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The misalignment of real effective exchange rate: Evidence from Tunisia

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Abstract

This paper presents an estimation of the Tunisian equilibrium exchange rate based on the Behavioral Equilibrium Exchange Rate approach (BEER). The BEER framework links exchange rates to its fundamentals: Tunisian productivity, partners' productivity, trade openness and terms of trade. We calculate the distortion between the observed Real Exchange Rate (RER) and the equilibrium rate, and the misalignments related thereto. Vector autoregressive models and vector error correction models are applied to characterize the joint dynamics of variables in the long run, using quarterly data over the period 1990-2020.We find that this period was marked by phases of overvaluation and undervaluation of the RER. The empirical results indicate a low sensitivity of the RER to monetary and trade shocks. Indeed, the error correction mechanism on the one hand confirms one of the convergences of the real exchange rate series of its trajectory to its long-term target value. On the other hand, it reflects the success of monetary and commercial policies exploited to absorb unpredictable shocks capable of preventing the stability of real exchange rate from its equilibrium value.

Keywords: Equilibrium exchange rate; Misalignment; BEER approach; Error correction model.

JEL: C32, F31, O55.

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1. Introduction

Effective exchange rates are an important measure of how a country's exchange rate changes in relation to its trading partners, which allows for a broad interpretation of a country's price competitiveness. This competitiveness is in turn a major determinant of a country's ability to increase productivity, stimulate innovation, and improve the country's economic performance. The real exchange rate is a key variable for the conduct of economic policy in developing countries. This variable not only represents a main variable in the conduct and implementation of economic policies (particularly monetary and exchange rate policies) but also reflects the stance of the economy (growth, external balance, etc.).

The analysis of exchange rate behavior has been a perennial topic in international monetary economics. The Tunisian real effective exchange rate (REER) is considered as one of the relevant determinants that evaluates price competitiveness at the micro level to the macro level. This paper aims to extend the existing discussion of the literature by estimating the equilibrium real exchange rate for Tunisia in terms of certain fundamental variables to evaluate the exchange rate policy in Tunisia over a given period.

One strand of this literature relates to the explanation of observed movements in nominal and real exchange rates in terms of relevant economic variables. A different strand focuses on assessing exchange rates relative to economic fundamentals and coming to a judgment as to whether a particular exchange rate is misaligned, i.e., over- or undervalued. Assessing whether the overall external position, including exchange rates, is in line with fundamentals is a key mandate of the IMF, informing country-specific analysis of Article IV Staff Reports and supporting multilateral surveillance (IMF, 2007). In this context, assessing the degree of misalignment in real effective exchange rates (REERs)—or the extent to which REERs deviate from some notion of their equilibrium level—can provide information on the currency/price movements necessary to correct (excessive) external imbalances.

The review of the theoretical as well as the empirical literature shows that real exchange rate imbalances may be regarded as a primary source of a country's economic vulnerability. Indeed, the persistence of the deviation of the real exchange rate from its equilibrium value results in or reflects a deterioration of the economic situation. An undervaluation of the exchange rate is a main element of price competitiveness, which is reflected by recurring devaluations and can ultimately trigger "currency wars". Symmetrically, depreciation (or devaluation in fixed parities) increases the price of imports but promotes price competitiveness by lowering the price of exports and should therefore improve the balance of the goods and services account by causing a shift in foreign and domestic demand towards national property.

Assessing the equilibrium levels of exchange rates is an important responsibility of macroeconomic policymakers. Exchange rates have a major influence on the prices faced by consumers and producers throughout the world, and the consequences of substantial misalignments can be extremely costly. The currency crises experienced by several emerging-market economies over the past decade testify to the large output contractions and extensive economic hardship that can be suffered when exchange rates become badly misaligned and subsequently change abruptly. Moreover, there is reasonably strong evidence that the alignment of exchange rates has a critical influence on the rate of growth of per capita output in low income countries[1].

[1]Hakan Kara &CagriSarikaya, 2013. "Turkiyeï¿½de KonjonkturelEtkilerdenArindirilmis Cari IslemlerDengesi," Working Papers 1340, Research and Monetary Policy Department, Central Bank of the Republic of Turkey.

The assessment of equilibrium values of the RER has consistently been a prominently discussed issue in international macroeconomics and has in the current context of global imbalances regained extensive attention in the literature. Indeed, since the mid-1990s – the beginning of a period characterized by the increase of imbalances of emerging countries relative to global total imbalances – the accelerating international financial integration process has engendered a growing disconnection between RER variability and growth (Béreau et al. 2009). A large literature has highlighted the importance of closely observing the exchange rate for countries in transition such as Tunisia, and that it may also be used as a regulatory to mitigate, if not eliminate, the adverse effects of an overvalued exchange rate.

Since 1990, the Central Bank of Tunisia opted for a flexible exchange rate policy accompanied by advanced liberalization in Tunisia, aimed at giving exchange rate policy a more active role. The objective sought was to improve the competitiveness of the national economy while stabilizing the Tunisian dinar. The economic malaise faced by the country from 2011onwards, as observed in a deterioration of Tunisian economic conditions, a slower economic growth and large current account deficits may indicate a possible misalignment in the RER. Given the seriousness of the consequences of a potential misalignment on the economy, the Tunisian monetary authorities must therefore prioritize and analyze the question of how to determine the misalignment of the Tunisian REER which ultimately affects the choices made by policy makers in economics and trade policies.

In summary, the purpose of this article is to contribute to the existing literature by examining the long and short term dynamics of the REER in terms of certain fundamental variables in order to evaluate the exchange rate policy in Tunisia applied to quarterly data (1990-2020) for Tunisia. The use of the co-integration technique by the adoption of a vector error correction model (VECM) model based on a BEER approach, allows us to calculate the equilibrium real exchange rate and compare it to the observed rate. The difference is then used to measure the actual misalignment. The results obtained highlight the existence of a significant correlation of the real exchange rate with its economic fundamentals. The study period was marked by phases of overvaluation and undervaluation of the RER with different amplitudes strongly linked to the economic environment in Tunisia.

The outline of the remainder of this paper is as follows. In the next section, we briefly review the literature of the equilibrium exchange rate approaches and its principal determinants. In Section 3, we discuss our data set and, specifically, its construction. Our methodology is sketched in Section 4. The results in which we calculate the equilibrium exchange rate and its misalignment are presented in Section 5. In Section 6, we test the robustness of our results. Some concluding remarks are drawn in Section 7.

2. Theoretical literature

2.1. Equilibrium exchange rate approaches

Before conducting any estimation of the equilibrium exchange rate, it is important to examine different approaches, with which the exchange rate can be modeled. The effectiveness of the real exchange rate as an instrument of economic analysis is subordinated to the knowledge of its equilibrium level: without this reference, the notion of under- or overvaluation of a currency would have little meaning. The equilibrium exchange rate is generally defined as the exchange rate that would prevail when internal and external balances are achieved.

The domestic equilibrium is generally defined as real growth maintained at its potential long-term rate and an unemployment rate at its irreducible level, while the external equilibrium corresponds to the equilibrium of the balance of payments.

The effective exchange rate misalignment is defined as the deviation of the real effective exchange rate from its equilibrium level. An overvaluation of a currency was often shown to be a source of loss of external competitiveness especially in developing countries such as Tunisia where the external demand for domestic products is very price elastic. This loss of competitiveness can generate a fall of exports and a deceleration of economic growth. The difference between the observed real exchange rate and its equilibrium value is an important variable in economic policies and determines whether a country can meet the demands of growth and to prevent the onset of financial and currency crises. Its calculation is one of the most debated questions of open economy macroeconomics.

Economists have developed various methods for assessing equilibrium exchange rates. Each method involves conceptual simplifications and/or imprecise estimates of key parameters; different methods consequently generate different quantitative estimates for the equilibrium exchange rates. This makes it difficult to put extensive confidence in estimates derived from any single methodology on its own. Therefore, policymakers must conduct several different methodologies when assessing equilibrium exchange rates. (Driver and Westaway, 2004): “what matters when choosing between different equilibrium concepts (and the models that have been used to represent them) is their relevance to the question in hand.”

In fact, in the 1980s, a consensus emerged agreeing on the importance of the correct alignment of the real exchange rate and its stability as one of the determining factors in the process of economic development (Williamson, 1996). This observation becomes even more important whenever we speak of the prerequisites for economic recovery. It also emerges as an irrevocable necessity for economies being at a rather early stage of the emergence process, such as Tunisia, to assess the equilibrium level of their exchange rate and avoid deviations and competitiveness bias.

The performance and estimation of real exchange rates has extensively been discussed in the literature, including the work of (Rogoff, 1996), (Edwards, 1989), (Hinkle and Montiel, 1999), (Coudert, 1999), (Edwards and Savastano, 2000), and (MacDonald and Wójcik, 2004). These approaches can be divided into two streams:

The first, which is the oldest, the best known and the most empirically tested, is the famous purchasing power parity, which has been subject to numerous theoretical reviews and econometric tests (Froot and Rogoff, 1995); (Sarno and Taylor, 2002). 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". This is extended to a theory of exchange rate determination by introducing assumptions about the behavior of importers and exporters in response to changes in the relative costs of national market baskets. The PPP theory states that monetary policy does not influence the real exchange rate in the long run. Thus, countries with different inflation rates should expect their bilateral exchange rates to adjust to offset these differences over the long run. In response to real shocks, however, the exchange rate may deviate persistently from its target level in the long run. This version of the PPP is no longer valid because the real exchange rate can be linked to different economic fundamentals.

These criticisms have led economists to look for alternative models of the equilibrium RER that contribute to more efficient policy analysis. The non-stationarity of real exchange rates and the slow pace of convergence toward the PPP-projected equilibrium path have been the main underlying factors behind the design and elaboration of new approaches to identify shorter-term equilibriums of the exchange rate.

