector Auto Regression

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INTRODUCTION

After the collapse of Bretton-Woods monetary system, several economical and financial phenomena have been emerged. Specifically, there was more freely floating currencies, international financial liberalization1, recalibration of capital controls[2] with a consequent reduction in foreign direct investments and trade barriers[3]. Nevertheless, there were unforeseen repercussions such as greater instability[4], trade disequilibria, memorable financial crises as well as higher exchange rate variability.

Since then, several studies are being carried to know the common trigger for all these events. They came to the point of making the exchange rate misalignment matters the most, that is the deviation of the real exchange rate (RER) from its equilibrium level.

Actually, exchange rate misalignment has been commonly perceived to be culprit of various domestic and global economic ills. A recent example is the assertion that exchange rate misalignment has contributed to severe global imbalances, threatened global economic stability, fed the 2008–2009 global financial crisis (GFC) and impeded recovery from the crisis.

Therefore, there has been renewed interest in the long-run determinants of real exchange rates in order to assess possible misalignments.

For the case of Tunisia, the economic malaise facing the country, which is ultimately observed in slower economic growth and large current account deficit, is already seen by experts as indicative of possible misalignment in the RER.

Furthermore, at the end of 1992, Tunisia has introduced convertibility of the dinar for current and capital account transactions for non-residents and is moving towards facilitating payments for capital account transactions for residents. A premise for both partial and total convertibility is an appropriate exchange rate i.e. an equilibrium RER. Otherwise, it may negatively affect internal and external equilibrium.

[1] See Eatwell 1996
[2] See Mussa and Goldstein 1993
[3] See Obstfeld 1998; Baldwin and Martin 1999
[4] see Blecker 2005

The determination of the equilibrium RER is a prior requirement to misalignment analysis, in the absence of which the concepts of under- or overvaluation of a currency relative to another have little meaning[5].

Equilibrium rate identification has been widely treated in previous studies. The most useful fundamental models for developing countries are:

(1) The purchasing power parity (PPP) (effective in the long run) (Cassel, 1918),

(2) The fundamental equilibrium exchange rate (FEER) (Williamson, 1994),

3) The behavioral equilibrium exchange rate (BEER) as proposed by Clark and MacDonald (1998).

While, the second model does not describe the convergence to the equilibrium but gives the exchange rate misalignment degree, the last model controls the exchange rate misalignment with a behavioral model.

Deviation of the observed RER from that long-term esteem is called RER misalignment[6]. As mentioned above, whether positive or negative, misalignment reflects bad exchange rate policy, costly regarding external balance, allocation of productive resources, and well-being, which may lead to the crisis (the Asian crisis of the 90s).

Indeed, an undervalued RER may lead to a current account surplus by making exports more profitable and imports more expensive, which would generate inflationary pressures (the case of Yugoslavia and Brazil during the 1980s). Alternatively, an overvalued rate can deepen the current account deficit and leading indicators of an economic crisis[7] (e.g. Mexico in 1994, South Korea, Malaysia, the Philippines, and Indonesia in 1997, Brazil in 1999).

Within this context of global imbalances, the debate continues about the best strategies for the management of exchange rates to achieve both internal and external balance.

More recently, literature has emerged that offers contradictory findings of the consequences of misalignments on the current account. Nevertheless, if the current account–RER misalignment nexus has been well established from a theoretical viewpoint[8], very few empirical studies have investigated this relationship[9].

[5] See Edwards and Savastano (1999)
[6] Edwards (1989),
[7] See Frankel and Saravelos (2012)
[8] Mundell, 1961; Dornbusch and Fischer, 1980; Rodriguez, 1980; Branson, 1981
[9] See Arghyrou and Chortareas, (2008).

More surprisingly, to our best knowledge, no empirical contribution has focused on such a relationship in Tunisia. On the one hand, the literature that attempts to address this issue is confined to the link between the current account and the real exchange rate, without actually paying attention to exchange-rate misalignments. On the other hand, they have studied the impact of misalignments on growth and trade balance neglecting their effect on the current account.

This essay seeks to remedy these problems by investigating whether the persistence of current-account deficit in Tunisia depends on real exchange-rate misalignments.

Added to that, almost of all the existing studies apply generally only econometric tools such as GARCH models, Causality tests, Co-integration test, and Vector Auto Regression (VAR) models to examine the dependence between above-mentioned variables. Therefore, this work is the first which uses the copulas to shed new light on the bivariate dependence and specifically the causal link from RER misalignment to CA in Tunisia.

For that purpose, this thesis begins by estimating a long-term relationship between equilibrium RER and its fundamentals using Edwards' methodology (1994). It will then go on to the use of the co-integration technique, applied to annual data (1980-2018) for Tunisia, which enables us to estimate the equilibrium RER and then obtaining the misalignment level during the full sample period.

The estimated misalignment is used in the second part to examine its association with the current account using bivariate dependence by applying a Student-t copula. The latter provides more accurate results concerning average dependence and tails dependence that gives dependence structure and causal link not only during the average conditions but also in several bearish and bullish trends.

The dissertation of is laid out as follows:

Part 1:

In chapter 1, we provide theoretical concepts.

In chapter 2, we describe our data set, present our methodology, compute the preliminary tests and then use the Johansen's co-integration method to estimate the equilibrium RER and its misalignment.

Part 2:

In chapter 1, we introduce the CA variable as well as the extant literature review about the linkage between RER and CA. Then, we introduce the mathematical background of the dependence modeling using Copula theory.

In chapter 2, we describe our data, present our methodology, compute the preliminary tests and then use the Student-t copula to model the dependence between variables under study.

Finally, we conclude, discuss policy implications and suggest possible future extensions of our work.

PART 1

DETERMINATION OF EQUILIBRIUM REAL EXCHANGE RATE AND MISALIGNMENTS

CHAPTER 1: THEORETICAL CONCEPTS

INTRODUCTION

The movements of globalization and financial integration since the 1980s have increased international trade in the world. These movements require the use of foreign currencies. Through the exchange rate, the foreign exchange market plays a vital role in promoting economic stability and prosperity.

The foreign exchange market is undoubtedly the largest market in the world today. It is a market that is not physically located in any particular place since traders and transactions are spread all over the world. That is a permanent market that is open 24 hours a day, a highly liquid market which has not experienced any interruption even during past financial crises (1987, 2001 and 2007) to check: it is a market with very strong speculative connotation. The Forex market is also very sensitive to expected changes, which makes it difficult to predict.

At the present time, the sensitivity of the international economic environment characterized by a series of major crises and shocks, has made both management and control of exchange rate policies increasingly arduous.

The purpose of this first chapter is to identify the different concepts of the exchange rate and, its determinants. Furthermore, we will try to describe and analyze the main theories of exchange rates so that we can fully understand the exchange rate mechanism. The latter is essential for understanding international economic relationships.

In the first section, we start by defining the foreign exchange rate. Then, we introduce the concept of the exchange rate system and define basic concepts related to it (its types, the criteria for selecting an adequate exchange rate regime and the advantages and disadvantages for each one). The reminder of the section will be dedicated to elaborate on almost of the factors that affect the foreign exchange rate.

The second section deals with different approaches of equilibrium exchange rate namely the PPP, FEER and BEER.
From there, we will decide which is best for estimating the Tunisian equilibrium RER during the study period.

SECTION1: GENERALITY ON EXCHANGE RATE

1-1-Theforeign exchange rate

1-1-1-Definition

A foreign exchange rate is the rate at which one currency can be exchanged for another. It is considered to be a price and follows market rules, so it is the result of matching the supply and demand of currencies at a given price level.

For this price level, oversupply will exert downward pressure on the exchange rate of the currency provided, and vice versa. That is also called "currency parity".

1-1-2-Types of Exchange rates

A- Bilateral exchange rate

In simple terms, a bilateral exchange rate refers to the value of one currency relative to another.

- **Nominal exchange rate (NER)**

The nominal exchange rate is defined as: The number of units of the domestic currency that are needed to purchase a unit of a given foreign currency. It expresses the price of a currency determined by the confrontation of supply and demand on the foreign exchange market, without taking into account the differences in terms of purchasing power of the two respective currencies.

The NER can be expressed in three ways:

Direct quote: Is the domestic exchange rate quoted with the foreign currency in the denominator. It is called direct quote because it can be used to determine the units of foreign currency needed to buy or sell a unit of domestic currency.

Indirect quote: Is the foreign exchange rate quoted with the domestic currency in the denominator. It is the inverse of the direct quote. A direct quote can be converted to an indirect quote using the following formula:

$$EUR / USD \text{ quote} = 1 / (USD/EUR) \text{ quote} \quad (1)$$

Cross rate: The cross rate is the foreign exchange rate for currency A and B worked out using two quotes for currency A/C and C/B. If the no-arbitrage condition holds, Cross

Rate for:

$$A/B = A/C * C/B \quad \textbf{(2)}$$

Why does it exist?

Actually, even though there are 164 currencies in the world, each country transacts with only a limited number. Countries usually negotiate in the currency of their main trade partners which are available in its financial institutions However, if the currency wanted is not available, we have to use a third currency, in international circulation, to intermediate. The main vehicle currencies are the dollar, euro, yen, and sterling pound.

Equilibrium exchange rate: That nominal exchange rate is the rate compatible with equilibrium in the balance of payments (BOP). Then, it is a price established by the balance between supply and demand of a given currency, as is the case for prices in any market.

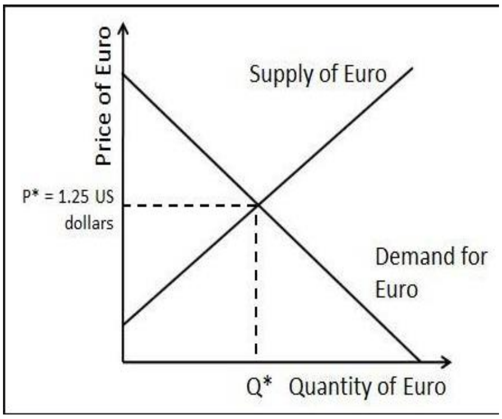
In fact, foreign currency supply comes mainly from exports. When the price of the national currency falls, exporters will be more competitive, so the volume of exports will increase. As a result, their export earnings will be enhanced, and they will provide more foreign exchange in the foreign exchange market.

Foreign direct investors also contribute to foreign currency inflows as well as foreign debt. In terms of demand, it depends mainly on imports: domestic importers need foreign currency to purchase from abroad. The fall in foreign currency prices makes buying foreign products more favorable, which increases the outflow of foreign currency.

Demand and supply are also affected by capital movements: due to the globalization of the world economy, speculative movements play an increasingly important role in determining exchange rates. In that way, if investors expect a given currency to appreciate, they will rush to buy it and then increase their demand. Taking the early 1980s as an example, due to optimistic expectations, large amounts of capital exports to the USA led to a significant appreciation of the dollar. **« André Cartapanis (2004) ».**

Thus, an excess supply of foreign currency would be reflected in a surplus in the BOP. With an excess of foreign currency in the market, its price tends to fall, that is, there will be an exchange rate appreciation. The appreciation of domestic currency, on the one hand, would make imports cheaper and, on the other, reduce the income from exports as measured in domestic currency. Exports contract and imports increase, which reduces the surplus in the BOP and, consequently, the excess supply of foreign currency. Foreign direct investors also contributed to foreign currency inflows as well as foreign debt.

For example, the equilibrium price of the euro against the dollar P* is determined as follows:



That equilibrium level is a rate that gives meaning to the terms "undervalued" and "overvalued, it allows the BOP to be balanced and ensures medium-term growth. The measure of the equilibrium exchange rate is used to correct long-term deterioration (overvalued or undervalued). Its calculation is useful for the need to stabilize exchange rates.

- **Real exchange rate (RER)**

The real exchange rate measures the price of foreign goods relative to the price of domestic goods. While the nominal exchange rate measures the relation between the prices of two currencies, the real exchange rate measures the relative price of goods.

The real exchange rate by definition consists of two components, namely the nominal exchange rate and the relative price differential as expressed in Eq (3).

$$\boldsymbol{RER = NER \times P*/P} \quad (3)$$

RER: the real exchange rate expressed as units of domestic goods per unit of foreign goods, NER: The nominal exchange rate expressed as domestic currency per unit of foreign currency, P: the domestic price index, P*: the foreign price index, P*/P: the relative price differential (inflation differential)

An increase in the real exchange rate means that foreign goods are more expensive than domestic goods. In other words, the purchasing power of the domestic currency decreases, which represents a RER depreciation. Analogously, a reduction in the RER, as defined in Eq (3), denotes an increase in purchasing power of the domestic currency, which corresponds to RER appreciation.

Thus, a country with a high inflation rate has an overvalued currency if its nominal rate varies less than its inflation rate. **(DURAND LASSERVE 1996)**

Note: Competitiveness can be improved because of one or more of the three phenomena:

- An increase in "RER "(depreciation).

- An increase in foreign prices P*.

- A decrease in local prices P.

Assuming that the equilibrium real exchange rate is a path rather than a value, we are consistent with the work of **Montiel (1999), Baffes et al. (1999), Edwards (1989, 1994) and Williamson (1994)** who define the RER as the relative price of tradable goods (Pt) and non-tradable goods (Pn):

$$RER = Pt/Pn \quad (4)$$

For sustainable (equilibrium) values of some fundamentals, the RER results in a simultaneous internal and external equilibrium: (i) Internal equilibrium is reached when the market for non-tradable goods is currently in equilibrium and is expected to be in equilibrium in the future. (ii) External equilibrium is achieved when the CA balance is consistent with long-term sustainable capital flows.

Then, after knowing the equilibrium nominal exchange rate, what is the equilibrium value of the real exchange rate? The answer of this question is not as simple as that. It will be resolved in Section 2.

B- Effective exchange rate (EER)

The effective exchange rate is commonly considered to be much more comprehensive way of comparing two economies. For instance, it is generally viewed as an overall measure of the country's external competitiveness.

- **Nominal effective exchange rate (NEER)**

The NEER is a weighted geometric average of the nominal bilateral exchange rates of the home currency in terms of a basket of foreign currencies as follows:

$$\boldsymbol{NEER} = \prod_{i=1}^{n} \left(\frac{e_i}{e_i^*}\right)^{w_i} \quad \textbf{(5)}$$

Where :

- n: number of countries (currencies) from the basket;
- e_i: exchange rate of the national currency against the currency of the country i;
- e_i^*: exchange rate of the national currency against the currency of the country i during the base period;
- w_i: country's weight (of the currency).

The NEER makes possible to evaluate the competitiveness of a country towards a set of partners. **Ndong (2002)**.

- **Real effective exchange rate (REER)**

The REER or the multilateral exchange rate is a weighted average of the bilateral real exchange rates, taking into consideration the trade share of each partner in the country's total trade, defined as:

$$\boldsymbol{REER} = \prod_{i=1}^{n} \left[\left(\frac{e_i}{e_i^*}\right)\left(\frac{p_i}{p}\right)\right]^{w_i} \quad \textbf{(6)}$$

- n: number of countries (currencies) from the basket;
- e_i: exchange rate of the national currency against the currency of the country i;
- e_i^*: exchange rate of the national currency against the currency of the country i during the base period;
- w_i: country's weight (of the currency) $w_i = (Xi + M_i) / \sum_{j=1} (Xi + M_i)$where Xi and M_i are imports and exports between the home country and country i.[10]
- pi: inflation rate in country i
- p: domestic inflation rate

An increase in REER implies that exports become more expensive and imports become cheaper; therefore, an increase indicates a loss in trade competitiveness.

[10] Notice that the weight of the bilateral real exchange rate is higher for the more important trade partners.

1-2-Exchange rate determinants

Overall, the achievement of different equilibria within an economy cannot be concrete without first understanding the relevant variables that can affect the currency price.

1-2-1-Geopolitical and social events

The response of foreign exchange market to geopolitical tension is becoming one of the major concerns of economists and financiers worldwide. Hence, because experience has shown that currencies are extremely sensitive to such circumstances.

If the government adopts a fixed exchange rate system, political tensions will arise, leading to an illegal foreign exchange trading. Whereas if a floating exchange rate system is adopted, whether it is managed or free, such political events lead the exchange rate to fall.

Then, due to the unstable situation and concerns about short and medium-term political and economic turmoil, many operators involved in the foreign exchange market tend to be cautious, and they tend to convert their national currencies into foreign exchange so as to protect their savings and purchasing power. That is the so-called "fly to quality" principle.

1-2-2- Inflation rate

Performance in the fight against inflation also plays a prominent role. According to the purchasing power parity theory, a country with a higher inflation rate than its trading partner should see its exchange rate weakening.

Moreover, inflation erodes the purchasing power of consumers as well as savings and damages investment decisions. By the way, the implication of inflation changes on the exchange rate has attracted the attention of many authors.

1-2-3- International reserves

The government intervened directly in the foreign exchange market by buying and selling foreign currencies and affect, thereby, their prices. The government's transactions in foreign currency are summarized in the international reserves account. Through them, the government acts as an additional agent that supplies and demands foreign currencies.

To maintain an appreciated exchange rate, and given an excess demand for foreign currency at that rate, the government must sell international reserves to prevent its depreciation. Thus, a sufficiently large stock of international reserves is needed. Nevertheless, the latter cannot be unlimited, so it is impossible to maintain an appreciated exchange rate indefinitely.

1-2-4-Monetary policy

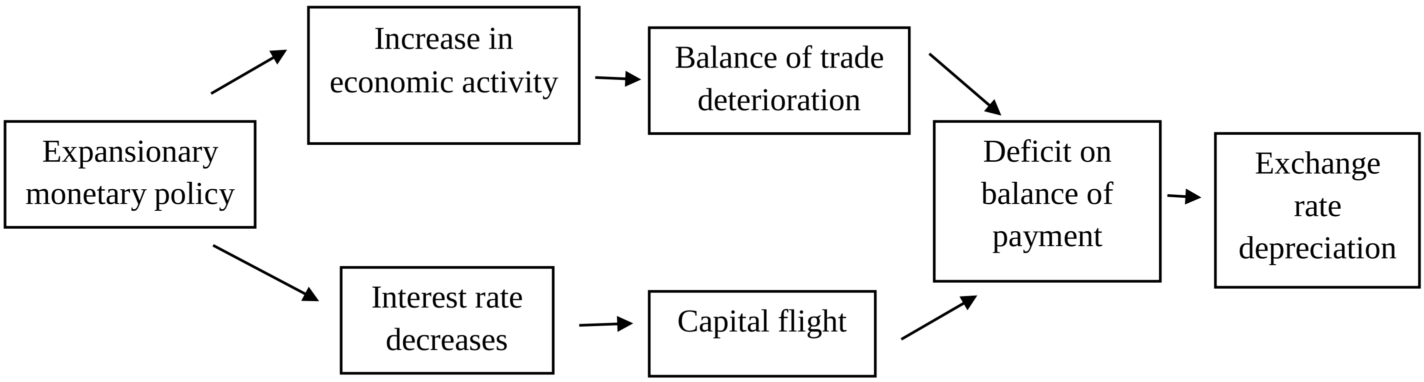
Central banks can indirectly affect the exchange rate by stimulating private agents to increase or decrease their demand for foreign currency. The monetary policy which they conduct has an impact on exchange rate movements.

In concrete terms, the interest rate is one of the monetary policy tools available to central banks. For instance, contractionary monetary policy causes domestic financial assets to be more attractive to foreign investors. That leads to financial capital inflows and an increase in foreign currency supply, causing the exchange rate appreciation.

It depends on each country's inflation level. In Tunisia, for example, to curb hyperinflationary, the interest rate was raised twice, respectively in March and June 2018, by 75 and 100 basis points, reaching 6.75% by the end of the first half of 2018. Followed by other foreign exchange policy measures, such monetary action succeeded in maintaining the dinar at a steady level over the first half of 2019 and curbing its depreciation[11].

Furthermore, under a fixed exchange rate system, monetary policy is entirely devoted to defending the national currency. However, when a flexible exchange rate system is adopted, an expansionary monetary policy allows for bearing the economic activity and preventing new capital inflow.

Hence, this policy leads to exchange rate depreciation as shown below:



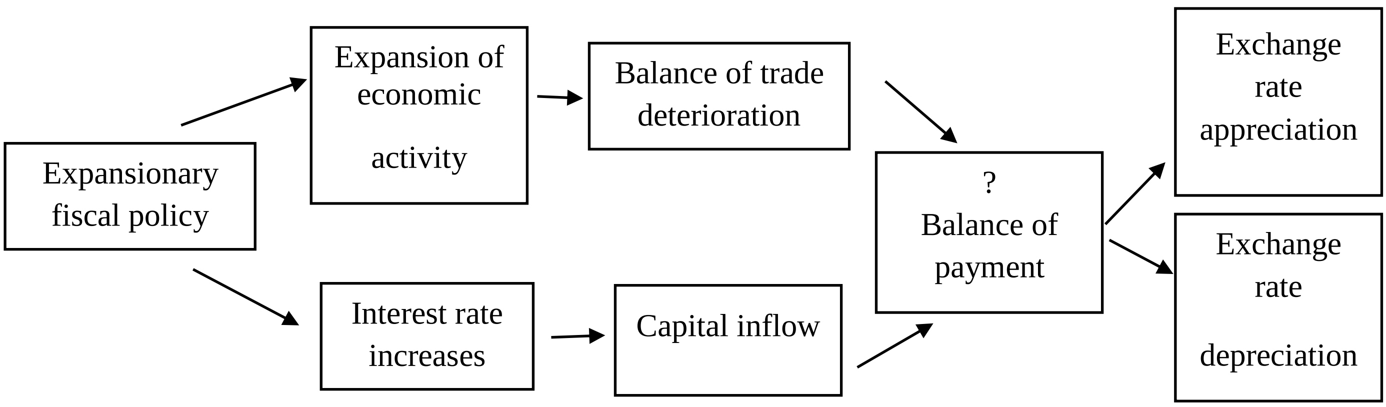
[11] The exchange rate depreciated, on average, by 12.9% against the euro and 8.6% against the dollar in 2018.

1-2-5-Fiscal policy

Under a fixed exchange rate system, an expansionary fiscal policy (increasing government spending, reducing taxes, or their combination) leads to an increase in real production of goods and services (**Frenkel and Razin (1987)**). That will boost the demand for money. Consequently, the central bank has to increase the money supply to keep the exchange rate unchanged and guarantee the foreign exchange market equilibrium.

Under a flexible exchange rate system, the increase in public spending, with a fixed money supply, pushes the interest rate up once at the time of government borrowing and twice to finance the surplus activity initiated. Besides, the capital inflow improves the capital account. However, the expansion of economic activity deepens the current account deficit. If the deterioration in the CA dominates the inflow of capital, a depreciation of the exchange rate follows and vice versa.

To sum up, a fiscal stimulus leads to an appreciation of the exchange rate or a depreciation as shown in the following figure:



1-2-6- Economic growth

Economic growth, as measured by Gross domestic Product (GDP), is a mark of economic performance. The speed of a country's economic growth influences the demand for its national currency. Indeed, sustained economic growth is more likely to attract international investors, which in turn enhances the foreign exchange reserves and makes an appreciation of the national currency in the foreign exchange market.

However, for the case of Tunisia, exchange rate appreciation doesn't reflect an improvement economic and financial conditions. In fact, the economic growth was 1.1% for the first quarter of 2019 and 1.2% for the second one. The slower economic growth cannot justify the Tunisian dinar's recovery in that time.

1-2-7- Public debt

Over-indebtedness suggests uncertainty about the government solvency and generates inflation, which leads to RER depreciation. That's means that:

- If investors are confident, it has no direct impact on the exchange rate;
- If they have doubts about government solvency, which will negatively affect the currency price.

1-2-8- Parallel market

It has been found that the parallel market underestimates the national currency. In fact, given the difference between the official exchange rate and the parallel market rate, the more foreign currency sellers are attracted to that illicit market, the more it will develop.

1-2-9- Terrorist attacks

Terrorist attacks imply a notable increase in uncertainty, and subsequently, the foreign exchange market will be affected by higher risks. Certainly, terrorism in a given country generates both higher volatility and significant depreciation of its domestic currency.

For instance, the Tunisian government considers the attack touching "Bardo" Museum on March 18, 2015, to be a major shock facing the tourism industry and so to the foreign exchange market. Consequently, following the economic turbulence in 2015, the dinar depreciated by 13.4% against the US dollar and by 3.5% against the euro (against depreciations of 4.4% and 4.2% respectively in 2014).

1-2-10- Oil price

Commodity currencies are a key variable that may be used by governments to maintain financial stability. A main area of interest has been investigating the relationships between raw materials and macroeconomic factors such as exchange rates.

Crude oil is considered among commodities that have been extensively examined with the exchange rate.

Being one of the key macroeconomic indicators to investigate in the backdrop of oil price dynamics, results show that the exchange rate is driven by oil prices. In fact, that link has been an important topic of theatrical and empirical investigations starting with **Krugman (1983)** who shows that an increase in oil prices can have a positive or a negative impact on USD exchange rate, which depends on the relative benefits of the oil price variation on the BOP of oil exporters and importers. Besides, **Throop (1993)** and **Zhou (1995)** highlight that **"**a rise in the real price of oil will worsen the trade balance (TB) of a net oil-importing country and, therefore, calls for RER depreciation to improve its competitive position.**"** **Norden (1998)** also shows that real oil price causes the long-run evolution of Germany, Japan, and USA's RER over the post-Bretton Woods period.

Conclusion

From a macroeconomic perspective, the exchange rate between two currencies is affected by several parts. These factors affect each other and confront to determine the observed exchange rate.

1-3-Exchange rate systems

The exchange rate system is a set of rules that defines the intervention of the monetary authority in the foreign exchange market. There exist a variety of exchange rate regimes, which are devoted to two extremes: fixed and floating.

The exchange rate system guides the authorities' interventions in the foreign exchange market and, possibly, the attitude of monetary policy to defend or influence exchange rate movements. Therefore, it affects the stability and competitiveness of the economy.

Currently, the global monetary system is very heterogeneous. While some currencies are highly restricted, such as the Chinese yuan and, for unknown reasons, the Japanese yen, others are freely floating, namely, the US dollar and the euro. According to the International Monetary Fund (IMF)'s statistics, the proportion of pure floating regimes, which had increased until the early 2000s, is tending to decrease in favor of managed float regime.

1-3-1- Fixed exchange rate system

A fixed exchange rate system implies the definition of a reference parity (or a basket of currencies). When the foreign exchange market is liberalized, the central bank must intervene whenever the exchange rate deviates from the fixed price: it buys the domestic currency if it tends to depreciate and sells it otherwise.

Generally speaking, the fixed exchange rate system is more suitable for smaller countries with high trade openness, great workforce mobility, and a business cycle closely linked to that of the currency-pegged country.

1-3-2- Flexible exchange rate system

Under such a policy, the authorities allow the exchange rate to be freely determined by market forces - that is, by the law of supply and demand of foreign currencies in the foreign exchange market. While monetary policy restores its autonomy, the central bank abandons control of the nominal exchange rate.

- ✓ **Managed float system:** In practice, no exchange rate is pure float i.e naturally determined by market forces. The prevailing system is the managed float, whereby there is periodic intervention by monetary authorities in the foreign exchange market to achieve strategic objectives **(Mordi, 2006).**

  Hence, the monetary authority controls exchange rate movements without first promising exchange rate paths. That is the case of Argentina, Singapore, Algeria....

- ✓ **Clean float:** Unless the exchange rate fluctuations are extremely significant, the central banks have no right to interfere in foreign exchange matters. The present regime is adopted by the United States, Japan, Switzerland, the United Kingdom and some emerging countries such as Brazil.

The floating system is much more suitable for strong nations with large internal than external trade. A floating currency is not an ideal choice for sick economies with economic and financial constraints.

1-3-3- The Intermediate exchange rate System

The intermediate system is based on the fluctuations allowed by the central banks around the reference parity as well as adjustments frequency. That exchange rate system takes the following specific forms:

- ✓ **Crawling band system:** A wide band that is adjusted in small steps in order to keep the exchange rate in line with the fundamentals, but that is defended in the traditional ways.

- ✓ **Monitoring band system:** a wide band with similar properties, but that is defended only when the rate goes outside the band.

Table1: Summarized table of advantages and disadvantages of each exchange rate system

	Fixed	***Flexible***
Advantages	- Minimizing investments and international trade operations' costs; - Eliminating foreign exchange risks, which is likely to promote trade and attract international investors; -Stability of exchange rate; - Promoting international trade and foreign direct investments (FDI); - Ensure confidence in the domestic currency; - Controlled inflation.	-Allowing for monetary independence; -Market forces play a role in determining the exchange rate value; -Enabling easier shocks' absorption.
Disadvantages	- Losing monetary autonomy -Financial vulnerability; -Need to make enough foreign exchange reserves towards defending the domestic currency against speculators and external shocks; - Risk of speculative attacks and currency collapse in case of capital mobility.	- Disruptive effects due to Foreign exchange market volatility; - Damaging international trade and investments: exchange rate fluctuations make it difficult to forecast relative prices; - High volatility of exchange rate forces central banks to intervene.

Source: Own redaction

In brief, a pure floating regime is undesirable since it is hard for the economic mechanism to hold the exchange rate close to a consistent level with its fundamentals. Alternatively, a fixed exchange rate system makes sense only if all conditions are well satisfied.

Instead, the current context of high capital mobility makes limited flexibility to be the most prudent choice.

Tunisia's foreign exchange rate system: An Historical Overview

Alike states worldwide, Tunisia has experienced menu options of exchange rate policies in the last years: first, it belonged to the Franc zone since the country did not have its own exchange rate policy at that time. However, by the creation of the dinar things have been changed.

Since the collapse of the Bretton Woods International Monetary System, Tunisia has experienced two mains exchange rate systems.

