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Research

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The misalignment of Tunisia's real effective exchange rate via the BEER approach

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Abstract

This paper adopts the methodology of error correction models on the BEER (Behavioral Equilibrium Exchange Rate) approach to express the Tunisian real effective exchange rate based on-trade openness, the money supply in terms of GDP, and GDP per capita on the period (1975-2017). Indeed, the error correction mechanism confirms one of the convergences of the REER series of its trajectory to its long-term target value and on the other hand, it reflects the success of the monetary and commercial policies exploited to absorb all unpredictable shocks capable of preventing the stability of ERER from its equilibrium value. The empirical results also show the low sensitivity of the REER to monetary and trade shocks.

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

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1. Introduction

The Tunisian real effective exchange rate (REER) is considered as one of the relevant determinants that evaluates price competitiveness either at the micro level to the macro level. Indeed, it has an exceptional place, since it is determined firstly by internal factors resulting from the supply and demand of money. Then, it is based on external factors indicating the evolution of the value of Tunisian dinar (TND) against the currencies of principal trading partners. Finally, it has interactive relationships with internal and external factors in the performance of the economy. Thus, the stabilization of TND is generally attributed to the evaluation of the degree of integration of the national economy in the global economic sphere. In reality, the misalignment of the REER may create real problems for outward-looking economies. An overvaluation of the home Currency can put the country ahead of major risks materialized s by increasing foreign debt, worsening the deficit and its current account, and the risk of exposure to speculative attacks. On the other hand, the undervaluation of a currency can be a tool to promote exports, to influence the inter-temporal allocation of productive resources by arbitrage between tradable and non - tradable goods. Thus, determining the misalignment of the Tunisian REER is a prerequisite for the choices made by policy makers in economic and trade policies.

In summary, the purpose of this article is to contribute to the existing literature by examining the long-term dynamics of the REER in terms of certain fundamental variables in order to evaluate the exchange rate policy in Tunisia during the period (1975- 2017). This research work begins first with the theoretical underpinning of the adoption of the VECM model based on a BEER approach. Then we conduct a descriptive analysis of all variables in the model and a description of their resources is required to give a credibility to the study. Thus, a careful analysis is done to confirm the presence of relation of long-term causality and the existence of co-integration relations between the REER and its fundamentals. Finally, the estimate of the misalignment of the REER enables us to determine the phases and to evaluate the TND in real terms that can be interpreted through the changes in the exchange rate regime in Tunisia.

The rest of the study is proceeds as follows. In Section 2, we briefly discuss the theoretical literature. The data and methodology are covered in Section 3. Section 4 presents and discusses the empirical results, while Section 5 concludes and gives some policy recommendations.

2. Theoretical literature

The study of the trajectory of the real long-term exchange rate is designed according to three distinct approaches. The first said Fundamental Equilibrium Exchange Rate "is proposed by Williamson in1983. The real effective fundamental equilibrium exchange rate is based on conditions simultaneously reflecting internal and external equilibrium. But this approach responds to a judgment of value insofar as the internal equilibrium results from the achievement of a desired level of output or a desired level of inflation, whence the the normative character of the FEER. The second balance ensures the sustainability of the current account balance financed by long-term capital flows (Williamson,

1994). Indeed, the FEER results from the solution of a current balance able to adjust in order to equalize the excess of desired savings.

A few years later, MacDonald (1997) and Clark and MacDonald (1999) suggested the original version of a second approach "BEER" (Behavioral Equilibrium Exchange Rate) which differs from its antecedent by a bedrock called positive. An empirical study done by MacDonald (1998) demonstrated changes in the rate of equilibrium real effective exchange rate (TCER) long term. The basis of the model is the condition of financial equilibrium of the unchanged interest rate parity. This type of approach raises several limitations as developed by MacDonald (2002) who noted that the variables included in the BEER calculation are mixed in terms of time horizon. Then, the systematic variable becomes a variable whose content is heterogeneous which allows introducing into the determining equation of the real exchange rate variables that are not necessarily related to the structural equation of the model. Finally, since the BEER is econometric modeling its original while still depends the usual robustness issues of study design such as the long-term relationship, the choice of variables and the study period (Durand and LOPEZ, 2012).

The third class of models is the natural exchange rate (NATREX). It takes into account the characteristics of economies such as the size of the country compared to its main partners, the degree of substitutability of goods and financial assets ... (Federici and Gandolfo, 2002). It is based on the cornerstone of any theoretical construction ($SI = CA$)³. NATREX simultaneously corresponds to the balance of the goods market and the balance of payments in the absence of changes in foreign exchange reserves, speculative capital movements and cyclical factors when output reaches its potential level. The basis of the theoretical construction of NATREX is inspired by inter-temporal optimization methods under uncertainty as in the work of Edwards (1989) and Obstfeld and Rogoff (1995). NATREX is also based on BEER on a positive view of the real exchange rate. The modeling of the NATREX models deals with both the dynamics of the real exchange rate and its interaction with external debt, its interaction with changes in productivities, and its response to changes in total consumption (Rey, 2009). Despite this, the BEER approach is still the most used in the foundation of VECM models⁴ thanks to the simplicity of its formulation which facilitates the estimation of the Real Effective exchange rate of Equilibrium (REERE), the positive underpinning of the approach and the examination of misalignment as a recall force (Bouveret and Sterdyniak, 2005 ; Gnansounou and Verdier-Chouchane, 2012) .