The second, more recent trend concerns equilibrium real exchange rates in more macroeconomic terms. New theories determine the equilibrium real effective exchange rate based on economic fundamentals that have an impact on the value of the equilibrium exchange rate. To overcome the deficiencies of an indicator-based approach, it is necessary to relate the discussion and analysis of exchange rates more directly to the notion of a sustainable or equilibrium exchange rate. Originally developed by the IMF (IMF 1984); (Clark, Bartoloni, Bayoumi, and Symansky, 1994), these approaches were popularized by the admittedly normative work of Williamson's Fundamental Equilibrium Exchange Rate (1983, 1994). Since then, they have diversified according to different theoretical streams. Among these streams are Stein and Allen's Natural Real Exchange Rate (1997) (NATREX) and the BEER developed by (Clark and MacDonald, 1998).

To determine the misalignment of the real effective exchange rate of Tunisia, we opted for the BEER. The BEER approach estimates directly the structural (long-run) relationship between relevant economic fundamentals and the real equilibrium exchange rate and interprets it as the equilibrium relationship. It searches for a statistically significant relationship between the variables (e.g., productivity differentials, net foreign assets, terms of trade, etc.) and the real exchange rate without specifying the structure that the relationship should take. The BEER approach is less rigorous but allows the analysis to be tailored to country-specific circumstances (Al Shehabi and Ding, 2008). In the spirit of (Clark and MacDonald, 1998), we specifically account for the structural determinants of RER. In the empirical literature, there is no consensus on the exchange rate fundamentals that precisely determine the equilibrium real exchange rate (ERER). In the next section, we provide an overview of the most explanatory variables employed in recent BEER model studies.

2.2. Real exchange rate determinants

Recent abrupt and large changes in many major and emerging market real exchange rates have served to re-emphasize the importance of a thorough understanding of the relationship between exchange rates and their fundamental determinants. Empirical studies differ on the choice of economic fundamentals that drive the exchange rate in the long run. The literature has extensively the most plausible choice of fundamentals and the expected sign and magnitude of the parameters (for a comprehensive literature review see (Fidora et al., 2017). In most writings, it is taken for granted that the rise of per-capita GDP (GDP) leads to an appreciation of the real exchange rate. Another popular explanation for long-run trends in equilibrium real exchange rates emphasizes the role of net foreign assets (NFA). The third most used explanatory variable in BEER regressions is the terms of trade (TOT). For this study, the variables that enter the model were selected based on economic theory, the empirical literature, and data availability are used to determine exchange rate movements in Tunisia. For our work, the following variables were entered into the final long-run REER model. The fundamentals retained in our model were chosen based on theoretical analysis and data availability.

2.2.1. Terms of Trade

Terms of trade epitomize a channel for the transmission of global macroeconomic shocks to the local economy. The terms of trade are defined as the ratio of country export prices to import prices and might affect the real exchange rate in several different and conflicting ways, which can generally be divided into an income effect and a substitution effect. An increase in terms of trade, caused for example by higher export prices, boosts domestic income and spending on both types of products. This creates greater demand, which causes appreciation if some of it is spent in the non-tradable sector. The effect of the terms of trade on the REER occurs through the income and substitution effects, with the net impact depending on the relative strength of both factors since they work in opposite directions (Aliyu, 2007). If the income effect outweighs the substitution effect, then an improvement in terms of trade will generate an appreciation in the RER (Domaç and Shabsigh, 1999); (AlShehabi and Ding, 2008). Conversely, deterioration in the terms of trade tends to appreciate the equilibrium RER if the substitution effect is not only positive but also above the income effect. Otherwise, depreciation in the RER will take place. Although theoretically important as a determinant of the REER, the direction of the impact of terms of trade on the exchange rate remains unclear.

2.2.2. Trade Opening

Calculated as the sum of exports plus imports divided by GDP, the extent to which the country is connected to the rest of the world is measured and can be regarded as an approximation the level of trade liberalization. The degree of trade openness may be relevant to a country's real exchange rate, but the direction is unclear a priori. On the one hand, a tariff reduction can decrease the domestic prices of imports. This will generate a decline in prices of tradable goods, and therefore creates an appreciation of the RER. There is a large literature pointing to the beneficial impact of trade openness on productivity and growth. Greater competition from abroad can spur domestic innovation and efficiencies, with positive spillovers for wages and prices in the non-tradable sector. However, on the other hand, greater trade liberalization leads to a depreciation of the RER; since it allows for increased trade and price convergence (Goldfajn and Valdes, 1999).Trade liberalization could therefore lead to real depreciation due to foreign competition in the tradable sector.

2.2.3. Productivity

While the effect of monetary and financial fundamentals on the exchange rate continues to remain an elusive topic for research, the effect of productivity on the real exchange rate has long been viewed as a reasonably stable axis, at least in the long run. The relevant literature has been marked by voluminous empirical research which indicates that one of the most common explanations for real exchange rate movements is the Balassa-Samuelson effect, which highlights the link between productivity in the tradable sector and real appreciation. Earlier papers include the original paper of (Balassa, 1964), and those of (Officer, 1976), (Hsiesh, 1982), and (Marston, 1987).The impact of the productivity differential on the real exchange rate is expected to follow the well-known Balassa-Samuelson doctrine, which states that relatively larger increases in productivity in the traded goods sector are associated with a real appreciation of the currency of a country. If a country experiences an increase in the productivity of the tradable sector (relative to its trading partners), its real exchange rate would tend to appreciate, because the productivity gains would push up the wages in the tradable sector, which would lead to a demand-driven faster increase in the price of non-tradables in the domestic economy relative to its trading partners

(MacDonald and Ricci, 2003). According to (Maeso-Fernandez, Osbat, and Schnatz, 2001) productivity can be measured in two ways; direct and indirect. The direct measure uses ration of total employment to GDP, while the indirect one uses the relative price differential between traded and non-traded goods at home and abroad. It is widely used to simply capture the effect of productivity increases in the traded goods sector.

We have decided to restrict our model to the above four variables for the following reasons. First, our reading of the literature shows that these variables are the most relevant factors influencing long-term movements in real exchange rates. Second, a larger set of variables would constrain the country and time coverage of our sample and hence affect the reliability of the out-of-sample forecasting contest. Third, a larger BEER model would be subject to greater estimation error and hence less likely to deliver competitive forecasts.

3. Data sources and definitions

To highlight the short- and long-term relationship between the real effective exchange rate and its fundamental determinants defined in the previous section, we present, in the following, the variables chosen for the equilibrium exchange rate model. The definitions of the variables and sources of the data are given below.

3.1. Real effective exchange rate:

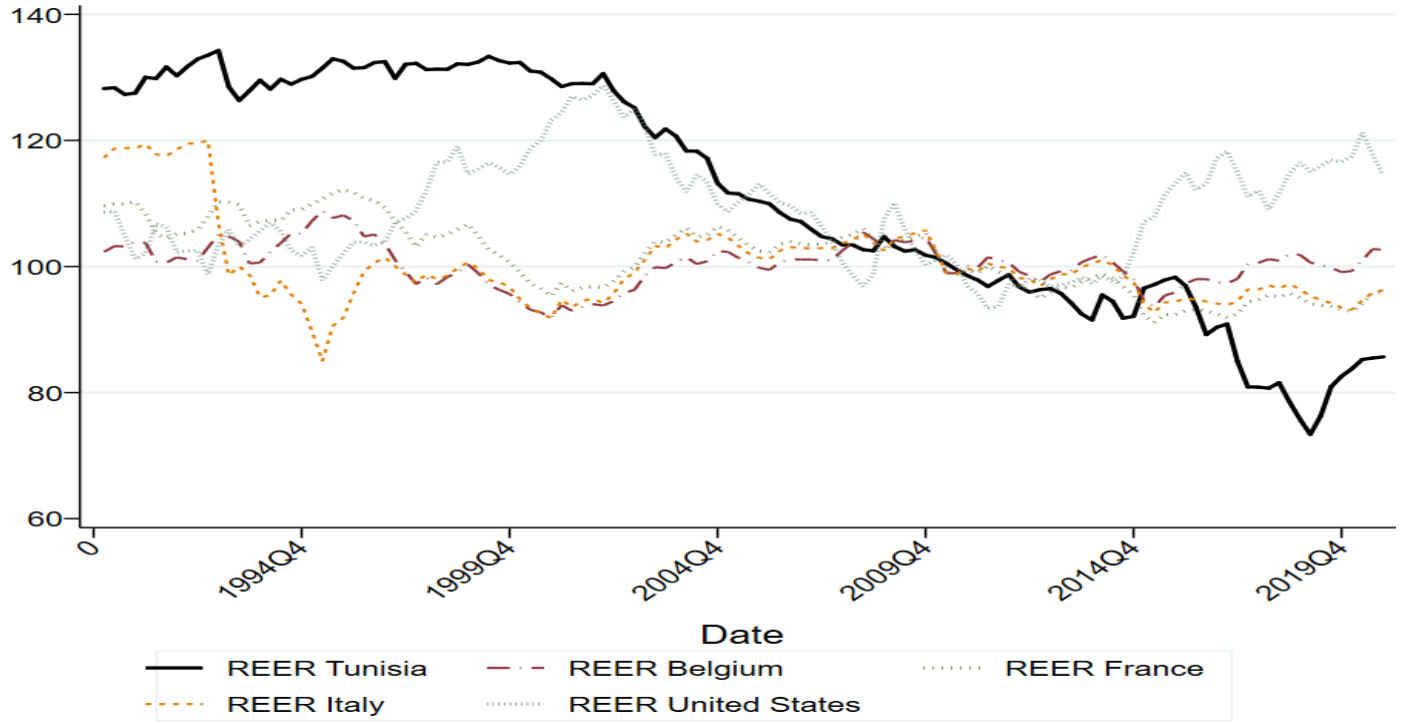
The construction of the real effective exchange rate can be shown as:

$$\boldsymbol{REER} = \sum_i \boldsymbol{\beta}_i \frac{\boldsymbol{EP}_i^*}{\boldsymbol{P}}, \text{ with } \boldsymbol{\beta}_i = \frac{\boldsymbol{X}_i + \boldsymbol{M}_i}{\boldsymbol{X} + \boldsymbol{M}}$$

Where (P_i^*) is the price of foreign country (i) and (β_i) is a trade weigh assigned to each real exchange rate of domestic currency against foreign currency (i).The trade weigh is calculated as the share of trade with country (i) in relation to the overall total trade of domestic economy. X and M denote exports and imports. In general, several currencies from major trading partners, with their total trades making up at least around 75 percent of total trade of the domestic economy, are included in constructing the real effective exchange rate.

