PERSISTENCE OF REAL EFFECTIVE EXCHANGE RATE MISALIGNMENTS IN TUNISIA

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ABSTRACT

This article's aim is to assess misalignments in Tunisia's real effective exchange rate and to draw attention to their persistence. Thus, over the period 1980-2019, the Autoregressive and Distributed Lag (ARDL) model was used to estimate the relationship between the real effective exchange rate and its fundamental determinants, which are the following: productivity, government expenditure, investment, net foreign assets and trade openness. According to empirical evidence, the key fundamental determinants of the Tunisian real effective exchange rate have a significant long-run association with the Tunisian real effective exchange rate. The findings have revealed the persistence of the series of misalignments in the real effective exchange rate. This property has emerged as a result of either idiosyncratic shocks resulting from internal economic/political problems or structural global forces conveyed through the nominal exchange rate, capital flows, and policy-induced actions.

Keywords: Real Effective Exchange Rate, Misalignment, ARDL Model, Persistence

INTRODUCTION

In free economies, the equilibrium exchange rate is a crucial term. Its value by its own is insufficient to decide whether the currency is overvalued or undervalued. These distortions are expressed in misalignments, which are described as "sustained deviations of the current real exchange rate from its long-term equilibrium stage" in the literature (Edwards 1989). That is, misalignments, whether positive or negative, pose a threat to a country's economy.

As a result, determining the "appropriate" amount, which is the real equilibrium exchange rate, is critical since failure to do so will have negative consequences for the economy's external and internal equilibrium. The real exchange rate mismatch is still one of the main indicators that lead to a country's economic vulnerability, according to theoretical and empirical studies.

Indeed, misalignments are often persistent. Therefore, in order to minimize them; the question arises about their level of equilibrium (Coudert, 1999). The main concern is related to the estimation of this rate. As a result, its knowledge becomes recurrent and plays a prominent role in both the academic and political debates for two reasons. To begin with, this equilibrium rate must be measured with great accuracy in order to make the best macroeconomic decisions possible. Second, there is no one-size-fits-all standard. The first method used as a guide was the Purchasing Power Parity (PPP) principle. Its popular usage in economic literature is due to its simplicity. However, PPP has been accused of having many flaws, the most notable of which is the notion that any difference in the real exchange rate can be viewed as a divergence from the equilibrium standard (Frait & Komárek, 2001; Hussain, Hassan, Bakhsh & Abdullah, 2020). Because of the non-stationarity of the real exchange rate, this PPP vision is no longer true. As a result of these critiques, economists are looking for alternate versions of the equilibrium real exchange rate that can help with successful policy analysis. The FEER, BEER, and NATREX models are among the many that have emerged. Both of these hypotheses agree that the equilibrium real exchange rate defined by its basic economic variables is not constant.

The primary goal of this paper is to determine the long-run equilibrium for the Tunisian real effective exchange rate and its fundamental determinants, as well as the percentage of misalignment between the real exchange rate and its equilibrium value.

The proposal presented in this paper is split into six sections in order to accomplish this aim. The second section examines a research on calculating misalignments and estimating the

equilibrium exchange rate. The third section will focus on developing the econometric technique. In section 4, the study's findings will be summarized. The discussion of the findings and their consequences for economic policy will be expanded in the fifth section, and the key conclusions will be addressed in the sixth section.

LITERATURE REVIEW

We will address the findings of several empirical studies aimed at analyzing the behavior of the equilibrium exchange rate and misalignments by describing various econometric approaches and methods in this section.

Edwards (1988) studies the equilibrium real exchange rate and misalignments in a small emerging economy using a dual exchange rate system using a three-part dynamic model (exportable, importable, and non-tradable). Then, while using the instrumental variables of fixed country effects methodology, he tests his model in a study of twelve countries with a fixed exchange rate system from 1960 to 1985. The findings suggest that as the terms of trade increase, the real exchange rate continues to appreciate. Real appreciation is statistically negligible as a result of rates and capital flows. The government consumption has no significant effect. Technological development, on the other hand, continues to depreciate the equilibrium effective exchange rate substantially. Expansionary and unsustainable monetary and fiscal strategies aim at appreciating the real exchange rate in nominal terms.

From 1980 to 2008, (Louhichi, 2009) attempted to estimate the equilibrium exchange rate of 11 South Mediterranean nations. To do so, he used the BEER approach to examine the behavior of the equilibrium real exchange rate, as well as the panel co-integration model for non-stationary data to estimate the long-term relationship between the real effective exchange rate and its fundamentals. He deduced the conclusion that rising per capita income, government expenditure, terms of trade, and net external position aim at appreciating a country's real exchange rate, while rising trade openness depreciates it.