3. Methodology

3.1 Sources and transformation of variables

Based on available data, the series used in this research for the period (1975 -2017) are annual s. All the variables are from the WDI CD-ROM (2018). The modeling is preceded by the transformation of all the variables into a logarithmic function ($\log TCER = LTCER$, $\log MM = LMM$, $\log OC = LOC$ and $\log PIBT = LPIBT$). This transformation allows a better description of the phenomenon under examination. But, by the nature of the translated variables in logarithmic function belong to the interval] 1, + ∞ [to guarantee the positive sign of the transformed variables.

³The difference between savings and national investment equals the balance of the balance of payments. It is the excess or lack of the desired savings.

⁴Vector Error Correction Model: error-correction model is used in the case of non-stationarity of all level variables and if there are cointegration relations such that $(0 < r < n)$ with n the number of variables endogenous.

3. 2 Determination of the real effective exchange rate and its fundamentals: descriptive analysis

In order to conduct a comprehensive study, we begin by defining the variables and describing the possible relationships of existing between the fundamental variables and the REER by referring to the theory.

3.2.1 Real effective exchange rate

The real effective exchange rate, quoted at certain rates, is the value of the Tunisian dinar calculated on the basis of a weighted average of a basket of foreign currencies determined by the IMF econometricians who have chosen 2010 as the base year.

3.2.2 Degree of openness

Trade opening (LOC) is defined by the logarithm of the ratio of the sum of exports and imports to GDP expressed in values. Changes in a country's trade policy towards greater liberalization affect the real exchange rate by two reverse effects. Strengthening the measures of trade liberalization reduces the price of domestic currency imports, which constitute part of the tradable goods, which leads to a decrease in their prices and results in the appreciation of the REER. Nevertheless, some economists like Goldfajn and Valdes (1999), and Drine and Rault (2005) stated that the amplification of trade liberalization implies the real depreciation of the exchange rate since it brings together the increase of trade and the convergence of prices. Baffesandali (1999) supported this process for developing countries because the openness rate of these latter is pointed to by the higher increase in imports, which leads to the depreciation of the TCR. Works and Drine and Rault (2005) on Africa, Asia and Latin America and those of Hadj Amor and El Araj (2009) on the MENA countries affirm the negative correlation between economic openness and the TCR. The trajectory of the LOC is ascending throughout the period with the exception of two sub-periods. Between 1981 and 1987, the decline in external openness is explained by the recessionary phase that invaded the country during the crisis of the 1980s. From 1988 the opening on the outside increases reaching in 1999 the highest rate of 121.5% (figures 1) succeeded by a decline of the commercial opening between 2000 and 2004. In spite of this decline the degree of the opening remains high throughout the period (1981-2013), which proves the strong dependence of the country from outside. In the end, the Tunisian trade liberalization policy materialized by the increase in the rate of trade opening allows us to predict a negative relationship between trade opening and the REER (Figure 1). The two variables show opposing trends that prove, on the one hand, the intensification of international trade in goods and services and, on the other hand, the country's strong dependence on the outside world.

3.2.3 Ratio of the money supply

The logarithm of money supply has a percentage of GDP (LMM), monetary policy indicator led by the central bank of any country, is integrated in our model in order to examine the supply on the REER. In other words, this ratio makes it possible to evaluate the effectiveness of discretionary monetary policy in controlling the value of the REER in the vicinity of its target value. Indeed, the role of the Central Bank of Tunisia (CBT) is to defend the parity of the national currency by appropriate interventions to offset the inflation differential between Tunisia and its main trading partners following fluctuations in the US dollar and / or the Euro. The CBT injects national currency into the economy, which increases the money

supply in the case of an overvaluation of the REER and the absorption in the opposite case. To keep the value of TND and control inflation, the Central Bank maintains liquidity by lower money market rates to 3.16%, which finds its lowest rate in 2012 (compared to the CBT, 2014). This expansionist policy has been distinctly observed since the year 2011 during which the BCT has lowered interest rates, has limited banks' reserves and has injected an amount of 3.87 million dinars (Abderrahim and Castel , 2012) .The resort to monetary policy to avoid the widening of the gap between the observed and expected REER proved to be effective during the 1990s, when the monetary authorities adopted a policy of targeting the REER with the aim of stabilizing the high volatility in the terms of trade and exchange rate and to promote growth . As a result, we expect a negative relationship between the REER trend and the money supply ratio shown in Figure 1.

3.2.4 *Gross domestic product per capita*

There have been many empirical tests that have demonstrated a positive correlation between the relative price of non-tradable and per capita GDP (Samuelson, 1964, Kravis, 1982, Rogoff, 1996). Thus, the higher the per capita income relative to the other countries, the higher the relative price of non-tradable goods would be. Therefore, considering the Edwards RER definition, 1989: the RER is the ratio between the price of tradable goods and non-tradable goods (Dornbusch, 1980, Mussa, 1984, Edwards 1988, Blanchard 1998) so there is a negative correlation between the per capita income of a country and its TCR. Edwards and Savastano (1999) and Montiel (1999) showed the significance of the Balassa effect on data samples including a large number of countries. Generally, the unavailability of productivity differences between sectors for developing and emerging countries was the origin of the approximation of productivities in gross domestic products per capita (GDPT), which represent levels of development. Nevertheless, this type of test does not distinguish between the supply effect and the demand effect.