From 1973 to 1986, a fixed regime has been adopted. During that period, the exchange rate went through five stages **(Safra and Ben Marzouka, 1987)**:

- **1973-1978:** The significant instability of the French franc (FF) led the Tunisian authorities to abandon the FF peg[12] and to choose the Deutsche Mark (DM) as a reference.

- **1978-1981:** Tunisia adopted the policy of pegging the dinar to a basket of currencies (FF, the DM and the US Dollar) to avoid fluctuations in a single currency. The availability of foreign exchange reserves for these currencies has been considered.

- **1981-1984:** The drop in oil prices and the export promotion policy led the monetary authorities to expand the basket in line with the trade pattern.

-**1984-1985:** Following the real appreciation of the dinar, they decided to widen once again the basket of currencies. That policy aimed to promote exports and improve Tunisian economy's competitiveness.

-**1985-1986:** The persistent recession and BOP problems forced the Tunisian authorities to adjust the weight of reference currencies. Nevertheless, these adjustments were inefficient to prevent the BOP crisis. They were obliged to devalue the dinar by 10% in 1986 **(Hanna, 2001)**.

Since then, the Central bank of Tunisia (CBT) attempted to stabilize the REER so that the Tunisian economy could maintain its international competitiveness **(Domaç, Shabsigh, 1999)**.

During the '90s, Tunisia made significant progress in opening its external sector. This strategy aimed toward ensuring a competitive environment for national companies and products. In 1992, the authorities decided to introduce further flexibility to the exchange rate via the REER targeting, regular adjustments in the NER, and establishing the convertibility of the dinar for the non-residents.

[12] In the early 70's, the authorities chose to peg their currency to the FF, since France was their principal trading partner.

During the same decade, an interbank foreign exchange market was established in 1994. In 1997, resident and non-resident licensed brokers were allowed to operate in foreign exchange forward transactions on behalf of their resident customers[13].

Since 2000, following the IMF advice, the CBT has limited its intervention in the foreign exchange market and allowed for a more flexible exchange rate using a managed float policy.

Aforementioned regime aimed to improve competitiveness. It is considered as an intermediary step toward a floating exchange rate system.

Table 2: Exchange rate regimes in Tunisia

Period	Tunisian exchange rate system
1973-1991	Pegging to a basket of currencies
1992 – 2000	the real exchange rate was targeted, but introduced more flexibility afterward[14]
2000-2010	Managed float
2011-2019	Crawling pegs[15]

Source: Own redaction

Conclusion

The choice of an exchange rate regime is crucial for countries' macroeconomic frameworks. Nowadays the sensitivity of the international economic environment, marked by a series of major crises and shocks, hinders the optimal choice of exchange rate policy.

In fact, there is no a priori answer to an optimal exchange rate system for a given country. It depends on a range of factors namely, the degree of development of the country and the level of openness, its geographic specialization, its debt structure, and its economic objectives as well as the specificity of the given period.

[13] For import of goods and services and financial transactions for a maximum period of 12 months and export transactions for a maximum period of 9 months.
[14] (Dropsy and Grand 2004)
[15] IMF (2012a)

SECTION2: EQUILIBRIUM EXCHANGE RATE APPROACHES

Introduction

Given its concern in policy analysis, the literature that aims at estimating the equilibrium real exchange rate is extensive. Yet, there is still an extensive debate on which approach is the most convenient to make judgments about exchange rates being over or under-valued[16].

What is an "equilibrium" exchange rate?

The concept may seem trivial since, at any given moment, the observed exchange rate is already an equilibrium rate.

The equilibrium exchange rate is usually defined as the level that balances the market without "noise". Such a noise may create changes in the short-term due to information disclosed by press agencies and possible speculative phenomena. We are therefore not talking about the short-term, but about the medium or long term.

The Purchasing Power Parity is the oldest methodology to estimate equilibrium exchange rates. To explain the movements of equilibrium exchange rates, that method only relies on relative prices. It ignores, however, other structural factors and seems too schematic, even when completed by a Balassa-Samuelson effect. Beyond the PPP hypothesis, three main theories of equilibrium exchange rates can be distinguished:

a) The Fundamental Equilibrium Exchange Rate (FEER) (Williamson, 1983) and its recent developments (Cline, 2008),

b) The Behavioral Equilibrium Exchange Rate (BEER) which is an econometric approach (Clark and MacDonald, 1998)

c) The Natural Real Exchange Rate (NATREX), which tries to give a theoretical basis with a dynamic analysis (Stein and Allen, 1997).

[16]Cheung et al. (2009) and Dunaway et al. (2009) study the robustness of estimates of equilibrium exchange rates across different methodologies in the case of the Chinese real exchange rate.

2-1- The Purchasing Power Parity (PPP) approach

The concept of PPP is derived directly from international trade theory's law of one price. That law states, that "in bilateral trade there will be one price (excepting for tariffs, transportation costs and non-tariff barriers)" **(Krugman 1992)**. So, it is a proposal that in the absence of transport costs and trade restrictions, the price of an internationally traded good would be made equal in all countries through arbitration" **(Salvatore, 2008)**.

The theory of PPP was introduced by **Gustav Cassel (1918)** who asserted that "the exchange rate between two countries will be determined by the ratio of their general price level".[17]

It is also called the "inflation theory of exchange" as the first theory that links the exchange rate and the level of inflation between two countries, such as the Dornbusch announcement. "Purchasing Power Parity is a theory of exchange rate determination. It asserts, in the most common form, that the exchange rate change between two currencies over any time is determined by the change in the two countries' relative price levels. Because the theory singles out price level change as the overriding determinant of exchange rate movements it has also been called the inflation theory of exchange rates" **(Dornbusch (1985)).**

According to the abovementioned statement, when the inflation rate rises relative to that of another country, the former's currency is expected to depreciate. Yet, in terms of the different PPP concepts, such as absolute and relative PPP, the nature of the change in the exchange rate is different.

2.1.1- The absolute and the relative PPP

The absolute PPP is similar to the Law of One Price. The concept of the Law of One Price means that the prices of the same products in different countries should be equal when they are measured in a common currency. Consider the dollar–euro exchange rate. Thus, the formula we face is as follows:

$$\frac{USD}{EUR} = \frac{P_{US}}{P_{EU}} \tag{7}$$

[17] Gustav Cassel, The present situation of the foreign exchanges. Economic Journal, mars 1916, p.62.

Where USD/EUR, P_{US}, andP_{EU} indicate the dollar-euro exchange rate, the price level in the U.S., and the price level in the E.U, respectively. Note that the absolute PPP can also be shown as the equality of the price levels in both countries where, using the dollar-euro exchange rate (*E*), the UE price level is expressed in dollars:

$$\boldsymbol{P_{US} = P_{EU} \times E} \qquad \textbf{\textit{(8)}}$$

Therefore, for the absolute PPP to hold, the dollar–euro exchange rate should reflect the ratio of the price levels in the US (P_{US}) and the EU (P_{EU}).

In reality, there are market imperfections such as nontransferable inputs, transportation costs, tariffs, quotas, and so forth. Therefore, the relative PPP takes these imperfections in consideration and relaxes the relationship between the exchange rate and the price levels of two countries. It does so by considering the relationship between the changes in these two variables.

The relative PPP, on the other hand, indicates that the changes in the dollar–euro exchange rate reflect the changes in the ratio of the U.S. and E.U. price levels (P_{US} and P_{EU}):

$$\Delta\left(\frac{\boldsymbol{USD}}{\boldsymbol{EUR}}\right) = \Delta\left(\frac{\boldsymbol{P_{US}}}{\boldsymbol{P_{EU}}}\right) \qquad \textbf{\textit{(9)}}$$

In other words, the PPP compares the cost of living. Under a fixed exchange rate system, if the real price of goods differs from one country to another, the additional demand for goods in the "cheapest" country will lead to prices increase: there is an exchange rate adjustment through price. In the floating exchange rate system, the price difference is adjusted by the exchange rate change: therefore, the exchange rate change reflects the inflation differential.

A purchasing power parity (PPP) approach is a useful tool in analyzing international competitiveness; however, as the economy undergoes major economic structural adjustments, it cannot capture the impact of major changes in economic policies. Under an economic reform plan, policy makers will successively introduce and implement new policies, and real prices (including real exchange rates) should be adjusted to new equilibrium values. The deviation from long-term PPP may be short-term or long-term. The persistence of the long-run disturbances[18] makes the PPP approach incomplete.

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[18]Real disturbances, including changes in terms of trade, tax systems, or productivity will lead to a new equilibrium real exchange rate.

The alternative approach to PPP focuses on integrating the real aspects by defining the ERER as the rate that is consistent with the internal and external macroeconomic balance. It concludes that it cannot be constant, since variations in fundamentals will inevitably affect the movement of ERER over time.

These approaches focus on the absorption of external imbalances, with two different concepts of external equilibrium:

- A flow concept for the FEER**:** a current balance corresponding to the "sustainable" capital flows proposed by **Williamson (2006);**

- A stock concept for the BEER: a stable net external position at its equilibrium level (net external positions of equilibrium estimated by **Bénassy-Quéré et al. (2008).**

2.2- Fundamental Equilibrium Exchange Rate (FEER)

We are introducing a method that focuses on assessing the exchange rate relative to economic fundamentals. This method involves the calculation of the so-called Fundamental Equilibrium Exchange Rate (FEER). The literature on the FEER has grown considerably since **Williamson (1983)** first popularized the idea.

In this approach, the equilibrium exchange rate is defined as the REER that is consistent with macroeconomic balance. The latter is generally interpreted as when the economy operates at full employment and low inflation[19] (internal balance) and a sustainable current account flows (external balance), namely, which reflects the potential and expected net capital.

In this sense, the FEER is a normative measure, and indeed **Williamson (1994, pp. 180-181)** has characterized it as the equilibrium exchange rate that would be consistent with "ideal economic conditions." This normative aspect by itself is not a criticism of the approach, as it simply reflects the objective of calibrating the exchange rate at a set of well-defined economic conditions.

The core of the macroeconomic balance approach is the identity equating the current account to the (negative of) the capital account (KA) (the full BOP equation)

$$CA = -KA \qquad (9)$$

$$CA = ntb + nfar \qquad (10)$$

$$ntb = b_0 + b_1 q + b_2 ydpot + b_3 yfpot \qquad (11)$$

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[19]The level of output consistent with both full employments, and a low and sustainable rate of inflation

With $b_1 > 0; b_2 < 0 \; and \; b_3 > 0$ (we observe a real effective depreciation when q increases).

$$\boldsymbol{nfar = f(q)} \quad (\mathbf{12})$$

The BOP identity indicates that the CA balance is equal to the opposite of theKA. The CA balance is a sum of the net trade balance (ntb) and returns of net foreign assets ($nfar$): interest income received (or paid) on a country's net foreign asset (or debt) position,

The net trade balance is a positive function of the real effective exchange rate (q) and full employments output of foreign economies ($yfpot$). The net trade balance is a negative function of domestic full employment output ($ydpot$). Eq.(12) captures the effects of exchange rate variations on the returns of the net external position ($nfar$).

Combining Eqs. (9) and (12) gives:

$$\boldsymbol{CA^* = f(q^{REER}, ydpot, yfpot) = -KA^*} \quad (\mathbf{13})$$

With CA∗, the level of equilibrium current account at medium term. To determine the FEER, we solve the following equation:

$$\boldsymbol{q^{FEER} = f(KA^*, ydpot, yfpot)} \quad (\mathbf{14})$$

We obtain the fundamental equilibrium exchange rate (q^{FEER}), which realizes simultaneously the external and internal equilibrium for all trading partners.

All other things being equal, a country must devalue its currency if it is unemployed or if it has an excessive trade deficit. In fact, Williamson suggests that each country should use its fiscal policy to achieve full employment and exchange rate policy to achieve its trade balance target.

This approach involves many theoretical and empirical difficulties. The FEER is a static model (only valid at a specific point in time). Economists set a priori a current balance target that is assumed to be sustainable, on this basis, define the equilibrium exchange rate.

The model does not take into account the current balance dynamics: a country may have a deficit if it attracts FDI flows; accumulation of foreign assets may require a surplus; it may be forced to achieve a trade surplus, given the interest it has to pay on its external debt. The model does not consider these dynamics.

Thus, a country's exchange rate can be evaluated by comparing the current level of a country with the calculated FEER. The exchange rate under this approach remains unchanged as long as the positions of internal and external balance are undisturbed,

In concrete terms, this approach requires defining full employment production level in the country and its partners, the sustainable level of the CA and estimating a TB equation.

2.3- Behavioral Equilibrium Exchange Rate (BEER)

The BEER approach proposed by **Clark et MacDonald (1997)**[20] involves the direct econometric analysis of the behavior of the exchange rate: it explains the exchange rate dynamic with some main variables (usually the net foreign assets, the terms of trade, the productivity, the oil prices, employment rate…) which influence the real exchange rate at long term. Then look for cointegrating relationships between the exchange rate and these variables.

In this approach, the real exchange rate is influenced by long-run variables, medium-term determinants and short-run shocks. As sad above **Clark and MacDonald (1997)** first proposed the model, which is presented here with some additions from **MacDonald and Dias (2007).** Such a reduced-form expression is represented in general terms by equation:

$$\boldsymbol{q_t = b_1 Z_{1t} + b_2 Z_{2t} + \tau T_t + \varepsilon_t} \qquad (\mathbf{15})$$

In equation (15) the actual, observed real effective exchange rate is explained exhaustively in terms of a set of economic fundamentals that are expected to have long-run persistent effects on the equilibrium real exchange rate, Z_{1t}. $Z_{2t}$is a set of fundamentals that affect the real exchange rate over the medium term (that is, over the business cycle); $T_t$is a set of variables with transitory, or short-run, effects;b_1, b_2 and τ are vectors of reduced-form coefficients; and $\boldsymbol{\varepsilon_t}$is the random error term.

The current misalignment Cm_t, is defined as the sum of transitory variables and the random error term. In other words, the current misalignment represents the difference between the actual real exchange rate and the real exchange rate given by the current value of

[20]See also Mark, 1999; Chinn, 1999; Alberola et al., 1999, 2002; Lane &Milesi-Ferretti, 2002; MacDonald, 2002; and Paya et al., 2003.

all fundamentals. The real exchange rate given by the current value, q'_t, of the fundamentals can be defined as:

$$\boldsymbol{q_t = b_1 Z_{1t} + b_2 Z_{2t}} \qquad (16)$$

$$\boldsymbol{Cm_t = q_t - q'_t = \tau T_t + \varepsilon_t} \qquad (17)$$

Clark and MacDonald argue that the current value of these fundamentals may deviate from their long-run levels. The idea is to emphasize calibration of fundamentals at the level consistent with the goals of internal and external balance, comparable to the definition under the FEER. With fundamentals at their long-run levels, we can now define total misalignment, Tm_t,as the difference between the actual real exchange rate and the real exchange rate based on the long-run levels of these fundamentals:

$$\boldsymbol{Tm_t = q_t - \bar{q}_t = q_t - b_1 \overline{Z_{1t}} - b_2 \overline{Z_{2t}}} \qquad (18)$$

Adding and subtracting q'_ton the right-hand side and replacing for the value of fundamentals, we get:

$$\boldsymbol{Tm_t = (q_t - q'_t) - b_1 \overline{Z_{1t}} + b_2 \overline{Z_{2t}} + b_1 Z_{1t} + b_2 Z_{2t}} \qquad (19)$$

$$\boldsymbol{= \tau T_t + \varepsilon_t + [b_1 (Z_{1t} - \overline{Z_{1t}}) + b_2 (Z_{2t} - \overline{Z_{2t}})]} \qquad (20)$$

Therefore, the total misalignment at any point in time can be factored into effects due to transitory components, the random error and the degree to which the fundamentals deviate from their long-run levels.

MacDonald and Dias (2007) suggest that the BEER is a general approach to estimating the equilibrium exchange rate, since is not based on any specific model of exchange rate determination. Nonetheless, there are some key ideas used in explaining the BEER approach. The first element is the risk-adjusted real interest parity relationship as shown in Eq.(21). This condition was exploited in **Clark & MacDonald (1999) and MacDonald (2002)**'s studies, that exposition of the BEER approach in this section draws heavily on them.

$$\boldsymbol{E_t(\Delta s_{t+k}) = -(i_{t,t+k} - i_{t,t+k}{}^{*})} \qquad (21)$$

Wheres_t is the foreign currency price of a unit of domestic currency (so that an increase indicates an appreciation),i_t is the nominal interest rate at home (an asterisk denotes the corresponding foreign variable), Δ the first difference operator, E_t is the conditional expectations operator and (t + k) defines the maturity horizon of the bonds. Equation (21) can be converted in real terms by subtracting the expected inflation differential from both sides of the equation. After rearrangement this gives:

$$\boldsymbol{q_t = E_t(q_{t+k}) + \left(r_{t,t+k} - r_{t,t+k}{}^{*}\right) + e_t} \qquad \mathbf{(22)}$$

Where q_t is the ex ante real exchange rate,r_t the ex ante real interest rate and e_t is an error term. It is customary to assume in this approach that the unobserved component $E_t(q_{t+k})$ represents the influence of economic fundamentals other than interest rates.

Thus, the current equilibrium exchange rate comprises both components: the systematic component $\hat{q}(= E_t(q_{t+k})$ determined by economic fundamentals**)** and the real interest rate differential.

In order to determine the equilibrium exchange rate $\hat{q}$, the following long-run equilibrium exchange rate condition, which suggests a balanced current account, is used:

$$\boldsymbol{ca_t = tb_t + r_t^{*} nfa = 0} \qquad \mathbf{(23)}$$

$$\boldsymbol{tb_t = -r_t^{*} nfa_t} \qquad \mathbf{(24)}$$

In simpler terms, the current account (ca_t) is the sum of the trade balance (tb_t)and interest (r_t^*) earned on outstanding net foreign assets (nfa_t): one of the key variables that explain the real exchange rate is the net foreign asset (nfa_t) position of a country such that, when a country accumulates a surplus in its current account, its net external position increases in percentage of GDP. To stabilize its net external position, its currency must appreciate in real terms above its equilibrium value and, thus, appears overvalued. In the long run, the net foreign asset position as percentage of GDP is stabilized so the current account is equal to zero.

As such, any deficit or surplus on the trade account is matched by net borrowing or lending from abroad. The TB and exchange rate are inversely related, which suggest that, in a steady state, a larger trade deficit implies greater depreciation. That is seen in Eq.(26). Also, in Eq.(25),x_t represents other factors determining the real exchange rate. The TB is replaced by $r_t^* nfa_t$ in Eq.(26). The real exchange rate is increasing in nfa.

$$\boldsymbol{q_t = \alpha\, tb_t + \beta\, x_t} \qquad \mathbf{(25)}$$

$$\boldsymbol{q_t = \delta\, r_t^{*} nfa_t + \beta\, x_t} \qquad \mathbf{(26)}$$

In the empirical estimation of the equilibrium exchange rate, we will draw inspiration from the behavioral method BEER.

Economic fundamentals are selected according to the empirical work dealing with the identification of a long-term link between the Tunisian RER and some fundamental factors.

The most common factors are the following: terms of trade, net equity flows, the productivity differential (**Charfi 2008),** US interest rate, public expenditure, net foreign assets, economic openness **(Chnaina Khaled (2013)),** trade openness, Foreign direct investment, the current account balance, transfers received from outside (**HadhekZouheir, SakliHniya and MosbahLafi (2019))**, the share of public expenditure in GDP; the money stock; international financial integration (**Caporale, G. M., Hadj Amor, T., &Rault, C. (2011)).**

For our purposes, the long-run equilibrium rate is assumed to be a function of the following variables:

$$q_t = f(TB_t, CA_t, TOT_t, Prod_t, FDI_t, CO_t) \quad (27)$$

Where, CA is the current account, TB is the trade balance, TOT is the terms of trade, Prod is the relative productivity, FDI is the foreign direct investment, CO is the commerce opening and εt is a white noise.

Conclusion

In this study we focus on REER misalignments. While there are many ways to calculate the equilibrium REER rate, there is no longer an absolutely recommended method. It depends on the characteristics of the given economy and the study time frame.

The first measure, the PPP, has been widely criticized in the literature since it ignores the long-run real determinants of the REER **(MacDonald, 2000).** The second, the FEER, is the rate that closes the CA gap. An alternative measure is represented by the BEER, where the importance of the determinants of the REER is recognized and they are used to calculate the "equilibrium" rate itself without aiming to close any macroeconomic gap. The last method is applied in our essay.

CHAPTER 2: ESTIMATION OF EQUILIBRIUM REAL EXCHANGE RATE AND MISALIGNMENTS

INTRODUCTION

In simple terms, exchange rate misalignment means that a nation's currency either is under or overvalued. It is under (over) valued when it is more depreciated (appreciated) than its 'ideal' value. The ideal is some measure of equilibrium, which is a steady-state level towards which the exchange rate tends to converge.

The equilibrium is the level of the real exchange rate that is consistent with the goals of internal and external balance. In practice, the exchange rate misalignment has come to be associated with overvaluation, particularly in the case of developing countries.

However, the risk of having an undervalued exchange rate, which creates a large trade surplus and a stronger traded goods sectors, is more difficult to recognize **(Ilker Domaç and Ghiath Shabsigh 1999)**. It is widely acknowledged that such misalignments adversely affect economic growth.

The estimate of this equilibrium rate is a particularly delicate process for two reasons: firstly, it is necessary to find this rate with great precision in order to make the right macroeconomic decisions, and secondly, there is no single model that is indispensable.
However, as mentioned above, these models cannot be applied to all countries. The size of the country and its position in the international environment govern the choice of the model to be used.

Therefore, in this essay, we have chosen the model the most advisable for small developing countries, notably the BEER methodology. This theoretical model, developed in the previous section, defines a long-term relationship between the real exchange rate and a set of macroeconomic fundamentals.

To that end, the present chapter will be devoted to the theoretical attempt to calculate the equilibrium REER through the BEER model and the analysis of the misalignments.
According to the BEER methodology, the reduced-form equation, implied by the cointegrating vector, is called a current equilibrium exchange rate. The total equilibrium is derived by estimating the long run (sustainable) values of the fundamentals. These values are estimated by the **Hodrick and Prescott (1997)** filter. That is a univariate smoothing method,

which estimates the long run components of the variable. The overall estimation is undertaken by the well-known **Johansen's (1988, 1991)** cointegration technique.

SECTION 1: RESEARCH METHODOLOGY

1-1- Cointegration and Johansen procedure

Two or more non-stationary time series are said to be cointegrated if there exists at least a linear combination of them that is stationary. Considering a set of **MI(1)** time series$\boldsymbol{y_t} = [\boldsymbol{y_{1,t}}, \boldsymbol{y_{2,t}} \dots \boldsymbol{y_{M,t}}]^{\boldsymbol{T}}$,$\boldsymbol{y_t}$ is cointegrated if there exists a vector $\boldsymbol{\beta} = [\boldsymbol{\beta_1}, \boldsymbol{\beta_2} \dots \boldsymbol{\beta_M}]^{\boldsymbol{T}}$such that:

$$\boldsymbol{\beta^T y_t} = \boldsymbol{\beta_1 y_{1,t}} + \boldsymbol{\beta_2 y_{2,t}} + \boldsymbol{\beta_3 y_{3,t}} + \dots + \boldsymbol{\beta_M y_{M,t}} = \boldsymbol{z_t} \sim \boldsymbol{I}(\boldsymbol{0}) \qquad (\boldsymbol{28})$$

Where the vector b is called a cointegrating vector and $\boldsymbol{z_t}$ the cointegration residual or long-run equilibrium relationship between time series. Since $\boldsymbol{y_t}$ is M-dimensional, there may exist at most **M-1** linearly independent cointegrating vectors. It should be noted that for the time series to be cointegrated, they must have shared/common trends and the same order of integration.

If $\boldsymbol{y_t}$ is cointegrated with $\boldsymbol{N_r}$ cointegrating vectors, where **0** $<\boldsymbol{N_r}<$ **M**, the cointegration relationship given by **Eq. (24)** can be extended to multiple cointegration:

$$\boldsymbol{\beta^T y_t} = \begin{bmatrix} \boldsymbol{\beta_1^T} & \boldsymbol{y_t} \\ \dots & \\ \boldsymbol{\beta_{Nt}^T} & \boldsymbol{y_t} \end{bmatrix} = \begin{bmatrix} \boldsymbol{z_{1,t}} \\ \dots \\ \boldsymbol{z_{Nt,t}} \end{bmatrix} \sim \boldsymbol{I}(\boldsymbol{0}) \qquad (\boldsymbol{29})$$

Where the **M-by-**$\boldsymbol{N_r}$ matrix B is the cointegration matrix. Two approaches have been followed to estimate the cointegration vector(s). The first one is the Engle-Granger procedure which is suitable only for bivariate data sets. The second one is the Johansen procedure which is a maximum-likelihood multivariate estimation procedure.

The Johansen procedure is a combination of cointegration and error correction models (ECM) in a Vector Auto-regression model (VAR). However, the cointegration relationships are not explicitly apparent in the VAR representation. They become apparent when the VAR model is transformed to the Vector Error Correction Model (VECM) which takes the form:

$$\Delta \boldsymbol{y_t} = \boldsymbol{\pi y_{t-1}} + \boldsymbol{\tau} \Delta \boldsymbol{y_{t-1}} + \dots + \boldsymbol{\tau_{k-1}} \Delta \boldsymbol{y_{t-k+1}} + \boldsymbol{\theta d_t} + \boldsymbol{\varepsilon_t} \qquad \textit{\textbf{(30)}}$$

The **M-by-M** matrixes $\boldsymbol{\pi}$ and $\Gamma_{\mathbf{i}}$ contain, respectively, information on the long-run and short-run adjustments to changes in $\boldsymbol{y_t}$ and dt contains the deterministic terms (e.g. no constant, constant only or constant plus time trend). In fact, $\boldsymbol{\pi} = \boldsymbol{AB^T}$, where A represents the speed of adjustment to disequilibrium and **B** is the matrix of long-run coefficients, that is, the cointegration matrix.

Defining $\boldsymbol{\mu_{0,t}} = \Delta \boldsymbol{y_t}$; $\boldsymbol{u_{1,t}} = \boldsymbol{y_{t-1}}$; $\boldsymbol{u_{2,t}} = [\Delta \boldsymbol{y_{t-1}}^{\boldsymbol{T}}, \Delta \boldsymbol{y_{t-2}}^{\boldsymbol{T}}, \dots, \Delta \boldsymbol{y_{t-k}}^{\boldsymbol{T}}, \boldsymbol{d_t}^{\boldsymbol{T}}]^{\boldsymbol{T}}$ and $\boldsymbol{\Psi} = [\Gamma_{\mathbf{1}}, \Gamma_{\mathbf{2}}, \dots, \Gamma_{\boldsymbol{k-1}}, \boldsymbol{\Phi}]$Eq. (30) can be rewritten as:

$$\boldsymbol{u_{0,t}} - \boldsymbol{AB^T u_{1;t}} = \boldsymbol{\varphi u_{2;t}} + \boldsymbol{\varepsilon_t} \tag{31}$$

The short-run dynamics can be taken out by regressing $u_{0,t}$and $u_{1;t}$separately on the right-hand side of Eq. (27). The residual vectors $r_{0,t}$ and $r_{1,t}$ are then obtained from:

$$\boldsymbol{u_{0,t}} = \boldsymbol{C_1 u_{2,t}} + \boldsymbol{r_{0,t}} \tag{32}$$

$$\boldsymbol{u_{1,t}} = \boldsymbol{C_2 u_{2,t}} + \boldsymbol{r_{1,t}} \tag{33}$$

Being the coefficient matrixes $\boldsymbol{C_1}$ and $\boldsymbol{C_1}$ obtained by ordinary least squares. The residual vectors $\boldsymbol{r_{0,t}}$ and $\boldsymbol{r_{1,t}}$ can be used to form residual product moment matrixes:

$$\boldsymbol{S_{ij}} = \frac{\mathbf{1}}{\boldsymbol{T}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{T}} \boldsymbol{r_{ij}\, r_{jt}^T} \qquad \boldsymbol{i, j} = \mathbf{0.1} \tag{34}$$

Where, **T** is the number of observations or data points. Finally, the cointegrating vectors **B** are found as the eigenvectors of the eigenvalue problem,

$$\left| \boldsymbol{\lambda S_{11}} - \boldsymbol{S_{10}\, S_{00}^{-1} S_{01}} \right| = \mathbf{0} \tag{35}$$

The cointegrating vector associated with the highest eigenvalue corresponds to the most stationary linear combination of the original variables. Indeed, the eigenvalues $\boldsymbol{\lambda_i}$ are a measure of how strongly the cointegrated relations are correlated with the stationary part of the process. The cointegrated relation is 'more stationary' the larger the eigenvalue is. Readers are referred to for the explanation of the theory behind the Johansen's cointegration procedure.

One important step in the Johansen procedure is the choice of number of lags **k**. In this work the number of lags **k** will be chosen using the stationarity-based approach proposed by **Dao, et al**. It can be summarized in the following steps:

1. Define the maximum and the minimum number of lags,$\boldsymbol{K_{min}}$and $\boldsymbol{K_{max}}$respectively. K_{min} Will be set to 3 and K_{max} will be set according to the following Eq.

$$\boldsymbol{K_{max}} = \left|\mathbf{12}\left(\frac{\boldsymbol{T}}{\mathbf{100}}\right)^{\frac{1}{4}}\right| \quad (\mathbf{36})$$

Where the square brackets denote the integer part of the result.

2. Determine **B** and calculate the M-1 cointegration residuals for all lag lengths between $K_{min}$and K_{max}.
3. Calculate the ADF statistic for all cointegration residuals.
4. Calculate the average ADF statistic for each lag length. The lag length with the most negative average ADF statistic is the lag length that produces the most stationary residuals obtained for the undamaged condition.