Of course, determining the fundamental variables of the equilibrium RER in a group of six SEMCs (Algeria, Egypt, Lebanon, Morocco, Tunisia, and Turkey) and analyzing the predicted theoretical consequences of the fundamentals (in particular, trade openness and international financial integration) on the RER is essential, (Amor & El Araj, 2009) developed a basic macroeconomic model for estimating the long-term RER for developing countries, especially SEMCs. The proposed model is based on the theoretical models of the REER proposed in the work of (Edwards, 1989; Elbadawi, 1994). Indeed, the authors explain the REER as a function in terms of trade, the productivity differential, the share of public expenditure in GDP, the growth rate of money and quasi-currency (annual %), trade openness, a measure of international financial integration, foreign exchange reserves and debt service. Using data from 1979-2004, they found that the RER's long-term behavior is largely determined by each country's economic uniqueness, especially its degree of financial inclusion and trade openness. Furthermore, for certain nations, the evolution of RER misalignments was found to be persistent and recurrent throughout the study period.

In MacDonald's study (2002), the author tried to look at the New Zealand dollar's behavior after late 1999. To do so, a calculation of the equilibrium exchange rate was required. To calculate the long-term equilibrium rate of the New Zealand dollar's RER, the BEER model (Clark & MacDonald, 1999; Hussain & Hassan, 2020) was used as a guide. Indeed, he believed that the following basic variables express New Zealand's long-term equilibrium RER: the production difference between the domestic country and the rest of the world, the actual interest rate, and the terms of exchange. Over the period 1985-2000 (quarterly data), he used Johansen's co-integration techniques for empirical application. He deduced the conclusion that both of these variables gave the predicted outcomes and that all of the coefficients are statistically significant. He then estimated misalignments and discovered that the New Zealand dollar has been significantly undervalued since 1999.

Bouoiyour & Rey (2005) looked at how the Moroccan dirham's REER behaved against European currencies (the EU). To evaluate the degree of misalignment, they used the NATREX model of the equilibrium exchange rate. The following are the variables that are likely to influence the characteristics of the RER used in the equation: social consumption, productivity and terms of trade. They found that exchange rate variability (volatility and misalignments) has an effect on Morocco's trade flows with the EU, all based on annual data from 1960 to 2000.

Bouraoui & Phisuthtiwatcharavong (2015) used monthly data from January 2004 to December 2013 to analyze the behavior of the Thai baht exchange rate against the US dollar. The analytical findings showed that the terms of trade and foreign reserves had a statistically significant effect on the nominal THB/USD exchange rate by using the multiple regression method. However, the interest rate differential, the manufacturing production index, the money supply and public debt have no significant relationship with the exchange rate in Thailand.

Adusei & Gyapong (2017) used the simultaneous equation model with the partial least squares approach on annual data from 1975 to 2014 to examine the effect of inflation, the policy rate, the current account balance, the money supply, the annual GDP growth rate, and external debt on the exchange rate in Ghana. Empirical results have shown that the macroeconomic variables used in the model explain 82% of Ghana's adjusted exchange rate variance.

Vural (2018) hypothesized that the exchange rate is tied to the following fundamentals in order to ascertain the long-term equilibrium activity of the Turkish lira: real GDP per capita relative to trading partners, oil prices, fiscal spending, international openness, and net foreign assets. The findings of applying the co-integration methodology to quarterly data from the first quarter of 1989 to the fourth quarter of 2014 revealed that, with the exception of net foreign assets, all of the variables used in the estimation had a significant impact on the equilibrium exchange rate of the Turkish lira.

Finally, Mahraddika (2020) used a panel dataset for 60 emerging economies from 1980 to 2014 in order to investigate the relationship between RER misalignments, exchange rate flexibility, and capital account openness. The findings indicate that the degree of persistence and magnitude of RER to its equilibrium value are related to exchange rate flexibility and capital account. In terms of the size of the RER misalignments, the findings suggest that more liberalized policy configurations are correlated with larger misalignments in both overvaluation and undervaluation.

Our study is related to Cottani, et al., (1990); Sallenave (2010); Abida (2011); Elbadawi (2012); Bouzahzah & Bachar (2014); Terra & Valladares (2010); Caputo (2015); Adusei & Cryapong (2017); Couharde, et al., (2018); Khomo & Aziakpono, 2020; Hussain, Nguyen, Nguyen & Nguyen (2021). As our contribution to the existing literature, we evaluate misalignments in Tunisia's real effective exchange rate and focus attention on their persistence from 1980 to 2019 by applying the Autoregressive and Distributed Lag (ARDL) model.

DATA AND METHODOLOGY

Data

A time series data spanning from 1980 to 2019 were employed from World Bank databases. Six studies variables were used in the study, which include the following: REER - real effective exchange rate, PROD- productivity, OPEN - the trade openness as a percentage of GDP, GOV - the public expenditure as a percentage of GDP, NFA - the net foreign assets as a percentage of GDP and INVEST - the investment as a percentage of GDP. All the original series were transformed into logarithms.