It is expected therefore that the coefficient relative LGDP be negative for economic development can r é cart accompanied by a growing between productivity relative in the goods and services exchangeable sector, which is reflected by an appreciation of real exchange rate.

Figure 1 : Descriptive graph of used variables.

3.3. Estimation of the error correction model

The theoretical underpinning of the econometric modeling chosen in this study reveals two properties corresponding to the long-term equilibrium. The first relates to the existence of a stationary state relation between the REER and its fundamentals. This procedure is based on a linear form represented as follows:

$$LTCER = \beta_0 + \beta'Z + \varepsilon \quad (1)$$

Where $LTCER$ is the REER quoted at certain and expressed in logarithmic value ; Z is the vector of the model's fundamental variables expressed in logarithmic form ; and ε represent residues identically and independently distributed.

The second property requires the presence of a stationary and dynamically stable state only when all the variables of the model have the same order of integration. (Haorau, 2006)⁵. To meet such a requirement, we adopt the following VECM model:

$$\Delta LTCER_t = \theta (LTCER_{t-1} - \beta_0 - \beta'Z_{t-1}) + \sum_{j=1}^p \lambda_j \Delta LTCER_{t-j} + U_t$$

⁵Self-correcting mechanisms are created following an exogenous shock on the REER leading to its convergence towards the equilibrium of the system (Haorau, 2006)

Where Δ represents the operator of the first differences; U_t is an iid residue ; and θ is an error correction term.

According to Baffes and Elbadawi (1999), the long-term equilibrium is stable only if $(-2 < \theta < 0)$. Is calculated across the estimation of equation (1) according to ordinary least squares written as follows:

$$LTCER_t = \beta_0 + \beta_1 * LOC_t + \beta_2 * LMM_t + \beta_3 * LPIBT_t + \varepsilon_t$$

LTCER, LOC, LMM and LPIBT refers respectively to logarithms of the real effective exchange rates, the degree of trade openness as a proxy for trade policy, the ratio of the money supply as a percentage of GDP and the gross domestic product per capita. The coefficients β_i represent the parameters to be estimated and ε_t the error term.

As a result, the equation for calculating the effective equilibrium effective exchange rate is written after the estimate as follows:

$$LTCER_t = 13.31265 - 0.575103 * LOC_t - 0.354250 * LMM_t - 0.560387 * GDPT_t \quad (1)$$

3.3. 1 optimal delay

To obtain the optimal delay between the different variables, we go back to the criteria sequential modified LR statistic test (LR), final prediction error (FPE), Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ). The symbol (*) pointed at the table (1) indicates the optimal delay retained by each criterion. The selected optimal delay number resulting from the intersection between the maximum delay order selected by the set of criteria and the minimum delay is equal to three ($p = 1$).

Table 1 : Determination of the optimal number of delays.

Delay	LR _(p)	FPE _(p)	AIC _(p)	SC _(p)	HQ _(p)
$p = 0$	N / A	8.12e-08	-4.974965	-4.804343	-4.913747
$p = 1$	352.6119	5.81e-12	-14.52539 *	-13.67228 *	-14.21930 *
$p = 2$	27.96060 *	5.35e-12 *	-14.63690	-13.10130	-14.08594
$p = 3$	18.32638	6.45e-12	-14.52125	-12.30316	-13.72542
$p = 4$	13.63732	9.11e-12	-14.32061	-11.42004	-13.27991
Optimal delay	2	2	1	1	1

Source : Table prepared by the author on Eviews 10 with 1975-2017 annual data entered from the WDI database (2018).

3.3. 2 Stationarity: Augmented- Dickey-Fuller test

The pioneering work in unit root tests is that of Fuller (1976) and Dickey and Fuller (1979, 1980). Dickey-Fuller's tests are parametric tests to show the non stationarity of a time series through a deterministic process or a stochastic process. These tests are based on the estimation of an autoregressive process. Dickey and Fuller consider three basic models for a series X_t :

Model (A): model without constant or deterministic trend

$$X_t = \rho X_{t-1} + \varepsilon_t$$

Model (B): model with constant and without deterministic trend

$$X_t = b + \rho X_{t-1} + \varepsilon_t$$

Model (C): model with constant and deterministic trend

$$X_t = b + a_t + \rho X_{t-1} + \varepsilon_t$$

In each of the three models, the error term is hypothetically following a white noise $\varepsilon_t \rightarrow BB(0, \sigma^2)$.

The test principle is as follows:

$H_0: \rho = 1$ presence of a unit root then the series is not stationary

$H_0: |\rho| < 1$ absence of unit root then the series is stationary

If the hypothesis $H_0: \rho = 1$ is retained in one of these three models then the process is not stationary.

The test strategy is sequential, we start with the model (C), then we go to the model (B) and finally we make the model (A).

For the model (C), we test the significance of the slope coefficient of the trend **a** from the Student statistic. If **a** is significantly different from zero, then for the same model the coefficient of **ρ** is tested by the same test.

We reject **$H_0: \rho = 1$** , that is, the series is stationary. On the other hand, if the coefficient **a** is significantly zero, we go directly to the test on the **$t_{\rho} > t_{\alpha}$** model (B), we test the significance of the constant **b** by the Student's test. If **b** is significantly different from zero, then for the same model the coefficient of **ρ** is tested by the same test. If the constant **b** is significantly zero, we pass the test on the model (A).