On the choice of the cointegration vectors

After the cointegration matrix **B** is determined, only the cointegration vectors that produce stationary cointegration residuals should be retained and used to project new data in the cointegration space. The determination of the cointegration vectors is made by means of a likelihood ratio statistic test proposed by Johansen, the trace test. For **I(1)** variables, in order to the product $\boldsymbol{\pi y_{t-1}}$ in **Eq. (26)** to be stationary, the matrix $\boldsymbol{\pi}$ is required to be rank deficient. If $\boldsymbol{\pi}$ has full rank, the **I(1)** variables cannot be cointegrated.

The trace test tests the null hypothesis $\boldsymbol{\pi}$ having rank **r** against the alternative hypothesis of $\boldsymbol{\pi}$ having full rank. Recalling that the rank of $\boldsymbol{\pi}$ is equal to the number of non-zero eigenvalues. The trace statistic is used to test the hypothesis that there are at most recointegration vectors is:

$$\boldsymbol{\lambda_{trace}} = -\boldsymbol{T}\sum_{\boldsymbol{i=r+1}}^{\boldsymbol{M}} \mathbf{ln}(\mathbf{1}-\boldsymbol{\lambda_i}) \quad \boldsymbol{for} \quad \boldsymbol{r} = \mathbf{0}, \mathbf{1}, \ldots\ldots, \boldsymbol{M}-\mathbf{1} \quad \mathbf{(37)}$$

SECTION 2: EMPIRICAL PART

2-1- Data description and statistical analysis

It is obvious to define our variables and discuss the likely theoretical effect of each economic fundamental on the real exchange rate.

Then, definitions are given below.

- **The real effective exchange rate (REER):** We will be consistent with many authors who defined the REER as the real effective exchange rate index computed with respect its trading partners.

$$\boldsymbol{REER}=\sum_{i=1}^{n} w_i\, e_i(WPI_i/CPI) \quad \textbf{(38)}$$

$e_i$is the bilateral nominal exchange rate vis-à-vis country i, WPI_i is the wholesale price index of country i and proxies for the foreign price of tradable goods, CPI is the consumer price index of the home country and proxies for the domestic price of non-tradable goods, w_i is the share of partner i in the home country's exports.

The REER is deemed a good proxy for a country's degree of competitiveness in international markets. A rise in the REER represents a real exchange appreciation or a rise in the domestic cost of producing tradable goods. A decline, on the other hand, reflects a real exchange rate depreciation or an improvement in the country's international competitiveness.

The purpose here is to define the retained macroeconomic fundamentals and to discuss the expected effects of their exogenous shocks on the behavior of the real exchange rate.

- **Commercial opening (CO):** It can be measured by the structure of protection or by the sum of exports and imports relative to GDP. The CO is considered as a fundamental variable in the behavior of the RER according to **Edwards (1989), Elbadawi (1994) and (Elbadawi et al. (2005))**. Then, if an economy is following a policy of trade liberalization, the relationship between openness and REER is expected to be negative, due to the fact that trade liberalization leads to greater trade openness. So, an increase in openness depreciates the REER.
- **Relative productivity (Prod):** Productivity is included to capture the Balassa-Samuelson effect **(Balassa, 1964; Samuelson, 1964)**. Based on their theorem, productivity growth is assumed to be higher in the tradable sector compared to the non-tradable sector. Under the

assumption that the law of one price holds for tradables, the productivity improvements that occur under conditions of full employment and perfect labour mobility increase the absorption of workers from the non-tradables to the tradables sector (supply effect) and therefore drive-up real wages for all sectors of the economy as well as ensuring higher overall prices due to sectoral mobility. Hence, improvement in productivity is hypothesized to be associated with REER appreciation **(Obstfeld and Rogoff, 1996).**

The BS assumptions suggests that richer countries tend to have higher price levels and so, appreciated currencies. In fact, the traded goods sector has higher productivity and higher wages. Therefore, a country with rapid productivity growth will experience rapid inflation and long-term appreciation of their exchange rate.

A possible explanation for that is: an increase in the productivity of the tradable goods sector relative to the non-tradable goods sector results in an expansion of the tradable goods sector at the expense of the non-tradable one. It will improve the TB, which will cause a real appreciation of the currency to keep the trade account at a sustainable level. Moreover, a positive innovation to the relative productivity leads a long-run appreciation (**Minsoo Lee (2002)).**

However, we should mention that the overall impact of productivity on the REER depends on the strength and direction of these effects[21].

Apart from these findings, several previous studies[22] have reported insignificant effect in different countries. Generally, the difference in per capital real GDP is used as a proxy for the relative productivity as following:

$$\boldsymbol{Prod} = \frac{\boldsymbol{GDPPC_i}}{\sum_{i\neq j}^{n} \boldsymbol{w_{ij}} * \boldsymbol{GDPPC_j}} \qquad (\mathbf{39})$$

Where GDPPC is the per capita GDP at home (i) and trading partners (j)[23].

The use of per capita GDP in this work was motivated by the lack of a better proxy for productivity, such as a ratio of output to workers employed or the ratio of output to primary-age worker etc.

- **Foreign direct investment (FDI):** Capital flows are usually materialized in the form of FDI or portfolio investments (PFI). However, the PFI are not crucial sources of financing

[21]Benigno and Thoenissen (2003) show in a dynamic general equilibrium model the case where the drop in tradable prices is more important than the increase in non-tradable prices, leading to the real exchange rate depreciation.
[22]AnjanPanday (2015)
[23]France, Italy, Germany, China and Turkey

for the Tunisian economy, therefore they will not be included in our model. As a result, capital flows will be composed entirely of FDI.

Rationally, an increase in FDI leads to a real appreciation of the exchange rate. Nevertheless, FDI inflows has been proven to cause real depreciation in Tunisian dinar, (**Addison, T., &Baliamoune-Lutz, M. (2017))**. That may be argued by the fact that investors prefer a week currency in order to minimize their expenses.

- **The terms of trade (TOT):** The terms of trade are the relative price of exports to imports. That is, how many units of exports are required to purchase a single unit of imports?

$$\boldsymbol{TOT = (export\ prices/import\ prices) * 100} \qquad (\mathbf{40})$$

When more capital is leaving than is entering into the country, the **TOT** is less than 100%. When it is greater than 100%, the country is accumulating more capital from exports than it is spending on imports.

The **TOT** is included to account for the effect of exogenous adjustments in world prices that will influence the RER. Income growth generated by improvements in **TOT** leads to higher demand for non-tradables. To maintain the equilibrium, the price of non-tradable needs to increase thereby causing the REER to appreciate. However, it is possible to observe REER depreciation under this condition where the substitution effect is larger than the income effect **(Edwards, 1989).**

- **The substitution effect**: an increase in the TOT improves the CA and as a consequence the exchange rate appreciates.
- **The income effect**: the improved CA will increase domestic income. So, domestic consumption of imported goods increases and as a result the domestic currency has to depreciate to restore equilibrium. The final effect depends on the relative price elasticity of demand for imports and exports.

Logically, the first effect comes before the second. Therefore, we expect that the direct effect of a positive terms of trade shock on the exchange rate is the appreciation of the effective exchange rate. **(Edwards and van Wijnbergen (1987))**.

This fact is in line with **N. Giannellis, A.P. Papadopoulos**'s study who show that the substitution effect will overshoot the income effect[24]. Thus, the RER rises in response to a positive shock.

[24]The improvement in the current account will be higher than the increase in domestic income.

As result, TOT may lead to real appreciation or depreciation depending on the significance of income effects and substitution effects. For instance, **Minsoo Lee (2002)** highlights that a positive shock[25] on New Zealand's TOT against the US leads the RER to depreciate in the short-run and then eventually to an appreciation in the long-run. So we suppose a positive effect of an improvement in the TOT on the equilibrium REER.

- **The current account balance (CA):** The CA equals the difference between domestic saving and investment (i.e. the saving-investment balance). A CA deficit generates an additional net external debt to be financed by a range of international investments **(MacDonald & Ricci, 2003; Chudik&Mongardini, 2007).** Given that Tunisia's current account is still in deficit, the assumed link between the CA balance and the REER IN Tunisia is only negative; i.e. CA deficit implies a depreciating REER.
- **The trade balance (net exports) (TB):** The trade balance is another key economic variable. Persistent surplus or deficit in the trade account is a matter of concern for the long-term sustainability of the external sector. Any lasting imbalance in the trade account also affects goals towards internal balance by affecting domestic production and employment that are export oriented.

As per theory, a decline in the trade deficit requires a real deprecation in order to restore competitiveness.

However, the long-run estimate suggest the opposite in some researches. For instance, **Anjan Panday (2015)** study's investigates that increasing imports results in appreciation of Nepal's RER. In fact, Nepal's real sector has been underperforming for long time and the excess of aggregate demand over domestic production is met through imports, mainly from India. Meanwhile, with average GDP growth in India, prices there have generally risen faster than in Nepal. Under a pegged exchange rate regime, Nepal has effectively borrowed the impact of rising prices in India on its domestic prices through imports. As a result, a falling in domestic production, combined with increasing imports, have resulted in appreciation of Nepal's REER.

[25]such shock leads to an increase in demand for imported manufactured goods which will deteriorate the trade balance because these are New Zealand's major import commodities. An improvement in the terms of trade causes the output in non-tradable goods to decline which, in turn, will create excess demand in the non-tradable goods sector. An improvement in the terms of trade is expected to lead to an appreciation in the equilibrium exchange rate.

On the whole, based on the theoretical and empirical literature, the equilibrium REER in Tunisia will be estimated as a function of the following variables (with the signs below the variable names denoting the partial derivatives):

$$q_t = f(CO, Prod_t, FDI_t, CA_t, TOT_t, TB_t)$$

- + + + +/- +

Our database consists on annual time series for all variables on the period that spans from 1980 to 2018. Even if we can have monthly or semestrial data for some variables, the annual frequency is used because available data for others are only annual.

Moreover, the data are collected from different sources. First, the REER, the Foreign Direct Investment, the Commerce opening and the terms of trade are derived from the word bank website (https://www.worldbank.org/). Second, the trade balance as well as the current account are extracted from the IMF website (https://data.imf.org/). Finally, the GDP per capita, as a proxy for the productivity, is collected from (https://www.theglobaleeconom.com/)[26].

Variable	Measurement unit
REER	Base Period: 2010
CO	Percent of GDP
Prod	Thousand current USD
FDI	Billions current USD
CAD	Billion current USD
TOT	Percent
TBD	Billion current USD

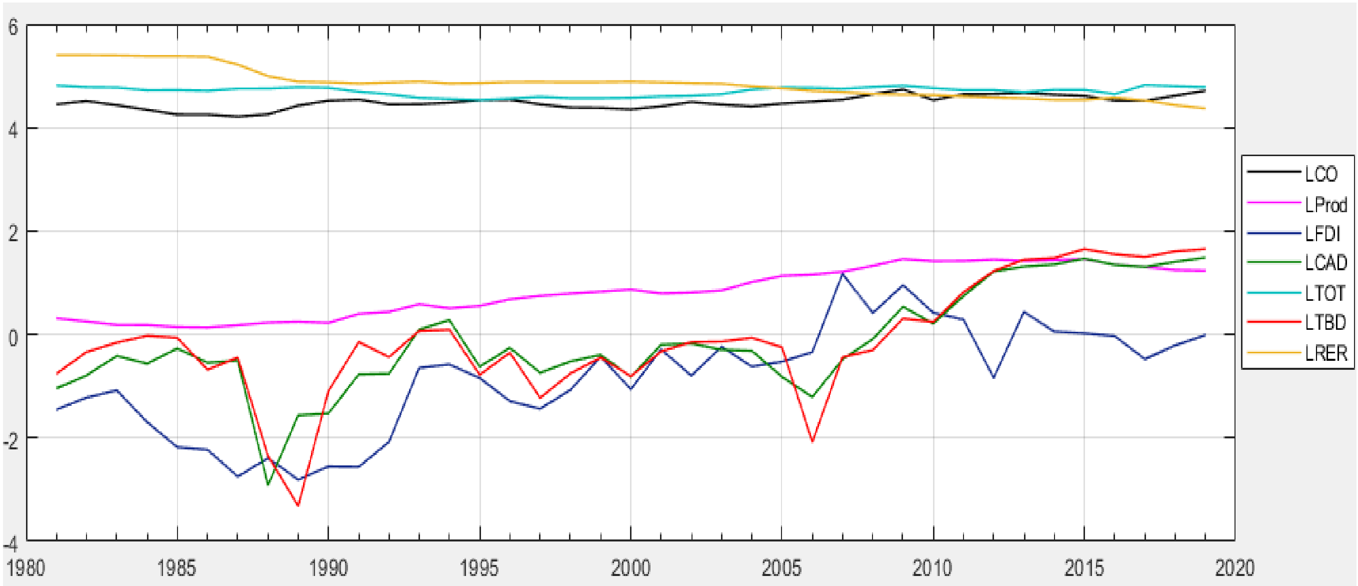
First, we have proceeded to logarithmic transformation in order to transforming highly skewed variables into more normalized dataset.

Figure1 displays the evolution of variables mentioned above during the sampling period, which seem to be non-stationary and to have a same direction. The observation of

[26] The unavailability of data on the interest rate differential led us to eliminate it from our model.

their dynamics leads to some preliminary analyses. Globally, it is clear that some variables are interdependent and all of them went through many shifts over time.

Figure 1: Dynamics of the LREER, LProd, LFDI, LCAD, LTOT and LTBD in Tunisia during the period 1980-2018



Source: Matlab 2019

Table 3 reports summary statistics for the annual data of the macroeconomic variables employed in this study.

Table 3: Descriptive Statistics for all variables

	LCO	LProd	LFDI	LCAD	LTOT	LTBD	LREER
Mean	4.4880	0.8218	-0.8432	-0.1482	4.7023	-0.1078	4.8523
Standard deviation	0.1277	0.4740	1.0401	0.9863	0.0866	1.1078	0.2845
Maximum	4.7393	1.4603	1.1756	1.4881	4.8246	1.6548	5.3984
Minimum	4.2120	0.1375	-2.8031	-2.9132	4.5362	-3.3140	4.3713
Kurtosis	2.6840	1.5266	2.3058	3.2094	1.9074	3.7264	2.6992
Skewness	-0.1934	-0.0484	-0.2642	-0.0377	-0.5196	-0.3897	0.6685

Source: Matlab 2019

As it is shown, all the means are not close to zero and the standard deviations are relatively high which means that all series are volatile and are not around the mean.

The CAD and the TBD have the highest standard deviations. Indeed, Tunisia's current account balance has been rather volatile over the past years, reflecting the small size and narrow sectorial base of the economy. Obviously, current imbalances are increasingly linked to trade imbalance and consequently have similar characteristics, among others, in terms of volatility. FDI also demonstrates a high volatility.

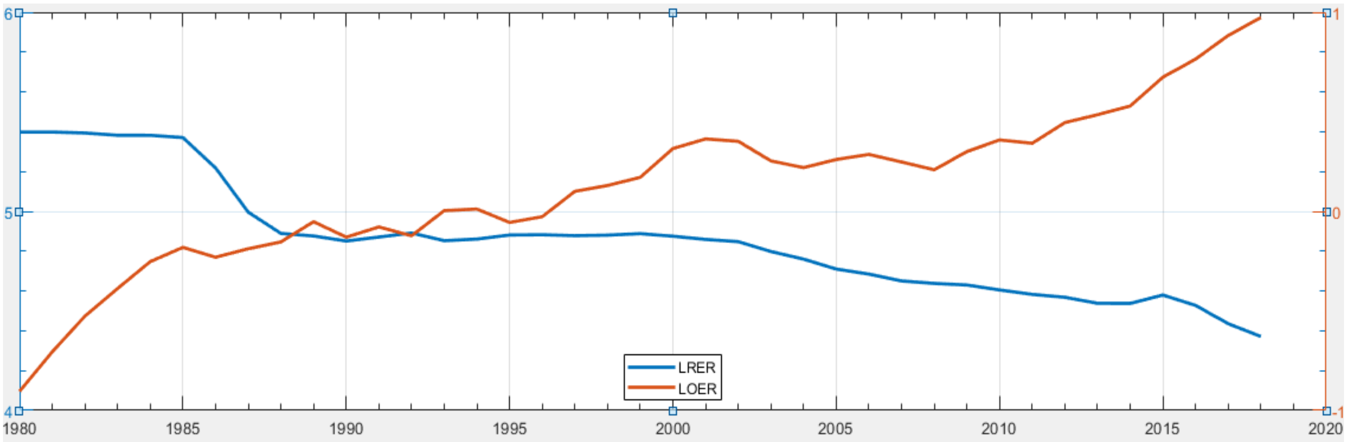
Moreover, asymmetry and fat tails are evident for all series. In one hand, all variables exhibit a significant and negative skewness, except for the LRER, which implies that all series are left skewed and have the propensity to generate negative returns with greater probability than suggested by a normal distribution.

In the other hand, the kurtosis coefficient is above 3 for LCAD and LTBD, hence these series are leptokurtic (the distribution has larger and thicker tails than the normal distribution). That means that a sadden movement (shock) will set off serious fluctuations and volatility due to fat tail feature of series. Remaining variables are platykurtic (have thinner tails than a normal distribution, resulting in fewer extreme positive or negative events.)

Thus, the results for the skewness and the kurtosis reinforce the rejection of normality.

- **LREER**

Figure 2: Dynamics of the LREER and LOER in Tunisia during the period 1980-2018

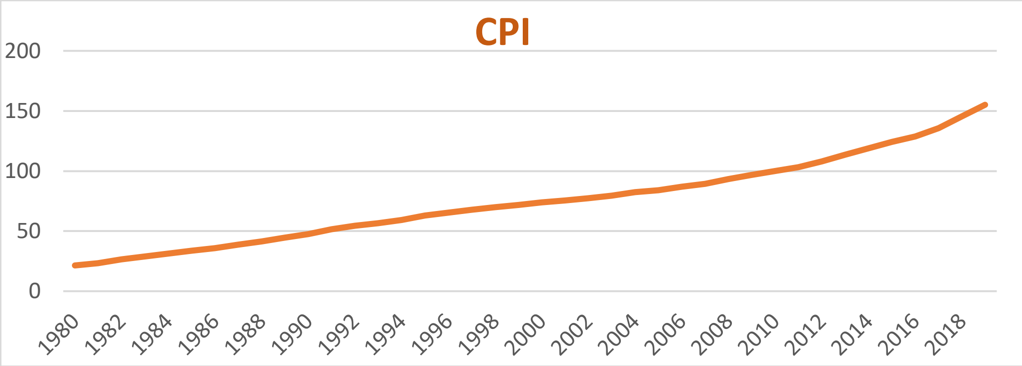


Source: Matlab 2019

Figure 2 shows the simultaneous evolution of the real exchange rate (LREER) and the official exchange rate (LOER) of the Tunisian dinar. Overall, Tunisian REER depreciated steadily for most of the period studied, with the exception of the 1990s, when a constant REER rule was applied **(Fanizza et al. 2002).**

Over the long-term, Tunisia have experienced REER depreciation, reflecting declines in its real GDP per capita relative to trading partners as well as its level of inflation which continues to have a clearly upward trend as shown by the figure provided below.

Figure 3: Dynamics of the consumer price index in Tunisia during the period 1980-2018



Source: Excel 2019

The exchange rate policy undertaken by the Tunisian authorities, between 1970 and 2006, has allowed the country to record remarkable economic performances. It also permitted to the CBT to achieve its objectives of maintaining the REER in, relatively, constant level and to support competitiveness and achieve export growth.

During the first phase, running from 1980 to 1986: A sharp depreciation of the REER is shown at the beginning of the period toward a slight appreciation of the dinar's, which lasted until the structural adjustment program's (SAP) implementation in 1986. The end of the period experienced a nominal depreciation (in August 1986), pointing the fact that changes in the basket weights were insufficient to limit the balance of payments constraints.

The second phase, 1986-1999: With regard to REER dynamics it is clear that the exchange rate policy combined with appropriate structural reforms have resulted in a gradual depreciation of the REER that started in 1986. It is also evident that the sharp devaluation of the dinar that took place in the same year[27] combined with a gradual process of trade liberalization and restrictions dismantlement has had a significant impact on exports growth and contributed to ensure a sustainable trend.

That epoch was characterized on the one hand by the country's involvement in SAP and the introduction of the new rules of the economic liberalization. On the other hand, following the imperatives of economic recovery and fluctuations, particularly of the dollar, the dinar underwent an official devaluation of 10% in 1986, followed by a sustained slide

[27] The BCT let the dinar depreciate by nearly 40% over the period 1984 to 1986.

until 1992. The objective of such a policy was to stabilize the REER vis-à-vis partner countries and to correct the inflation differential between them.

As shown in the figure, such measures have had the effect of curbing the downward trend of the dinar's and have led to a clear stabilization, reinforced by the performance achieved in terms of inflation, which has led to a reduction in the inflation differential with partner countries.

The depreciation of the dinar, coupled with an ambitious economic reform program in the late 1980s and early 1990s, stabilized the foreign exchange markets, allowing the liberalization of the exchange rate for current account purposes in December of 1992.

However, foreign exchange transactions were kept exclusively at the central bank until the establishment of the interbank spot exchange market in March 1994.

Additional liberalization of the foreign exchange market during June-July 1997, increased the flexibility of the spot market (e.g., raising the foreign exchange exposure limit from 5 percent to 10 percent) and allowed banks to transact in the forward foreign exchange market.

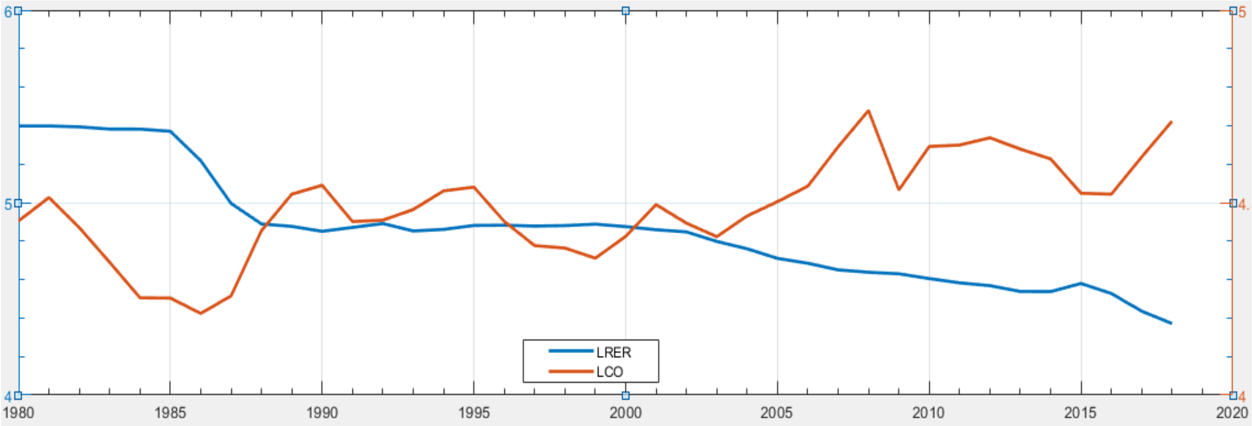
The third stage, covering the period 1999-2009. Analysis of Tunisia's price competitiveness according to the figure shows that the downward trend in the REER has improved competitiveness. That is very clear and is justified by the fact that the REER has never marked an appreciation over the last decade where the country is supposed to have acquired a good experience on the market economy.

For the remaining period, the decline in the real exchange rate is explained, on the one hand, by pressures on external balances, in particular the widening of the current account deficit, which has reached a record value for the year 2018. In 2019, there has been a sustained upward correction.

Figures below represent, at the same time, the evolution of the LREER and fundamentals considered in our study.

- **Commerce opening (CO):**

Figure 4: Dynamics of the LREER and LCO in Tunisia during the period 1980-2018



Source: Matlab 2019

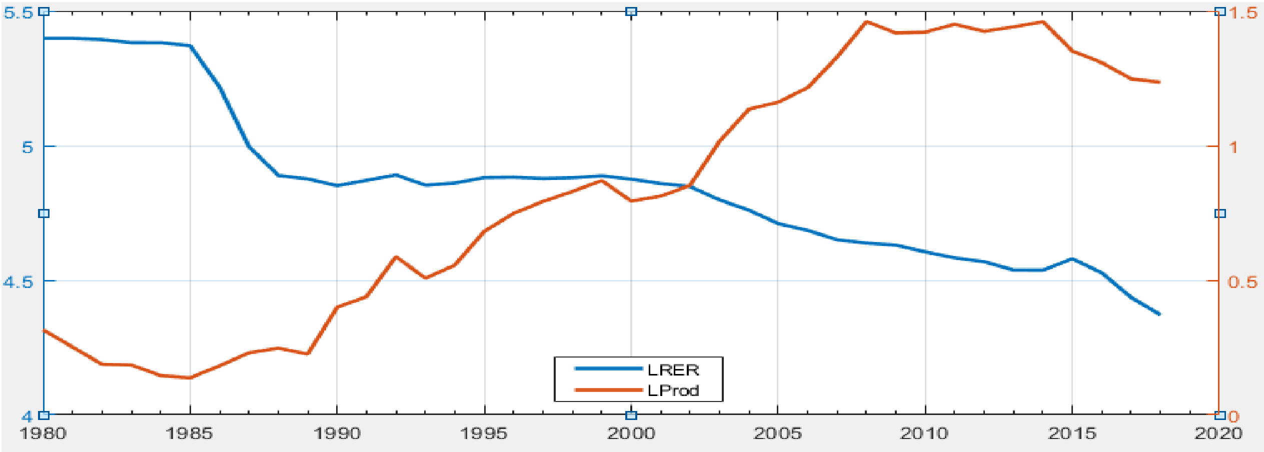
The commerce opening is denoted as the sum of imports and exports relative to GDP. We observe, according to figure 4, rapid and notable evolution of the LCO over the studied period except for the time between the years 1981-1987 and the year 2008.

The first decline was a result of the crisis' period following the country's adoption of SAP. However, the break observed in 2008 may reflect the impact of the subprime crisis (2008) on the Tunisian economy.

The favorable evolution of the CO during the remainder of the period possibly accounts for the awareness that the interest now lies in adopting an extroverted development strategy. Indeed, during the 1980s, a growing number of Southern and Eastern Mediterranean countries (SEMC) joined the idea that they should accelerate the opening-up of their economies and increase and diversify their exports. Thus, extroversion is supposed to be more growth-promoting than autarchy. Adding to that, the continuous assimilation and adaptation of foreign technology are, obviously, more favored by the first strategy than by the second.

- **Relative productivity (Prod)**

Figure 5: Dynamics of the LREER and LProd in Tunisia during the period 1980-2018

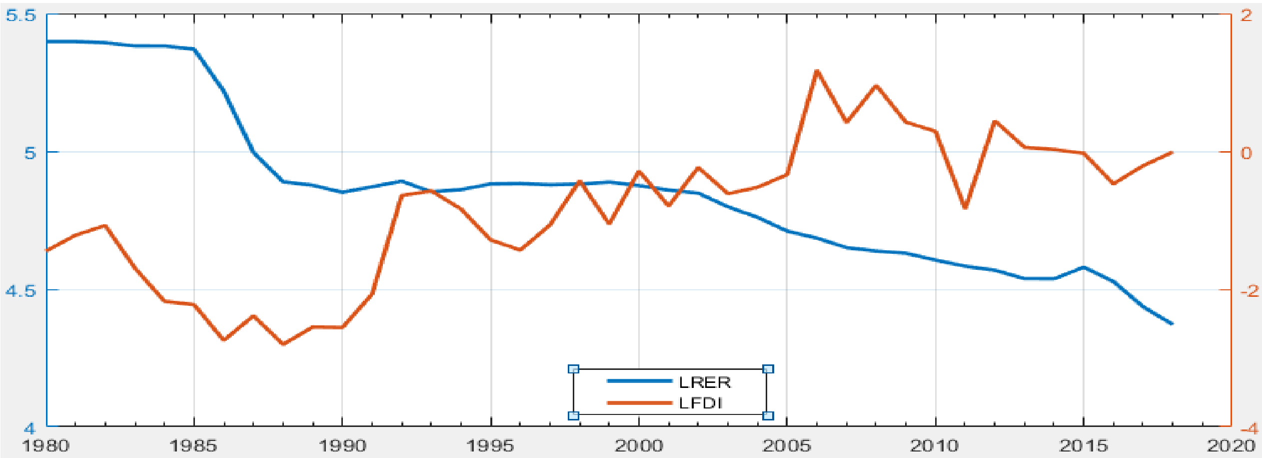


Source: Matlab 2019

Defined as the GDP per capita. Over the entire period, a trend in productivity growth can be observed (Figure 5). At the same time, there was a depreciating trend in the REER. That reflects the policy adopted by the Tunisian authorities, which sought to improve the competitiveness of its products for export.