The relationship between REER and its fundamental determinants in Tunisia can be expressed using a linear function, as seen in Eq. (1) (with the predicted sign of the coefficients in brackets):

REER=f (PROD, OPEN, GOV, NFA, INVEST), (1)
(-) (+) (+/-) (+/-) (+)

Real Effective Exchange Rate (REER) is the value of the Tunisian dinar calculated on the basis of a weighted average of a basket of foreign currencies determined by the World Bank econometricians who have chosen 2010 as the base year.

Productivity (PROD) is defined as the Tunisia's GDP per capita relative to the main trading partners. It is intended to capture the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964) which has demonstrated a positive correlation between the relative price of non-tradable and per capita GDP. As a result and based on Edwards' RER concept, 1989: the RER is the ratio of the price of tradable goods to the price of non-tradable goods (Mussa, 1984; Edwards, 1988). There is a negative relationship between a country's per capita income and its RER.

Trade openness (OPEN) is defined as the sum of exports and imports as a percentage of GDP. The impact of the country's trade policy is reflected in this openness rate. The market for tradable goods rises as trade Openness (OPEN) increases. In order to restore equilibrium, the RER must depreciate in order for the demand to shift away from tradable products and toward non-tradables. Assuming that tradables and non-tradables are replacements, and that the substitution effect is greater than the income effect, the RER is assumed to be strongly linked to trade openness (Edwards, 1989).

Government Consumption Expenditure (GOV) is known as the share of public expenditure in GDP. It has an unclear effect on the RER since it is dependent on how they are distributed into tradable and non-tradable products (Edwards, 1989). Indeed, a high proportion of non-tradable products put downward pressure on the relative price of non-tradable goods, resulting in a real depreciation (positive sign) and, in some cases, a decline of the country's competitive position. On the other hand, a low non-tradable goods composition would inevitably lead to a real exchange rate appreciation, which is needed to boost the country's competitive position. The effect of public spending on RERs, according to Drine & Rault (2005), varies depending on the community of the surveyed countries. Indeed, an increase in government expenditure leads to an appreciation in the RER in Latin America but depreciation in Asia and Africa.

Net Foreign Asset (NFA) is widely considered in the literature as a fundamental variable of the RER (Faruqee, 1995; Aliyu, 2007). As a consequence, the idea of having a lot of foreign net assets (or wealth) typically means having a lot of demand for goods. The above puts a lot of pressure on the prices of non-tradable goods, which helps to lower the relative price of tradable goods and increase the RER's value. Their long-term effect, however, is unclear.

Investment (INVEST) is measured as the ratio of gross fixed capital formation to GDP. According to (Edwards, 1989), an increase in investment should be predicted to result in a reduction in the real interest rate, with all other considerations being equal. A fall in the real interest rate, on the other hand, results in a depreciation of the real exchange rate (positive sign).

The descriptive study of 40 results from the time series variables is shown in Table 1. The skewness findings show that the real effective exchange rate, productivity, investment, trade openness, and government expenditure value-added all have a long right-tail distribution, while the remaining variables have a long left-tail distribution. The kurtosis findings indicate that platykurtic distributions exist for real effective exchange rate, productivity, investment, and trade openness, while leptokurtic distributions exist for net foreign assets. The Jarque-Bera test, which works under the null hypothesis that series are normally distributed, shows that we support the null hypothesis of normal distribution for all variables except net foreign assets value-added at the 5% level of significance. The productivity produces a high value of 3.626, according to the mean results. The standard deviation analysis shows that productivity is the most volatile indicator, with a deviation of 0.124, followed by the real effective exchange rate.

Table 1
DESCRIPTIVE STATISTICAL ANALYSIS

Statistic	REER	PROD	INVES	NFA	OPEN	GOV
Mean	2.098	3.626	-0.622	0.051	-0.047	-0.77

Median	2.102	3.625	-0.622	0.053	-0.046	-0.78
Maximum	2.034	3.8	-0.468	0.168	0.058	-0.68
Minimum	1.893	3.459	-0.744	-0.383	-0.17	-0.84
Std.Dev	0.122	0.124	0.065	0.082	0.054	0.035
Skewness	0.682	0.067	0.353	-3.652	-0.102	0.845
Kurtosis	2.784	1.409	2.927	21.128	2.664	3.597
Jarque-Bera	3.183	4.246	0.842	636.66	0.258	5.361
Probability	0.203	0.119	0.656	0.000*	0.878	0.068
*Rejection of the null hypothesis at 5% p value						

The association analysis is seen in Table 2. The findings suggest a negative monotonic association between REER and the independent variables (productivity, trade transparency, and government expenditure) (dependent variable). The other variables have a positive monotonic relationship; but, as rho (ρ) reaches -1, the frequency of the correlation between REER and PROD grows greater.