If the series **X_t** in level is not stationary, one applies the test DF and with the same procedure to the differentiated series **ΔX_t** .

It is recalled that the DF test on the three models assumes that the residue process is a white noise. But there is no reason for the variables to be unrelated. To account for the serial correlation of errors, Dickey and Fuller developed their test. In 1981, a test known as the Augmented Dickey-Fuller (ADF) test proposed AR (p) autoregressive representation based on these three models:

Model (D): model without constant or deterministic trend

$$X_t = \varphi X_{t-1} + \sum \alpha \Delta X_{t-j} + \eta_t$$

Model (E): model with constant without deterministic trend

$$X_t = \varphi X_{t-1} + \eta_0 \mu + \sum \alpha \Delta X_{t-j} + \eta_t$$

Model (F): model with constant and deterministic trend

$$X_t = \varphi X_{t-1} + \theta + \beta_t + \sum \alpha \Delta X_{t-j} + \eta_t$$

The implementation of the ADF test is similar to the DF test only the statistical tables differ. The ADF test application requires first to choose the number of delays p to be introduced so as to blot the residues. The optimal delay value previously determined is equal to one.

We adopt the sequential strategy of the ADF test to study the stability of the variables. To verify the existence of a unit root, we perform the Augmented Dickey-Fuller tests with the following assumptions :

$$H_0 : \alpha = 0$$

$$H_1 : \alpha < 0$$

We accept H_0 if $ADF_{cal} > ADF_{tab}$ otherwise we accept H_1 .

Table (2) below shows the results of the ADF test application on the LTCER series.

Table 2 : Stationarity of the LTCER series

	Variable	Coefficient	Stderror	Statistic	prob	t_{tab} at 1%, 5% and 10%	t_{cal}
Model (C)	LTCER (-1)	-0.149110	0.049514	-3.011449	0.0047	-4.198503	-3.011449
	C	0.796687	0.271654	2.932729	0.0057	-3.523623	
	Trend (1975)	-0.003415	0.001348	-2.532929	0.0157	-3.192902	
Model (B)	LTCER (-1)	-0.030699	0.020430	-1.502657	0.0416	-3.605593	-1.502657
	C	0.133790	0.099728	1.341544	0.0481	-2.936942 -2.606857	
Model (A)	LTCER (-1)	-0.003359	0.001444	-2.326584	0.0256	-2.624057 -1.949319 -1.611711	-2.326584

Source : Table prepared by the author using annual data from 1975 to 2017 captured from the base from WDI (2018).

For the model (C), the coefficients of the trend and the constant are significant (the probability < 0.05) so we reject the hypothesis H_0 , the coefficients are non-zero. We note that $t_{cal} = -3.011449 > t_{tab} = -3.523623$ for the value of $\alpha = 5\%$, so the L series TCER (C) is not stationary. For the model (B), the coefficient of the constant is significant (the probability = 0.0481 < 0.05) so we reject the hypothesis H_0 , the coefficients are zero, we notice that $t_{cal} = 1.341544 > t_{tab} = -2.936942$ for the value of $\alpha = 5\%$, so the series TCER (B) is not stationary. As for the model (A), the coefficient is significant (the probability = 0.0210 < 0.05), we notice that $t_{cal} = -1.949319 > t_{tab} = -2.326584$ so we accept H_0 for the value of $\alpha = 5\%$, so the series of TCER (A) is not stationary.

Thus, we find that the TCER series is not stationary. We take the approach set out above for the other variables and we have shown below a summary table for $\alpha = 5\%$.

Table 3 : The stationarity of all the variables at the level

	LTCER		LOC		LMM		LPIBT	
models	t_{cal}	t_{tab}	t_{cal}	t_{tab}	t_{cal}	t_{tab}	t_{cal}	t_{tab}
(C)	-3.011449	-3.523623	-2.883263	-3.520787	-2.213648	-3.523623	-1.346225	-3.520787
(B)	-1.502657	-2.936942	-2.265793	-2.933158	-0.294670	-2.935001	-0.651592	-2.933158
(AT)	-2.326584	-1.949319	0.837674	-1.948886	1.660437	-1.949097	5.859684	-1.948886

Table (3) shows that the results of the stationarity analysis of the series according to the ADF test reject the rejection of the hypothesis of the presence of a unit root for all the variables used in this modeling of the REER. Consequently, we proceed to the first differentiation in order to eliminate the disturbances that may appear in the system (see Appendix Table A).

The analysis of all series shows that the fundamentals of Tunisia's real effective exchange rate are all of the same order of integration (I (1)) (see Appendix Table A). This conclusion makes it possible to test the number of cointegration vectors that are retained in the VECM. This will be the subject of the next point.

3.3.3 Test of Johansen's trace

The goal in performing the Johansen Trace test is to detect the number of cointegrating vectors. The assumptions of this test are as follows:

H_0 : there are at most r cointegration vectors

H_1 : there are at least r cointegration vectors

If the Trace statistic is less than the critical value at a threshold of 0.05 or the Prob > 0.05 then we accept H_0 . If the Trace statistic is greater than the critical value at a threshold of 0.05 or the Prob < 0.05 then we accept H_1 .