- **Foreing Direct Investement (FDI)**

Figure 6: Dynamics of the LREER and LFDI in Tunisia during the period 1980-2018



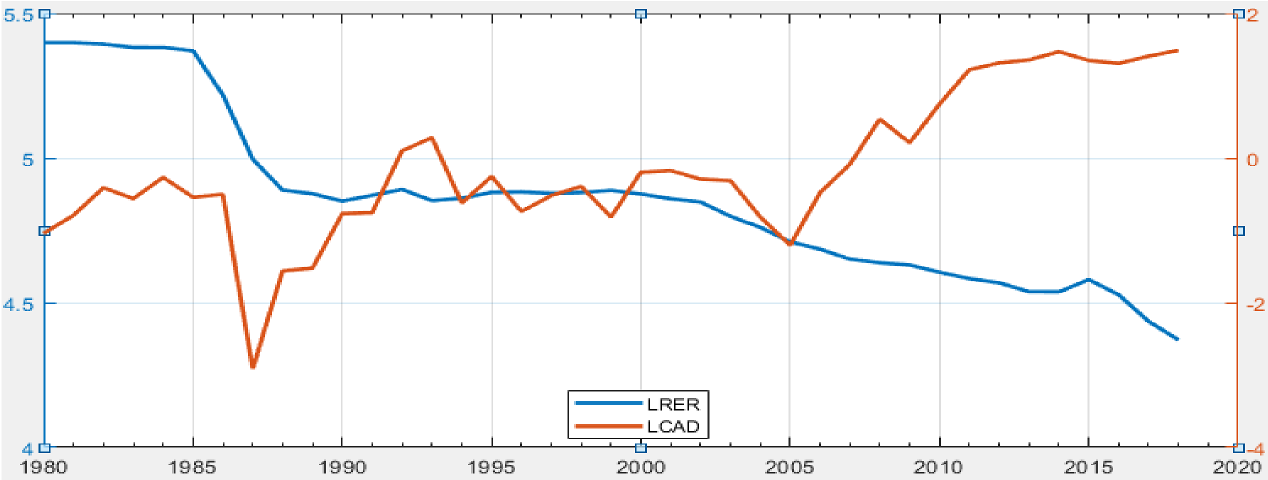
Source: Matlab 2019

The FDI are expressed in Billions of current USD. An increasing trend in FDI reflects the new orientation towards greater integration into international financial markets. Actually, the main investors in Tunisia are from France, Qatar, Italy, and Germany. The majority of FDI were allocated to industry, followed by energy and services. This evolution has been accentuated during the period that spans from 1990 to 2010. A geopolitically attractive atmosphere can explain such a shift fundamentally at that time.

Being outstanding, a significant decline during the crisis period of the 1980s and a further decline following the 2011 revolution. Nevertheless, the Tunisian government is still seeking to attract FDI through incentives granted to investors (elaboration of an investment code that specifies tax benefits).

- **Current Account Deficit (CAD)**

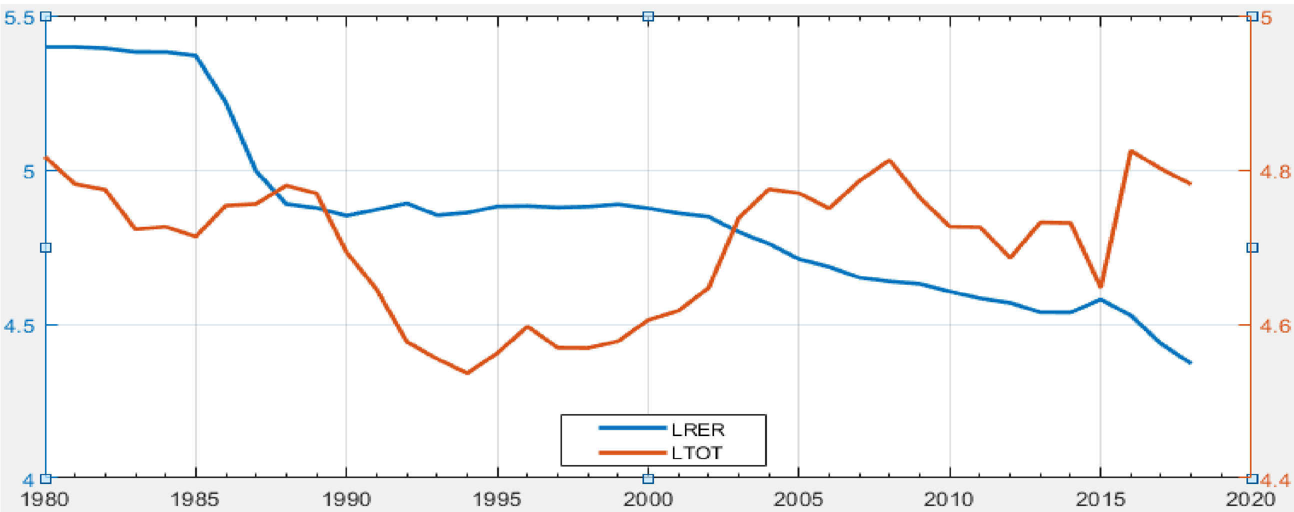
Figure 7: Dynamics of the LREER and LCAD in Tunisia during the period 1980-2018



Source: Matlab 2019

- **Terms of trade (TOT)**

Figure 8: Dynamics of the LREER and LTOT in Tunisia during the period 1980-2018

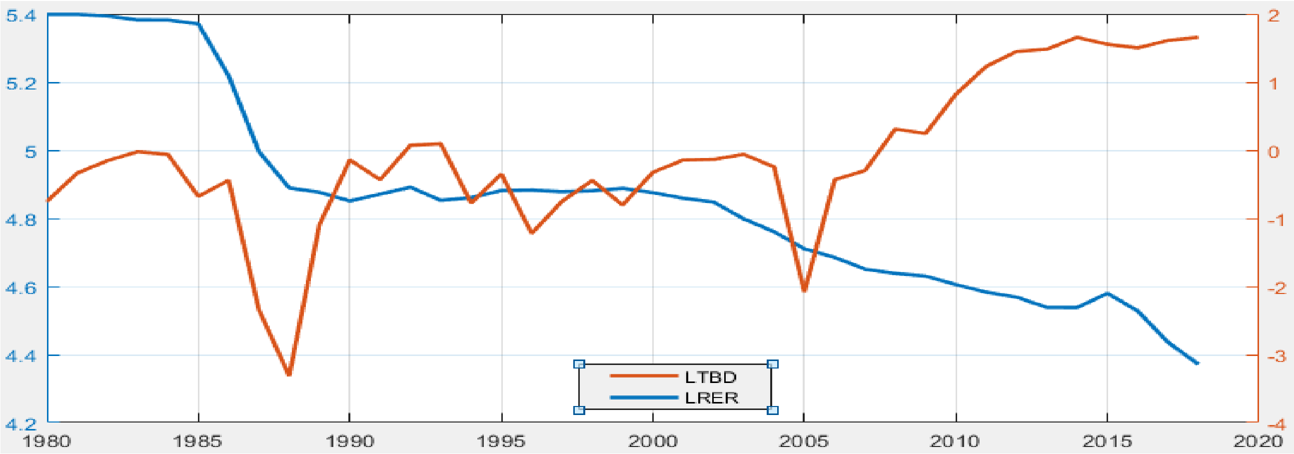


Source: Matlab 2019

The terms-of-trade is defined as the ratio between the unit values of exports and imports. It is apparent from figure 8 that unlike the evolution of the LREER, the trajectory of LTOT is ascending.

- **Trade balance deficit (TBD)**

Figure 9: Dynamics of the LREER and LTBD in Tunisia during the period 1980-2018



Source: Matlab 2019

The trade balance deficit is increasingly important, especially during the post-revolutionary period. There was also an historical improvement in the 1980s (a peak in 1988).

Going back to the origin of things, Tunisia has been facing external competitiveness challenges on the global market, as it can be shown by the low and stagnating shares in global exports. That limited export competitiveness has hampered external demand, growth, and employment, causing then deepened trade balance deficit (Brixiova, Z. et al (2014)).

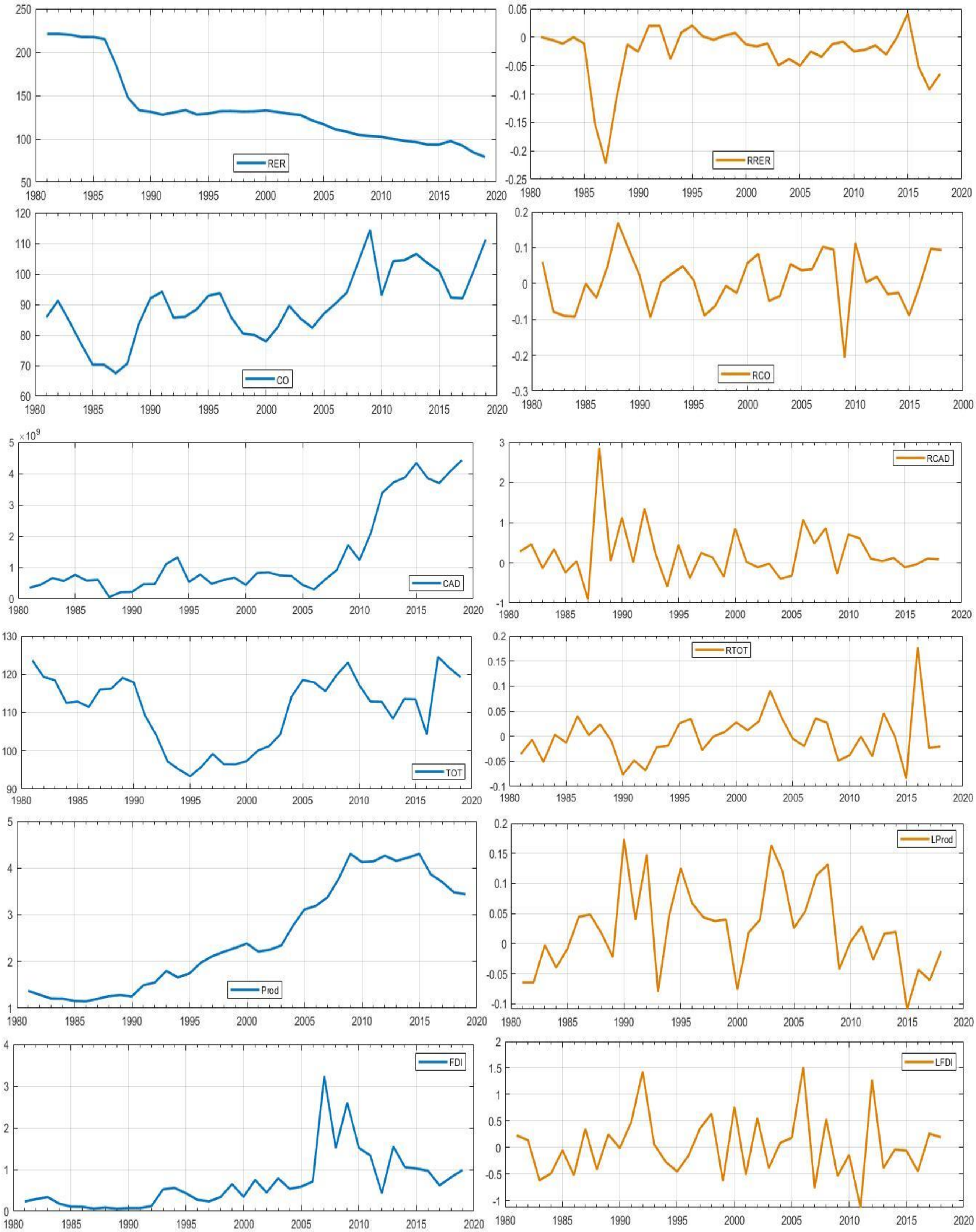
The import-export imbalance is explained mainly by a reluctance to export despite the incentive measures taken by the Tunisian State as well as increasingly weak dinar. The growing and irrational demand for imported products also matter.

Besides, Tunisia's exports are less diversified than some other emerging market economies at comparable levels of development (e.g. Turkey). In particular, Europe has accounted for a disproportionate share as an export destination, which reflects a geographical closeness and long-established business ties.

2-2-Stationarity testing

The purpose of the unit root test is to determine the order of integration of the variables.

Figure 10: Dynamics of annual data of LREER, LProd, LFDI, LCAD, LTOT and LTBD (left) and their returns (right) in the Tunisia during 1980-2018



Source: Matlab 2019

According to **Figure 10** on the left, we have a clear upward and downward slope indicating that our series display a trend in the mean. Hence, they are not moving around the constant mean. Also, the different fluctuations imply that the variance is not constant. Thus, we can conclude that the stationary condition is violated. We compute then, the returns of all variables by taking the logarithmic difference of two successive annual values.

By looking on the right, the variations of the returns exhibit an autoregressive pattern (volatility clustering). Besides, (the recent global financial crisis and the Tunisian revolution exhibited high deviations in the return series.

In addition to the graphical intention, we use unit root tests in order to determine the order of integration of each variable. Hence, the Augmented Dickey-Fuller (ADF), the Kwiatkowski–Phillips–Schmidt–Shin (KPSS), and Phillips-Perron tests are carried out to confirm the stationarity of the time series data under study.

2-2-1-Augmented Dickey-fuller (ADF) test

Through the ADF we are going to test:

{ H0: Presence of unit root ===>the variable in non-stationary;
H1: Absence of unit root ===>the variable is stationary.

Decision rule:

{ if Prob* ≤ 5% or t-Statistic < critical value (5%) ===> accept H1;
if Prob* > 5% or t-Statistic ≥ critical value (5%) ===> accept H0.

Table 4 reports the results for the ADF test.

Table 4: ADF test (5%) for all series

	LCO	LProd	LFDI	LCAD	LTOT	LTBD	LREER
H	0	0	0	0	0	1	0
T-Statistic	0.5143	1.4517	-1.5877	-0.8265	-0.1557	-1.9683	-0.4230
P-value	0.8221	0.9611	0.1047	0.3434	0.5885	0.0479	0.4909

Source: Matlab 2019

The results of the ADF test show that the variables are non-stationary at level (except forLTBD).

Table 5: ADF test (5%) for all returns

	RCO	RProd	RFDI	RCAD	RTOT	RTBD	RREER
H	1	1	1	1	1	1	1
T-Statistic	-5.2475	-4.3057	-8.3363	-8.0102	-6.3093	-6.7805	-4.5342
P-value	10^{-3}	10^{-3}	10^{-3}	10^{-3}	10^{-3}	10^{-3}	10^{-3}

Source: Matlab 2019

Referring to the last output, all ADF statistics are greater than the critical value which prove that all the returns are stationary.

2-2-2-Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test

The KPSS is an alternative way for testing unit root. It tests the null hypothesis of stationary time series against to the alternative one of non-stationarity.

Table 6: KPSS test (5%) for all series

	LCO	LProd	LFDI	LCAD	LTOT	LTBD	LREER
H	0	1	1	1	1	1	1
T-Statistic	0.1242	0.3234	0.2344	0.3943	0.5746	0.3315	0.1504
P-value	0.0904	0.01	0.01	0.01	0.01	0.01	0.0463

Source: Matlab 2019

Table 7: KPSS test (5%) for all returns

	RCO	RProd	RFDI	RCAD	RTOT	RTBD	RREER
H	1	1	1	1	1	1	1
T-Statistic	-5.2475	-4.3057	-8.3363	-8.0102	-6.3093	-6.7805	-4.5342
P-value	10-3	10-3	10-3	10-3	10-3	10-3	10-3

Source: Matlab 2019

The KPSS test reported in Table 6 and 7, confirm the non-stationarity of all series at level (except for the LCO) and the stationarity of all returns. Then, in order to confirm our results, we need an additional test.

2-2-3-Philips-Perron (PP) test

Phillips-Perron test assesses the null hypothesis of a unit root in a univariate time series.

Table 8: PP test (5%) for all series

	LCO	LProd	LFDI	LCAD	LTOT	LTBD	LREER
H	0	0	0	0	0	1	0
T-Statistic	0.5143	1.4517	-1.5877	-0.8265	-0.1557	-1.7683	-0.4230
P-value	0.8221	0.9611	0.1047	0.3434	0.5885	0.0579	0.4909

Source: Matlab 2019

Table 9: PP test (5%) for all returns

	RCO	RProd	RFDI	RCAD	RTOT	RTBD	RREER
H	1	1	1	1	1	1	1
T-Statistic	-5.2475	-4.3057	-8.3363	-8.0102	-6.3093	-6.7805	-4.5342
P-value	10-3	10-3	10-3	10-3	10-3	10-3	10-3

Source: Matlab 2019

Various unit root tests were conducted to determine the order of integration of our series. Results from these tests suggest that the null of a unit root cannot be rejected for most of the variables. According to previous results, all series at level are non-stationary but stationary in first difference (except for the LTBD).

It is safe to conclude that all of the variables are integrated in the same order I(1), at 5% significance level, (except for TBD that will not be taken into account in the cointegration relation estimation).

2-3-Specification of VAR model and lag selection

Before estimating the relationship between the equilibrium REER and its fundamental determinants, it seems more useful to begin by first specifying our VAR system through the selection of its optimal lags number.

The constraint of the reduced number of observations provided by the study period (39) as well as the annual frequency of our data, led us to choose in a pragmatic way a number of lags ranging from 1 to 2. Table 10, summarizes the maximum number of lags' results in the VAR representation, we found that according to the four criteria (LR, FPE, HQ, AIC and SC) (p*=1) lag has been recommended. Then, the optimum lag would be 1 and we shall use this number of lags in Johansen test and also in the ECM estimates.

Table 10: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	22.11616	NA	1.69e-08	-0.871144	-0.609914	-0.779048
1	211.1829	306.5948*	4.42e-12*	-9.145023*	-7.316413*	-8.500352*
2	243.5239	41.95587	6.32e-12	-8.947238	-5.551249	-7.749993

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

Source: Eviews10

➔The specified model will be VAR (1).

2-4-Cointegration Test

The cointegration test allows us to check if there is a long-term relationship between non-stationary variables. Two cases arise: in the absence of a wedge-integration relation, we estimate an autoregressive model (unrestricted VAR), whereas, if there is a cointegration relation, we must estimate an error-correction model (ECM).

Precondition: variables must be integrated of same order as were proved.

The test for the number of cointegrating relations is given by the trace value that tests for the existence of "at most" r cointegrating vectors against the alternative hypothesis of the existence of "at least" (r + 1) vectors.

Table 11: Summary of Johansen Cointegration Test with One Lag

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	3	4	3	4	4
Max-Eig	1	1	1	2	2

Source: Eviews10

Johansen's trace and maximum eigenvalue statistics showed whatever the type of test, the existence of at least one cointegrating relationship at 5%. Meaning that these variables have a log-run association-ship.

The result, just obtained, allows us to move on to the next step, namely running a restricted VAR that is VECM model: the estimation of long-term and short-term solutions for the equilibrium exchange rate.

2-5-Estimation results

Table 11 below presents the long-term relationship between REER and macroeconomic fundamentals. A summary of the estimates is presented in Table 12.

Table 12: Estimation of the long-run relationship between the equilibrium REER and macroeconomic fundamentals

Variable	Coefficient	Std.error	t-statistic
LCO	1.076892	0.37087	-2.90367
LProd	-0.514006	0.15091	3.40614
LFDI	1.07141	0.385705	-2.77779
LCAD	-0.275811	0.05391	5.11618
LTOT	0.118452	0.35125	-0.33723

R^2= 0.49 adjusted R^2= 0.399 *Source: Eviews10*

The sample size is large (T > 30), we can compare | t | directly with the critical value of the centered and reduced normal distribution which is 1.96 (for a 5% risk): according to the central limit theorem, Student's distribution tends towards a normal distribution when T is large enough.

Therefore, if | t | > 1.96 ⇒ we reject H0 and accept H1: the coefficient is significant and the variable plays an explanatory role in the model.

Interpreting results:

Observing the long-run model results, we first find that all variables were statistically different from zero to 5 percent (except for LTOT)

The model is well specified, R^2 ≈ 0.5, in other words, the variables explain more than 50% of the LREER. However, concerning the sign of coefficients relative to the long-run dynamic of LRER, results do not fit well into theoretical predictions.

Commerce Opening: The elasticity of the real exchange rate vis-à-vis Tunisian trade policy isn’t plausible in relation to previous work and to what is often predicted by economic theory. The positive coefficient corresponding to the trade opening support the idea that for developing countries, greater openness rate, is marked by a stronger increase in imports. Thus, an increase (decrease) in openness may appreciate (depreciate) the REER **(Faso, Baffes et al., 1999)**. Thus, a 10% improvement in the degree of openness of the Tunisian economy generates a real appreciation of around 10.7%.

Relative Productivity: The negative coefficient relative to LPROD puts us away from**Balassa (1964), Edison and Klovland (1987), and Marston (1987**)'s workswho argue that the fast-growing countries face real appreciation of their currencies. Also,**Zouhaier Hadhek, HniyaSakli &Tahar Lassoued,(2018)** show that a rise in income per capita lead to a long-term appreciation in the Tunisian real exchange rate.

However, we are in line with **Marston (1990)**. In his cross-sectional analysis, he argues that higher productivity in the tradable goods sector, which was normally manufacturing, makes prices cheaper, so that a country may experience a depreciation of the REER when measured by the price of manufacturing goods only. Moreover, perhaps the GDP per capita proxy was inaccurate to the relative productivity in the case of Tunisia.

FDI: The long relationship between FDI and REER fits well into the theoretical predictions. The cointegration coefficient is positive and an increase in foreign capital inflows of 10% generates an appreciation of 10.7% of the LREER.

Hence, an increase in net capital inflows will result in higher current expenditure on all goods, including non-tradables. This, in turn, will lead to an increase in the price of non-tradables, or equilibrium real appreciation in that period. Nevertheless, it is likely that the effect of FDI on the REER, and the real economy, varies across time: an initial construction phase of the project, in which large volumes of non-tradable services and goods are purchased, followed by a period in which output, including exportable, is supplied to the market. **(Addison, T., &Baliamoune-Lutz, M. (2017).**

Our findings are in line with **Baffes, Elbadawi, & O'Connell, (1999),** who prove that FDI inflows lead to real appreciation if they are spent on non-tradables.

Current account deficit: Regarding the relationship between the current account balance and RER, it fits well in the theoretical predictions. Thus, the current account deficit generates a real depreciation of the REER equilibrium.

Terms of trade: the coefficient relative to LTOT turned out not to yield significant estimates of the EREER. That is not surprising since several previous studies have also reported an insignificant effect in different countries.

The positive sign shows that an improvement in the terms of trade will cause a capital inflow into the tradable sector, creating a real appreciation. Then an improvement in the terms of trade of 10% leads to depreciation of 11.8% of the REER.

2-6-Estimation of an error correction model

Regarding the short-term of the equilibrium RER, it was examined by estimating a vector error correction model (VECM).

The model is written as follows:

$$\Delta \text{ LRER}t = \alpha 1 * \Delta\text{LRER}t + \alpha 2 * \Delta\text{LCOt} + \alpha 3 * \Delta\text{LPROD}t + \alpha 4 * \Delta\text{LFDIt} + \alpha 5 * \Delta\text{LCADt} + \alpha 6 * \Delta\text{LTOTt} + \alpha 7 * \varepsilon t{-}1 + \mu t \quad (41)$$

Where μt is a white noise, εt-1 is the residual from the long-term cointegrating relationship, $\alpha 7$ is the coefficient of the error correction term; it represents the recall force to long term equilibrium. This parameter must be significantly non-null and negative otherwise the representation as an error-correction model is not valid.

The estimation results of the error-correction model are reported in the following table:

Tableau 13: Estimation of the ECM for the equilibrium REER

The short-term of the equilibrium RER							
	Error correction term	**LCO**	**LPROD**	**LFDI**	**LCAD**	**LTOT**	**LREER**
One year	-0.098696	0.0259	-0.0855	-0.019259	0.003488	-0.045082	0.82842
	0.03446	0.11244	0.09693	0.01182	0.01239	0.14919	0.13549
	-2.386372	0.23035	-0.91356	-1.62887	0.28158	-0.27201	6.08802

Source: Eviews10

The coefficient associated with the error correction term is negative in sign and statistically significant at 5%. Then we can say that there is a long-run causality running from LCO, LPROD, LFDI, LCAD, and LTOT to LREER.

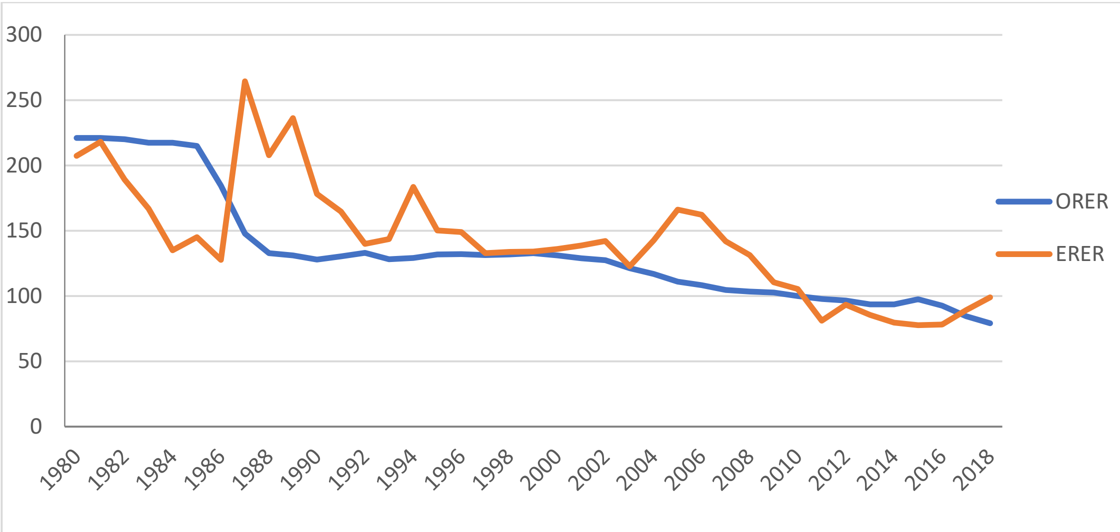
In our case, the coefficient value is well below the unit in absolute value that confirms the adjustment's slowness: it is the rate at which the equilibrium real exchange rate converges towards the equilibrium path following a shock.

We note that only the LCAD exerts on the LREER the same effects already found in the long-term relationship. However, the other variables produce the opposite of their long-run effect. These results indicate a steady behavior of the REER in the long-term as well as a gradual convergence of the REER towards its long-term value.

Adjustment speed appears to be relatively low. One plausible explanation is associated with the exchange rate regime adopted in Tunisia. Indeed, a managed exchange rate regime tends to adjust slower than a pure floating regime but faster than a fixed exchange rate regime.

The following Figure shows the evolution of the observed REER (ORER) compared to its equilibrium value (ERER).

Figure 11: Dynamics of the ORER and ERER in Tunisia during the period 1980-2018

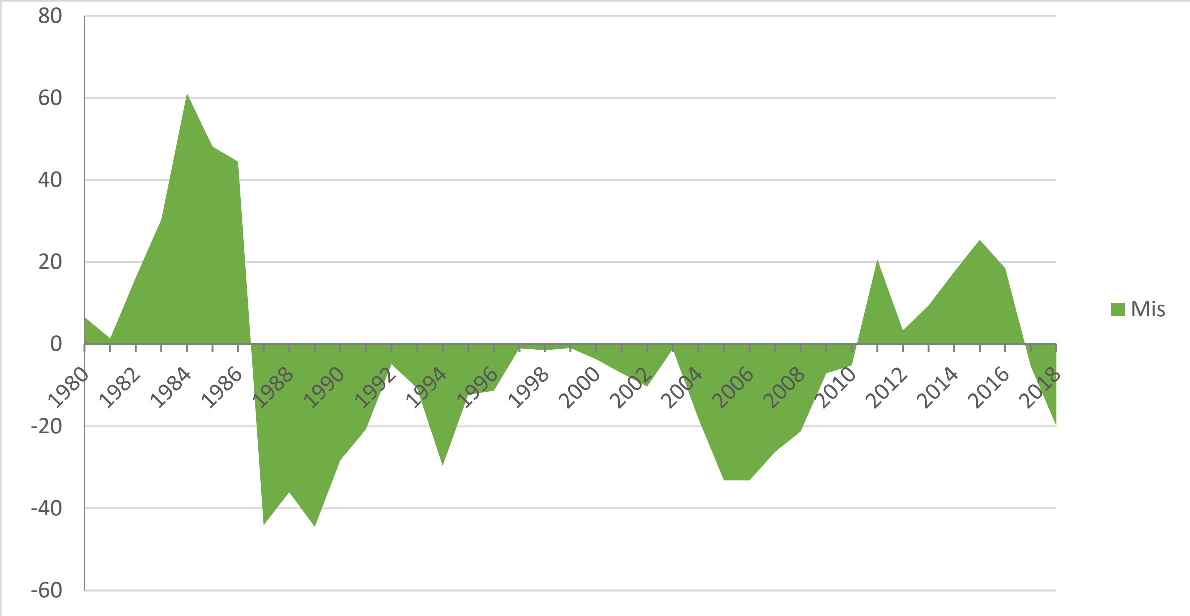


Source: Excel 2019

Once the equilibrium REER has been determined, it is possible to calculate the REER misalignment, which is defined as the difference between the observed REER and the equilibrium RER. Analytically, the measurement of the misalignments is done according to the following formula:

$$\textbf{Mis} = 100*(ORER - ERER)/ERER \quad \textbf{(42)}$$

Figure 12: Real exchange rate misalignment in Tunisia during the period 1980-2018



Source: Excel 2019

Figure 12 highlights the discrepancy of the REER from its equilibrium value, for some periods. This gap refers to the misalignment. Specifically, when the estimated series is over the actual series, it implies an undervalued (or more depreciated) REER. Similarly, when the estimated series is below the observed series, it implies an overvalued (or more appreciated) REER. **(Lim G 2000).**

Typically, an overvaluation inhibits economic growth: in that case, Tunisian products' attractiveness decreases on the international market, which causes lower exports against higher imports.

An undervalued REER is a favorable atmosphere for economic growth: this predicts an undervaluation of the Tunisian dinar on the international market with the improvement of exports, given the competitiveness of Tunisian products internationally in terms of prices, against the decline in imports due to the increased domestic production. So, there will be a lower demand for foreign products.

The misalignment includes all factors that can influence the observed real exchange rate without influencing the ERER. It can, therefore, be attributed to both structural changes in the country and the choice of economic policy (monetary and fiscal instability) **(Cottani et al.,1990).** Similarly, the behavior of economic fundamentals can be related to the levels and direction of misalignment.