Table 2
CORRELATION

	REER	PROD	INVES	NFA	OPEN	GOV
REER	1					
PROD	-0.871	1				
INVES	0.85	-0.701	1			
NFA	0.072	0.001	0.234	1		
OPEN	0.726	0.712	-0.463	0.011	1	
GOV	-0.622	0.644	-0.699	-0.439	0.349	1

The trend of the study variables is depicted in Figure 1. Almost all of them go down over time; however, the remaining variables go up quickly.

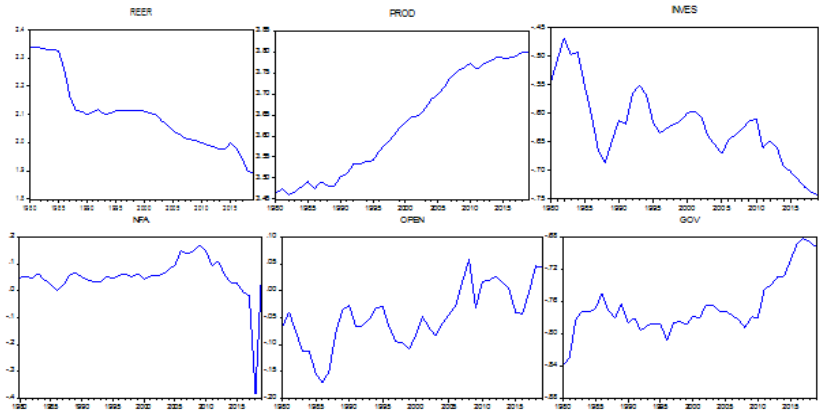

FIGURE 1
TREND OF THE STUDIES VARIABLES

In order to have a stable conclusion to prevent spurious regression outcomes, the stationarity of the variables is checked using the ADF and PP tests. The findings of the unit root evaluation are summarized in Table 3. The findings show that all of the study variables are non-stationary at a level, but stationary in the first difference, implying that variables are integrated at 1.

Table 3 UNIT ROOT TESTING				
Augmented Dickey-Fuller				
	Levels		**Difference**	
Variables	**t-statistic**	**p-value****	**t-statistic**	**p-value****
REER	-1.661	0.0907	-2.757	0.007
PROD	5.061	1	-2.024	0.042
INVES	1.016	0.915	-4.265	0
NFA	-1.816	0.066	-11.195	0
GOV	-1.692	0.085	-5.959	0
OPEN	-1.508	0.121	-5.579	0

Methodology

To estimate the long-run equilibrium relationship between REER and the independent variables, the analysis uses the ARDL (Autoregressive and Distributed Lag) method of co-integration (PROD, OPEN, NFA, INVEST and GOV). Pesaran & Shin (1999); Pearsan, et al., (2002) introduced the ARDL co-integration method (2001). In contrast to other previous and conventional co-integration approaches, it has three benefits. The first is that the ARDL does not mandate that any of the variables under analysis be integrated in the same order; it can be used for variables that are integrated in order one, order zero, or fractionally integrated. The second advantage is that the ARDL test is relatively more efficient in the case of small and finite sample data sizes. The final and third advantage is that by using the ARDL technique, we can achieve unbiased long-run model estimates (Harris & Sollis, 2003). The following is the ARDL model used in this study:

$$\Delta \mathrm{REER}_t = \alpha_0 + \delta_1 \mathrm{REER}_{t-1} + \delta_2 \mathrm{PROD}_{t-1} + \delta_3 \mathrm{NFA}_{t-1} + \delta_4 \mathrm{OPEN}_{t-1} + \delta_5 \mathrm{INVEST}_{t-1} + \delta_6 \mathrm{GOV}_{t-1} + \sum_{i=0}^{p} \beta_{1j} \Delta \mathrm{REER}_{t-i} + \sum_{i=0}^{p} \beta_{2j} \Delta \mathrm{PROD}_{t-i} + \sum_{i=0}^{p} \beta_{3j} \Delta \mathrm{NFA}_{t-i} + \sum_{i=0}^{p} \beta_{4j} \Delta \mathrm{OPEN}_{t-i} + \sum_{i=0}^{p} \beta_{5j} \Delta \mathrm{INVEST}_{t-i} + \sum_{i=0}^{p} \beta_{6j} \Delta \mathrm{GOV}_{t-i} + \theta ECT_{t-i} + \varepsilon_{1t} \quad (2)$$

Where α the intercept, p is is the lag order, ε_t is the error term, Δ is the first difference operator, β_ij (i=1,…,6) are the short-run coefficients, δ_i (i=1,…,6) are the long-run coefficients and ECT the error correction term (θ should be negative and significant in order to validate the long-run relationship).