The Johansen test applies sequentially from $r = 0$ to $r = k-1$. It makes it possible to show the existence of more than one long-term equilibrium relation between the variables having the same order of integration.

After performing the test based on Johansen $p = 1$, were pooled results in the table (4):

Table 4 : Johansen's trace test

Nothing	Eigenvalues λ_i	Trace	Critical value at threshold 5%	Probability
r = 0	0.522197	52.33915	47.85613	0.0179
r = 1	0.326751	22.05830	29.79707	0.2953
r = 2	0.103084	5.837073	15.49471	0.7147
r = 3	0.033018	1.376571	3.841466	0.2407

Source: chart developed by the author from the Eviews 10 software.

The number of cointegration relationships is tested by the "Likelihood Ratio" statistic provided by Johansen, which is written as follows:

$$\text{Trace} = Qr = -T \ln (1 - \lambda_i), i = r + 1, \dots,$$

T is the number of observations,

λ_i (estimated) is the i th largest eigenvalue,

r is the number of cointegration relationships tested.

k the number of endogenous variables of the estimated error correction vector .

The Trace can test :

$H_0 : r = k$ so there are $r = k$ cointegration relationships

$H_1 : r > k$ so there are $r > k$ cointegrating relationships.

We note that the value of the trace associated with $r = 0$ is greater than the critical value at the 5% threshold, so we REJE tones H_0 . We conclude that there exists at least one cointegrating vector. Therefore, all the conditions are checked to confirm the presence of long-term causal relationship through the estimation of VECM.

3.3. 4 A long-term causal elation

The estimation of the error correction model of the Tunisian REER allowed us to retain the following equation :

$$\Delta (\text{LTCER}) = -0.102810 * (\text{LTCER}_{(t-1)} - 12.6370853113 * \text{LOC}_{(t-1)} - 12.6092991181 * \text{LMM}_{(t-1)} + 13.0687781228 * \text{LPIBT}_{(t-1)} - 2.42335939447) + 0.560448 * \Delta (\text{LTCER}_{(t-1)}) + 0.059460 * \Delta (\text{LOC}_{(t-1)}) + 0.028584 * \Delta (\text{LMM}_{(t-1)}) + 0.567818 * \Delta (\text{LPIBT}_{(t-1)}) - 0.026839 \quad (2)$$

$\theta = -0.102810 < 0$ and $\alpha = 0.0183 < 0.05$ so there is a long-term causal relationship between LTCER and LOC, LMM and LPIBT.

The adjustment coefficient associated with the restoring force is negative (-0.102810) noted in equation (2) determines the rate at which any imbalance between the actual level of TCER and its desired level is resorbed in the period following any shock. In other words, there is thus an error correction mechanism that indicates the convergence of the trajectory of the REER series towards the long-term target. Thus, any shock suffered by the Tunisian REER will be corrected by 10.28 % by feedback effect. In fact, it would take exactly 9.72 years ($1 / -0.102810$) or just under ten years for the real effective exchange rate observed to regain its equilibrium value after a shock to make up for the equilibrium position .

3.3. 5 Relation of short-term causality

T Wald test shows the presence of a short-term causal relation between each fundamental variable and the REER if the probability is less than 5%, otherwise it proves its absence. Table (5) below summarizes the application of the Tunisian REER determinants test.

Table 5 : Wald test.

Probability	Conclusion
0.5414	Absence of a short-term causal relationship between L OC and L TCER
0.8741	Absence of a short-term causal relationship between the LMM and the LTCER
0.0636	Absence of a short-term causal relationship between the LPIBT and the LTCER

Source: Table developed by the author from Eviews 10 software.

3.3.6 Basic Functions impulse responses and the variance decomposition

To evaluate the internal dynamics of our system, we first use the impulse response functions and secondly the decomposition of the variance of the forecast error. At this level, the study attributed to the innovation response functions makes it possible to analyze stochastic trends in the short and long term fluctuations of the various variables. Indeed, an impulse response function summarizes the information concerning the evolution of a variable following an impulse on another variable on a specific date and assuming that the other variables in the model are constant at this time. The standardized impulse response functions designed by the Cholesky decomposition allow us to conclude that the response of the LTCER variable to a positive shock on the LOC is persistent. In fact, the REER does not recover its long-term equilibrium after ten periods. This phenomenon, termed hysteresis, refers to all temporary shocks with persistent effects despite the desorption of shock after a certain period (Bouveret A. and Sterdyniak H., 2005). However, the LTCER responds differently following a positive shock on the LMM and on the LPIBT. In fact, an increase in GDPT leads to the immediate appreciation of the real effective exchange rate, which reaches its maximum (1 %) three years after exposure to shock. The latter is qualified as temporary since four years later (t_4) the LTCER has returned to its expected value. Similarly, a positive shock on the money supply causes the depreciation of the REER, which decreases by 1 % at (t_4) and the REER and regains its value at t_9 (see appendix figure A).

The results of the variance decomposition, a shock on the LOC n' is not explained in the short term (t_1) in the money supply and GDP per head. However, it is explained at that time par fluctuation of 2.96% REER. This effect persists in the long term with a slight decrease for the LOC which reaches 80.21% and an increase of the participation of LTCER, LMM, LPIB which reach respectively 15.09 %, 1.73 % and 2.95% after 10 years of shock (see Table B in appendices).