Based on empirical observation of misalignment direction. The pattern in misalignment is discussed as follows:

It can be seen in figure 11below that, prior to the adoption of the SAP, the disparity of the REER from its equilibrium esteem is significant. Indeed, Tunisia has neither enhanced nor maintained its competitiveness at that epoch. That divergence could just disturb further the nation's economy and aggravate the crisis. Facing such a situation, the Central Bank of Tunisia went towards more aggressive exchange policy allowing the Dinar to depreciate by 10 percent in August 1986 under the SAP.

A gradual depreciation was maintained in the late 1980s, following the devaluation of the dinar in 1986. This strategy led to an up to 40% undervaluation of the national currency, which was supposed to help Tunisia to overcome the 1986 oil price collapse[28] and drastically enhance its external competitiveness. Nevertheless, experts have subsequently come to the view that the latter devaluation was not efficient to adjust the REER to its equilibrium value, it rather required 15 semesters for the equilibrium rate to coincide.

According to our estimates, such monetary action was not defended by the model until 1992. The observed value of the REER was set apart by a significant underestimation. Then, we can say that Tunisia couldn't preserve its competitiveness despite a growth in exports as a share of GDP grew from 10% in the mid-1980s to 20% in the mid-1990s.

During the period that spans from **1992 to 2003**, misalignment remains low. Indeed, in the mid-1990s, Tunisia has changed markedly its exports' structure from primary commodities to manufactured products. Moreover, it has been able to maintain its macroeconomic performance.

The slight misalignment, observed at that time, could be explained by the gradual importance of the exchange system flexibility adopted. In fact, **in 1992**, the authorities decided to introduce a more flexible regime[29] by targeting the real effective exchange rate through regular adjustments in the value of the nominal exchange rate and established the convertibility of the dinar for the non-residents. This exchange rate policy combined with very prudent and sound monetary and fiscal policies helped the country not only to avoid currency and financial crises, but it also contributed to reducing inflation from 8% in 1991 to nearly 3% since 2000 as well as establishing a credible commitment to macroeconomic stability **(Fanizza and al (2002))**.

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[28]Oil accounted for 47% of Tunisia export earnings

[29] Exchange rate was targeted but introduced more flexibility afterward (**Dropsy and Grand 2004**).

Besides, the relative flexibility of the exchange rate system brought about tendency for the REER to depreciate, fueled by negative terms-of-trade shocks and the increased openness of the economy. The depreciation strengthened the price competitiveness of exports, however structural bottlenecks subsisted.

Then, the undervaluation lasted for 10 years from 1992, but its magnitude was low and its peak was reached just before the creation of the interbank foreign exchange market (1994). Some authors, such as **Corden (1993),** attribute this undervaluation to the fact that, before the creation of the interbank foreign exchange market, the authorities set off from an undervalued rate to avoid the risk of overvaluation once the foreign exchange market was free.

From 1997, the dinar was around its equilibrium value (when it deviates slightly, as shown by the misalignment calculation, a recall force brings it back to the estimated value), until 2002 when a slight undervaluation reappeared (by about 10%). Over this period, we cannot speak of misalignment since undervaluation does not prove to be of great magnitude and never persist over time. These results are consistent with those reported by **Fanizza et al (2002)**.

Although it was not a forex crisis, the 2007-2008 crisis was another challenging period to mention. Actually, we mention an indirect effect of this global financial crisis (GFC) on the Tunisian exchange rate misalignment where a more depreciated REER is observed.

Tunisia has undergone the GFC effects owing to various reasons: monetary instability caused mainly by the rise in oil prices, which has reached a record of 134 dollars in July 2008. Moreover, the higher cost of credit has impacted debt servicing. These events have in turn negatively affected the value of the dinar.

Even so, one cannot deny that Tunisian economy has been able to resist and overcome these troubled times thanks to healthy macroeconomic management through the favorable trend of its fundamentals. In addition, the Central Bank of Tunisia has initiated other measures during the first half of 2009, taking into account the evolution of the international economic situation and the crisis persistence and its repercussions on some export sectors.

Besides, Tunisia's policy of liberalization has resisted the impact of the GFC. As a matter of fact, the government has further lowered customs duties so as to boost overall trade and to comply with international commitments such as the Agadir Agreement, the World Trade Organization and the Arab Maghreb Union (AMU) free trade agreement….

The low misalignment in the **last decade** can be explained by the abandonment of the real exchange rate targeting and the gradual introduction of exchange rate flexibility, with a view to introduce a floating system and complete capital mobility over the medium term. This goal had initially been set for 2010 but was postponed to 2014 because of the global financial crisis.

From 2011, Tunisia has further liberalized the exchange rate, which has accelerated the decline of the dinar. In a difficult economic and financial context, the authorities abandoned, in 2012, the peg to the basket of currencies and moved to the "pricing".

As for the period after 2014, it is marked by two phases. In 2015, we observe significant overvaluation which was followed by the IMF's encouragement to opt for greater exchange rate flexibility.

The remaining part of the 2016 and 2018 years, the real exchange rate is undervalued. Logically, that is due to the crucial fall of the observed REER faster than the equilibrium rate, especially after the 2015 terrorist attack. Then, under a policy of FDI encouragement and improving competitiveness, Tunisian authorities tend voluntarily to lower the value of the dinar.

One interesting finding from this analysis is that, from 2010, overvaluation in the exchange rate was found to be associated with a substantial increase in both current account deficit (figure 8) and trade deficit (figure 9).

Conclusion

In spite of the increasing awareness of the adverse consequences of REER misalignment for economic performance, few empirical studies have directly attempted to address this issue in Tunisia.

The main objective of this chapter was to estimate the level of misalignment of the real effective exchange rate during the period 1980-2018 for the case of Tunisia. The misalignment series, that we derived, will be used later in the second part of our study as a measure of the REER variability.

To do so, we have, firstly, estimated the equilibrium real effective exchange rate (EREER).The rate estimate is based on the BEER model exposed in the previous chapter.

The estimation is undertaken by the well-known Johansen's cointegration technique. Under that framework, we have accepted at least one cointegrating vector, which confirms that the REER and the vector of fundamentals form a valid long-run relationship. Then, the fundamentals can explain the Tunisian real exchange rate fluctuation.

Besides, by normalizing the cointegrating vector, we have derived the reduced form equation, which explains the short-term relationship between the abovementioned variables.

The estimates from the **Johansen** cointegrated model suggests that Tunisia's real effective exchange rate was alternating between over and undervaluation periods with critical episodes of high misalignment.

PART 2:
THE EFFECT OF REAL EXCHANGE RATE MISALIGNMENTS ON THE CURRENT ACCOUNT

CHAPTER1: THEORETICAL CONCEPTS

INTRODUCTION

A study of exchange rate variability's impact on Tunisian current account balance is of major interest. In fact, there are two types of exchange rate variability, being volatility and misalignment. In the study, we will focus on the second type.

Therefore, the results of the misalignment series computed in the previous chapter will serve us in the last part of the analysis.

In order to provide an answer to our problem, we are seeking mainly to have a look and to study empirically the dependence structure between the current account balance and the real exchange rate misalignment in the case Tunisia, by applying a copula model. This theory allows us to study the bivariate dependence structure and the causal link between above-mentioned variables.

To do so, we have followed a typical procedure, consisting in presenting in a first section a detailed definition of the current balance review of various theoretical works that have analyzed the relationships between the real exchange rate and the current account balance, since the effects of misalignment on the latter have been taken into account in more recent empirical studies.

The following section presents the research methodology and the last one will contain the empirical results of our analysis as well as their inherent econometric and economic interpretation.

SECTION 1: GENERALITY ON CURRENT ACCOUNT

1-1- The current account

It seems crucial to define the main variable under study that is "the current account". To that end, we have to understand as a first step all components of the balance of payments (BOP). Hence, "The balance of payments, for a specific period, registers transaction of goods, services, and assets between the residents of one country and those of the rest of the world. It is connected to the system of national accounts, which is a systematic structure for presenting the macroeconomic statistics of a country "(**Terra, C. (2015)**).

Following the nature of each transaction, the balance of payments is split into several accounts. There are mainly three accounts:

- Current account,
- Capital account
- Financial account.

The fundamental distinction between the current account and the others is that it deals with flows that have an impact on a specific period, while the other two accounts deal with assets and liabilities in relative relation to the rest of the world.

In the present study we will especially focus on the current-account balance where we want to examine the way in which exchange rate variability affects its position for the case Tunisia.

The Current Account

The current account provides a record of trade in goods and services, as well as income payments, partitioned between primary and secondary income balances.

Trade in goods and services: Goods are physical objects that are manufactured and for which possession can be established. Consequently, imports and exports of goods represent the transfer of ownership between a resident and a non-resident. Services, on the other hand, are the result of a productive intervention that modifies what is consumed, or makes it easier to exchange goods and financial assets.

In most cases, there is nothing tangible that can be possessed: transportation and communication services, royalties, natural gas liquefaction, oil refineries, as well as other international activities that have grown with globalization, such as packaging of goods, assemblage of electronic products and clothing, and the transaction of goods that are delivered via the Internet, such as software...

An export is recorded as a credit in the goods and services account and is treated as a positive inflow. Under the double-entry system, the resulting payment, be it cash or credit, appears as a debit to the financial account.

If it is qualified as a donation, i.e. without any counterpart, it will appear as a debit on the balance of secondary income in the current account or in the capital account. And vice versa for the case import.

In addition to transactions in goods and services, the current account covers income flows between residents and non-residents. These incomes are listed as primary and secondary revenues. The primary income account records payments to factors of production, income from financial assets and resource rents.

Income received is recorded as a credit to this account and includes wages and salaries received by resident workers from a non-resident company. It also focuses on dividends from multinational companies, interest earned on loans made abroad, among others.

Secondary incomes are redistributed through current transfers, such as international aid, personal transfers (remittances by immigrants to their families), as lottery winnings, income tax paid by non-residents, among others. Note that there are two types of transfers: current transfers, recorded here, and capital transfers, recorded in the capital account. Capital transfers occur when there is a transfer of ownership of an asset that is not a currency. By exclusion, current transfers are those that are not capital transfers.

Remark: the balance of the primary income affects the national income, while the combination of primary and secondary income balances has an impact on the disposable national income. The transfers of capital do not affect the disposable income, and for such are not computed in the capital account. **Terra, C. (2015).**

Current Account	Credits (+)	Debits (–)
Goods and Services		
Goods	Exports	Imports
Services	Sales	Purchases
Primary Income	Received	Sent
Secondary Income	Received	Sent

The national accounts system, of which the BOP is a part, relies on a normalized accounting system to record economic activity.

Thus, it remains imperative to understand how, through the national accounts, a country's transactions with the rest of the world are associated with the main national macroeconomic aggregates.

The main national accounts aggregate is the gross domestic product (GDP), the measure of all that is output within national boundaries minus the consumption of intermediate goods.

Nevertheless, these products are not necessarily owned by residents. We note examples of the profit of subsidiaries owned by multinationals whose owners of the capital, among other factors of production, do not reside in that country. Gross national income (GNI) takes into account this fact and registers only the value of the goods and services produced by resident factors of production.

Defining the payment of income PI between residents and nonresidents as the primary income account of the current account balance, we have that:

$$\mathbf{GNI - GDP = PI} \qquad \mathbf{(42)}$$

The goods and services available for use in a country correspond to the sum of GDP (Y) and the import of goods and services (M). These latter can be used for private consumption (C), investment (I), government consumption (G), or to be exported (X). This way of accounting can be illustrated as follows:

Y + M = C + I[30] **+ G + X** **(43)**

Which is rewritable again as:

$$\mathbf{Y = C + I + G + TB} \qquad \mathbf{(44)}$$

Where TB is the trade balance, which is the balance of the goods and services account.

Using equation (44) and then adding the balance of primary incomes on both sides of equation (43) gives:

$$\boldsymbol{Y + PI = C + I + G + PI} \qquad (\mathbf{45})$$

Finally, adding the secondary income balance to both sides, we get:

$$\underbrace{\mathbf{GNI + SI}}_{\text{Gross National Disposable}} \mathbf{= C + I + G +} \underbrace{\mathbf{TB + PI + SI}}_{\text{Current Account}}$$

[30]The purchase of machinery and equipment, among others, for use in the production of goods.

Which we represent by:

$$\mathbf{Yd = C + I + G + CA} \qquad \textbf{(46)}$$

The left side of the equation is the total disposable income of domestic residents and the right side represents the uses for this income.

$$\mathbf{Yd - (C + I + G) = CA} \qquad \textbf{(47)}$$

A negative current account balance indicates lower national income than expenditure and a need to borrow from the rest of the world.

A further interpretation for equation (46) is to differentiate between private savings (Sp) and public savings (Sg). To do so, we both add and subtract the taxes (T) on the left side of (47), to obtain:

$$\mathbf{(Yd - T - C) + (T - G) - I = CA} \qquad \textbf{(49)}$$

$$\mathbf{SP + Sg - I = CA} \qquad \textbf{(49)}$$

According to the equation, a deficit in current account means that investment in the country is greater than savings. The equation also shows that a reduction of the account deficit has as a counterpart an increase in savings and/or a reduction in investment.

Then, we're going to use this last remaining current account equation as a basis for our study.

Nevertheless, the formula (48) has only an accounting aspect, it is valid independently of ideological approaches or visions concerning the economic behavior. This equation highlights the relationship between the variables without giving the causal link between them. Consequently, in order to study the impact of a shock of one variable on another, it is necessary to have a good understanding of the economy's functioning and how the variables relate to each other. Thus, it was be proved that the effects of a shock or a change in the economy depend on the reaction of the economic agents.

Economic models try to represent individual incentives in order to capture the dependence among macroeconomic variables. In the reminder of this section, we will present a multivariate model that explains how variables such as real exchange rate affects the current account balance in Tunisia. In what follows we give a brief literature that shed lights on correlation between exchange rate and current-account.

1-2- literature review on exchange rate and current account

Generally, the real exchange rate of a country has a great influence on its economy. It plays an important role in determining the trade balance, thereby largely affecting the resource allocation between tradables and non-tradables. Variations of the real exchange rate influence employment, nominal exchange rate, economic policies, and economic structures. The current account balance is considered among the latter.

Finance researchers and practitioners pay attention to the importance of relationships between, exchange rate and current- account balance. From a policy perspective, a better understanding of the factors underlying longer-term developments in the current account, is central to assessing whether policies aimed at attaining domestic economic objectives are compatible with a sustainable external position. Also, these studies are of key role regarding the information that they may give about the insights for adjustments strategies.

The interaction between exchange rate and CA balance has been an important topic of theoretical and empirical investigations starting with **Pentti (1976),** who investigates the relationship between exchange rate and BOP in the short and long-run period from the monetary policy approach. His findings show a significant departure from the traditional analysis by establishing a link between monetary policy and the inflow or outflow of capital through the effect of exchange rate on aggregate demand and output and thereby on the current account.

Frenkel (2004) examines aggregate employment behavior in response to real exchange rate movements in Argentina, Brazil, Chile and Mexico between 1980 and 2003. He proves that RER has an expected long-run negative impact on current account, the implication of which is that in order to achieve CA equilibrium, stable and competitive real exchange rate should be pursued.

Besides, **Lee and Chinn (2006, 2009)** discuss a useful framework for explaining the CA and RER dynamics. They adopt the Blanchard and Quah (1989) approach to the open economy model. They specifically impose a long-run restriction in a two-variable vector autoregressive (VAR) model composed of the CA and RER. They argue that it is possible to analyze the empirical results from the perspective of recent open macroeconomic models, where prices are rigid in the short run but flexible in the long run.

They assert that if we interpret temporary shocks as monetary shocks, they depreciate the real exchange rate and improve the current account, which is consistent with the implications of recent open macroeconomic models. They also find that, while temporary shocks are the main source of CA fluctuations in the G7 countries excluding the AS, permanent shocks are the main source of real exchange rate fluctuations.

Then, With the exception of the UK, temporary shocks depreciate the real exchange rate and improve the current account balance. Permanent shocks appreciate the real exchange rate and, in some countries, improve the current account balance in contradiction to many extant models.

In 2009, Chinn and Lee argue that it is likely that the relation between the real exchange rate and the current account has changed, and suggest that the decline in the pass-through[31] of the exchange rate has contributed to this change.

Shibamoto, M., & Kitano, S. (2012) statistically examined the possibility that structural change occurred in the dynamic relation between the two variables. Results showed ample evidence that structural change occurred in the 1990s in all G7 countries. They identify the 1990s as the time during which structural change occurred, which is consistent with the empirical evidence of a downward trend in the pass-through of exchange rates in many countries and which has been discussed vigorously in recent years.

The exchange rate system also plays a key role in the relation between exchange rate and CA. For instance, until 2005 (from 1997), China was criticized for fixing the value of the Renminbi (RMB for short) to the U.S. dollar. In July 2005, a new regime was instituted and from that date, the RMB rate against the dollar slightly appreciated. Nevertheless, American critics did not consider this appreciation to be sufficient. They therefore deduced that Chinese exchange rate interventions were the cause of the Chinese current account surplus and at least played a role in the overall U.S. current account deficit. Then, the real objection to this was clearly related to the large current account surplus, rather than to a fixed exchange rate per se.

[31]It is often measured as the percentage change, in the local currency, of import prices resulting from a one percent change in the exchange rate between the exporting and importing countries.[1] A change in import prices affects retail and consumer prices. When exchange-rate pass-through is greater, there is more transmission of inflation between countries.

However, some authors argue that exchange rate regimes are not really connected with global CA imbalances. Global current account imbalances have been associated with all kinds of exchange rate regimes. Spain has a large deficit while the Netherlands has a surplus. Yet both have a fixed exchange rate to the euro, i.e. they are both part of the Eurozone.

According to them, suppose a country has a floating exchange rate regime with no intervention in the foreign exchange market at all, nevertheless, its government wishes to induce a CA surplus, with the accompanying depreciation of the exchange rate. That is certainly possible if there is international capital mobility. The government can loosen monetary policy and so induce capital outflow through the lower domestic interest rate.

Alternatively, it can contract fiscal policy, leading to a reduced budget deficit and thus, again, a lower domestic interest rate and thus depreciation, capital outflow and, again, a CA surplus. In both cases exchange rate intervention is not needed to bring about a CA surplus. But this argument does not apply to China because capital outflows are strictly controlled, as is the interest rate.

However, the case of the US has raised doubts about the relationship between the variables under study. Indeed, the flow of capital into the US since the early 1990s is not simply a function of the insatiable demand of the U.S. consumer; it is a result of capital flight out of the emerging world following the Asian currency crisis of 1994, the Russian debt default and Mexican currency crises of 1997 and 1998, FDI from Europe, and the huge purchase of U.S. Treasury instruments by China over the past two decades.

The combination of the aforementioned developments has provided enormous support for the significant global macroeconomic imbalance fueled by the unwillingness of the US to save and the lack of domestic consumption on the part of China. Between 1995 and 2002, the development of the imbalance and the explosion of the US CA deficit did not have a deleterious impact on the value of the U.S. dollar, thus challenging the fundamental notion that the CA matters in the determination of exchange rates. One would normally expect that nations with a current-account surplus would see appreciation of their currencies and those with a deficit would experience depreciation. In fact, this tends to occur over time. A look at the comparison of the trade-weighted value of different national currencies versus their CA positions tends to demonstrate an inverse relationship between the size of a CA deficit and the value of a national currency.

So how did the United States finance its current account during that time without a concomitant decline in the value of the dollar?

The structural shift caused by the flow of capital away from emerging markets and towards the US provided net support for the value of the dollar. But that structural shift proved temporary. Beginning in mid-2002, macroeconomic factors began to reassert themselves, and flows of capital began again to move towards Asia and emerging markets.

A straightforward balance of trade model would make a strong case that trade flows should determine the path that exchange rates take. Countries that run large current-account deficits, like the US, should experience significant depreciation of their national currencies, whereas countries that run large surpluses should see increasing demand for their currencies and see markets drive up the value of those units of exchange. An alternative explanation to current-account explanation would be the portfolio-balance model of exchange rates. Using this formulation, a change in the geographical location of capital wrought by a change in the CA balance can facilitate a positive correlation between the current account and the determination of exchange rates. Thus, as wealth is transferred from countries that run deficits to those that run surpluses, residents in the surplus countries prefer to possess assets denominated in their home currencies over those in a foreign country.

Over time, a shift in wealth causes a change in the composition of demand for global assets that favor the currency of the surplus country over that of the deficit country, which should, in turn, cause an increase in demand for the currency of the former and a depreciation of the currency of the latter. A portfolio-balance model of exchange rate, then, strongly implies that it is not the flow of trade that determines exchange rates, but the transfer of wealth driven by a change in individuals' choice of asset denomination that provides the causal link between the current account and exchange rates.

Another competing explanation of medium-term exchange-rate trends is monetary or financial shocks. A sudden burst of fiscal activity or change in monetary policy can cause the CA and exchange-rate trends to proceed in the same direction. For example, tight monetary policy pursued by a country would result in higher interest rates, an improved CA position, and an increase in the value of the domestic currency. Thus, one would expect to see a highly positive correlation between the CA and the exchange rate. Should an accommodative policy path be pursued, one would expect to observe deterioration in the CA position and the value of the national currency. However, this may not always be the case. Under conditions of an accommodative monetary policy and a major expansion in fiscal policy, one might instead observe an appreciation of the currency due to higher real interest rates on the back of an increasing budget deficit: this describes the experience of the U.S in the early 1980s.

The U.S. case may be generalized to a number of advanced and emerging economies that have experienced a high growth in capital flows over the past twenty years. Throughout the 2000s, this growth was accompanied by large CA imbalances, raising many concerns with respect to the potential adverse consequences of abrupt interruptions of these capital flows. In particular, the magnitude of exchange rate depreciation over the adjustment process of current accounts has been a central element of discussion (**Corsetti et al., 2013; Lane and Milesi-Ferretti, 2012; Obstfeld and Rogoff, 2007; 2005)),** reviving the famous debate between **John Maynard Keynes and Bertil Ohlin** over the payment of war debts in Germany during the 1920s, known as the "Transfer Problem".

Concerning the transfer problem debate, **Keynes (1929)** argued that, in order to pay for the war damages in foreign currency, Germany would have to raise resources through trade balance surpluses. The relative price of tradable goods would then have to increase, implying a RER depreciation.

The reversion of large CA imbalances brings about a similar adjustment mechanism, where the magnitude of RER depreciations may be mitigated by the income effect, particularly in more open economies.

Romelli, D., Terra, C., &Vasconcelos, E. (2018).investigate whether openness to trade magnifies CA and TB improvements in face of exchange rate depreciations. Using a simple theoretical framework, they find that more open economies can rebalance their CA and TB with smaller domestic currency depreciations after an external shock. Hence, more open economies would be better able to overcome external shocks that entails the need of CAreversals.

A misalignment of savings and investments has led to unsustainable credit boom. Rising credit has been the main catalyst for the increase in an unsustainable trade deficit. The flight to safety for international investors and the effort to support the peso caused a drawdown of international reserves and, ultimately, the breakdown of the exchange rate regime. The 1994 to 1995 Mexican banking and financial collapse origins can be traced to an unsustainable current-account deficit and overvalued currency.

In the purpose to explore the factors that may affect the long-run determination of the CA, **Hamid Faruqee and Guy Debelle (1996)** use cross-section and panel data. The estimation of a partial-adjustment and error-correction models highlight a significant impact from changes in the real exchange rate, among others.

Influential contributions by **Obstfeld and Rogoff (2005, 2007)** have revisited the Keynesian approach to the transfer problem by emphasizing how the unwinding of the U.S. CA deficit may be related to "the potential collapse of the dollar."

Corsetti, G., Martin, P., &Pesenti, P. (2013) have showed that while in real effective terms the movements of the dollar in the pre-crisis period (between 2002 and 2007) have been quite significant, their impact on global CA balances has been limited. Real dollar depreciation has been large relative to countries without a significant CA surplus vis-à-vis the U.S (such as the European countries), but very contained relative to countries with large bilateral surpluses (such as China and the Gulf countries), that is, relative to the main counterparts of the large U.S. imbalance. Since late 2008 the contraction of world activity and the collapse of oil and commodity prices associated with the meltdown of global financial markets have partially contributed to closing the U.S. net saving gap, at the same time the U.S. dollar has somewhat appreciated in effective terms, due to safe-haven considerations in international markets.

Recent experience suggests that exchange-rate movements are associated with CA imbalances. In particular, the 1978 depreciation of the dollar against the German mark (15.1 percent), Japanese yen (23.3 percent), and the Swiss franc (23.5 percent) coincided with a large deficit in the U.S. CA balance, and large surpluses for Japan, Germany, and Switzerland.

The news hypothesis is that exchange rates change in response to unexpected new information about underlying payments positions **[Isard (1980), Hooper and Morton (1980), Mussa (1980), Dornbusch (1980)]**. The argument is that statistics on current-account balances provide such information. When the U.S. registers an unexpectedly large CA deficit, it signals that the U.S. dollar is overvalued in real terms. A real depreciation of the dollar is required to move the U.S. current account back towards equilibrium.

Dornbusch (1980) provides an ingenious test of this theory. The hypothesis is that unexpected[32] current accounts cause unexpected exchange-rate changes. He observes a correlation between unexpected current accounts and unexpected depreciation, but the causation could run in either direction: Consider an unexpected appreciation of the yen, e.g., due to a stochastic element in portfolio preferences. If there are J-curve effects of exchange-rate changes on current-account balances, in the short run an appreciation of the yen will cause the Japanese CA to move into surplus rather than deficit, particularly if the yen appreciation is unexpected.

An unexpected yen appreciation will impact Japanese terms-of-trade when it occurs but have very little immediate effect on the volume of trade. It may take a long time for Japanese trade volumes to adjust to the higher value of the yen. Consequently, a J-curve effect can account for the observed correlation of unexpected Japanese current-account surpluses and unexpected yen appreciation, with the direction of causation running from exchange rates to current accounts. However, it is shown here that his test is flawed by a simultaneity problem.

Similarly, Golub, S. S. (1981) shows that in 1978, for each of Japan, Germany, and the US the forecast error of trade balances is accounted for by unexpected unit value of trade rather than unexpected volume of trade movements. This suggests that the correlation between unexpected exchange rates and unexpected current accounts is at least partially attributable to J-curve and valuation effects, rather than the 'news' hypothesis.

In their paper, **Pentti J. K. Kouri** illustrate dynamics of the foreign exchange market that Is consistent with observed exchange rate behavior in recent years with the currencies of surplus countries appreciating and those of deficit countries depreciating in excess of differences in inflation rates: Domestic currency appreciates whenever the current account is in surplus and depreciates whenever it is deficit. They argue their findings by the fact that the purchase of foreign exchange translates to an exactly equal cumulative surplus in the current account, and after the initial depreciation domestic currency appreciates back to the same long-run equilibrium level. The initial impact of intervention on the exchange rate depends on the size of the central bank's purchase of foreign exchange in relation to total international

[32]Unexpected exchange-rate changes are defined as the difference between the forward premium and the actual exchange-rate change.

investment, while the duration of the impact depends on the strength of the induced current account response, as is clear from earlier analysis.

During the last few years, a large number of analysts in academia and applied research institutions have expressed increasing concerns regarding the growing U.S. current account deficit. Some authors have gone as far as suggesting an imminent collapse of the U.S. dollar, and a global financial meltdown.

According to some authors, growing international portfolio diversification implies that the "rest of the world" will be willing to accumulate large U.S. liabilities during the next few years; maybe even in excess of 100% of U.S. GDP. According to this perspective, since the U.S. current account deficit does not pose a threat, there are no fundamental reasons to justify a significant fall in the value of the U.S. dollar **(Dooley, Folkerts-Landau and Garber 2004a, 2004b).**

Furthermore, the magnitude of adjustment in exchange rates that would be generated in the current account adjustment has been extensively debated in the context of the discussion on large global current account imbalances.

Being always in the case US, **Edwards, S. (200*5)*** analyzes the relationship between the U.S. dollar and the U.S. current account. He deals with issues of sustainability, and discuss the mechanics of current account adjustment. The simulation model indicates that foreigners' (net) demand for U.S. assets doubles relative to its current level, in the not too distant future, the U.S. will have to go through a significant adjustment.

Indeed, according Edwards, S., it is not possible to rule out a scenario where the U.S. current account deficit would shrink abruptly by 3 to 6 percent of GDP. According to his simulations, this type of adjustment would imply an accumulated real depreciation of the trade-weighted dollar in the range of 21%-28% during the first three years of the adjustment.

A number of authors have recently addressed this issue using a variety of simulation and econometric models. Most of other studies have asked what is the real exchange rate adjustment "required" to achieve a certain current account balance. Some of them, such as Obstfeld and **Rogoff (2000, 2004) and Blanchard, Giavazzi and Sa (2005),** have considered the case where the deficit is competently eliminated. For instance, **Obstfeld and Rogoff (2000),** analyzes the effect on RER of an exogenous shock that results in a reduction of the

CA deficit. They find that, the effect on the nominal value of the USD could be even higher if the reduction in the CA is very rapid. Moreover, result indicates that an elimination of the CA deficit will imply a 16% RER depreciation, and a 12% nominal depreciation of the USD.

O'Neill and Hatzious (2002), Estimates "required" RER depreciation in order to bring CA deficit to 2% and NIIP not to surpass 40%. Leading to the fact that U.S. will not be able to continue to attract foreign purchasing for its assets at observed low rates of return. Thus, the U.S. CA deficit is clearly unsustainable. A return to sustainability will imply a depreciation of the RER of as much as 43%.