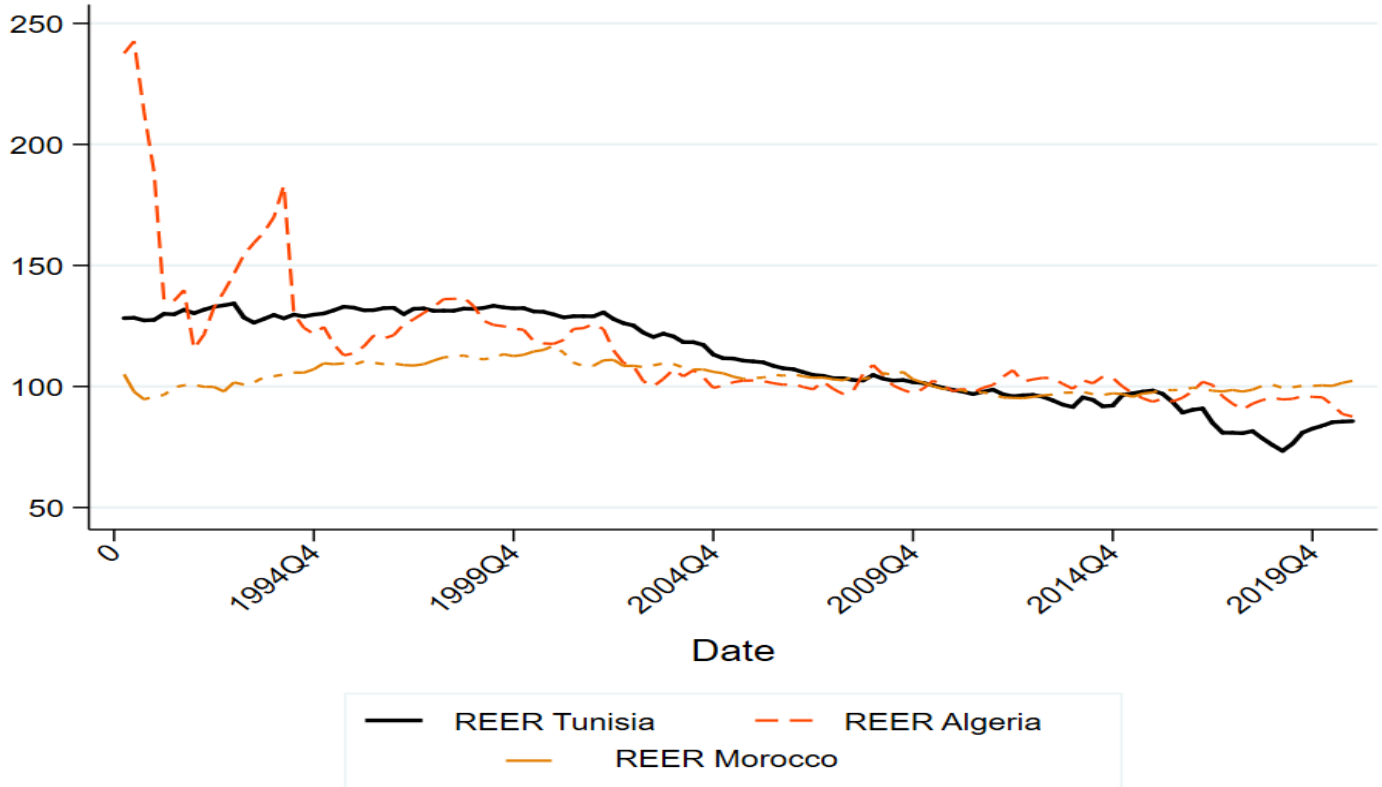
Given the predominance of the dollar and the euro in the Tunisian's international settlements with weights exceeding 70% for both trade and external debt, Chart 1 describes the evolution of the real exchange rate against the currencies of partner's countries especially on the EU market and the USA. The Tunisian RER shows a downward trend since the end of the 90s after a period of targeting of a constant RER. However, the RERs of the economies of the Euro zone are almost stable (not the same case for the USA). To consolidate the competitiveness of the national product on foreign markets, the second graph analyzes the evolution of the exchange rate against the currencies of neighboring countries. The evolution trend of Tunisian and Moroccan RER is similar. However, the Algerian currency experienced high variability in the early 1990s.

Graph1: Evolution of Tunisia's REER compared to its main trading partners



Graph1 represents the evolution of the Tunisian real exchange rate compared to those of its major trading partners. The Tunisian RER shows a downward trend since the end of the 90s after a period of the targeting a constant RER. However, the RERs of the economies of the Euro zone are almost stable (not the same case for the USA).

Graph2: Evolution of Tunisia's REER compared to its neighboring countries



Graph2 represents the evolution of the Tunisian real exchange rate compared to its neighboring countries. The evolution trend of the Tunisian and Moroccan RER is similar. However, the Algerian currency experienced high variability in the early 1990s.

3.2. Explanatory variables

The fundamentals retained in our model were chosen based on theoretical analysis and data availability. The most statistically significant fundamental variables are productivity, terms of trade and trade openness.

- **Terms of trade (LnTOT):** calculated as the ratio of export prices (unit value index) to import prices (unit value index) of Tunisia. They may lead to real appreciation or depreciation depending on the significance of income effects and substitution effects.
- **Openness (LnOpenness):** expressed as the sum of imports and exports relative to GDP. Given that the Tunisian economy is following a policy of trade liberalization, the relationship between openness and RER is expected to be positive.

- **Tunisian Productivity (LnProdTN):** calculated as the ratio of Tunisian GDP to active population. Despite of the mixed evidence in the literature regarding the overall impact of productivity on the REER, one can expect the local productivity to be positive.

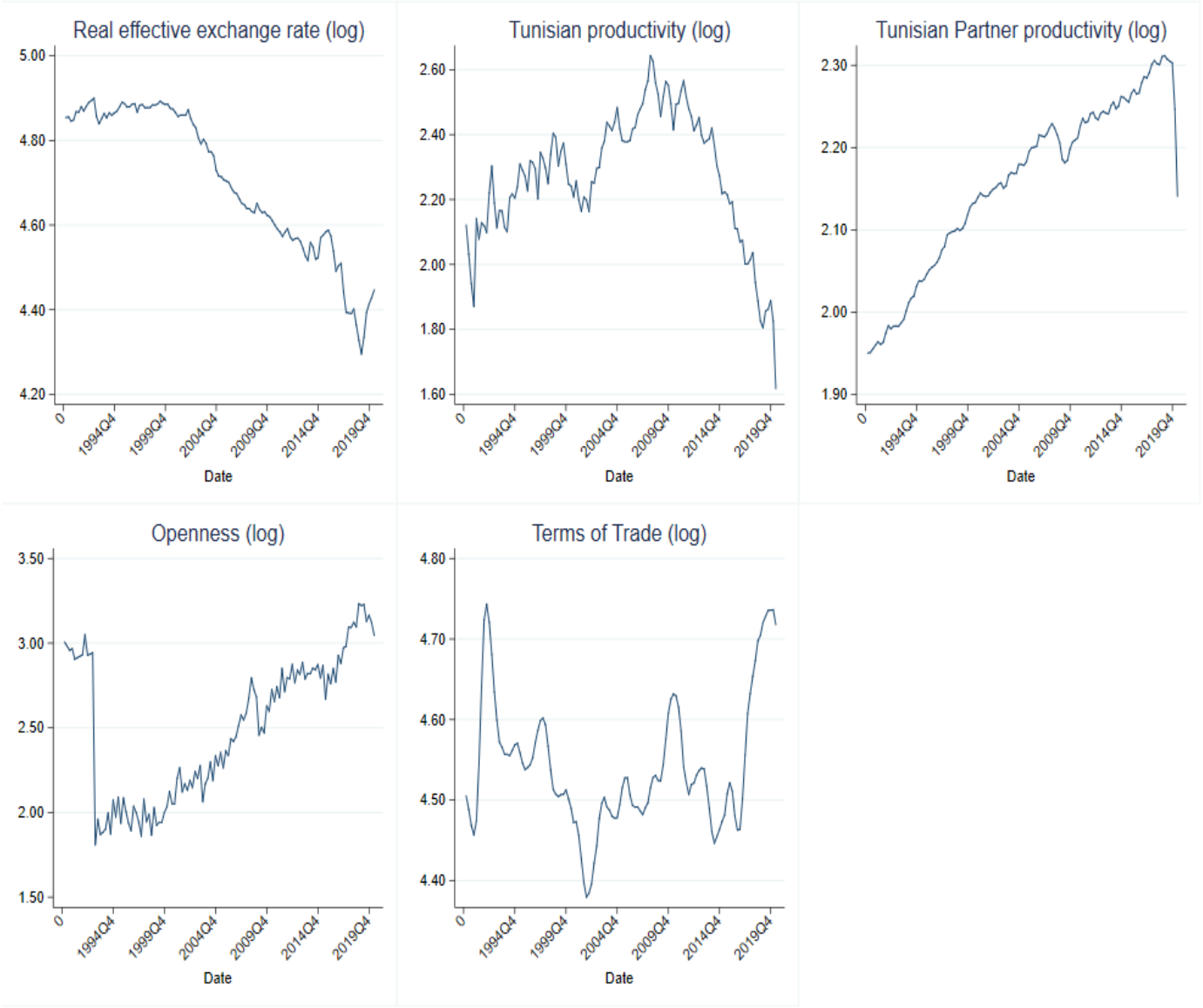
- **Tunisian partners' Productivity (LnProdpartner):** defined as the ratio of GDP to active population of Tunisian's trading partners, weighted according to the considered countries' shares of Tunisian's trade balance. We expected that the sign of the coefficient of this variable to be negative.