According to the results of the decomposition of the variance, a shock on the LMM is not justified by the LPIBT at (t_1). The explanation of the effect of the shock is at its maximum (t_9) where LTCER contributes to explain the fluctuations 17.56 % and 19.45% of LPIBT (see Appendix Table B).

According to the results of the decomposition variance, a shock on LPIBT is explained slightly by the fluctuations of LTCER ions of 2.78 % to (t_1). This percentage remains low even at (t_{10}) where it reaches its highest level, which allows us to conclude that the shock provocation on the LPIBT is poorly explained by fluctuations in the LTCER be it short, in the medium and long term (see Annex Table B).

3.3. 7 Properties and respect for fundamental assumptions

To highlight the stability of the coefficients and the robustness tests, we have followed the following procedure:

First, the graphs of the CUSUM and CUSUM squared tests above (Figure 2) show the stability of the relationship between the money supply as a percentage of GDP, the gross investment rate, and the commercial opening and the REER throughout the study period as there is no curve beyond its corridor

Figure 2. Results of the recursive residue tests.

Second, we carry out the tests of normality, homoscedasticity and autocorrelation of the errors summarized in the table (6).

Table 6 : Results of tests of fundamental assumptions

Decisionrule	tests	probabilities	conclusions
We don't accept Ho if the probability is greater than 5%	JarqueBera	0.7854	Normality of errors
	Breusch- Pagan- Godfrey	0.9787	Presence of homoscedasticity of errors
	Breusch- Godfrey	0.3346	Absence of autocorrelation of errors

Source: Table developed by authors from Eviews 10

Finally, we note the stationarity of the residue as shown in the following table:

Table 7

Study of the stationarity of the residue (U)

	Variable	Coefficient	Stderror	DoesStatistic	prob	t _{tab} at 1%, 5% and 10%	t _{cal}
Model (C)	U (-1)	-0.967420	0.166188	-5.821224	0.0000	-4.205004	-5.821224
	C	-0.011159	0.012827	-0.869992	0.3899	-3.526609	
	@Trend	0.000522	0.000511	1.020971	0.3139	-3.194611	
	(1975)						
Model (B)	U (-1)	-0.927649	0.161649	-5.738675	0.0000	-3.605593	-5.738675
	C	0.000555	0.005737	0.096790	0.9234	-2.936942 -2.606857	
Model (A)	U (-1)	-0.927408	0.159564	-5.812156	0.0000	-2.624057	-5.812156
						-1.949319	
						-1.611711	

The previous year is mandatory to affirm the robustness of our model. To examine the evolution of the REER relative to the equilibrium REER, it is imperatively required to estimate the misalignment of the REER, which will be the subject of the next section.

4. Estimation of misalignments: methodological aspects

The equilibrium REER is a path of achievable values when the internal and external macroeconomic balance is reached (Marrakchi-Charfi, 2008). The basic assumption that calculates TCERE postulates that the conjugation of the model's fundamental variables generates the annual equilibrium values of the REER. Edwards 1989, El Badawi, (1994) prefer to replace the fundamentals observed by the averages centered on several years. In this sense, we used smoothing series of fundamental variables according to the moving average process for 4 periods.

As a result, the differences between the observed values of the real effective exchange rate and its estimated values determine the misalignment. The calculation of the misalignment of the REER in relation to its equilibrium level allows us to detect periods of overvaluation and undervaluation of

the Tunisian REER. The misalignment of the REER in relation to its equilibrium level is determined by the following formula:

$$\text{Misalignment} = \text{LTCER} - \text{The REERE}$$

This allows us to delineate the periods of overvaluation and undervaluation of the Tunisian REER. Explicitly, if the LTCER is below its equilibrium level then the misalignment is of negative sign : the Tunisian dinar is thus undervalued in real terms. However, the misalignment is positive when the LTCER is above its equilibrium level. Thus, the REER of a country may be overvalued (undervalued) for two categories of reasons: either because it has appreciated (depreciated) following the intervention of the monetary authorities, or because the exchange rate equilibrium depreciated (appreciated) as a result of a deterioration (improvement) in the fundamentals of the country.

Given that the number of observations is quite important (43 observations), we can thus admit that the observed exchange rate is equal to the average equilibrium exchange rate over the entire period. Indeed, because of the cointegrating relationship highlighted, the real exchange rate observed cannot deviate permanently from its equilibrium. The longer the study period, the more likely the equilibrium will be reached during this period. Presumably, considering that equilibrium is reached on average over the long period is probably a more acceptable assumption than choosing an arbitrary equilibrium date ([Coudert](#), Couharde and Mignon , 2012).

4. Results and discussions

Analysis of Figure (3) which presents the evolution of the observed TCER and TCER balance and of the figure (4) of the misalignment of TCER be overvalued TCER the periods [1975, 1987] and [2008, 2017] and undervaluation during the period]1987, 2008[. The magnitude of the REER deviations from the TCERE has resulted in three periods of divergence between these two indicators (Figure 3). If we assume a tolerance range of [- 1 0 %; 1 0 %] for the policy of misalignment of the exchange rate in Tunisia, we note that there are two critical periods: a period of overvaluation of [1978, 1985] and a period of undervaluation [1989, 2000].