Others, including **Mussa (2004)** and **Roubini and Setser (2004)**, have considered the reduction of the deficit to a positive, but smaller than current, level. Thus, **Mussa (2004)** analyzes the RER adjustment compatible with a gradual reduction of the CA deficit to 2% of GDP and a NIIP between 40% and 50%. Relative to its value in mid-2004, **Mussa** estimates that the RER will have to depreciate another 20% to achieve a long-term CA deficit of 2%.

Another strand of thought is the IS-LM model, in which depreciation is theoretically expected to have positive effect on export since it makes domestic goods cheaper to foreign consumers. It is expected that depreciation would reduce import as a result of the higher relative price of imported goods. Also, depreciation is theoretically expected to be accompanied by increase in money supply, leading to a reduction in interest rate and an improvement in investment. Increase in investment would lead to a current account surplus.

In addition, according to some researchers, the fiscal contraction reduces aggregate demand and causes the relative price of non-traded goods to fall, leading to a depreciation of the real effective exchange rate. However, as **MacDonald & Ricci (2004)** argue, in the context of a portfolio balance model, the current account surplus resulting from the real depreciation will have to be eliminated in the long-run by a real appreciation that leads to a trade deficit.

Conclusion

There are numbers of empirical studies dealing with the impact of exchange rates on CA, albeit with mixed results. On examination of the literature, we discern two major areas of research. While some studies have found a contractionary effect of depreciation of exchange rate on domestic output which consequently impacts the CA position negatively (e.g.

Alejandro, 1963; Kandil, 2004; Pierrer-Richard, 1991), others find expansionary effects of exchange rate depreciation **(Adewuyi, 2005; Bahmani&Kandil, 2007).**

SECTION 2: RESEARCH METHODOLOGY

2-1- Modeling multivariate dependence: Copula theory

2-1-1- Modeling the marginal distributions

In this section, we describe time series models which are able to explain a number of stylized facts common to the most financial data such as volatility clustering, leptokurtosis, leverage effects. Hence, to produce a series of i.i.d observation, we fit an adequate order autoregressive model to the conditional mean of the returns and GARCH type model to the conditional variance to each variable.

We adopt that the dynamics of conditional mean returns can be represented by ARMA (m, n) model:

$$\boldsymbol{R_t = a_0 + \sum_{i=1}^{m} a_i R_{t-i} + \sum_{i=1}^{n} b_i \varepsilon_{t-i} + \varepsilon_t} \quad \textbf{(50)}$$

We can write also the ARMA (m, n) model as:

$$\boldsymbol{\Phi\ (L)^{*}\ R_t = a_0 + \Theta\ (L)\ ^{*}\varepsilon_t} \quad \textbf{(51)}$$

Where the AR lag operator polynomial is defined as: Φ (L) = $1-\phi_1 L-\phi_2 L^2$ - $\ldots-\phi_m L^m$, MA lag operator polynomial is defined as: Θ (L) = $1+\Theta_1 L+\Theta_2 L^2$ -…+$\Theta_n L^n$,R_{t-i} are lagged returns, z_t is a sequence of identically and independently distributed normal random variables with zero mean and unit variance.

Also, we assume that $\varepsilon_t$follows one of the GARCH type models which are briefly defined below:

- **GARCH (p, q) process**

The ARCH and GARCH models are used to study time series data and they have been and expanded to deal with heteroskedastic time series issues where the variance is not constant. The Autoregressive conditionally heteroscedastic (ARCH) model was introduced by **Engle (1982)** and later it was extended with **Bollerslev in 1986** by creating a model more general named GARCH (generalized ARCH).

Furthermore, those models are based on the endogen's parameterisation of the conditional variance. The family of ARCH presents two important subfamilies. The first is based on a quadratic specification of the conditional variance (linear models) and the second on the asymmetric properties of the perturbation (nonlinear models). In these models, the key concept is the conditional variance, that is, the variance conditional on the past. Due to this specification, the models are able to study the complete properties and to capture the characteristics of the concerning time series. This indicates that the use of ARCH-GARCH models is simply a specific representation of non-linearity providing a simple model of incertitude.

Hence, the GARCH (p, q) process is given by:

$$\boldsymbol{\varepsilon_t = z_t \sqrt{h_t}}, \qquad z_t \text{follows a white noise process}$$

The variance equation: $h_t \ = \boldsymbol{\omega} + \sum_{i=1}^{q} \boldsymbol{\alpha_i \varepsilon_{t-i}^2} + \sum_{j=1}^{p} \boldsymbol{\beta_j h_{t-j}}$ **(52)**

Where $z_t$is a sequence of identically and independently distributed normal random variables with zero mean and unit variance, $h_t$represents the conditional variance of the process which is function of a constant term, an ARCH term $\varepsilon_{t-i}^2$and a GARCH term h_{t-j}.

To ensure a positive conditional variance and the stationary of GARCH model, two conditions are imposed respectively:

$\boldsymbol{\omega} > 0$, $\boldsymbol{\alpha_i \geq 0}$, $\boldsymbol{\beta_j \geq 0}$ **and** $\sum_{i=1}^{q} \boldsymbol{\alpha_i} + \sum_{j=1}^{p} \boldsymbol{\beta_j} < 1$**.**

Even the use for example of the GARCH model to mitigate the issue of clustering, there still be some problems due to the asymmetric presented by the time series.

This means that an increasing and a decreasing movement of the same amplitude doesn't have the same effect on the volatility. This phenomenon is known as the leverage effect treated firstly by **Black (1976)** who concludes that the increasing on the volatility severity is more important flowing bad news than the good news.

Thus, the symmetric model of ARCH-GARCH model assuming the symmetric effect of the positive and negative error terms on the volatility are an appropriate and usually violated. To the end of solving this issue and to take into account this fact, many extensions of the GARCH model were introduced. Three important classes dealing with the asymmetry are the Exponential GARCH (EGARCH) developed by **Nelson (1991)**, the GJR-GARCH model proposed by **Glosten Jagannathan and Rankle (1993)** and Asymmetric Power ARCH (APARCH) model introduced by **Ding et al. (1993).**

- **GJR-GARCH model**

The GJR-GARCH model is proposed by **Glosten Jagannathan and Rankle (1993),** in order to take into account asymmetric leverage effect and leptokurtosis in the conditional variance behavior. Besides, it gives more weight to negative shocks than the positive one which is the fact in financial series.

Hence, the GJR-GARCH (p, q) process is given by:

$\boldsymbol{\varepsilon_t = z_t \sqrt{h_t}, z_t}$ follows a white noise process **(53)**

The variance equation: $\boldsymbol{h_t} = \boldsymbol{\omega} + \sum_{i=1}^{q} (\boldsymbol{\alpha_i} + \boldsymbol{\gamma_i} \mathbf{I}_{t-i<0})\, \boldsymbol{\varepsilon_{t-i}^2} + \sum_{j=1}^{p} \boldsymbol{\beta_j}\, \boldsymbol{h_{t-j}}$ **(54)**

Where $w > 0, \alpha_i \geq 0,\ \beta_j \geq 0$ and γ_i are the asymmetric effect coefficient giving negative Changes additional weight and $\mathbf{I}_{t-i} = \begin{cases} \mathbf{1}\ \boldsymbol{if}\ \boldsymbol{\varepsilon_{t-i}} < 0 \\ \mathbf{0}\ \boldsymbol{if}\ \boldsymbol{\varepsilon_{t-i}} \geq \mathbf{0} \end{cases}$ **(55)**

To ensure the stationary of GJR-GARCH model, two conditions are imposed respectively:

With: $\begin{cases} \sum_{i=1}^{q} (\boldsymbol{\alpha_i} + \boldsymbol{\gamma_i}) \geq \mathbf{0} \\ \sum_{i=1}^{q} \boldsymbol{\alpha_i} + \frac{\mathbf{1}}{\mathbf{2}} \sum_{i=1}^{q} \boldsymbol{\gamma_i} + \sum_{j=1}^{p} \boldsymbol{\beta_j} < 1 \end{cases}$ **(56)**

2-2- The Copula theory background

Modelling dependencies between random variables remains controversial and still has a prominent interest in statistics. Many studies have found that using copula function is the best way to model relations between random variables. In this light, it is worthy of note the definition of this modern application. A copula is a function pairing the marginals to form a joint distribution. It returns a joint probability of events as a function of a marginal probability of each event. The powerful notion of copula function has been introduced into the field of finance by **Roger B.Nelsen (1999)** and **Straumann (2000)** and aims to study dependence between several risk factors and to model a multivariate distribution to univariate marginals (Sklar's theorem (1959)). In other words, **Sklar**, as the prior who used copula in mathematics, diffuses the spotlight on the capacity of copula to capture the dependence structure of multivariate distributions and link univariate marginals (one dimensional margin whose are uniform) to their multivariate distribution function.

Recently, it has become a very important statistics tool used in several areas like finance (correlate on probabilities), insurance (inverse map probabilities to correlate losses), biology, oil and gas, high uncertainty project risk analysis, etc. After 2000, the use of copulas is vigorously soaring day by day and gains ground in many empirical studies thanks to numerous advantages.

First, the decomposition of the joint distribution into univariate marginals and a multivariate (dependence structure) presented by copulas. Second, when marginals are known, the structure of joint distribution become easier and each variable can be independently described by an entirely different distribution like Gamma, Pareto, Gaussian…

In this case, the composition of joint distribution gives more information about the average dependence which facilitates the modelling of random variables. Moreover, the strength of copula results from the capacity to detect a complete dependence structure and construct a non-Gaussian model. This feature is extremely important in finance because Gaussian model is rarely used and modelling dependencies of many risk factors is very complicated.

Even more, copulas functions solve the incapacity of correlation coefficient which is a traditional method used to implement correlation and measure only co-variations up to second order.Furthermore, copula theory gives a tool in which we can examine the tail dependency assumptions (such as the assumption of "zero" as in the Gaussian copula). Last and not the least, Copula approach provides information on the probability that two variables jointly experience extreme upwards or downwards movements. In this section, we introduce some definitions and properties related to copula.

2-2-1-Copula definition

Definition: A d-dimensional copula is defined as a function C from$[0,1]^d$ to $[0,1]$which fulfills the following properties:

a- Boundary conditions:

For every random vector$\boldsymbol{u} = (\boldsymbol{u_1}, \dots, \boldsymbol{u_d}) \in [\boldsymbol{0}, \boldsymbol{1}]^{\boldsymbol{d}}, \boldsymbol{C}(\boldsymbol{u_i}, \dots, \boldsymbol{u_{i-1}}, \boldsymbol{u_{i+1}}, \dots, \boldsymbol{u_d}) = \boldsymbol{0}$, if at least a value$\boldsymbol{u_{i=1,..,d}} = \boldsymbol{0}$

$$C(\boldsymbol{1}, \dots, \boldsymbol{1}, \boldsymbol{u_i}, \boldsymbol{1}, \dots \boldsymbol{1}) = \boldsymbol{u_i} \quad , \forall\, \boldsymbol{u_i} \in [\boldsymbol{0}, \boldsymbol{1}],\ \boldsymbol{i} = \boldsymbol{1}, .., \boldsymbol{d} \qquad \textbf{(57)}$$

b- Monotonic conditions:

C is n-increasing i.e. $\forall\, u = (u_1, \dots, u_d)\ and\ v = (v_1, \dots, v_d)$ in $[0,1]^d$,such that $u_i \leq v_i$, for $i = 1, \dots, d$:

$$\sum_{i_1=1}^{2} \cdots \sum_{i_d=1}^{2} (-\boldsymbol{1})^{i_1+\cdots+i_d} \times \boldsymbol{C}(\boldsymbol{x_{1_{i_1}}}, \dots, \boldsymbol{x_{d_{i_d}}}) \geq \boldsymbol{0} \qquad \textbf{(58)}$$

Where $\boldsymbol{x_{1_j}} = \boldsymbol{u_j}$ and $\boldsymbol{x_{2_j}} = \boldsymbol{v_j}$, $\forall\, \boldsymbol{j} \in \{\boldsymbol{1}, \dots, \boldsymbol{d}\}$

In the particular case of 2-dimentional copula, the definition can be simplified as:

$C: [0,1]^2 \to [0,1]$ is a 2-dimensional copula which fulfills the following properties:

a- Boundary conditions:

For every$\in [0,1]$,

$$C(\mathbf{0}, \boldsymbol{u}) = \boldsymbol{C}(\boldsymbol{u}, \mathbf{0}) = \mathbf{0} \quad \textbf{(59)}$$

$$\boldsymbol{C}(\boldsymbol{u}, \mathbf{1}) = \boldsymbol{C}(\mathbf{1}, \boldsymbol{u}) = \boldsymbol{u} \quad \textbf{(60)}$$

b- Monotonic conditions:

C is 2-increasing i.e. for every $(u_1, u_2) \in [0,1]^2, (v_1, v_2) \in [0,1]^2$such that $0 \leq u_1 \leq v_1 \leq 1 \; and \; 0 \leq u_2 \leq v_2 \leq 1$ we have:

$$\boldsymbol{C}(\boldsymbol{v_1}, \boldsymbol{v_2}) - \boldsymbol{C}(\boldsymbol{v_1}, \boldsymbol{u_2}) - \boldsymbol{C}(\boldsymbol{u_1}, \boldsymbol{v_2}) + \boldsymbol{C}(\boldsymbol{u_1}, \boldsymbol{u_2}) \geq \mathbf{0} \quad \textbf{(61)}$$

Indeed, the first propriety (Boundary conditions) ensures that marginal distributions are uniform distributions and the last one (Monotonic conditions) ensures that the copula is an increasing cumulative distribution function if the percentiles u_i increase.

2-2-2-Basic properties of copula

A. Sklar's theorem

Sklar's theorem **(1959)** states that:

Theorem: For any random vector $X = (X_1, X_2, \dots, X_d)' \in \mathbb{R}^d$with a joint distribution function $\boldsymbol{F}(\boldsymbol{x_1}, \boldsymbol{x_2}, \dots, \boldsymbol{x_d}) = \boldsymbol{P}(\boldsymbol{X_1} \leq \boldsymbol{x_1}, \dots, \boldsymbol{X_d} \leq \boldsymbol{x_d})$and continuous marginal distribution function $\boldsymbol{F_i}(\boldsymbol{x}) = \boldsymbol{P}(\boldsymbol{X_d} \leq \boldsymbol{x})$**(for *i*=1,..,d),** there exists a unique *d*-dimensional copula function $\boldsymbol{C} \in [0,1]^d$, such that :

$$\boldsymbol{F}(\boldsymbol{x_1}, \boldsymbol{x_2}, \dots\dots, \boldsymbol{x_d}) = \boldsymbol{C}\big(\boldsymbol{F_1}(\boldsymbol{x_1}), \boldsymbol{F_2}(\boldsymbol{x_2}), \dots, \boldsymbol{F_d}(\boldsymbol{x_d})\big), \text{for}(x_1, x_2, \dots, x_d) \in \mathbb{R}^d \textbf{(62)}$$

From (18) we can obtain the copula according to the following formula:

$$\boldsymbol{C}(\boldsymbol{u_1}, \boldsymbol{u_2} \dots., \boldsymbol{u_d}) = \boldsymbol{F}(\boldsymbol{F_1^{-1}}(\boldsymbol{u_1}), \boldsymbol{F_2^{-1}}(\boldsymbol{u_2}), \dots, \boldsymbol{F_d^{-1}}(\boldsymbol{u_d})) \quad \textbf{(63)}$$

Where F_i^{-1} are the inverse distribution functions of the marginal and $u_i = F_i(x_i)$ for i=1,...,d. The contribution of Sklar's Theorem to the modeling field, is that is separate the modeling of the marginal distributions $F_i(x)$ from the copula.

B. Copula density function

If the above joint cumulative distribution function (CDF hereafter) $\boldsymbol{F}$ is d-times differentiable, then the joint probability distribution function (PDF hereafter) can be obtained as follow:

$$\boldsymbol{f(x_1, x_2, \ldots\ldots, x_d) = \frac{\partial^d}{\partial x_1 \partial x_2 \ldots . \partial x_d} F(x_1, x_2, \ldots\ldots, x_d)}$$

$$\boldsymbol{= \prod_{i=1}^{d} f_i\,(x_i)\, \frac{\partial^d}{\partial u_1 \partial u_2 \ldots . \partial u_d} C(u_1, u_2 \ldots., u_d)} \qquad \textbf{(64)}$$

$$\boldsymbol{= \prod_{i=1}^{d} f_i\,(x_i) c(u_1, u_2 \ldots., u_d)}$$

And the PDF of the copula is:

$$\boldsymbol{c(u_1, u_2, \ldots, u_d) = \frac{f(F_1^{-1}(u_1), F_2^{-1}(u_2), \ldots, F_d^{-1}(u_d))}{\prod_{i=1}^{d} f_i(F_i^{-1}(u_i))}} \qquad \textbf{(65)}$$

C. Fréchet-Hoeffding bounds

Theorem: For every d-dimensional copula **C** and every $u \in [0,1]^d$

$$\mathbf{C}^- = \mathbf{max}(\boldsymbol{u_1} + \cdots + \boldsymbol{u_d} - \boldsymbol{d} + \mathbf{1}, \mathbf{0}) \leq \boldsymbol{C(u)} \leq \mathbf{min}(\boldsymbol{u_1}, \ldots, \boldsymbol{u_d}) = \mathbf{C}^+ \textbf{(22)}$$

With $\mathbf{C}^+$ and $\mathbf{C}^-$ are called the Fréchet-Hoeffding upper and lower bounds respectively and the cases of increasing monotone dependence and decreasing monotone dependence respectively.

2-3- Measures of dependence and concordance

As **Jogdeo (1982)** notes, « Dependence relations between random variables is one of the most widely studied subjects in probability and statistics. The nature of the dependence can take a variety of forms and unless some specific assumptions are made about the dependence, no meaningful statistical model can be contemplated. »

In this section, we should shed light firstly on the definition of dependence and methods used to measure it. Furthermore, we should make attention on the interesting role that copulas play in the study of dependence. Dependence in statistics is a statistical association between two random variables or groups of data. It's the case where random variables do not respect the probabilistic independence condition. The measure of dependence is an application which counts the degrees of dependence between two variables and summarizes this relation into a real number. In statistics, there is a variety of ways to discuss and measure dependence. However, these applications must verify a number of properties and be a concordance measure. In what follows, we will present the popular measures.

We can mention Kendall's tau and Spearman's rho as measures of association. These two measures are popular and widely known and considered as a form of dependence namely concordance.

2-3-1-Linear Correlation

The **Pearson**'s Coefficient **(1986)** is the most frequently-used dependence measure (between two random variables) used in a bivariate distribution.

Definition: Let $(X_1, X_2)'$ be a vector of two random variables with $V(X_d) < \infty$ and $V(X_d) > 0$, *d=1, 2*, the Pearson's coefficient $\rho(X_1, X_2)$ is defined by:

$$\boldsymbol{\rho(X_1, X_2)} = \frac{\boldsymbol{Cov(X_1,X_2)}}{\sqrt{\boldsymbol{Var(X_1)Var(X_2)}}} \qquad \textbf{(66)}$$

Where: $\boldsymbol{Cov(X_1, X_2)} = \mathbb{E}(\boldsymbol{X_1 X_2}) - \mathbb{E}(\boldsymbol{X_1})\mathbb{E}(\boldsymbol{X_2})$

And Var(X_1) and Var(X_2) represent the variances of X_1 and X_2, respectively.

The correlation coefficient measures the correlation between tow random variables X and Y and it indicates if these tow variables tend to have the same sign or not (tendency to move on the same direction). Let say that the interpretations of correlation coefficient and covariance are the same, that's mean that:

$\rho(\boldsymbol{X_1}, \boldsymbol{X_2})$ **= -1 or +1** => We have a perfect linear dependence.

$\boldsymbol{\rho(X_1, X_2)} < 0$ **(> 0)** =>we have a negative (positive) dependence$\boldsymbol{\rho(X_1, X_2)}$**= 0** =>$X_1$ *and* X_2 are independent

Although the simplicity in calculating the correlation coefficient, this measure of correlation has many disadvantages. First of all, it doesn't detect non-linear dependence and structure (it is used only for linear dependence case). After that, in finance Gaussian (elliptical) distribution the correlation coefficient is not usually used. In this case correlation presents a limited notion of dependence.

2-3-2-Rank correlation

The concordance is to focus on the type of relation between the two random variables. Rank correlation measures the trends to increase (concordance) or decrease (disconcordance) of one variable when the other one increases. Informally, we can state that two random variables are concordant if large (respectively small) values of one tend to be associated with large (respectively small) values of the other.

A. Definition

For any pair of observations (X_i, Y_i) and (X_j, Y_j):

-If both $X_i > X_j$ and $Y_i > Y_j$ and if both $X_i < X_j$ and $Y_i < Y_j$, then we say observations (X_i, Y_i) and (X_j, Y_j) are concordant↔ $(X_i - X_j)(Y_i - Y_j) > 0$
-If both $X_i > X_j$ and $Y_i < Y_j$ and if both $X_i < X_j$ and $Y_i > Y_j$, then we say observations (X_i, Y_i) and (X_j, Y_j) are discordant↔ $(X_i - X_j)(Y_i - Y_j) < 0$

B. Kendall's tau:

Kendall's tau is a form of measure of concordance which measures dependence based on ranks. In fact, this version of the measure of association compares the probability of concordance (dis-concordance) of two random variables. In term of concordance and according to a mathematical approach, Kendall's tau is defined as follows **(Kruskal 1958; Hollander and Wolfe 1973, Lehman 1975)**.

Definition: Let (X_1, Y_1) and (X_2, Y_2) be independent and identically distributed random vectors with distribution function F, Kendall's tau is defined as follows:

$$\boldsymbol{r_k(X,Y) = \Pr(concordance) - Pr(discordance)}$$
$$\boldsymbol{= \Pr[(X_1 - X_2)(Y_1 - Y_2) > 0] - \Pr[\,(X_1 - X_2)(Y_1 - Y_2) < 0]} \quad \textbf{(67)}$$

Furthermore, the Kendall's tau can be written as a function of the copula as follow:

$$\boldsymbol{r_k(X,Y) = 4\int_0^1 \int_0^1 C(u,v)\, d(u,v)} \quad \textbf{(68)}$$

$$\boldsymbol{= 4E[C(U,V)] - 1}$$

Where U, V ~ U (0, 1) with joint distribution function $\boldsymbol{C}$

<u>Properties</u>: The most important properties of r_k are:

-Symmetric: $r_k(X,Y) = r_k(Y,X)$
-Normalized to the interval [-1, 1]: -1 < $r_k(X,Y)$< 1
If $r_k(X,Y) = 1$ ↔ conomotic dependence between X and Y.
If $r_k(X,Y) = -1$ ↔ anticonomotic dependence between X and Y.
If $r_k(X,Y) = 0$ ↔X and Y are independent
-Invariant under non-linear transformations: $r_k(T_1(X), T_2(Y)) = r_k(X,Y)$, if T_1 and T_2 are two increasing continuous functions.

C. Spearman's rho

The Spearman's rho measure was proposed by **Charles Spearman (1904)** which is equivalent to the Pearson's coefficient for the correlation between the ranked observations.

Definition: Let $(X_1, Y_1), (X_2, Y_2)$and$(X_3, Y_3)$are three i.i.d random vectors, Spearman's rho is defined as follow:

$$\boldsymbol{\rho s(X,Y) = 3(\mathbb{P}[(X_1 - X_2)(Y_1 - Y_3) > 0] - \mathbb{P}[(X_1 - X_2)(Y_1 - Y_3) < 0])} \quad \textbf{(69)}$$

The Spearman's rho can be written as a function of Pearson's coefficient ρ as follow:

$$\boldsymbol{\rho s(X,Y) = \rho(F_X(X), F_Y(Y))} \quad \textbf{(70)}$$

Where F_X and F_Y are the cumulative distribution functions, respectively, of X and Y

Furthermore, the Spearman's rho can be computed using copula function as follow:

$$\boldsymbol{\rho s(X,Y) = 12 \int_0^1 \int_0^1 uv\, dC(u,v) - 3} \quad \textbf{(71)}$$

$$\boldsymbol{= 2 \int_0^1 \int_0^1 C(u,v)\, du\, dv - 3}$$

Where U, V ~ U (0, 1) with joint distribution function $\boldsymbol{C}$

Properties:

The most important properties of ρs are:

-Normalized to the interval [-1, 1]: -1<$\rho s(X,Y)$<1

If $\rho s(X,Y)$=1 ↔ comonotone dependence between X and Y.

If $\rho s(X,Y) = -1$ ↔ antimonotone dependence between X and Y

If $\rho s(X,Y) = 0$ ↔ X and Y are independent.

- Invariant under non-linear transformation: $\rho s(T_1(X), T_2(Y)) = \rho s(X,Y)$, if $T_1$and T_2 are two increasing continuous functions.

Indeed, the main differences between rank correlation measures and linear correlation are; on one hand, Kendall's tau and Spearman's rho measure the degree of monotonic dependence, whereas Pearson's coefficient measures the degree of linear dependence and on the other hand, rank correlation measures are invariant under monotonic transformations.

2-3-3-Tail dependence

The tail dependence coefficient is the probability that a random variable exceeds a certain threshold conditional on the fact that another random variable has already exceeded that threshold. In other words, the tail dependence coefficient aims to measure the dependence in the upper (right) - tail or lower-(left) -tail of a bivariate distribution.

Definition (Upper Tail Dependence)**:** Let X and Y be random variables with distribution functions, respectively F_X and F_Y, the coefficient of upper tail dependence is defined as:

$$\boldsymbol{\lambda_U} = \lim_{u \to 1} \left[\boldsymbol{Y} > \boldsymbol{F_Y^{-1}(u)} \mid \boldsymbol{X} > \boldsymbol{F_X^{-1}(u)} \right] \quad \textbf{(72)}$$

Furthermore, the upper-tail coefficient may be written in terms of copulas as follow:

$$\boldsymbol{\lambda_U} = \lim_{u \to 1} \frac{1 - 2u + C(u,u)}{1 - u} \quad \textbf{(73)}$$

If $\lambda_u \in (0,1]$then X and Y are asymptotically dependent in upper tail.

If $\lambda_u = 0$ then X and Y are asymptotically independent in upper tail.

Definition (Lower Tail Dependence): Analogously, the coefficient of lower-tail dependence is defined as :

$$\boldsymbol{\lambda_L} = \lim_{u \to 0} \Pr \left[\boldsymbol{Y} \le \boldsymbol{F_Y^{-1}(u)} \mid \boldsymbol{X} \le \boldsymbol{F_X^{-1}(u)} \right] \quad \textbf{(74)}$$

Furthermore, analogously the lower-tail coefficient may be written in terms of copulas as follow:

$$\boldsymbol{\lambda_L} = \lim_{u \to 0} \frac{C(u,u)}{u} \quad \textbf{(74)}$$

If $\lambda_L \in (0,1]$ then X and Y are asymptotically dependent in lower tail.

If $\lambda_u = 0$ then X and Y are asymptotically independent in lower tail.

2-4- Copulas families

We shed light on the most important families of copulas which are the Archimedian copulas and Plakett copulas which are widely explained.

2-4-1-Elliptical Copulas

The probability distribution that generalizes the multivariate normal distribution, is an elliptical distribution. It's possible to extract an elliptical copula from these distributions. The copula associated to an elliptical distribution is unique and can be constructed by the inversion method. The elliptical copula is constructed from the multivariate distribution by applying the Sklar's theorem.

The most used elliptical copulas are the Gaussian and t-copula.

A. Gaussian Copula

The Gaussian copula function is widely used in finance modelling. It links the normal standard variables to the correlation and the marginals are standard normal.

The *d*-dimensional Gaussian copula (normal copula) function is of the form:

$$C(u_1, u_2, \ldots, u_d) = \Phi_R\left(\Phi^{-1}(u_1), \Phi^{-1}(u_2), \ldots, \Phi^{-1}(u_d)\right) \quad (75)$$

$$= \int_{-\infty}^{\Phi^{-1}(u_1)} \int_{-\infty}^{\Phi^{-1}(u_d)} \frac{1}{(2\pi)^{\frac{d}{2}}|R|^{\frac{1}{2}}} exp\left(\frac{-1}{2} y' R^{-1} y\right) dy_1\, dy_d$$

Where Φ is the cumulative distribution function of a standard normal distribution, Φ_Σ is the multivariate normal cumulative distribution function with mean zero and $m \times m$ correlation matrix R , Φ^{-1} is the inverse function of the standard univariate normal distribution, $|R|$ is the determinant of the correlation matrix R and $\boldsymbol{y} = (\boldsymbol{y_1}, \ldots, \boldsymbol{y_d})$.

The density function of the Gaussian copula is given by:

$$c(u_1, u_2, \ldots, u_d) = \frac{1}{|R|(2\pi)^{\frac{d}{2}}} exp\left\{-\frac{1}{2}(y' R^{-1} - IR)\right\} \quad (76)$$

The Gaussian Copula is symmetric without tail dependence hence it exhibits a poor representation of extreme events.

<u>Dependence properties</u>:

In the case of Gaussian copula, the Kendall's tau and Spearman Rho are computed respectively, as follow: $\rho\tau_{i,j} = \frac{2}{\pi} \arcsin \rho_{i,j}$ / $\rho s_{i,j} = \frac{6}{\pi} \arcsin \frac{\rho}{2}_{i,j}$.

Furthermore, the Gaussian copula is used when we look to preserve Gaussian dependence. The following figure studies the tail dependency of Gaussian copula by computing the tail dependence coefficients and shows that there is no tail dependence.

B. Student-t Copula

The t-copula is associated to the student bivariate distribution. It is also an important function for finance application (recommended by **Mashal and Zeevi (2003)** and **Breymaan and al. (2003)** and others). The normal copula presents a particular case of t-copula when $v \to \infty$. The importance of T-copula is that it adds joint fat tail to the Gaussian copula.