Table1. Variables used in our model

Variables	Meaning of the variable used in the model	Source
LREER	The logarithm of the real effective exchange rate (quoted at the uncertain)	IMF's International Financial Statistics (IFS) database
LnTOT	The logarithm of the terms of trade	World Bank database
LnProdTn	The logarithm of Tunisian productivity	GDP and active population retrieved from the World Bank database
LnProdpartner	The logarithm of Tunisian partner productivity	GDP and active population retrieved from the World Bank database
LnOpenness	The logarithm of the degree of trade openness	Import, Export, and GDP retrieved from IMF's International Financial Statistics (IFS) database

In this research, we employ the quarterly data covering the period from 1990 to 2020 to find more detailed evidence on Tunisian dinar misalignment.

Graph3: Graphical description of the variables



Graph3 illustrates the evolution of the different variables used in our model since 1990 namely the REER, the productivity of Tunisia and the productivity of its commercial partners, the terms of trade and the openness rate. These variables are expressed in logarithm. The graphs show a strong economic deterioration since 2011.

4. Methodology:

The Behavioral equilibrium exchange rate involves the direct econometric analysis of a model of the behavior of the real effective exchange rate. We illustrate this approach with the estimation of the equation of the real effective exchange rate for the Tunisian Dinar using cointegration methods. The BEER model uses a set of economic fundamentals to calculate equilibrium real exchange rate, using a single equation, unit root, and cointegration analysis method. Its model construction is simple, it can easily use modern econometric methods, and it can combine relevant economic theory and empirical study to choose economic fundamentals expediently. In the following section, we will explain the BEER methodology used to calculate the equilibrium exchange rate.

4.1. The BEER approach:

The BEER represents one of the latest approaches for determining the equilibrium exchange rate. It was developed by (Clark & MacDonald, 1998) as an alternative to Fundamental Equilibrium Exchange Rate (FEER) for assessing the current value of the exchange rate. BEER is primarily an econometric analysis. It estimates the misalignments that occur due to deviations of the actual exchange rate from its estimated values. The BEER is derived from the long run cointegration relationship of the macroeconomic fundamentals. According to (Clark and MacDonald, 1998), it can be described by a reduced-form equation:

$$q_t = \beta' Z_t$$

Where q_t is the BEER, Z_t denotes a vector of economic fundamentals and β is a vector of coefficients. The actual real effective exchange rate is composed of the BEER, transitory factor and disturbance term as below:

$$q'_t = \beta' Z_t + \tau' T_t + \varepsilon_t$$

Where q'_t is actual real effective exchange rate, Z_t denotes a vector of economic fundamentals, T_t is a vector of transitory factor affecting the real exchange rate in the short term, and β and τ are the vectors of coefficients. So current misalignment is the deviation of the actual exchange rate from its equilibrium real exchange rate:

$$q'_t - q_t = \tau' T_t + \varepsilon_t$$

Meanwhile, the long-run equilibrium real exchange rate is:

$$\bar{q}_t = \beta' \bar{Z}_t$$

Where $\bar{q}_t$ the long-run equilibrium is exchange rate and $\bar{Z}_t$ is the vector of long-run economic fundamentals. So total misalignment is deviation of actual real exchange rate from its long-run equilibrium exchange rate:

$$q'_t - \bar{q}_t = \tau' T_t + \varepsilon_t + \beta' (Z_t - \bar{Z}_t)$$

From this equitation, we see that the total misalignment is composed of transitory factors, disturbance term and effect of deviation of economic fundamentals from their long-run values.

When employing the BEER approach to measure one currency's equilibrium exchange rate, one of the most important things is to judge which economic fundamental determines the behavior of real exchange rate over a period. Accuracy and rationality of results when using the BEER approach strongly depend on an appropriate set of economic fundamentals. (Clark and MacDonald, 1998) apply three economic fundamentals, including terms of trade, relative price of non-traded to traded goods and net foreign assets, to estimate equilibrium exchange rates for the German mark, Japanese yen, and the US dollar. In (Zhang, 2001), the economic fundamentals include gross fixed capital formation, government consumption (fiscal policy), growth rate of export and ratio of sum of foreign trade to GDP (openness). (Iossifov and Loukoianova, 2007) estimate Ghana's equilibrium exchange rate by employing real GDP growth, real interest rate differential and real-world prices of Ghana's main export commodities as economic fundamentals.

(Wang et al., 2007) include more economic fundamentals as explanatory variables in the BEER model in assessing RMB equilibrium exchange rate. The considered variables are money supply, foreign reserves and terms of trade and relative price of non-tradable to tradable goods. The BEER has been widely used for the calculation of equilibrium exchange rates for the main industrial countries and more recently also for the so-called transition countries (Egert, Halpern and MacDonald, 2006), (MacDonald, 2007).

In this paper, we analyze the deviation of Tunisian exchange rates from its long-run equilibrium using the BEER approach for a quarterly data sample from 1990 to 2020. We use the BEER approach as it allows for the estimation of the dynamics of adjustment of exchange rates. According to (Thorstensen et al., 2014), the BEER reduces the subjectivity in the estimation of equilibrium and misalignments by allowing the use of a set of fundamentals that explain exchange rate behavior.

The estimation of the BEER essentially proceeds in four stages:

1) Estimating the statistical long-run relationship between the real exchange rate, the fundamentals, and short-run variables. This estimation is tantamount to estimating a reduced form real exchange rate model. This is normally achieved using a Vector Error Correction Model (VECM) approach or a panel estimator.

2) Calculating the actual or current misalignment. Short-term variables are set to zero and actual values of fundamentals identified in step 1) are substituted into the estimated relationship. The actual misalignment is calculated as the difference between the fitted and the actual value of the real exchange rate.

3) Identifying long run, or sustainable, values for the fundamentals. This can be achieved either by decomposing the series into permanent and transitory components (for example, using an HP filter or a Beveridge-Nelson decomposition), or using a subjective evaluation of the long-term values is also possible.

4) Calculating total misalignment. In this case long-term values of fundamentals are substituted into the estimated relationship, relating the real exchange rate to the fundamentals, while setting short-term variables again to zero. Total misalignment is the difference between the fitted and actual value of the real exchange rate when sustainable values of fundamentals are used. Total misalignment depends on the short-term effect and on the departure of fundamentals from their long-term value.

4.2. Estimating the Misalignment of the Real Exchange Rate

The analysis of the behavior of the RER will be conducted following the co-integration technique applied to non-stationary series. As we mentioned earlier, selection of a set of economic fundamentals which play a role in determining the equilibrium exchange rate is crucial in estimating the Tunisian Dinar (TND) equilibrium exchange rate and its misalignment.

In this study, we choose 4 economic fundamentals as shown below. The model is estimated as follows:

lnREER = f (lnProdTN, lnProdpartner, lnOpenness, lnTOT)

The estimated VECM used in our work is based on two important theoretical properties which relate to the long-term equilibrium:

1- The first is the existence of a long-term stationary relationship between the real effective exchange rate (REER) and economic fundamentals:

$$lnREER_t = \beta_0 + \beta_1 lnTOT_t + \beta_2 lnProdTN_t + \beta_3 lnProdpartner_t + \beta_4 lnOpenness_t + \varepsilon_t$$

2- The second is to have a stable dynamic stationary state: when there is an exogenous shock on the real effective exchange rate, self-correcting mechanisms must be put in place to produce a convergence towards the stationary equilibrium:

$$\Delta(lnREER)_t = C + \alpha(\varepsilon_{t-1}) + \delta_1 \Delta(lnTOT)_t + \delta_2 \Delta(lnProdTN)_t + \delta_3 \Delta(lnProdpartner)_t + \delta_4 \Delta(lnOpenness)_t + U_t$$

5. Results:

Empirically, for VECM analysis, we need to test if all variables are stationary or not. The purpose of the unit root test is to determine the order of integration of each variable. Appendix 2 below summarizes the results of the Augmented Dickey-Fuller (ADF) test. The variables are non-stationary in levels but stationary in first difference. We deduce that all variables are integrated in the same order I(1) (Appendix2).

With all variables being I(1), we estimate the lag length of the autoregressive process to determine the optimal delay. It is often advised to use the Akaike Selection Criterion (AIC) in selecting the lag length. From the output (Appendix3), the selected lag order is indicated by asterisks (*) which is lag order 4. The rule-of-thumb is to select the criterion with the lowest value which again is the AIC at -23.06655.

In the last step, we adopt the cointegration test allows us to check if there is a long-term relationship between non-stationary variables. Johansen's trace (Appendix 4) and maximum eigenvalue (Appendix 5) statistics indicates the existence of at least one cointegrating relationship. Thus, the trace test indicates the existence of two cointegrating vectors at the 5% level. While the maximum eigenvalue statistics indicates the existence of one cointegrating vectors at the 5% level.