In fact, Tunisia during the 1980s faced significant difficulties in the aftermath of the economic crisis (1982-1986), which threatened the country's competitiveness to a large extent. The e exchange rate real equilibrium coincides with the real effective exchange rate observed for the first time around 1987 In other words, a little over a year has almost the devaluation of the Tunisian dinar in 1986. It remains undervalued between 1988 and 2007. This undervaluation phase embodies the policy adopted by the monetary authorities that targeted the stabilization of the REER to support the country's competitiveness with the outside world. It also materializes the trade policy characterized by the gradual opening to the outside world marked by two important events: its accession to the World Trade Organization and the signing of the Free Trade Agreement with the European Union in 1995. Hence, undervaluing the real value of TND was the country's strategy for promoting its exports and expanding investment that expanded in the early 1990s.

Thus, we can conclude that mutations of the exchange regime embodied by: the current convertibility of TND, the creation of the interbank market in 1994 accompanied by an expansionary monetary policy led by the (CBT) could be the reason why the gap between the REER observed and that

of equilibrium narrowed until 2008. The balance is picked up in 2008. But on the evaluation of TND relative to its will, the actual balance sister between 2014 and 2017 fell by between 10 .08% to 5.25%, which reflects the tendency real exchange rate observed a shift to the depreciation to increase export-led growth.

Finally, the analysis of the dinar's REER misalignment in relation to its equilibrium trajectory shows that, since 1990, fluctuations in the real value of the TND have decreased thanks to the relaxation of its policy. foreign exchange interventions of the (CBT) to compensate for the differential rate of inflation and the state of reforms in trade policy by encouraging ant the export by the dismantling of tariff and non-tariff barriers . These renovations have led to a remarkable stabilization of the dinar by giving a breath of resistance for macroeconomic competitiveness and despite the instability of the context economic international during the 2000s.

The results confirm that a trade liberalization is accompanied by a depreciation of the REER which reflects the dominance of the substitution effect with respect to the wealth effect. In addition, the 10% improvement in trade opening resulted in a 5.7% depreciation of the REER. However, regarding the elasticity of the REER in relation to the money supply in terms of GDP, the increase in the money supply in terms of GDP of 10% contributes to the depreciation of the REER of 3.5%.

Figure 3. Evolution of the observed REER and Tunisia's equilibrium REER.

Figure 4. Evolution of the misalignment of the REER of Tunisia.

5. Conclusion and implications

This paper is a kind of observation and analysis on a scale macroeconomic contribution of behavioral real exchange rate in the evolution of the competitiveness of Tunisia. Our empirical study looked at the behavior of Tunisia's REER as an indicator of price competitiveness. This study is an attempt to model the REER over the period (1975-2017) using series of basic annual frequency variables. The estimation of the VECM model confirms the existence of a long-term causal relationship between all fundamental variables and the REER. The correction coefficient error (-0.1028) indicates the rate at which any imbalance between the actual level of TCER and its desired level is resorbed in the period following any shock.

The analysis of the impulse response functions conceived by the Cholesky decomposition allows us to conclude that the shock suffered by the LOC monetary variable is not transient since it does not regain its long-term equilibrium after ten periods. This phenomenon, called hysteresis, refers to all temporary shocks with permanent effects. This is the case of a system that affects an initial shock causing its modification. But despite the resorption of the shock after a certain period, the system does not resume its initial situation.

The absence of a short-term causal relationship entails the fundamental variables and the REER can be explained by an element typically related to the design of the modeling approach. The short-term relationship formalizes the mechanisms by which transitory shocks are amortized as it also integrates the existence of cointegration relationships. Generally, the fundamental variables that control the behavior of the real effective exchange rate do not exert an instantaneous influence on the latter because the transmission of the effects requires a more or less important time interval which depends in the first place on the nature of the structures of the economy and secondly on the speed of adjustment of the different sizes at their equilibrium levels. As a result, the absence of a short-term causal relationship between these fundamental variables and the REER is perfectly explained by the theory.

We note that the over-valuation of the REER has shrunk remarkably after the devaluation of 1986. This may be a support to defend the voices that criticize the decision of the devaluation of

the Tunisian dinar. In fact, the misalignment of the REER reached its maximum 22.51% in 1982. In other words, it took a little more than a year after the devaluation of the dinar by 10% in August 1986 for the observed REER to regain its target value.

Finally, although the data from the exploited series are of low frequency, the impact of the fundamentals of the Tunisian economy on the REER is easily captured in the long term. The existence of an error correction mechanism allows us to reach the following results: the first relates to the convergence of the trajectory of the series of the REER towards its long-term equilibrium value three times during the 43 years of study. As for the second result, it reflects the success of the monetary and commercial policies used to absorb all unforeseeable shocks capable of preventing the stability of the REER in its equilibrium path.