The *d*-dimensional Student-t copula (or briefly *t* copula) function is of the form:

$$C(u_1, u_2, \ldots, u_d) = T_{R,v}\left(T^{-1}(u_1), T^{-1}(u_2), \ldots, T^{-1}(u_d)\right) \quad (77)$$

$$= \int_{-\infty}^{T^{-1}(u_1)} \ldots \int_{-\infty}^{T^{-1}(u_d)} \frac{\Gamma\left(\frac{v+d}{2}\right)|R|^{-\frac{1}{2}}}{\Gamma\left(\frac{v}{2}\right)(v\pi)^{\frac{d}{2}}} \left(1 + \frac{1}{v} y' R^{-1} y\right)^{-\frac{v+d}{2}} dy_1 dy_2$$

Where $T_{R,v}$the standardized multivariate Student-t distribution function with $m \times m$ correlation matrix R of v degrees of freedom and T^{-1} is the inverse function of the standard univariate Student-t distribution with v degrees of freedom.

The density function of the Student-t copula is given by:

$$\boldsymbol{c(u_1, u_2, \dots, u_d) = |R|^{-\frac{1}{2}} \frac{\Gamma(\frac{v+d}{2})}{\Gamma(\frac{v}{2})} \left[\frac{\Gamma(\frac{v}{2})}{\Gamma(\frac{v+1}{2})}\right]^d \frac{\left(1+\frac{1}{v}y'R^{-1}y\right)^{-\frac{v+d}{2}}}{\prod_{i=1}^{d}\left(1+\frac{y_i^2}{v}\right)^{-\frac{v+1}{2}}}} \quad \textbf{(78)}$$

Unlike the Gaussian Copula, the Student-t Copula is symmetric with tail dependence hence it captures extreme events.

Remark: when v goes to infinity the Student-t copula degenerates to a Gaussian copula.

Dependence properties:

The Kendall's tau is the same as for the Gaussian copula whereas there is no explicit form for the Spearman Rho.

The tail dependence coefficient is given by:

$$\boldsymbol{\lambda = 2T_{v+1}\left(\frac{\sqrt{v+1}\sqrt{1-\rho}}{\sqrt{1+\rho}}\right)} \quad \textbf{(79)}$$

Where T_{v+1}denotes the distribution function of a univariate Student's t-distribution with ν + 1 degrees of freedom.

2-4-2-Archimedean copulas

Since there are cases where the causality betwixt stochastic processes flow in a certain pattern rather than situations where we observe random variables uniformly affected by a common underlying process. That's why the symmetry imposed by the most used copulas could be considered quite restrictive.

One of the few asymmetric classes of copulas is the Archimax. These new copulas were introduced by **Capéra and al. (2000)**. It covers the most common copula, more precisely, the Archimedean and extreme value classes. This family presents more modelling flexibility and was built from the generator $\boldsymbol{\varphi}$ which is a convex continuous decreasing function and a dependence function $\boldsymbol{A}$. Then, a bivariate copula is Archimax if it is written in this form:

Definition: A d-dimensional copula is called Archimedean copula if it can be generated by considering a generator function$\varphi : [0,1] \rightarrow [0, \infty]$ and its inverse φ^{-1} :

$$\boldsymbol{C_\theta(u_1, u_2 \dots, u_d) = \varphi^{-1}\big(\varphi(u_1) + \varphi(u_2) + \dots + \varphi(u_d)\big)}, \qquad \forall \boldsymbol{u} \in [\mathbf{0}, \mathbf{1}]^{\boldsymbol{d}}$$

(40)

Where θ is the dependence parameter and φ is the Archimedean generator φ which is continuous, strictly decreasing and a convex function such that $\lim_{x\to\infty} \varphi(x) = 0$ and $\varphi(1) = 0$ and the inverse $\varphi^{-1}$is d-monotone ($i.e.$ $(-1)^{-d}(\varphi^{-1})^{(d)} \geq 0$) which is given by:

$$\boldsymbol{\varphi^{[-1]}(t) = \begin{cases} \varphi^{-1}(t), & 0 \leq t \leq \varphi(0) \\ 0 & , \varphi(0) \leq t \leq \infty \end{cases}} \qquad \textbf{(80)}$$

<u>Dependence properties</u>:

For Archimedean copulas dependence measures may be expressed in terms of the generator and its inverse.

The Kendall's τcan be computed with the following formula proposed by **Genest and MacKay (1986):**

$$\boldsymbol{\tau = 1 + 4 \int_0^1 \frac{\varphi(t)}{\varphi'(t)} dt} \qquad \textbf{(81)}$$

The tail dependence coefficient for Archimedean copula can, also, computed via the generator function and its inverse.

If $\varphi^{-1'}(0) < \infty$, then the Archimedean copula does not have upper tail dependence conversely, $\lambda_U$is given by:

$$\boldsymbol{\lambda_U = 2 - 2 \lim_{u\to 0^+} \frac{\varphi^{-1'}(2u)}{\varphi'(tu)}} \qquad \textbf{(82)}$$

The lower tail dependence coefficient is given by:

$$\boldsymbol{\lambda_L = 2 \lim_{u\to \infty} \frac{\varphi^{-1'}(2u)}{\varphi'(u)}} \qquad \textbf{(83)}$$

Hereafter, we present some classes of Archimedean copulas that will be used along with our study.

A. Gumbel copula

The Gumbel copula was proposed by Gumbel (1960) with the following generator:

$$\boldsymbol{\varphi(u) = (-\ln(u))^\theta \quad where\ \theta} > 1 \qquad \textbf{(84)}$$

The d-dimensional Gumbel copula is defined as follow:

$$C(\boldsymbol{u_1, u_2, \dots, u_d; \theta}) = \boldsymbol{exp\left(-\left[\sum_{i=1}^d (-\ln u_i)^\theta\right]^{\frac{1}{\theta}}\right)} \qquad \textbf{(85)}$$

Dependence properties:

As the Clayton copula, the Gumbel copula is limited only to the positive dependence and cannot account for negative dependence, but attains the Frechet upper bound as $\theta \to \infty$.Lower tail dependence is equal to 0. It interpolates between independence and perfect positive dependence.

kendall's tau: $\tau_K = 1 - \frac{1}{\theta}$

Tail dépendance coefficients : $\lambda_U = 2 - 2^{1/\theta}$, $\lambda_L = 0$

B. Clayton Copula

The Clayton copula was proposed by **Clayton (1978)** with the following generator:

$$\boldsymbol{\varphi}(\boldsymbol{u}) = \boldsymbol{u}^{-\boldsymbol{\theta}} - \mathbf{1} \ \ where\ \theta > 0 \qquad \textbf{(86)}$$

The *d*-dimensional Clayton copula is defined as follow:

$$\boldsymbol{C}(\boldsymbol{u}_1, \boldsymbol{u}_2, \dots, \boldsymbol{u}_d; \boldsymbol{\theta}) = \left(\sum_{i=1}^{d} \boldsymbol{u}_i^{-\boldsymbol{\theta}} - \boldsymbol{d} + \mathbf{1}\right)^{-\frac{1}{\theta}} \qquad \textbf{(87)}$$

Dependence properties:

In contrast with the Gumbel copula, the Clayton copula is characterized by strong lower tail dependence. Otherwise, similar to the Gumbel copula, it accounts only for positive dependency.

kendall's tau : $\boldsymbol{\tau_K} = \frac{\boldsymbol{\theta}}{\boldsymbol{\theta}+\mathbf{2}}$

Tail dependence coefficients :$\boldsymbol{\lambda_U} = \mathbf{0}$, $\boldsymbol{\lambda_L} = \mathbf{2^{1/\theta}}$

C. Frank copula

The Frank copula (1979) is characterized by the following generator:

$$\boldsymbol{\varphi}(\boldsymbol{t}) = -\ln\left(\frac{e^{-\theta t}-1}{e^{-\theta}-1}\right), \textbf{ where}\boldsymbol{\theta} \in (-\infty, \infty)\backslash\{\mathbf{0}\}, \qquad \textbf{(88)}$$

The Frank copula is defined as follow:

$$\mathrm{C}_\theta(\boldsymbol{u}, \boldsymbol{v}) = -\frac{1}{\theta}\ln(1 + \frac{(e^{-\theta u}-1)(e^{-\theta v}-1)}{e^{-\theta}-1}) \qquad \textbf{(89)}$$

Dependence properties:

Unlike the Clayton and the Gumbel copula, the Frank copula is the only Archimedean copula that attains both the upper and lower Frechet bounds, thus allowing for positive and negative dependence.

The Kendall's tau: $\boldsymbol{\tau_K} = \mathbf{1} - \frac{4}{\theta}\left(\mathbf{1} - \boldsymbol{D_1}^{(\theta)}\right)$

The Spearman's rho: $\boldsymbol{\rho s} = \mathbf{1} - \frac{12}{\theta}\left(\boldsymbol{D}^{1(\theta)} - \boldsymbol{D}^{2(\theta)}\right)$

The tail dependence coefficients: $\boldsymbol{\lambda_U} = \boldsymbol{\lambda_L} = \mathbf{0}$

With $D_k(\theta)$ is the Debye function: $\boldsymbol{D_k(\theta)} = \frac{k}{\theta^k}\int_0^\theta \frac{t^k}{e^t - 1}\,dt\,, k = 1, 2\ldots$

2-5- Statistical Inference of Copulas

In this paragraph, it is worthy to shed light on methods used to estimate parameters. We have the parametric and non-parametric estimation.

Let $\boldsymbol{X} = (\boldsymbol{X_1}, \ldots, \boldsymbol{X_d})$denote a random vector with joint distribution function $\boldsymbol{F}(X, \theta)$of the copula$\boldsymbol{C}_\alpha$and marginal distribution functions $F_{i=1,\ldots,d}$.
Hence, the joint distribution function *H* of the copula is specified by the vector of parameters $\boldsymbol{\theta} = (\boldsymbol{\alpha}, \boldsymbol{\beta_1}, \ldots, \boldsymbol{\beta_N})$
And let $\boldsymbol{X} = \{(\boldsymbol{x_1^t}, \ldots., \boldsymbol{x_N^t})\}_{t=1}^{T}$ be a sample of size *T*. Thus, according to the theorem of Sklar we have:

$$F(X_1, \ldots, X_d, \theta) = C(F_1(x_1; \beta_1), \ldots, F_d(x_d; \beta_d); \theta) \quad \textbf{(90)}$$

2-5-1-Method of moments

This method was introduced by **Karl Pearson (1894).** The estimator of moments is simply given by equating the parametric expression (analytical) measurement with a nonparametric estimator of the same measure. This method imposes, in general, the computation of moments. Even when there are no analytical formulas, it is possible to use numerical integration or simulation. The MM is also used in various ways to simplify the complexity of estimation. Indeed, it exploit the relationship between the Kendall's $\boldsymbol{\tau}$ or the Spearman's $\boldsymbol{\rho}$ with the copula parameter $\boldsymbol{\alpha}$.
At the first stage, we solve the system of *n* equations in *n* unknown:

$$\begin{cases} \boldsymbol{\mu_{1,t}} = \boldsymbol{f_1}(\boldsymbol{\beta_1}, \ldots, \boldsymbol{\beta_n}) \\ \boldsymbol{\mu_{2,t}} = \boldsymbol{f_2}(\boldsymbol{\beta_1}, \ldots, \boldsymbol{\beta_n}) \\ \boldsymbol{\mu_{3,t}} = \boldsymbol{f_3}(\boldsymbol{\beta_1}, \ldots, \boldsymbol{\beta_n}) \\ \quad\quad . \\ \quad\quad . \\ \quad\quad . \\ \boldsymbol{\mu_{n,t}} = \boldsymbol{f_n}(\boldsymbol{\beta_1}, \ldots, \boldsymbol{\beta_n}) \end{cases} \quad \textbf{(91)}$$

Where $\beta_{i=1,\dots,n}$ are the marginal parameters to estimate, n is the dimension of the vector, $f_{i=1,\dots,n}$ the expressions of moments of order 1, 2, 3 until the n^{Th} order.

Then, at the second stage, we deduct th copula parameter from the inverse of the Kendall's τ or the spearman's ρ.

2-5-2-The semi-parametric estimation

<u>The Canonical Maximum Likelihood Method</u> (CML)

Unlike methods mentioned above (Moments Method, Exact Maximum Likelihood Method and The Inference Functions for Margins Method) which impose a parametric estimation of margins, the Canonical Maximum Likelihood method does not imply any a priori assumption on the marginal distribution and it estimates margins with a non-parametric application.

This method was introduced by **Bouye et al. (2000)** and estimators are realized as follow:

-We transform the dataset $(x_1^t, \dots, x_N^t)$ into uniform variates $(u_1^t, \dots, u_N^t)$ using an empirical distribution function:

$$\widehat{F}_{X_i}(x) = \frac{1}{T}\sum_{t=1}^{T} 1_{\{X_i \leq x\}} \qquad \textbf{(92)}$$

Where $1_{\{X_i \leq x\}}$ is an indicator function.

-We estimate the copula parameters in the following way:

$$\widehat{\alpha}^{CML} = argmax_{\alpha} \sum_{t=1}^{T} \ln c\ (\widehat{u}_1{}^t, \dots, \widehat{u}_N^t, \alpha) \qquad \textbf{(93)}$$

CHAPTER 2: EMPIRICAL STUDY OF THE RELATIONSHIP BETWEEN THE REER MISALIGNMENTS AND THE CURRENT-ACCOUNT

Introduction

We are seeking mainly to study the impact of a REER movements on the current account balance in Tunisia. To that end, we will try to have a look and to study empirically the dependence mechanism between above-mentioned variables by applying a copula model.
This theory allows us to study the bivariate dependence structure between series under study.

Its use is crucial since it gives information about the dependence on average and the dependence in times of extreme movements. In one hand, the dependence on average is given by correlation measures (Pearson's rho, Kendall's tau or Spearman's rho) which are obtained from the dependence parameter of the copula. In the other hand, the dependence in times of extreme movements is obtained from the copula tail dependence coefficients.

To this aim, we investigate the conditional dependence structure. As a first step, we filter the series using AR(1)-GJR-GARCH (1,1) processes. Then, we apply the empirical cumulative distribution function (ECDF) for the standardized residuals. As a final step, we introduce the copula model and we estimate the under-study copulas parameters using the CML method in order to examine the bivariate dependence.

SECTION 1: EMPIRICAL RESULTS PRESENTATION

1-1- Data presentation and descriptive statistics

We empirically examine the dependence structure between REER misalignment and the current account balance in Tunisia.

Our variables are described as follow:

- **The real effective exchange rate misalignment (Mis):** represents the difference between the actual real effective exchange rate and the real exchange rate given by the current value of all fundamentals that is the equilibrium REER.
- **The current-account deficit (CAD)**: Current account balance is the sum of net exports of goods and services, net primary income, and net secondary income. In Order to simplify

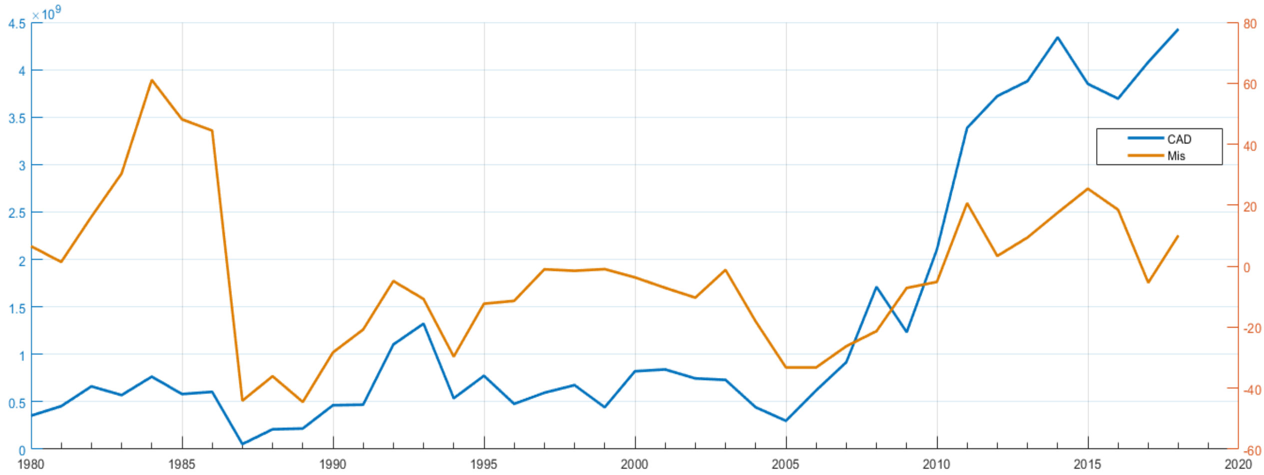
the evaluation of our results, it is better to consider the absolute values of the CA in Tunisia as a current account deficit, i.e. CAD

Our database consists of annual time series for all variables on the period that spans from 1980 to 2018, so we have 39 observations. Moreover, the data is collected from the website of the Word Bank (https://data.worldbank.org/).

After presenting the data, it is time to analyze the two series in spot values to know which specification be attributed to them. So, let's begin with the evolution of series over the period covered.

Figure 13 displays the price evolution of variables mentioned above in the Tunisia during the sampling period which seem to be non-stationary.

Figure 13: Dynamics of REER misalignment and CAD in Tunisia during the period 1980-2018



Source: Matlab 2019

Table 15 reports summary statistics for the annual data of the CAD and Mis variables employed in this study.

Table 15: Descriptive Statistics for CAD and Mis

	CAD	Mis
Mean	1.3635e+09	-2.6888
Standard deviation	1.3792e+09	24.3920
Maximum	4.4287e+09	61.0773
Minimum	5.4304e+07	-44.5044
Kurtosis	2.9354	3.1556
Skewness	1.2621	0.5324

Source: Matlab 2019

Table 15 provides descriptive statistics for our two variables. As it is shown, standard deviations are very high which means that series don't have a constant term and are not around the mean.

In one hand, Mis and CAD exhibits a significant and positive skewness, which implies that all series are left skewed and have the propensity to generate negative returns with greater probability than suggested by a normal distribution. In the other hand, the kurtosis coefficient is above 3 for both, hence all series are leptokurtic (the distribution of returns has larger and thicker tails than the normal distribution). That's means that a sadden movement (shock) will set off serious fluctuations and volatility due to fat tail feature of series. Thus, the results for the skewness and the kurtosis reinforce the rejection of normality.

1-2- Margins distributions

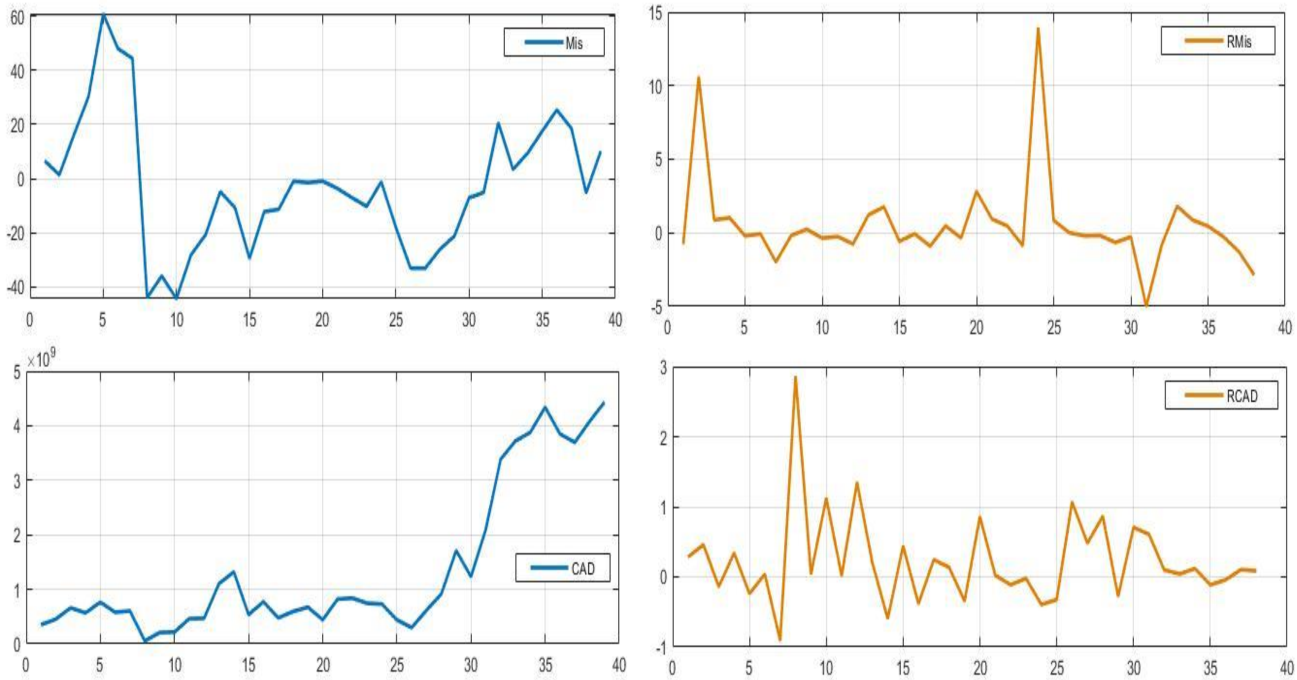
In order to build the distribution of our margins, several tests and graphical tools are employed, such as tests for stationarity, normality, autocorrelation and ARCH effect.

1-2-1- Stationarity testing

Empirical evidence on time series shows that statistical analysis of prices is difficult due to the high correlation between consecutive prices and the increasing trend in the variance of prices. Therefore, it is better to analyze changes in prices instead.

Furthermore, it is evident that all financial time series usually exhibit a volatility clustering phenomenon which is a type of heteroscedasticity as it is shown in Figure 14.

Figure 14: Dynamics of Mis and CAD (left) and their returns (right) Tunisia



Source: Matlab 2019

As is apparent from **Figure 14,** on the left, we have a clear upward and downward slope indicating that they display a trend in the mean. Hence, they are not moving around the constant mean. Also, the different fluctuations imply that the variance is not constant. Thus, we can conclude that the stationary condition is violated. We compute then, the returns by taking the difference in the logarithm of two successive annual values.

By looking to **Figure 14** on the right, the variations of the returns exhibit an autoregressive pattern (volatility clustering). Besides, as it is shown in the graph, the Tunisian revolution and the adoption of the SAP exhibit high deviations in the CA and the Mis return respectively, more especially in2014 and 1987.

In addition to the graphical intention, we use unit root tests, namely, the (ADF), (KPSS) and (PP).

Table 16: ADF, KPSS and PP test (5%) for the CAD and Mis and their returns

		Mis	CAD	RMis	RCAD
ADF	H	1	0	1	1
	Test Statistic	-2.5575	1.4452	-5.7258	-6.8993
	P-value	0.0121	0.9606	10^{-3}	10^{-3}
KPSS	H	1	1	0	0
	Test Statistic	0.3153	0.7201	0.0778	0.0385
	P-value	0.1	0.01	0.1	0.1
PP	H	1	0	1	1
	Test Statistic	-2.5575	1.4452	-5.7258	-6.8993
	P-value	0.0121	0.9606	10^{-3}	10^{-3}

Source: Matlab 2019

Table 16 reports the results for the unit root tests. According to these outputs, the Mis is non-stationary in level but stationary in first difference. However, the CA is stationary in level.

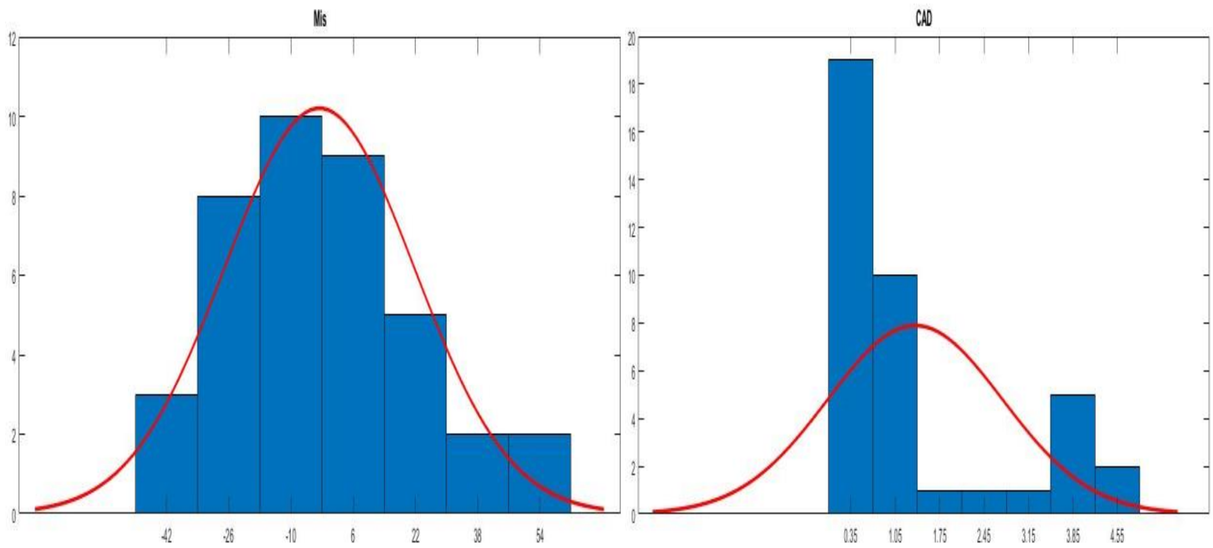
1-2-2- Normality testing

A-Graphical approach

The existing empirical findings confirm that the financial time series do not exhibit normal distribution hence there is no evidence for normality.

That's why, it is crucial as a first step to verify if our data set is normally or not normally distributed. For this purpose, there are several statistical methods. The most common graphical tools are the Histograms and the QQ-plot against the Gaussian distribution. The simple method is to construct a histogram and compare the shape with the normal distribution that has the same mean and the same standard deviation as the sample mean and the sample standard.

Figure 15 : Histogramsof Mis (right) and CAD(left) adjusted to the normal density

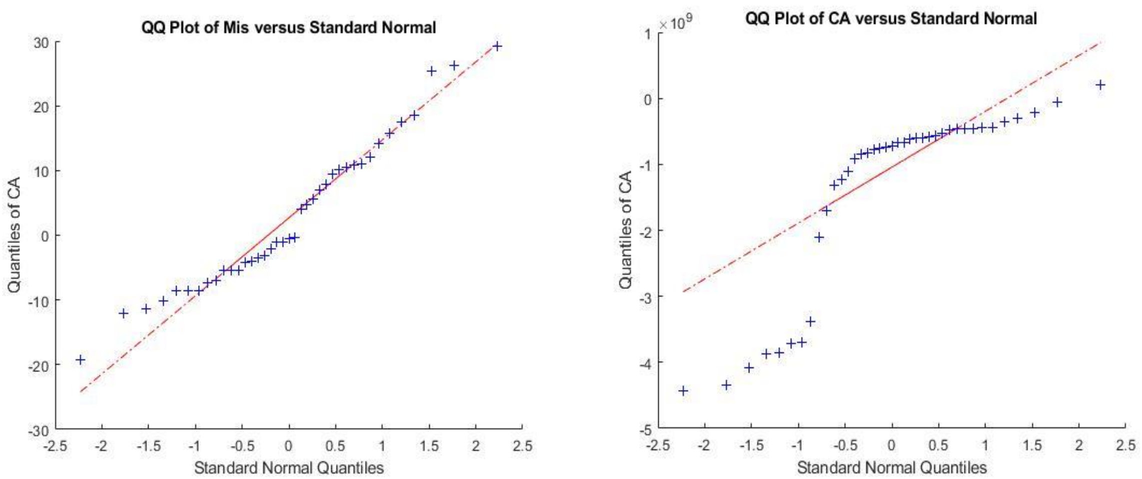


Source: Matlab 2019

Indeed, **Figure 15** which presents the histogram with the normal curve of annual data proves that the series appear far from being normally distributed.

An alternative graphical tool to check normality is the QQ-plot, which is very easy to interpret and lets us to see where the sample deviates from normality. (See **Figure 16**).

Figure 16 : QQ-plots of CA and Mis versus the normal distribution.



Source: Matlab 2019

As it is shown in **Figure 16**, series are symmetric and there is a significant deviation from the straight line in the tails showing that the distribution is more heavy-tailed than the normal distribution.

B-Jarque-Bera (JB) test

JB test is a goodness-of-fit test of normality. This test computes the Kurtosis and Skewness to construct the JB test statistic[33]. The JB test (1981) studies whether excess of kurtosis and skewness coefficients are jointly 0. Under null hypothesis the residuals are normally distributed while the alternative is the non-normality.

Table 17: JB test (5%) for the Mis and CAD

	Mis	CAD
H	**1**	**1**
Test Statistic	**11.8819**	**10.3601**
P-value	**0.02184**	**0.0133**

Source: Matlab 2019

The JB test results reported in **Table 17** show that the null hypothesis of normality is clearly rejected for both series (P-value < 5%). Nevertheless, the test indicates that they have non-normal distributions, which emphasizes the need of using GARCH like models in examining them.

1-2-3-Autocorrelation testing

We use the Ljung-Box (LB) Q-statistic test to examine the autocorrelation between series. The idea behind this test is to verify if any set of the time series are different from zeros. Under the null hypothesis, the residuals do not exhibit autocorrelation versus the alternative is the presence of autocorrelation. **Tables 18** present the LB test applied on the residual of the series.

Table 18: LB test (5%): Q (20) for the Mis and CAD

	Mis	CAD
H	**1**	**1**
Test Statistic	**45.7326**	**116.2620**
P-value	**8.7697e-04**	**1.4433e-15**

Source: Matlab 2019

The results from **Table 18** show that Mis and CAD are not autocorrelated. Then, we test for conditional heteroscedasticity by computing the LB test on the squared residual series.