EMPIRICAL RESULTS

The empirical evidence for the main results is discussed in this section.

Main Results

The first step is to select the best model for estimating long-run equilibrium relationships. The Akaike Information Criterion as seen in Figure 2 was used to choose the best model that met the specification: ARDL (3, 3, 0, 2, 0, 4).

(Top 20 models)

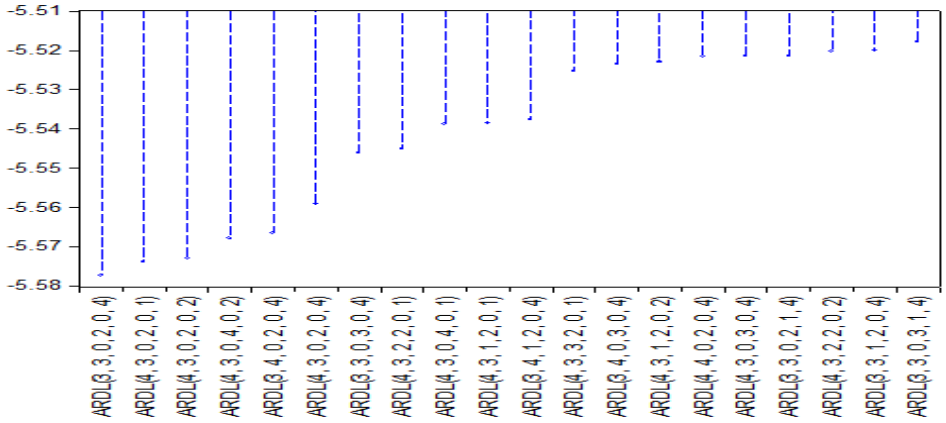

FIGURE 2
AKAIKE INFORMATION CRITERIAN MODEL SELECTION

Table 4 displays the ARDL bounds test for long-run estimation. At 10, 5, and 2.5 percent significance levels, the bounds co-integration test reveals that the approximate F-Statistic is above the upper bound. The null hypothesis of no long-run equilibrium relationship between variables is rejected at the 5% significance level.

Table 4
SUMMARY OF ARDL BOUNDS TESTING

Test statistic	Value	k
F-statistic	4.580*	5
Critical value bounds		
Significance	**I0 bound**	**I1 bound**
10%	2.26	3.35
5%	2.62	3.79
2.50%	2.96	4.18
1%	3.41	4.68
*indicates statistical significance at the 5% level		

Table 5 shows the rand's estimated long-run REER equation derived from the co-integrating equation. The short-run coefficients of the leads and lags of the co-integrating regressors are not stated since the main emphasis is on the long-run parameters. The findings reveal that:

ECT's predicted negative connotation is highly important. This reaffirms the importance of the equilibrium co-integration equation and the presence of long-term relationships among the variables.

A 10 % in PROD will appreciate REER by 3.39 % (Béreau et al., 2009; Bouoiyour & Rey, 2005). Tunisia has lost 3.39 percent of its competitiveness as a result of this. Concretely, this means that as Tunisia's productivity improves in comparison to its trading partners, the price of tradable goods decreases. Because of the price cut, these goods are in higher demand around the world, resulting in increased exports and an appreciation of the real effective exchange rate.

A 10 % increase in OPEN will depreciate REER by 3.92% (Baffes et al., 1999; Goldfajn & Valdes, 1999). This result is consistent with economic theory's requirements. This depreciation is needed to absorb surplus labor in the importable goods industry (Goldfajn & Valdes, 1999). Studies by Haj Amor & El Araj (2009) on the MENA countries and by Drine & Rault (2005) on Africa, Asia and Latin America confirm the positive relationship between the RER and economic openness.

A 10% increase in NFA will increase REER by 1% (Elbadawui et al., 2012). More precisely, our result shows that a 10% improvement in the net foreign assets generates 1 % real depreciation of the local currency.

A 10% increase in INVES will increase REER by 14.4%. The local currency continues to depreciate dramatically as a result of the investment; especially due to capital accumulation.

A 10% increase in GOV will appreciate REER by 14.14% in long-run estimates.