However, the strategy of continued depreciation of the national currency chosen to boost exports has led to an increase in the external debt in TND, imported inflationary pressures, the widening of the current account deficit accentuated by the inelasticity of imports and the destruction of exchange reserves. In reality, the inefficiency of this policy to boost exports is due to structural factors because the Tunisian economy suffers from the structural vulnerability of the industrial fabric whose companies stagnate in terms of competitiveness, job creation, and dominance of low added value sectors marked by the offshore-onshore dualism. The segmentation that limited these two sectors led to an increase in the production of intermediate products and a decline in locally manufactured products. In these circumstances, the scope for action aimed at improving the country's macroeconomic competitiveness deserves to be a major concern of the State and the monetary authorities, especially during the current crisis phase. It is necessary to stop any bill without reform program justifying it particularly all the decisions leading to the total opening of the capital account and to move to the floating exchange rate regime. For example, it is mandatory to cancel the June 2012 law that allows banks to no longer transfer their daily currency balances to the BCT. It seems urgent to suspend superfluous imports, such as luxury goods and products whose substitutes are made in Tunisia. It is obligatory to prevent the erosion of anarchic imports with Turkey and in particular with China by ensuring the implementation of technical standards for industrial products and sanitary and phytosanitary standards for agricultural products. It also seems necessary to start in the immediate future a courageous reform for the application of uniform and widespread taxation of all operating companies in the country. Similarly, the BCT should strengthen its analytical studies and develop its expertise in the prediction of REER variation.

Appendices

Table A: The stationarity of variables in the first difference for $\alpha = 5\%$

	D (LTCER)		D (LOC)		D (LMM)		D (LPIBT)	
models	t_{cal}	t_{tab}	t_{cal}	t_{tab}	t_{cal}	t_{tab}	t_{cal}	t_{tab}
(C)	-4.234855	-3.526609	- 4.505460	- 3.523623	-4.505460	-3.523623	-6.163105	-3.523623
(B)	-4.199741	-2.936942	-4.514629	- 2.935001	-4.514629	-2.935001	-6.245100	-2.935001
(A)	-2.936942	-1.502657	-4.099661	- 1.949097	-4.099661	-1.949097	-2.212698	-1.949319

Figure A: LTCER responses to shocks to its determinants

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Table B: Variance decomposition for LTCER, LOC, LMM and LPIBT

Variance Decomposition of LTCER:					
period	SE	LTCER	LOC	LMM	LPIBT
1	0.035480	100.0000	0.000000	0.000000	0.000000
2	0.064688	92.10378	6.493819	0.103846	1.298554
3	0.090212	80.25527	17.68284	0.305333	1.756550
4	0.110069	69.93008	27.60876	0.480933	1.980232
5	0.123788	62.72199	34.69383	0.635135	1.949045
6	0.132341	58.31732	39.10122	0.755377	1.826089
7	0.137357	55.83979	41.62611	0.830054	1.704043
8	0.140298	54.47792	43.02155	0.854161	1.646371
9	0.142150	53.67117	43.80507	0.842955	1.680811
10	0.143459	53.09935	44.25978	0.829415	1.811457
Variance Decomposition of LOC :					
period	SE	LTCER	LOC	LMM	LPIBT
1	0.063658	2.960328	97.03967	0.000000	0.000000
2	0.082239	3.388921	93.65086	0.729145	2.231075
3	0.088084	9.477523	87.54978	0.928891	2.043810
4	0.090772	14.41180	82.70315	0.925881	1.959169
5	0.093172	15.36637	81.88186	0.890951	1.860824
6	0.094920	14.86016	82.35143	0.951268	1.837143
7	0.095820	14.77331	82.16633	1.102642	1.957722
8	0.096333	15.02476	81.43431	1.298041	2.242886
9	0.096768	15.15202	80.73050	1.511851	2.605634
10	0.097157	15.09578	80.21049	1.736286	2.957438
Variance Decomposition of LMM :					
period	SE	LTCER	LOC	LMM	LPIBT
1	0.029455	0.503232	0.304762	99.19201	0.000000
2	0.040905	3.284171	0.944807	95.76103	0.009992
3	0.046566	6.497125	1.214844	91.31512	0.972911
4	0.049554	6.814265	5.864815	84.88411	2.436808
5	0.052217	6.371066	11.84743	76.64079	5.140709
6	0.055364	8.776952	13.68131	68.66057	8.881166
7	0.059352	13.14025	12.17179	61.63419	13.05377
8	0.063931	16.44176	10.79396	56.06032	16.70397
9	0.068457	17.56347	10.69367	52.28662	19.45625
10	0.072358	17.21250	11.14014	50.23917	21.40819
Variance Decomposition of LPIBT :					

period	SE	LTCER	LOC	LMM	LPIBT
1	0.024464	2.788574	4.575674	15.09645	77.53930
2	0.033859	3.318506	3.247205	27.19183	66.24246
3	0.042464	3.639662	2.083260	33.00534	61.27174
4	0.049552	3.863804	1.561463	37.51058	57.06415
5	0.055534	3.671942	1.338051	40.46091	54.52910
6	0.060363	3.227577	1.266389	42.69596	52.81007
7	0.064249	2.858464	1.181521	44.35971	51.60030
8	0.067414	2.825694	1.073380	45.55120	50.54973
9	0.070103	3.192291	1.068762	46.25453	49.48442
10	0.072492	3.869431	1.301140	46.49197	48.33746
Cholesky Ordering: LTCER LOC LMM LPIBT					

Declarations

Availability of data and materials

Data and materials would be made available upon request.

Competing interests

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Authors' contributions

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Figures

Figure 1

Descriptive graph of used variables.

Figure 2

Results of the recursive residue tests.

Figure 3

Evolution of the observed REER and Tunisia's equilibrium REER.

MESALIGNEMENT

Figure 4

Evolution of the misalignment of the REER of Tunisia.