[33]The Jarque-Bera test statistic is: $JB = n\left[\frac{S^2}{6} + \frac{EK^2}{24}\right]$, with n= number of observations, S= Skewness and EK= Excess of Kurtosis = K -3.

Table 19: LB test (5%) on the squared residual: Q^2 (20) for the Mis and CAD

	Mis	CAD
H	**1**	**1**
Test Statistic	**41.4191**	**81.0602**
P-value	**0.0033**	**2.5921e-09**

Source: Matlab 2019

According to the table, the Ljung Box Q^2statistics are statistically significant for all the variables under study, which prove the existence of autocorrelation in all the squared residuals. Therefore, there is a conditional heteroskedasticity.

- **ARCH effects testing**

As we say above, the series (squared or absolute values) exhibit a significant positive autocorrelation or persistence which leads to a volatility clustering phenomenon. The later refers to the observation that the large (small) fluctuations are more likely to be followed by large (small) price fluctuations.

There are several methods to test the ARCH effect. The conventional method is the Lagrange Multiplier (LM) test proposed by Engle (1982). Under null hypothesis there is no ARCH effect while under the alternative hypothesis the conditional error variance is given by an ARCH (q) process.

Table 20: ARCH test (5%) for the Mis and CAD

	Mis	CAD
H	1	1
Test Statistic	18.4103	34.0454
P-value	1.7809e-05	5.3842e-09

Source: Matlab 2019

The results reported in table 20show that the ARCH-LM test rejects the null hypothesis for both variables, confirming thus the presence of volatility clustering phenomenon.

- **Kolmogorov-Smirnov (KS) test**

The Kolmogorov-Smirnov test is a method to verify if a sample with unknown distribution is drawn from a continuous sample with a determined distribution. The empirical distribution function (EDF) presents the basis of this test. Under null hypothesis, the distribution of the series comes from the specific distribution object of test and under the alternative hypothesis their distribution is different from the distribution object of test.

As a first insight, the descriptive statistics show an excess of kurtosis and non-null Skewness values for all variables. Then, we expect to have heavy tailed distributions.

To deal with this issue, we fit the margins of our financial return series to the t-distribution CDF which exhibit heavier tail than the normal distribution.

Table 21: Kolmogorov-Smirnov (KS) test

	Normal			Student			
	H	**P**	**KS stat**	**H**	**P**	ϑ	**KS stat**
Mis	1	1.1e-10	0.5383	1	0.0839	3.30084	0.5385
CAD	1	8.2264 e-36	1	0	0.6785	6.077e+08	0.0240

Source: Matlab 2019

As expected, the results of the KS test reported in table 21 accept the null hypothesis for the student's t –distribution. Hence, the Student's t-distribution is more appropriate to model our financial time series.

GARCH Filter

Before fitting copula functions to the data, we must choose the most appropriate specifications for modeling the conditional heteroskedasticity, and for filtering the returns into an approximately i.i.d series.

In our study, a basic AR (1)-GARCH (1, 1) and AR (1)-GJR- GARCH (1,1) models are used for the conditional variance of our series, as they are the most common models to describe financial time series. Then, we estimate these models and compare their information criteria such as AIC, BIC and log-likelihood statistics.

Table 22 reports the information criteria for estimated models for Mis and CAD.

Table 22: Information criteria for estimated model (Mis)

	AIC	BIC	LL
GJR-GARCH	346.2531	349.5802	-170.12
GRACH	347.8159	352.8066	-171.90

Source: Matlab 2019

Table 23: Information criteria for estimated models (CAD)

	AIC	BIC	LL
GJR-GARCH	1737.5	1742.5	-865,773
GRACH	1774.9	1779.9	-884,449

Source: Matlab 2019

The estimation results of the different models allow us to conclude that the best model to be used is the AR (1)-GJR-GARCH (1,1) model for both variables.

Table 24: Mis AR (1)-GJR GARCH (1,1) Estimation

Parameter	**Value**	**Standard Error**	**T-Statistic**
C	0.57035	2.1524	0.26499
AR(1)	0.76793	0.11216	6.8468
K	41.732	90.438	0.46145
ARCH(1)	0.65551	0.2544	2.57344
GARCH(1)	0.67224	0.2850	2.3584
GJR(1)	-0.65551	0.2503	-2.61851
DOF	3.4345	1.1078	3.1001

Source: Matlab 2019

Table 25: CAD AR (1)-GJR GARCH (1,1) Estimation

Parameter	Value	Standard Error	T-Statistic
C	8.0316e+07	6.7327e-07	1.1929e+14
AR(1)	1	0.034642	28.867
K	9.2665e+16	2.0437e-13	4.5341e+29
ARCH(1)	0.85231	0.30456	2.79846
GARCH(1)	0.15457	0.04352	3.55161
GJR(1)	-0.85231	0.30416	-2.80212
DOF	10.112	3.0234	3.34455

Source: Matlab 2019

Table 26: AR -GJR-GARCH Estimation

	C*	AR (1)	W*	$\alpha(arch)$	β(garch)	δ(leverege)	v(dof)
Mis	0.57035	0.76793	41.732	0.65551	0.67224	-0.65551	3.4345
CAD	8.0316e+07	1	9.2665e+16	0.85231	0.15457	-0.85231	10.112

Source: Matlab 2019

The **Table 26** reports results for the fitted AR-GJR-GARCH models estimation for all variables. As it is indicated, the AR(1) coefficients are significant for both series.

Similarly, the coefficients which measure the adjustment to past shocks are positive and significant for both of variables. For instance, α parameter for Mis is 0.65551. In this case, the volatility of the exchange rate misalignment in response to past shock declines because of this positive parameter.

Moreover, β coefficients which measure the volatility persistence of the process are significant. For example, it's clear that the exchange rate misalignment has a high volatility (parameter is approximately around 0.7). This indicates that its conditional volatility is persistent over time and past-dependent. As a result, these series are described by significant GARCH effects**.**

To assess the impact of REER misalignment on the current account balance, we are going to analyze the dependence structure both of them. To this end, we use the dependence on average provided by the copula theory which models with more flexibility the joint distribution.

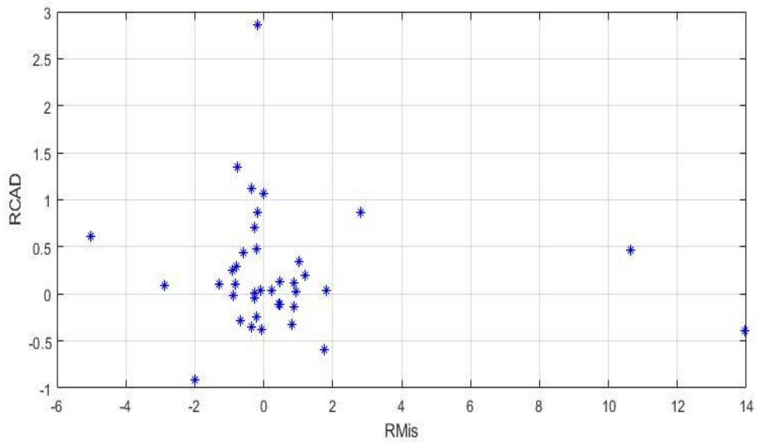
1-2-4-Bivariate dependence of Mis and CAD

To assess the role of exchange rate changes on the current account balance, we have analyzed the dependence structure between these two variables. To this end, we used copulas to flexibly model the joint distribution.

A-Graphical approach

As a preliminary step, we establish the scatter plot of the pair (Mis-CAD) so as to have a general insight of the dependence structure.

Figure 17 : Scatter plots of Mis against CAD returns



Source: Matlab 2019

The dependence structure presented in figure 17 between the pair is ambiguous and not very clear. However, since the dots are roughly plotted in the right side of the chart, we expect being positive indicates that an increase in exchange rate misalignment leads to an upward in the CAD.

B-Dependence measures

- **Linear correlation**

The Pearson coefficient is a linear correlation coefficient which measures the degree of relation between two variables. In our case, it measures the degree of which Mis /CAD tend to move together.

Table 27: Pearson correlation matrix

	Mis	CAD
Mis	1	0.3352
CAD		1

Source: Matlab 2019

Generally, the matrix of linear correlation shows an acceptable correlation. As we can see, exchange rate misalignment and current account deficit are positively correlated.

Nonetheless, the linear correlation is not an authentic measure. The reason why we need the use of more flexible tools such as the rank correlation measures.

- **Rank correlation**

The rank correlation measures the movement of the variables when the other variable moves in an exact direction without requiring the linearity of the movement in question. We present in Table.28 the rank correlations measures: Kendall and Spearman.

Table28: Rank correlation (Full sample)

	Kendall	Spearman
Mis-CAD	0.2821	0.4241

Source: Matlab 2019

During the full sample period, both Kendall and Spearman measures explore a relatively strong positive relationship for considered pair. These findings imply that when the real exchange rate misalignment rises, current account deficit should be seen growing.

To summarize, based on the rank correlation results during the full sample period, we can conclude that current account balance moves in opposite direction to fluctuations of exchange rate misalignment.

In some cases, Kendall and Spearman coefficients diverge with Pearson correlation. The reason is that the linear correlation studies linearity whereas the rank correlation overcomes this restriction. In our case coefficients are convergent and lead to the same interpretation. However, these results are insufficient until we select the best fitting copulas to our data.

C-Fitting copula

Our series are exposed to autocorrelations and ARCH effects. For that, for each series a AR(1)-GJR-GARCH (1,1) process is fitted. Standardized residuals are obtained from this filtration and then are transformed into uniform variables by using ECDF. As a final step, we employ the Canonical Maximum Likelihood (CML) method to estimate the parameter of different copulas.

Table 29: CML estimation of copulas parameters

	Gaussian	Student-t		Gumbel	Clayton	Frank
	ρ	ρ	v	Θ	θ	θ
Mis-CAD	0.1362	0.1309	197.1534	0.9386	0.6972	1.7646

Source: Matlab 2019

Table summarizes the estimated parameters of the studied copulas. By examining the Elliptical copulas, the dependence parameter of the Gaussian and Student-t copulas is positive for the considered pair.

Concerning the Archimedean copulas, we remark that both of Clayton and Gumbel copulas exhibit also a positive dependence parameter, which means that there is a positive relationship between Mis and CAD.

Given that the studied copulas provide different average and tail dependence characteristics, it is essential for us to select the most adequate copula to be able to test our hypothesis regarding the role that may play the exchange rate variability on the current account balance.

D-Copula selection

We select the copula that maximizes the log likelihood (LL) values and minimizes the AIC and BIC criterions. Results of the tables reported bellow show that for the considered pair, the Student-t copula yields the smallest values of the information criteria AIC and BIC and the highest values of the LL. Therefore, the Student-t copula is the best copula to describe the most adequately the dependence structure between Mis/CAD.

Table 30: Results for the LL, AIC and BIC for the Elliptical copulas

	Gaussian			Student-t		
	LL	**AIC**	**BIC**	**LL**	**AIC**	**BIC**
Mis-CAD	-1.4411	-0.8823	0.7813	$+\infty$	$-\infty$	$-\infty$

Source: Matlab 2019

Table 31: Results for the LL, AIC and BIC for the Archimedean copulas

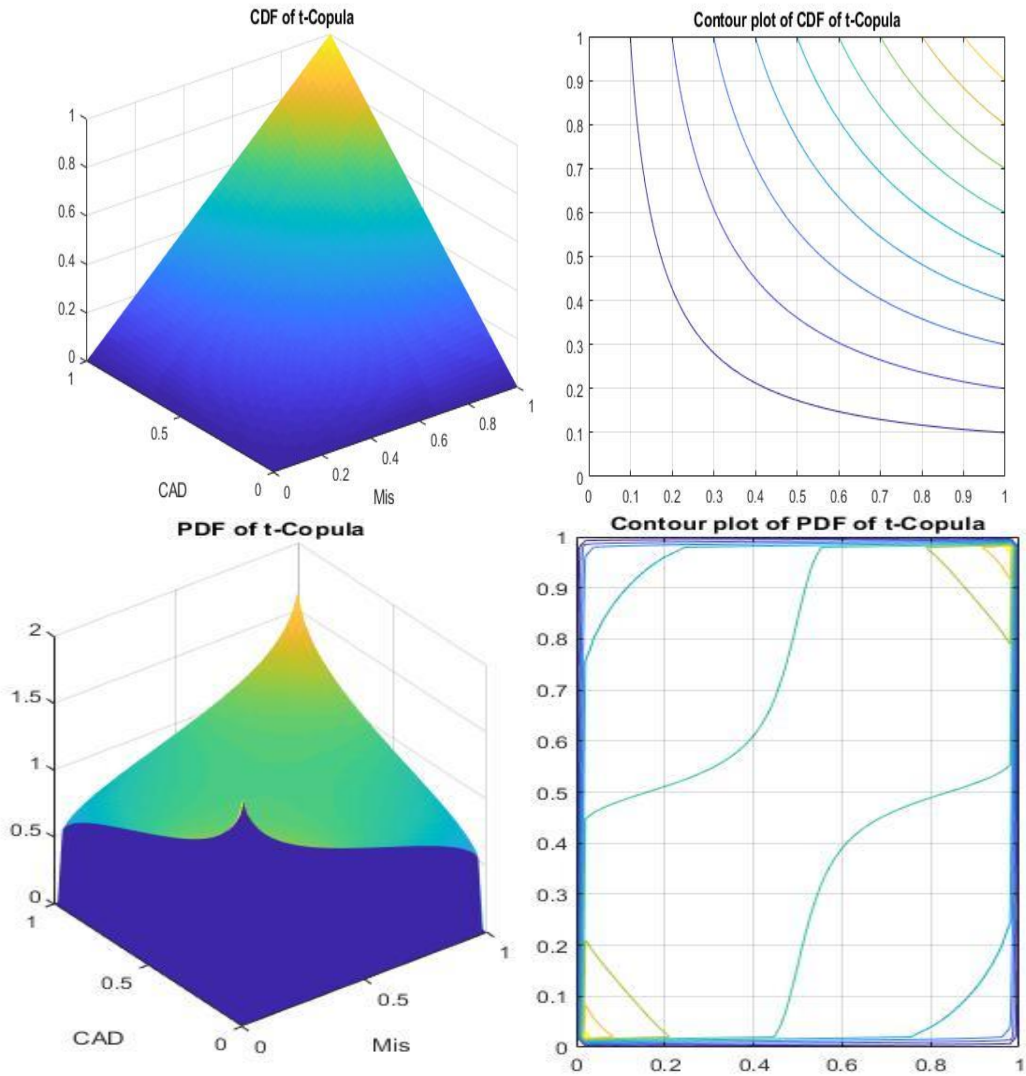
	Gumbel			Clayton			Frank		
	LL	**AIC**	**BIC**	**LL**	**AIC**	**BIC**	**LL**	**AIC**	**BIC**
Mis-CAD	-1.9885	-1.9769	-0.3134	-3.5446	-5.0893	-3.4257	-1.5665	-1.1330	0.5306

Source: Matlab 2019

To sum up, REER misalignment contributes to greater current account deficit.

In figure 18, we present the PDF and the CDF of the student-t copula or (t-copula) with their contour plots.

Figure 18 : PDF and CDF of t-Copula of the pair Mis-CAD



Source: Matlab 2019

1-2-5-Bivariate dependence analyses in extreme market movements

We shift our concern to investigate whether studied period has an influence on our previous findings. To this end, we tend to analyze the dependence structure between Mis/CAD in times of extreme market movements obtained from the tail dependence coefficients of the selected student-t copula.

Table 32: Tail dependence coefficients of the student t-copula

	λ_L	λ_U
Mis-CAD	0	0

Source: Matlab 2019

In table 32, we explore the results of the upper and the lower tail dependence between the considered pair respectively $\boldsymbol{\lambda_U}$ *and* $\boldsymbol{\lambda_L}$. As we can see, the student-t copula allows for symmetric upper and lower tail dependence, indicating similar dependence in bear as well as bull markets.

In line with these results, the values of tail coefficients; equal to zero, suggesting that there is no tail dependence between our variables, consequently, there is no effect of exchange rate misalignment on the current account balance neither during bearish nor bullish periods.

These findings appear to be illogical and contradictory with the evidence in the literature. Therefore, we will further refine our results by taking two extraordinary sub-periods namely the global financial crisis (GFC) and Tunisian revolution (TR).

A-The GFC andTR periods analysis

In this part we focus on the periods of sub-prime crisis and Tunisian revolution that dates respectively from2007 to 2010 and from 2011 to 2014.

Table33: Rank correlation (TR period)

	Pearson
Mis-CAD (TR)	-0.0222
Mis-CAD (GFC)	0.5565

Source: Matlab 2019

In **Table 34** we present the Kendall and Spearman correlation coefficients.

Table34: Rank correlation (TR period)

	Kendall	Spearman
Mis-CAD (TR)	0	-0.2
Mis-CAD (GFC)	0.6667	0.8

Source: Matlab 2019

Comparing the correlation during the crisis period and the full sample period, we observe some differences. In one hand, the correlation given by Spearman in TR is negative whereas Kendall show an independence between our main series during the second sub-period. In the other hand, concerning the GFC period the correlation remains positive for the pair, means that Mis positively impact the CAD even during that crisis period butthe co-movement was substantially higher than during the full sample period.

Then, we re-estimate the copula parameters during the GFC and TR periods in order we compute the tail dependence for each pair of variables based on the selected copula.

Table 35reports the parameters estimates of the different copulas models.

Table 35: CML estimation of copulas parameters (GFC and TR periods)

	Gaussian	Student-t		Gumbel	Clayton	Frank
	P	P	v	Θ	θ	Θ
Mis-CAD (TR)	0.9289	0.7850	0.5029	8.7870	0	2.8567
(GFC)	0.0070	0.0082	197.1535	1.4079	0.0133	0.3635

Source: Matlab 2019

Similarly to the analysis during the full sample period, after estimating the different copulas models we need to select the best fitting copulas based on the information criteria (LL, AIC and BIC). The results are contained in **Table 36.**

Table 36: Results of the LL, AIC and BIC for the Gaussian and Student-t copula (GFC and TR periods)

	Gaussian			Student-t		
Mis-CAD	**LL**	**AIC**	**BIC**	**LL**	**AIC**	**BIC**
(TR)	-33.1284	-64.2567	-64.8704	36.4299	-70.8597	-71.4734
(GFC)	-0.0032	1.9936	1.3799	$+\infty$	$-\infty$	$-\infty$

Source: Matlab 2019

Table 37: Results of the LL, AIC and BIC for the Frank, Clayton and Gumbel copulas (TR and GFC period)

	Gumbel			Clayton			Frank		
	LL	**AIC**	**BIC**	**LL**	**AIC**	**BIC**	**LL**	**AIC**	**BIC**
Mis-CAD	-2.6569	-3.3139	-3.9276	-3.1300	-4.2600	-4.8737	-35.9759	-69.9517	-70.5655
	-0.1706	1.6588	1.0451	-4.7342	-7.4685	-8.0822	-36.8729	-71.7458	-72.3595

Source: Matlab 2019

From the results shown in **Table 37**, the Student-t is the best fitting copula for the two sub-periods.

After selecting the adequate copulas, we move to computing the tail dependence parameters of Mis/CAD during each sub-period. The results for the tail dependencies for the different copulas are provided in **Table 38**

Table 38: Tail dependence (TR and GFC period)

	λ_L	λ_U
Mis-CAD (TR)	0	0
Mis-CAD (GFC)	0.5986	0.5986

Source: Matlab 2019

Hence, during the GFC period, a negative or positive shock leads the exchange rate misalignment to cause downward movement in current account balance. However, these results show that there is no co-movement between Mis and CAD during the post-revolution time if any shock happens.

SECTION 2: CONCLUSION AND POLICY IMPLICATIONS

While Pearson correlation shows an acceptable coefficient of 0.3352, the rank correlation, whichovercomes the linearity restriction, explores a relatively strong positive relationship (0.4241) for considered pair. Consequently, when the real exchange rate misalignment rises, current account deficit should be seen growing. In other words, we can conclude that current account balance moves in opposite direction to exchange rate misalignment level.

Seeing that our series are exposed to autocorrelations and ARCH effects, an AR-GJR-GARCH (1,1) process is fitted for both. Then and based on information criteria, the Student-t copula is found the best to describe the most adequately the dependence structure Mis/CAD.

According to Student-t copula's estimation, the correlation is also positive and relatively strong meaning that REER misalignment contributes to greater current account deficit.

Consistent with theoretical predictions and prior studies, the economic malaise facing Tunisia particularly over the last decade as well as large persistent deficit in the CA can be seen as indicative of possible misalignment in the real exchange rate.

In an attempt to explain that link, we can firstly discuss the effect of the exchange rate regime in place on such a relationship. As a matter of fact, Tunisia has adopted various exchange rate policies since the collapse of the Bretton Woods system in order to maintain or improve its competitiveness. Such an aim, however, only began to be achieved when it initiated the liberalization of the dinar exchange rate. A more flexible exchange rate system is therefore advisable for Tunisia. This is particularly needed given the ongoing context of Tunisia's trade opening. Indeed, since January 2008, free trade area has been established between Tunisia and the European Union and customs duties on imports have been abolished, which should lead to an increase in imports, but since exports failed to follow, through an insufficiently competitive and flexible exchange rate, significant current account imbalance has resulted.

One more key advantage of floating exchange rates as proved by **Engel 2002**, is that such a regime allows to face more easily current-account imbalances through a rapid change in relative prices between countries. Consequently, exchange-rate flexibility would be effective in absorbing current account deficit.

Nevertheless, absolute flexibility is also not advisable. Indeed, given the persistent deficit in CA, reversion to equilibrium often requires important costs from an economic viewpoint and this is particularly acute when adjustment by (nominal) exchange rates is not operational.

Apart from dependence in average, we have proceeded to analyze the dependence structure between Mis/CAD in times of extreme market movements obtained from the tail dependence coefficients. Results indicates similar independence in bear and bull market conditions. Such illogical finding inspired us to focus on the periods of sub-prime crisis and post-Tunisian revolution period which correspond respectively to an undervaluation and an overvaluation of the dinar.

Our main findings are given as follows:

During global financial crisis:

- ✓ Linear (0.5565) and Rank (0.66 and 0.8) correlations remain positive and the co-movement is substantially higher than during the full sample period.
- ✓ Estimated copula indicates a weak positive coefficient relative to average dependence (0.007) but a strong one for the dependence in times of extreme movements (0.5986).

Well then, during the global financial crisis, the dependence structure between Mis and CAD is stronger. Also, causality link from REER misalignment to current account deficit is greater except for times of market stress or turmoil. That means that a more depreciated dinar in that time has exerted only an indirect negative effect on the current account balance. This evidence support the idea that: On the one hand the GFC was not an effective exchange crisis but still vulnerable to have an impact on Mis/CAD link if combined with an exogenous shock whatever its direction. In the Other hand, Tunisian economy is open to world trade. And therefore, internal and external balances cannot be protected from external shocks.

Accordingly, the Tunisian current account deficit in that epoch, which reached 1,23 Billion current USD in 2009 against 0,29 in 2005, was certainly not only due to exchange rate undervaluation. It was probably amplified by other economic structural factors.

Prominent among these latter are the difficulties in public financial management since then which have led to excessive external debt justified by the lack of the State's own resources. This situation has been aggravated by the low growth rate and growing REER misalignment, thus deepening external imbalances.

In addition, Tunisia’s export concentration matters since it couldn't benefit from the competitive dinar due to the limited range of products intended for export. Therefore, export diversification would also offer the opportunity to take advantage of undervaluation phases by having more dynamic economic structure.

During Tunisian Revolution:

- ✓ Negative coefficients manifest from linear and rank correlation.
- ✓ The Student-t copula's estimation results indicates a strong positive dependence on average interlinking both of Mis and CAD (0.785)
- ✓ Added to that, we find upper and lower tail independence.

In brief, the overvalued REER during post-revolution period has directly and considerably impacted the current account balance.

These findings are consistent with **Rajan, R. S., Sen, R., & Siregar, R. Y. (2004)**'s studies who show that one of the important triggers that caused CAD in Thailand was the overvalued baht.

A possible explanation of these results may be that when MIS takes the form of domestic currency overvaluation, it lowers profitability in the industries in which relative prices are reduced and thus hurting tradable activities. Then, if export-oriented goods are uncompetitively priced due to the overvalued dinar, a current account crisis may ensue, especially since external demand for local goods in Tunisia is highly price elastic.

Moreover, the overvaluation lead to a systematic deterioration of the current account, especially when internal adjustment measures (such as wage compression) are not set up to correct the loss of competitiveness. That was exactly our case.

Obviously, in order to overcome deficit in CA Tunisian authorities has proceeded to devaluation whenever it deemed necessary. Hence, it is presumed that such a devaluation would initially tend to reduce the foreign prices of exports in proportion to the devaluation size. At these reduced prices, foreign demand for Tunisian exports would be increased[34], thus tending to bid up the foreign prices of exports part-way back toward their predevaluation levels. Similarly, on the import side, the initial effect of the devaluation is to raise the domestic price of imports, presumably leading to some reduction in the country's demand for imports. Consequently, trade balance deficit decreases and current account follows in turn. **(Sidney S. Alexander)**.

However, although the dinar has significantly felt the current account has only recorded a poor adjustment.

[34] Since a depreciation results in the appreciation of other currencies, there will be an expansion of activity among Tunisia's trading partners, with a positive feedback effect on demand for Tunisian exports.

Explanation for this result can be summed up as follow: First of all, it needs time for depreciation to take effect. Second, the exchange rate changes pass-through to export prices in case of Tunisia is relatively small compared with other countries. Thirdly, depending on the degree to which a fall in the dinar will push up Tunisia's inflation, monetary policy have to react and interest rates will rise, The resulting increase in the real interest rate of consumption implies that the price of present consumption will be relatively higher than that of future consumption. In this case, agents postpone part of consumption while increasing their savings. That suppose an improvement of the current account. But, the Tunisian behavior often seems to be inelastic to consumption prices. Thereby, no noticeable improvement in the current account is observed as a result of a restrictive monetary policy intervention.

Moreover, despite the improvement in the trade balance, the increase in interest payments on foreign debt due to more depreciated dinar argues the poor or the non-improvement of the current account adjustment.

Eventually, in economies where inflationary expectations are not well anchored, it is difficult to achieve sustained depreciation of the real exchange rate, because the nominal depreciation will be offset by higher inflation than its trading partners.

Even in the case of devaluation, there may be other factors that need to be taken into account for that action to be effective in absorbing the current account deficit. For instance, international experiences regarding the link between the exchange rate and the current account balance has shown that there is no typical standard effect. In some cases, a sharp depreciation in the exchange rate put end to the current account deficit. In Canada, for example, after the real effective exchange rate fell by about 25% in the 1990s, the current account balance moved from a persistent deficit to a surplus of about 2%.

Similarly, in Sweden, with the decline in the REER of more than 20% after 1992, the current account balance moved from a deficit of more than 3% of GDP to a surplus of about 4%. But we should mention that during the same period, both governments undertook substantial fiscal reforms, which may also have affected the external balance. Furthermore, the rise in public expenditure generates an increase in domestic demand, partly covered by imports, leading to a deterioration in the current account balance.

CONCLUSION

In Tunisia, concerns about real exchange rate misalignments have prevailed for some time given the countries' high unemployment, stagnating global export shares and low export diversification.

Moreover, during the last two decades, Tunisia has undertaken several reforms in the conduct of monetary and exchange rate policy. These reforms have generated a growing interest in assessing the performance of exchange rate policy and modelling the determinants of the dinar exchange rate. Most of the existing literature has focused on the estimation of the equilibrium exchange rate and on the valuation of its misalignment relative to this equilibrium.

On the other hand, the persistent current account deficit in Tunisia, especially during the last decade, brought us to study the real exchange rate misalignment impact on the current account balance.

In this essay, we attempt to focus on we have devoted our work into two main parts.

In the first part, we focused on REER misalignments. While there are many ways to calculate the equilibrium REER, we have chosen the most recommended method for the case of Tunisia namely the BEER methodology.

The results estimation of this model were reasonable because, in general, almost of all the coefficients had their expected theoretical sign and were statistically significant.

Our finding indicates that Tunisia's real effective exchange rate was alternating between over and undervaluation periods with critical episodes of high misalignment (1982-1985, 1988-1990, 2006-2008 and 2015).

Despite undervaluation seems beneficial for exports and growth, it should remain at a reasonable level so as not to shake the confidence of private investors owing to inflationary pressures, which could hurt exports and growth. Similarly, overvaluation has led to a significant loss of competitiveness.

In the second part, we were seeking mainly to have a to study empirically the dependence structure between the current account balance and the real exchange rate misalignment in Tunisia, by applying a bivariate copula model. This theory describes with flexibility the dependence and the causal link from REER misalignment to CA. on average and extreme movements (bullish and bearish market conditions).

Our findings suggest that the real exchange-rate misalignments affect the current-account gap differently, depending on the sign and size of the exchange-rate deviation from its equilibrium value.

In brief, while Most of previous studies find that the adjustment of the current account is associated with a real depreciation of the exchange rate, we find that the REER misalignment have negative and asymmetric impact on the current account. While overvaluation of the dinar deteriorates the current account, undervaluation does not improve it.

Finally, we highlight that despite authorities' interventions regarding exchange rate, Tunisia have experienced very deep and persistent current account deficit during the full sample period. Hence, export concentration, Inflationary pressures, weak economic growth not allowing for employment creation, large macroeconomic imbalances, limited resources and wage pressures as well as government's inability to manage its public debt exacerbate the impact of misalignment on the current account.

To ameliorate our findings, we propose the following suggestions for further research. First, we may improve our results by including other fundamentals for the equilibrium REER estimate.

Second, we may extend our analysis to the other developing countries in order to led comparisons with Tunisian case.

And finally, for sharper results, it is advisable to include various current account subsets and use a multivariate Vine-Copula model.

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