5.1. long-term relationship between RER and macroeconomic fundamentals

In this section, we estimate the long-run exchange rate equation obtained from our theoretical model. Table 2 below presents the long-term relationship between RER and macroeconomic fundamentals. According to (Baffes and Elbadawi,1999), the long-term equilibrium is stable only if ($-2 < \theta < 0$).

Table2. Estimation of the long-run relationship between the equilibrium RER and macroeconomic fundamentals

	LnProdTN	LnProdpartner	LnOpenness	LN_TOT	C
Coeff	0.042	-2.536	0.005	-1.094	15.056
T.Stat	-0.4	11.5	-0.1	4.4	-11.8

Table 2 summarizes the results obtained for the long-term regression of the REER with its economic fundamentals following an estimate by VECM. The results are mostly consistent with the economic literature. However, the coefficients obtained show that the effect of the explanatory variables is distinct.

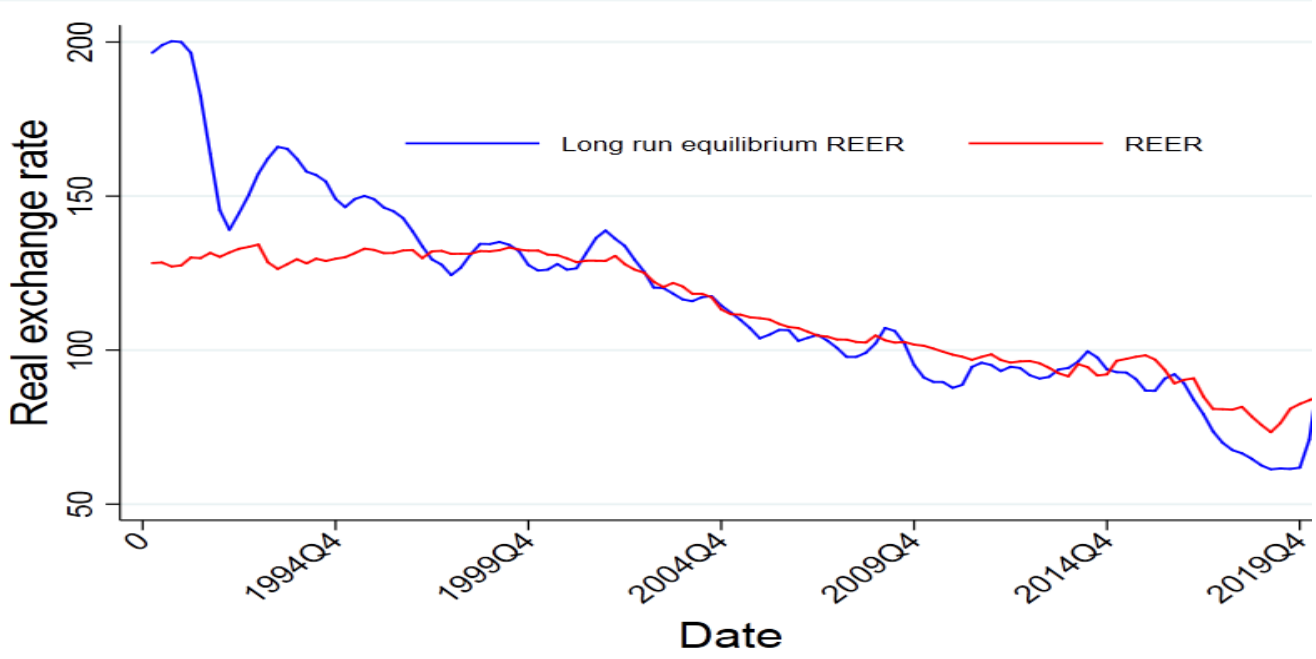
The positive coefficient corresponding to the productivity variable implies that the improvement of the local productivity contributes to an economic development that will be accompanied by an appreciation of the RER (Balassa-Samuelson effect). On the other hand, the negative coefficient of the Tunisian partner productivity indicates that an improvement in the partner's economies will lead to a depreciation of the Tunisian dinar. The positive coefficient corresponding to the trade opening variable supports the idea that trade liberalization is accompanied by a depreciation of the RER. According to (Balassa, 1975), the logic is straightforward: once a reduction in import tariffs is implemented, there is an imbalance in the current account because of the increasing demand for imports. In turn, this induces the need to generate depreciation in the real exchange rate. The variable "terms of trade" is negatively linked the RER. The deterioration of the Tunisian trade balance due to an increase in demand for imports pushes up the price of imports and hereby also declines foreign demand for domestic currency. This situation leads to real depreciation of the exchange rate.

5.2. Misalignment of the Tunisian real exchange rate

After having empirically estimated the long-run RER equation, in this section we calculate the value of the equilibrium exchange rate and the corresponding level of misalignment. The real exchange rate misalignments are measured as the deviation of the actual real exchange rate from some benchmark (or equilibrium) level. The equilibrium REER is a set of values corresponding to the internal and external macroeconomic balance being reached (Marrakchi-Charfi, 2008). The basic assumption that lies behind real equilibrium exchange rate postulates that the conjugation of the model's fundamental variables generates the annual equilibrium values of the REER.

The coefficients derived from the long run equation are used to calculate the level of the equilibrium exchange rate.

Graph4: Time-Series Plot of the observed and the equilibrium real effective exchange rate

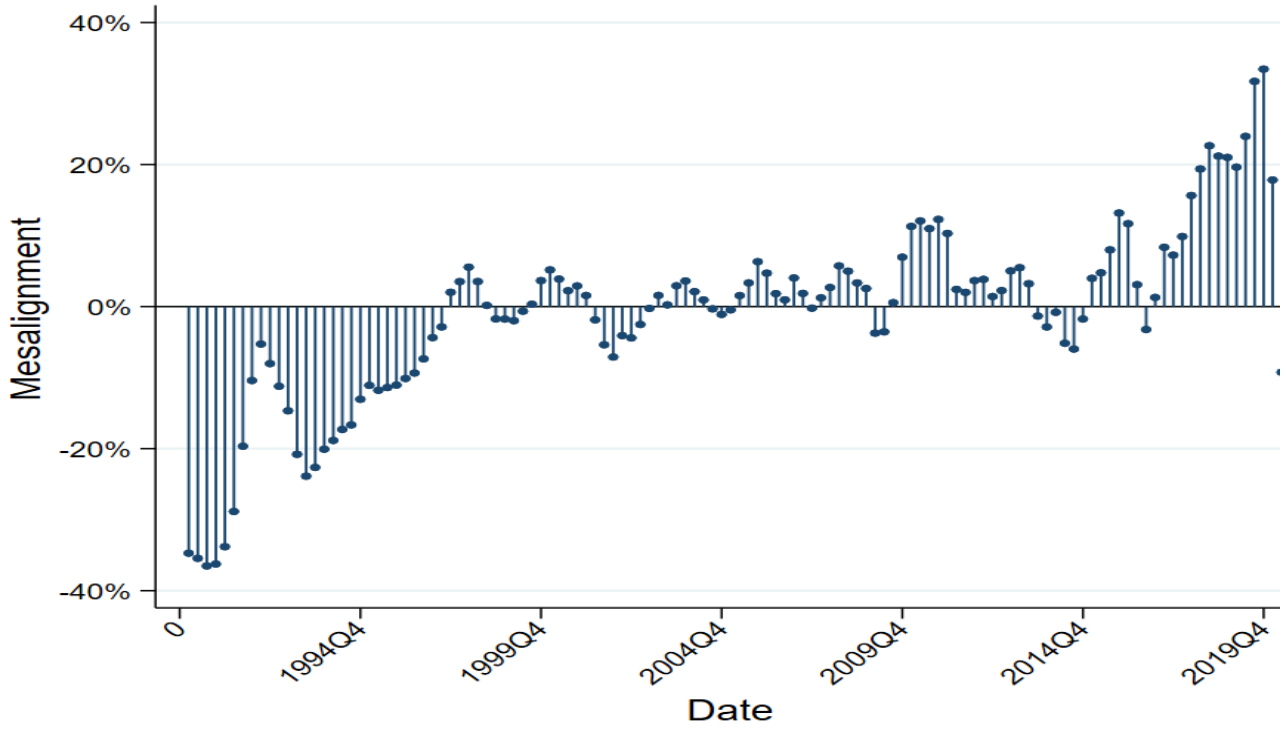


Graph4 shows the evolution of the observed and the equilibrium real exchange rate. Gaps refers to the misalignment.

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

$$Misalignment = \left(\frac{RER_t}{EREER_t} - 1\right) * 100$$

Graph5: The evolution of the level of misalignment in Tunisia



Graph5 shows the evolution the level of misalignment of the dinar. The results show that the period is characterized by periods of under and over evaluations

Since 2011, the misalignment of the fundamental value of the dinar has been gradually reabsorbed until 2015 before rebounding again in 2016 and 2017, reflecting the deterioration of the economic situation in Tunisia after the shock on the tourism sector following the terrorist attacks, aggravated by the shutdown of the phosphate and petroleum sector and the mistrust of FDI because of the uncertainties which marked the business climate in Tunisia.