Table 5
SUMMARY OF ARDL COINTEGRATION AND LONG-RUN COEFFICIENT ESTIMATION

Variable	Coefficient	Std.error	t-statistic	Prob.
PROD	-0.339	0.122	-2.764	0.011*
OPEN	0.392	0.176	2.223	0.037*
NFA	0.18	0.077	2.368	0.007*
INVES	1.44	0.167	8.609	0.000*
GOV	-1.414	0.364	-3.877	0.000*
C	5.232	0.641	8.161	0.000*
ECT(-1)	-0.553	0.127	-4.337	0.000*

*Denotes rejection of the hypothesis at 5%

ARDL was also exposed to a number of diagnostic tests, as seen in Table 6. The test results demonstrate that the null hypothesis cannot be rejected at the 5% significance level, implying that the model has no heteroscedasticity (Breusch-Pagan-Godfrey Test), the equations have been rewritten in their proper practical form (Ramsey RESET Test). In the model, there is no serial association at lag order h (Lagrange-multiplier test), and residuals are multivariate normally distributed (Jarque-Bera test). The CUSUM and CUSUM of Squares checks for parameter instability from the ARDL model are seen in Figure 3. The parameter instability of the equation used in the ARDL model is determined using the CUSUM and CUSUM of Squares measures. The parameter of the equation is robust enough to predict long-run and short-run causality in the sample since the plots in the CUSUM and CUSUM of Squares experiments lie below the 5% significance level or +/- S.E.

Table 6
DIAGNOSTICS OF ARDL MODEL

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.532129	Prob. F(15,21)	0.893
Obs*R-squared	10.1902	Prob. chi-square(15)	0.8076
Scaled explained SS	4.623174	Prob. chi-square(15)	0.9949
Ramsey RESET test			
	Value	df	Probability
t-statistic	1.3237	20	0.2005
F-statistic	1.752182	(1, 20)	0.2005
Residual Serial Correlation LM Tests			
F-statistic	0.074188	Prob. F(2,19)	0.9288
Obs*R-squared	0.286703	Prob. chi-square(2)	0.8664
Jarque-Bera test			
Jarque-Bera		Prob.	
2.001		0.367	

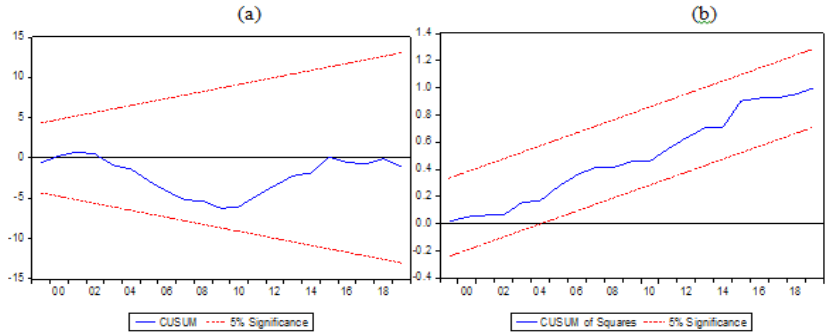

FIGURE 3
(a) CUSUM AND (b) CUSUM OF SQUARES TESTS FOR THE PARAMETER STABILITY FROM ARDL MODEL

Evaluation of the Degree of Misalignments

We will assess misalignments in Tunisia's real effective exchange rate in this section, with an emphasis on their persistence. In this case, we begin by determining the real effective exchange rate's equilibrium, which is influenced by productivity, trade openness, net foreign assets, investment, and government expenditure.

The Equilibrium Real Effective Exchange Rate

This exercise, as most scholars remember, necessitates a great deal of subjectivity. To get around this issue, some writers tend to use moving averages based on several years instead of fundamentals (Kuikeu). Others chose to use the Hodrick-Prescott filter to get around this issue (Linjouom, 2004). This approach will be used here, and the basics have been broken down into permanent and temporary components with a smoothing parameter of 100.

Cointeq=TCERHP – (0.339*PRODHP+0.392*OPENHP+0.180*NFAHP+0.140*INVESTHP - 1.414*GOVHP+5.232) (3)

Trajectories of the Current Exchange Rate and the Equilibrium Exchange Rate

The imbalance movements between the real exchange rate and the equilibrium exchange rate are shown in Figure 4 below. But, as the real exchange rate deviates from the equilibrium trajectory, can we talk about misalignments?