The development of the dinar as well as the level of misalignment reflects the nature of the pre- and post-2011 dinar exchange policy conducted by the Central Bank of Tunisia (BCT). The misalignment implied negative levels before 2007, thus showing an undervaluation of the Tunisian currency. The exchange rate policy conducted during this period helped to amplify the fall in the nominal exchange rate of the Tunisian dinar against the euro by nearly 7.5% and ultimately reduced the appreciation of the national currency against the dollar by about 11%. In real effective terms, the dinar was depreciated by around 12.5 index points. The misalignment rebounded sharply in the wake of the subprime crisis to post positive values at the RER misalignment level. The dinar thus entered a continuous phase of overvaluation which was accentuated by the macroeconomic disturbances post-2011. This phase is characterized by a quasi-stability of the REER around 130 at the beginning of the observed period. The Tunisian authorities have targeted a constant real effective exchange rate to preserve the competitiveness of the economy in relation to abroad. Subsequently, the monetary authorities opted to maintain the real value of the dinar in an equilibrium path which reflects the developments of the country's fundamentals and preserves its external competitiveness. However, although the exchange rate policy conducted between 2000 and 2011 contributed to achieving notable economic performance, it proved difficult to pursue this policy for a small economy which was increasingly liberalized, and which was exposed to external economic hazards (2008 Subprime crisis).

Since 2011, the BCT has initiated a reform process aimed at deepening the foreign exchange market and developing its capacity to provide the necessary liquidity to economic operators. The dinar exchange policy was rather focused on consolidating the economic, political, and social stabilization efforts undertaken by the Tunisian authorities to allow the country to return to the path of economic recovery. Despite the observable stability between 2011 and 2014 at around 15%, the misalignment rebounded again to nearly 20%, reflecting the new slippage in the economic situation in Tunisia after the shock of the tourism sector in 2015 following the terrorist attacks, in addition to the repeated interruptions of exploitation in the phosphate and petroleum sector and the mistrust of FDI because of the uncertainties which marked the business climate in Tunisia. The exchange rate policy was then focused on reducing external and internal imbalances. The BCT thus made more active use of monetary instruments by adjusting the key interest rates upwards and tolerating a more accelerated rate of depreciation of the dinar. The value of the dinar thus adjusted downward at an accelerated pace between 2016 and 2018.

This period of decline of the dinar allowed the level of misalignment to be absorbed in the first place. However, the deterioration in economic fundamentals neutralized this correction mechanism. The evolution of the real value of the dinar (real effective index) compared to the level of fundamental misalignment shows the nature of the dinar exchange policy conducted by the BCT. A new correction of the level of misalignment is observed in 2018, supported by the fall in the value of the dinar. As of 2020, the spread of the COVID-19 pandemic is expected to have negative repercussions on the economic fundamentals and consequently will most likely result in an increase in the level of misalignment.

5.3. Short-term relation:

This section discusses the results of the short-term relation between RER and its fundamentals. We also examine the impulse responses of each of the variables to one standard deviation in each of the fundamental shocks. Regarding the short-term of the equilibrium RER, an error correction model (ECM) was applied.

Table3. Estimation of ECM

	ΔLnProdTn	ΔLnProdpartner	ΔLnOpenness	ΔLnTOT	ECM
Coeff	-0.144	0.001	0.541	-0.053	-0.052
T.Stat	-2.1	0.1	3.2	-4.1	-2.5

Table 3 summarizes the results obtained for the short-term regression of the REER. The coefficients obtained also show that the effect of the explanatory variables is distinct.

Note, that the local production, the trade openness, and terms of trade have a significant effect on the RER, while only the trade openness has the same effect already found in the long-term relationship. Tunisian production and TOT occur in contrast to their effect under the long-term estimation.
The coefficient associated with the error correction term is negative and statistically significant. This indicates a gradual convergence of the equilibrium RER towards its long-term value.

Graph6: Response to Cholesky One S.D. Innovations

Chart 6 illustrates the impact of the various economic fundamentals shocks on the evolution of exchange rates. The impact of the variables is very different. The variables used are those used in the modeling of the first part.

The impulse response function traces out how the changes in one variable have an impact on current and future values of the real exchange rate. The impulse response functions can be used to produce the time path of development of the dependent variables in response to shocks from all the explanatory variables. Graph 6 displays the impulse response functions of the log of the RER to one standard deviation structural shocks. The combined graphs are based on the output of the VECM analysis with analytic response standard error over 10 periods and Cholesky degrees of freedom adjusted, which show the response to Cholesky one standard deviation innovation. The graph shows that the response of the real effective exchange rate to its own shocks is strongly positive. As for the impact of the Tunisian production shocks and the level of trade openness, the response of the RER is weakly positive. Finally, the response of the real exchange rate to the trading partners' production shocks and those of the terms of trade is weakly negative.

5.4. Variance decomposition

Table4. Variance Decomposition of LREER

Period	S.E.	LN_REER	LN PRODTN	LN PRODPARTNER	LN OPENNESS	LNTOT
1	0.02	100.00	-	-	-	-
2	0.03	99.84	0.09	0.03	0.01	0.04
3	0.04	97.61	0.31	1.42	0.03	0.63
4	0.05	95.47	0.22	3.63	0.03	0.65
5	0.05	94.37	0.18	4.93	0.03	0.49
6	0.06	93.71	0.37	5.52	0.05	0.35
7	0.07	92.72	0.54	6.41	0.07	0.26
8	0.09	91.64	0.55	7.55	0.06	0.20
9	0.10	90.89	0.54	8.35	0.05	0.17
10	0.11	90.48	0.55	8.72	0.04	0.20

Table 4 summarizes the results obtained from the variance decomposition. The coefficients allow the measure of the relative importance of fluctuation of nominal or real shocks to variations in real exchange rate

The variance decomposition technique measures the proportion of forecast error variance in one variable explained by innovations and the other variables. The table 4 above allows us to measure the relative importance of fluctuation of nominal or real shocks to variations in real exchange rate. The results suggest that real shocks can cause a smooth increase in real exchange rates.

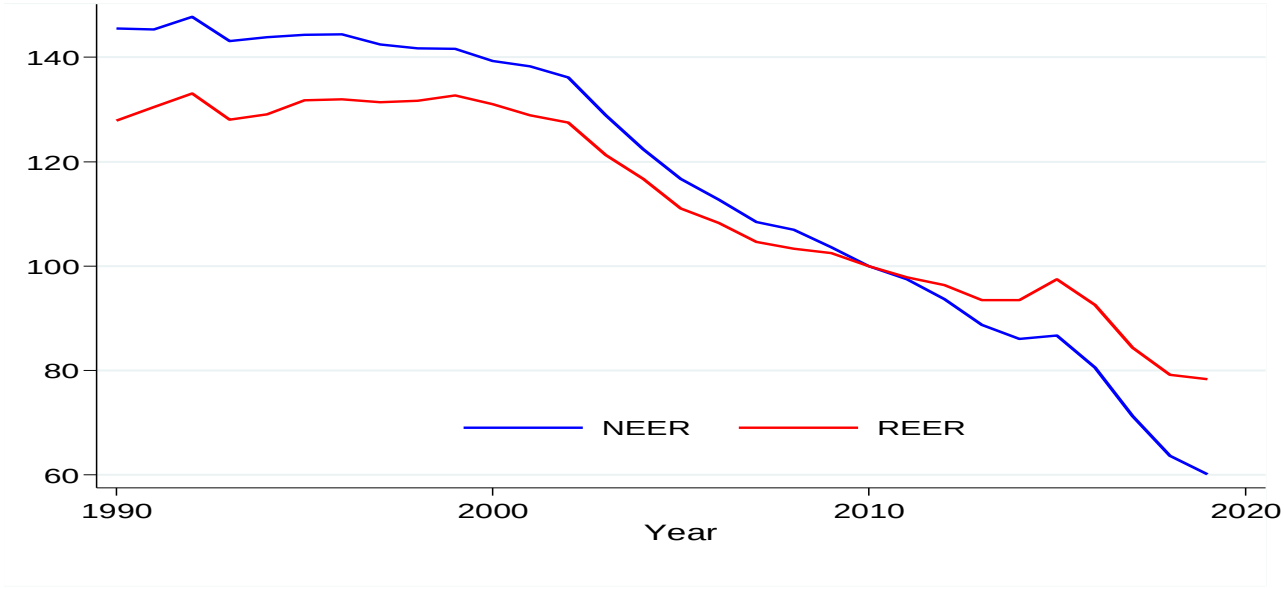
Moreover, shocks in local production and trade openness cause an unnoticeable effect on real exchange rates. However, shocks on Terms of trade and partner production tend to cause an increase in real exchange rates.

6. Robustness

Exchange rate policy has always played a key role in achieving macroeconomic objectives, including sound and sustainable economic growth and improved external competitiveness. Since the early 1990s, the monetary authorities have always taken a more flexible approach to managing the dinar's exchange rate policy by adjusting the exchange rate regime to reflect the various changes in the international monetary system and the needs of economic development.

The management of exchange rate policy, conducted since 1987 on a fund of realism and flexibility, has contributed effectively to the performance achieved by the Tunisian economy: sustained and sustainable GDP growth rates, a continuous increase in exports of goods and services, preservation of market shares in a more competitive environment and finally the restoration and safeguarding of external balances. During the 1990s, the Tunisian nominal effective exchange rate was determined to keep the real effective exchange rate constant (application of the purchasing power parity theory); the monetary authorities have aimed at preserving competitiveness (Faniza and al, 2002). In this period, an interbank foreign exchange market has been created in 1994. The declaration of the current convertibility of the dinar in 1992, the creation of the interbank foreign exchange market in 1994 and the move towards full convertibility of the dinar are the pillars of this liberalization process.

Graph 7: Evolution of Tunisian Nominal and real exchange rate since 1990



Graph6: Evolution of the Tunisian real effective exchange rate (REER) and the nominal effective exchange (NEER) since 1990. During the 1990s, the monetary authorities in Tunisia, aiming to preserve competitiveness, have targeted the REER via the intervention by the BCT to adjust the NEER to compensate for the inflation gap compared to Tunisia's commercial partners. However, since the 2000s, the BCT has implemented a flexible exchange rate policy. Domestic currency has depreciated since 2000 to support exportations. After January 2011, a depreciation of the dinar has been observed and Tunisia had to follow a more flexible exchange rate policy to preserve competitiveness and to avoid depleting exchange reserves[2].

To verify the stability and the robustness of our model, we will limit the study period to the period when the Tunisian monetary authorities decided to give the exchange rate greater flexibility. The objective of this part is to verify whether this flexibility has led to a greater absorption of the misalignment of the dinar. We follow the same approach to evaluate the equilibrium exchange rate and the level of misalignment over the period 1995 and 2020.

[2]Dahem, Ahlem & Siala Guermazi, Fatma, 2016. "Exchange rate Pass-through and Monetary Policy in Transition Economy: Evidence from Tunisia with disaggregated VAR Analysis," MPRA Paper 74179, University Library of Munich, Germany

First, we performed the ADF test to verify the stationary of our variables for the new study period. The variables always remained stationary of order 1 (Appendix6). For the choice of the optimal delay, the Akaike Selection Criterion (AIC) (Appendix7) indicated that the selected lag order is 4. The Johansen's trace and maximum eigenvalue statistics (Appendix 7 and 8) showed the existence of at least two cointegrating relationships.
Thereafter, we estimate the long-run exchange rate equation obtained from our theoretical model.

Table5. Estimation of the long-run relationship between the equilibrium RER and macroeconomic fundamentals

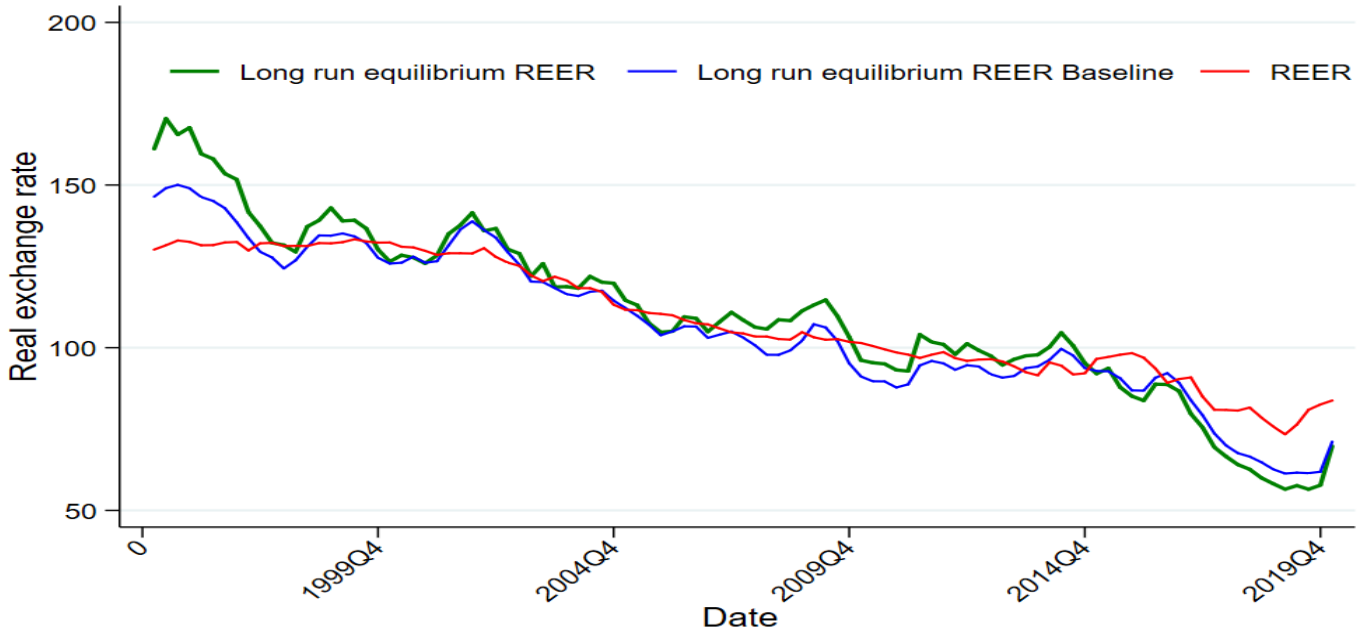
	LnProdTn	LnProdpartner	LnOpenness	LnTOT	C
Coeff	0.219	-3.775	0.206	-1.189	-17.314
T.Stat	-2.1	5.6	-1.7	4.1	

Table 5 summarizes the results obtained for the long-term regression of the REER with its economic fundamentals following an estimate by VECM.

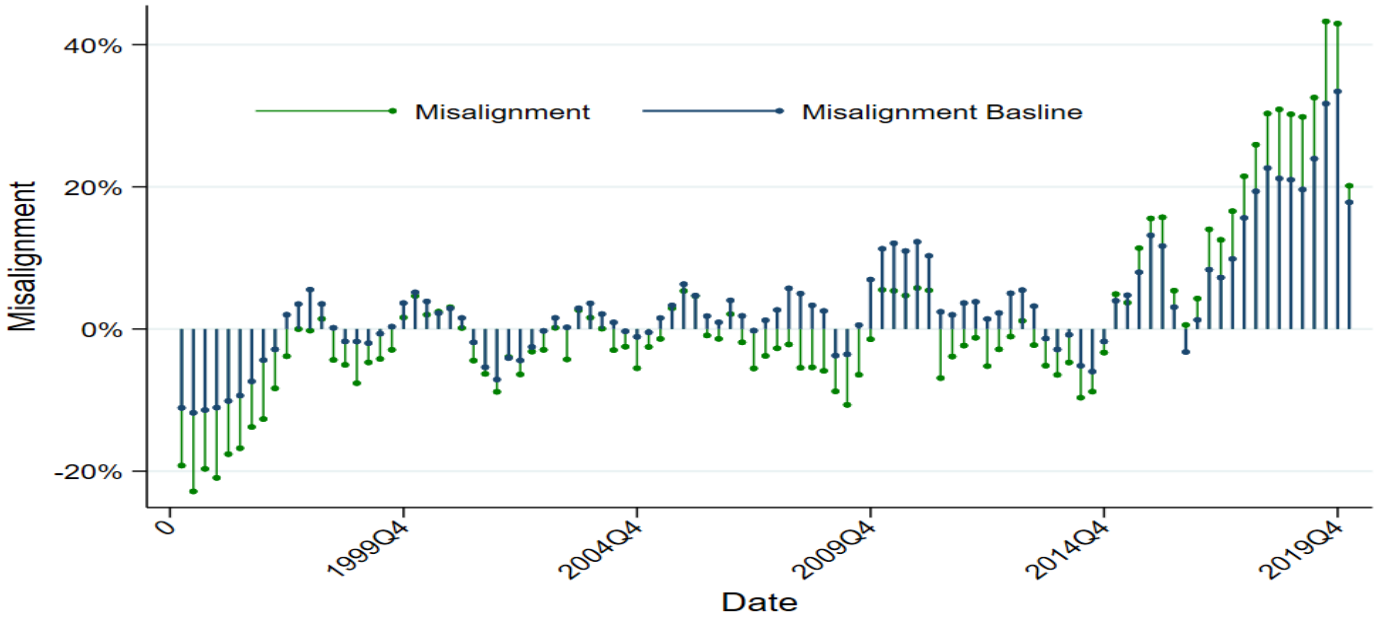
The new estimation of the long-term relationship of the real exchange rate to these economic fundamentals shows, that the variables have kept their signs. However, the size of the coefficients and their level of significance are different. For example, the coefficient of the local productivity has become significant and its effect on the RER is greater with a value of 0.22 compared to 0.04 in the first model. Similarly, the level of openness has increased from 0.005 to 0.2.
Using the new coefficients of the long-term relationship, we calculate as for the first part the new equilibrium level of the real exchange rate in Tunisia.

By comparing the level of the calculated equilibrium RER and the observed RER, we obtain the level of misalignment presented in Graph 8.

Graph8: Evolution of misalignment during the dinar flexibility period



Graph8a. shows the evolution of the observed and the equilibrium real exchange rate (baseline and robustness cases). Gaps refer to the misalignment.



Graph8b. shows the evolution of the misalignment. The graph presents a comparison between the misalignment calculated with the baseline and the period of robustness. The results show that the period is characterized by periods of under and over evaluations. The magnitudes of the level of misalignment have changed with higher levels.

Despite limiting our work to the period of exchange rate flexibility, the shape of the misalignment curve has not changed. The period is again characterized by periods of under- and overvaluation. The only change is that the magnitudes of the level of misalignment have changed with higher levels especially for the period 2011-2020, reaching nearly 20% by the end of 2019.

7. Conclusion

Approaches based on macroeconomic determinants of the exchange rate provide a satisfactory framework for analysis. Our work has been to explore this way, proposing an econometric model to estimate misalignments of the exchange rate with respect to its equilibrium value. The aim of this paper is to estimate the equilibrium RER for Tunisia and its level of misalignment from 1990 to 2020, using quarterly data, and based on the following fundamental variables: terms of trade, level of trade openness, local productivity and trade partner's productivity. Results show that the study period was marked by phases of overvaluation and undervaluation of the RER. The real exchange rate misalignment often reflects a dysfunction in the economy, which is costly in terms of external balance, allocation of productive resources and well-being and can lead to crisis (Asian crisis of the 1990s). Exchange rate policy alone cannot be sufficient to absorb the dinar's misalignment with its equilibrium value. While the depreciation of the national currency could promote the export competitiveness of domestic products, it also has adverse effects on the level of external debt expressed in local currency as well as on imports and inflation. The monetary and exchange rate policies adopted by the BCT to ensure the proper functioning of markets cannot, on their own, withstand in the long term, profound deficiencies affecting both the real and financial sectors.