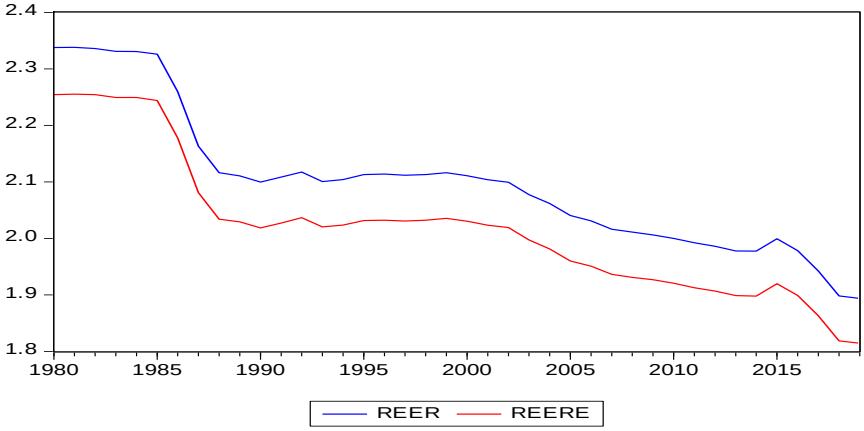

FIGURE 4
EVOLUTION OF THE CURRENT REAL EXCHANGE RATE *VS* EQUILIBRIUM EXCHANGE RATES

Determination of Exchange Rate Misalignments

As previously stated, our aim is to calculate misalignments in the Tunisian dinar's real effective exchange rate based on the estimation of the equilibrium real exchange rate. We can quantify the REER misalignments after calculating the equilibrium values of the real effective exchange rate, which are defined as the percentage change in the current exchange rate level compared to the equilibrium exchange rate level. Analytically, misalignments are calculated using the following formula:

MIS=(current REER- equilibrium REER)*100%

There are three scenarios based on the misalignments indicator's expression:

1. If MIS is positive, the current real effective exchange rate is overvalued,
2. If MIS is negative, the current real effective exchange rate is undervalued,
3. If MIS is zero, the current real effective exchange rate is aligned.

As a result, we obtain the results of misalignments in Tunisia's real effective exchange rate, as seen in Figure 5, which depicts the various degrees of misalignment in the TD's real effective exchange rate from 1980 to 2019. As a result, all values are over the equilibrium line, meaning that the real effective exchange rate has been overvalued, resulting in a lack of competition. This points at the nature of systemic limitations in the economy that keep the country's productivity from improving substantially and quickly.

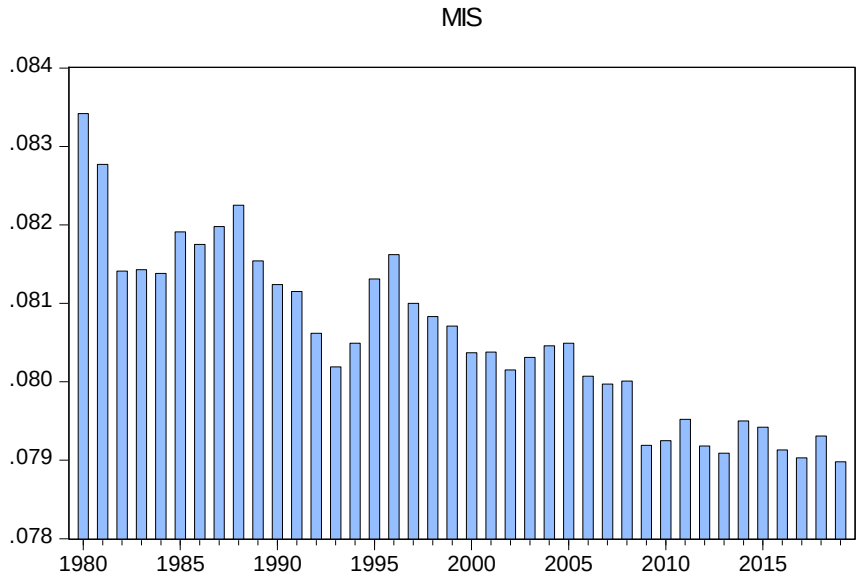

FIGURE 5
MISALIGNMENTS OF THE REAL EFFECTIVE EXCHANGE RATE OF THE TD

Persistence of Misalignments in the Real Effective Exchange Rate

It was important to deduce the parameter "d" from the ARFIMA method (Autoregressive Fractionally Integrated Moving Average) in order to account for the existence of misalignments of the Tunisian Dinar at its equilibrium value.

Hurst, an English hydrologist, used heuristic techniques in the 1950s. They entail estimating the parameter “d” by the auto-similarity parameter H using the following formula:

$$\hat{d} = \hat{H} - \frac{1}{2} (4)$$

This method is based on the statistic $Q(n)=\frac{R(n)}{S_n}$, where n defines the sample size and Q(n)>0, it allows to detect non-periodic cycles. This yields a value for the parameter H, which is known as the Hurst coefficient (and which is similar to the auto-similarity coefficient).

With:

$$H \approx \frac{logQ(n)}{\log(n)} \quad (5)$$

$$R(n)=\max_{1\le k\le n} \sum_{i=1}^{k}(Y_i - \bar{Y}_n) - \min_{1\le k\le n} \sum_{i=1}^{k}(Y_i - \bar{Y}_n), \quad (6)$$

$$S_n^2 = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y}_n)^2, \text{ the empirical variance,} \quad (7)$$

and

$$\bar{Y}_n = \frac{1}{n}\sum_{i=1}^{n}(Y_i), \text{ the empirical mean,} \quad (8)$$

The time series can then be divided into three families dependent on the value of parameter d:

When 0<d<1/2, the ARFIMA process is a stationary, long-memory process that can simulate long-term persistence.