The synergy between the actions of the BCT and fiscal policy must be strengthened to revive the economy and correct internal and external imbalances. The issue of the misalignment of the dinar's exchange rate will thus be systematically corrected.

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9. Appendix:

Appendix1. Descriptive statistics

	LnREER	LnProdTN	LnProdpartner	LnOpenness	LN_TOT
Mean	4.70528	2.27028	2.15639	2.50327	4.54136
Median	4.71490	2.29616	2.17891	2.56135	4.52306
Maximum	4.89983	2.64274	2.31151	3.23246	4.74330
Minimum	4.29549	1.61841	1.95029	1.81007	4.37953
Std. Dev.	0.17055	0.19882	0.10353	0.41917	0.08120
Skewness	-0.50926	-0.66125	-0.47089	-0.0533	0.81597
Kurtosis	2.05216	3.24207	2.11902	1.59509	3.3300
Jarque-Bera	9.84025	9.1887	8.45400	10.0911	14.0919
Probability	0.00729	0.01010	0.01459	0.00643	0.00087
Sum	574.044	276.974	263.079	305.4	554.04
Sum Sq. Dev.	3.51966	4.78318	1.2970	21.2603	0.7979
Observations	122	122	122	122	122

Appendix2. Results of ADF test

Variables	Stationarity	t-stat	Critical Value	Prob	Results
LnREER	in level	0.1545	-3,4860	0,9685	non-stationary
	In first differences	-8.3828	-3.4860	0,0000	Stationary
LnProdTN	in level	-0.0836	-3.4851	0.9478	non-stationary
	In first differences	-10.6112	-3,4855	0,0000	Stationary
LnProdpartner	in level	-2.5275	-4.9491	0,0645	non-stationary
	In first differences	-5.3814	-4.9491	0,0000	Stationary
LN_TOT	in level	-2.5197	-3.4885	0,1135	non-stationary
	In first differences	-6.0622	-3,4875	0,0000	Stationary
LnOpenness	in level	-1.1476	-3.4885	0,6949	non-stationary
	In first differences	-15.2084	-3.4855	0,0000	Stationary

Appendix3. Results of trace statistics

Null Hypothesis	Eigenvalue	Trace Statistic	Critical Value	P-value
None *	0.341915	114.8773	69.81889	**0.0000**
At most 1 *	0.255479	65.92203	47.85613	**0.0004**
At most 2 *	0.151357	31.40538	29.79707	**0.0324**
At most 3	0.074764	12.20368	15.49471	0.1474
At most 4	0.026248	3.112011	3.841466	0.0777

Appendix4. Results of maximal eigen statistics

Null Hypothesis	Eigenvalue	Trace Statistic	Critical Value	P-value
None *	0.341915	48.95531	33.87687	**0.0004**
At most 1 *	0.255479	34.51664	27.58434	**0.0055**
At most 2	0.151357	19.20171	21.13162	**0.0911**
At most 3	0.074764	9.091668	14.26460	0.2786
At most 4	0.026248	3.112011	3.841466	0.0777

Appendix5. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	466.1	NA	2.60e-10	-7.88	-7.76	-7.834
1	1266.9	1519.5	4.52e-16	-21.14	-20.43	-20.856
2	1382.8	210.1	9.58e-17	-22.69	-21.39*	-22.170
3	1422.0	67.7	7.56e-17	-22.94	-21.05	-22.174*
4	1454.3	53.1*	6.74e-17*	**-23.06***	-20.58	-22.060

Appendix6. Results of ADF test

Variables	Stationarity	t-stat	Critical Value	Prob	Results
LREER	in level	-0.442207	-3.497727	0.8966	non-stationary
	Infirst differences	-7.895143	-3.497727	0.0000	Stationary
Ln_ProdTn	in level	1.008185	-3.496346	0.9965	non-stationary
	In first differences	-8.773265	-3.497029	0.0000	Stationary
Ln_Prod_Partenaire	in level	-1.607135	-3.499910	0.4751	non-stationary
	In first differences	-5.093955	-4.949133	0.0000	Stationary
Ln_TOT	in level	-1.926882	-3.499167	0.3188	non-stationary
	In first differences	-4.586075	-3.499910	0.0003	Stationary
Ln_OpennessXM	in level	-0.582263	-3.499167	0.8686	non-stationary
	In first differences	-4.407262	-3.499167	0.0005	Stationary

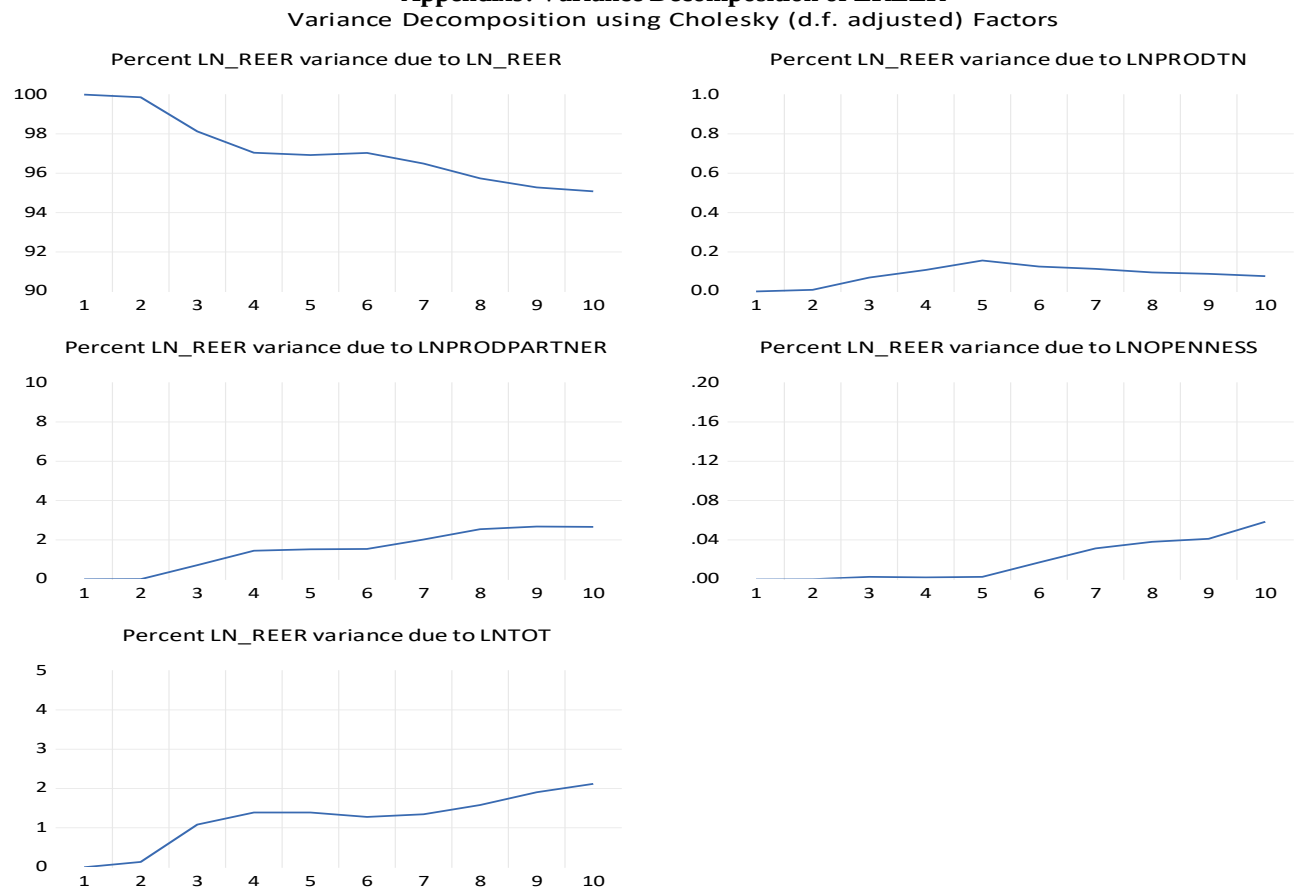
Appendix7. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
1	1101.2	NA	1.99e-16	-21.96	-21.31	-21.7
2	1201.8	180.5	4.28e-17	-23.51	-22.19*	-22.9
3	1239.3	63.7	3.34e-17	-23.76	-21.79	-22.9
4	1283.7	70.6*	2.29e-17*	-24.16*	-21.52	-23.1*

Appendix8. Results of trace statistics

Null Hypothesis	Eigenvalue	Trace Statistic	Critical Value	P-value
None *	0.346123	91.57233	69.81889	**0.0004**
At most 1 *	0.246456	50.36328	47.85613	**0.0285**
At most 2 *	0.129561	22.91538	29.79707	0.2503
At most 3	0.081002	9.455924	15.49471	0.3249
At most 4	0.012928	1.262237	3.84166	0.2612

Appendix9. Variance Decomposition of LREER



10. GLOSSARY

Nominal Exchange Rate – price of one currency in terms of another country's currency (Krugman, Obstfeld, 2000, p.329).

Real Exchange Rate – price of a typical foreign expenditure basket in terms of the typical domestic expenditure basket (Krugman, Obstfeld, 2000, p.329)

Nominal Effective Exchange Rate – the ratio of an index of the period average exchange rate of the currency in question to a weighted geometric average of exchange rates for the currencies of selected countries and the Euro Area (Introduction to IMF International Financial Statistics CD-ROM)

Real Effective Exchange Rate – the real effective exchange rate is a nominal effective exchange rate index adjusted for relative price movements at home country and foreign countries (Introduction to IMF International Financial Statistics CD-ROM)

Purchasing Power Parity theory – asserts that exchange rate between countries is equal to the ratio of their relative price levels, as measure by the money prices of a reference commodity basket (Krugman, Obstfeld, 2000, p.428-429)