- When d=0, the ARFIMA process (p,d,q) is reduced to a simple ARMA (p,q). No long-term correlation structure is present;

When - 1/2< d<0, the ARFIMA process (p,d,q) is an anti-persistent process. We are talking about negative long memory.

This approach has the advantage of allowing for the use of a "d" estimator with strong robustness properties.

The results of applying this approach to the series of misalignments obtained are seen in Table 7. Looking at this table, we can see that d<½, indicates the persistence of real effective exchange rate misalignments in Tunisia (more accurately, the persistence of overvaluation), which is likely to deteriorate the current account, contribute to a drain of foreign exchange reserves (Kaminsky et al., 1997), and has a negative impact on tradable goods activities (Ghura & Grennes, 1993).

Table 7
RESULT OF ESTIMATION OF THE FRACTIONAL INTEGRATION PARAMETER "d"

R(n)	S(n)	Q(n)	H	d
0.08	0.006	12.647	0.688	0.187

DISCUSSION OF RESULTS AND ECONOMIC IMPLICATIONS

The sensitivity of the empirical findings obtained in our research and their consequences for investors and policymakers are discussed in this section. We begin by stating that this paper empirically investigates a fascinating and timely subject centered on the relationship between the real effective exchange rate and its fundamental determinants.

We note that the results of the estimation of ARDL model showing that the misalignments and the equilibrium level of the real effective exchange rate of the TD are significantly affected by the macroeconomic variables which are: productivity, trade opening, net foreign assets, investment and government expenditure. The findings of the ARDL model estimation indicate that macroeconomic variables such as productivity, trade opening, net foreign assets, investment and government expenditure have a substantial influence on the equilibrium level of the real effective exchange rate of the TD and misalignments. Given the results obtained by other authors (MacDonal & Ricci, 2005; Drine & Rault, 2005; Amor & El Araj, 2009; Adusei & Cryapong, 2017; Couharde et al., 2018; Mahraddika, 2020), these findings are not unexpected. Furthermore, the measures of serial correlation, heteroscedasticity, and residual normality all produce good outcomes.

Now, assuming that these misalignments have an effect on Tunisia's economic efficiency, the authorities in charge of monetary and exchange rate policy should keep track of a variety of indicators:

Implications for productivity: This research discovered that productivity causes the real effective exchange rate to rise, which is associated with a lack of competition. These misalignments may be avoided with a support scheme for industries that produce non-tradable products.

Maintaining a strong trade policy: Trade openness may be used as a proxy for trade policy. This predictor has a positive and important effect on Tunisia's REER, according to the findings. This ensures that increasing the country's exposure to the global economy depreciates the REER. As a consequence, a strategy that helps our markets to benefit from trade liberalization must be enforced.

Implementing a policy to supervise the REER: Once it is understood that the TD's real effective exchange rate is overvalued, it is up to us to enforce a policy to maintain the real exchange rate's internal and external equilibrium. Since the analytical approach used in this study is macroeconomic, the exchange rate misalignments are also macroeconomic in nature. As a result, improved integration of macroeconomic policies within Tunisia is needed to correct these deviations. As a result, monetary policymakers must define a previously established range of over/undervaluation above which the RER can be readjusted. In order to establish an adequate structural basis for the application of this suggestion, these authorities will have to consider the modifications that they will need to make to the governing frameworks of monetary institutions.

CONCLUSION

Given the severity of the effects of monetary misalignment on the economy, the Tunisian monetary authorities must treat it as a major issue. As a result, the aim of this analysis was to quantify the percentage of misalignment between the real effective exchange rate and its equilibrium value from 1980 to 2019.

We first estimated the relationship between the REER and its determinants, including productivity, trade openness, government spending, net foreign assets and investment, using the ARDL model. Overall, the fundamental variables had statistically significant and predicted coefficients, according to the findings (in line with economic theory). The equilibrium REER was then determined using the previously estimated equation and the equilibrium values of the fundamental variables, which were calculated using the Hodrick-Prescott (1997) filter. What is generally referred to as misalignment is the difference between this equilibrium exchange rate and the observed exchange rate. Its calculation allowed us to show that the REER is overvalued. The application of the "Hurst" method to the series of misalignments highlighted the persistence of this series. This property is due to many factors, including, for example, structural changes in economic fundamentals, inefficiency in foreign exchange markets, asymmetric information, the existence of transaction costs in financial markets, mimetic behavior, heterogeneity of agents and rigidities.

Clearly, taking into account the phenomena of persistent exchange rate deviations helps economists and, most importantly, central bankers to decide the best course of action.

For more study, a comparative analysis between Tunisia and other Mediterranean basin nations, as well as competitors such as Morocco and Turkey, will be beneficial.

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