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Abstract

This article discusses the asymmetry of real effective exchange rate (REER) impact on economic growth in the Arab Maghreb Union during the period 1980-2016. This work quantifies the adjustment rate of the exchange-rate policy towards its equilibrium levels and hence justifying the use of nonlinear modelling. The complexity of the exchange rate dynamics leads to the application of the panel threshold regression. The empirical results reveal that the REER has opposite effects on the estimated threshold. This highlights the asymmetrical effect of unforeseen shocks on its volatility.

Keywords: exchange rates; economic growth; AMU; models of regime changes.

JEL Classification Codes: *C33; F31; F43; O55; O57.*

1. Introduction

The globalisation of the economy and integration into the world market have reduced the isolation of the Maghreb economies from the developed economies since the 1990s. Developing economies are increasingly exposed to positive or negative externalities from European economies. In a context of growing international trade, openness is beneficial, but trade contractions linked to economic, financial and monetary shocks act with opposite effects. The global integration of the Maghreb countries into this trade has made it possible to absorb these global shocks, such as the rise in oil prices from 2004 onwards, thus reducing the negative effects on growth

thanks to an increase in productivity and technology transfers improving the competitiveness of these emerging countries. However, the existence of structural gaps, differences in the endowment of raw materials, human capital and the capacity for the diffusion and absorption of technologies between the five countries of the Arab Maghreb Union (AMU) (Morocco, Algeria, Tunisia, Libya and Mauritania), produces differentiated effects on bilateral trade and economic growth. There are, moreover, other channels for the transmission of shocks between the economies of the countries, including European ones, and the countries of the AMU. It is legitimate to ask how does exchange rate variability affect economic growth for the Maghreb countries as a whole?

In the light of the exchange rate policy adopted by the AMU countries in recent decades, the questions that need to be raised concern the performance of the economy in terms of economic growth and the importance of the exchange rate in this context. Indeed, the relationship between the real exchange rate and economic growth is becoming an important area of study in both transition and developed countries. Economists argue that the exchange rate plays a central role in the public debate on trade and trade policy in countries with calls for appreciation, depreciation or simple stabilization.

In fact, trade between the five AMU countries represents only 3% of their total trade, making it the least integrated region in the world. As for the real effective exchange rate, it has depreciated by 8.7% in AMU in recent years, reflecting the widening of the inflation differential, which is close to 5.5 percentage points with the Euro Zone and the United States.

Moreover, the intra-regional trade between the Maghreb countries represents only 1.3% of the foreign trade of the 5 countries according to a study published in 2012, while a Maghreb economic integration could increase the lateral trade from 3 to 4.5% (i.e. 3 to 4 billion euros) and foreign direct investment (FDI) of 75%, or about 5 billion euros per year. In addition, the Maghreb region has managed to win in several respects with Mauritania as the largest producer of raw iron in Africa, Morocco with the largest production of renewable energy, Tunisia which has established

itself as a leader in liberties and democracy; Libya, the largest oil reserve; and Algeria, the second largest gas reserve, in Africa.

Despite the many achievements in various fields, the reality of the current situation of the AMU should not be overlooked. It is no secret that the AMU has been living for years under the impact of a political crisis. It has slowed its growth, negatively impacted its image and damaged its reputation and prestige. In addition, the situation was further complicated by the phenomenon of reducing its already scarce resources, both human and material, on the one hand and the frequent delays of Maghreb meetings, on the other hand.

We can anticipate that the exchange rate system will affect output growth through its impact on the rate of growth of its factors (investment or employment) or on total productivity growth. However, the transmission channels are diverse and contradictory, and the final effect is not easy to determine a priori.

The impacts of the exchange rate regime on output volatility are equally ambiguous. It is generally accepted that a flexible exchange rate helps to adjust real prices and wages, leading to smaller volume fluctuations. However, although speculative forces make the nominal exchange rate an independent source of volatility, a flexible exchange rate can also exacerbate variations in output.

For the above cited reasons, the economic and financial spheres have been characterized by numerous stock market crashes and financial crises over the past few decades. This instability is often seen as the main source of very persistent unpredictability and a-periodicity as well as turbulences, fluctuations and volatilities of the financial markets. Such irregularities have been a source of inspiration to Godwin (1991), one of the pioneers of nonlinear dynamic models in economics, to forward his reflections on a new perception of the economic phenomena that seem to escape any type of classical modeling.

Taking non-linearity, more precisely the study of the existence of regime change phenomena, into account has been deeply changing the approaches of econometrics applied to

macroeconomics and finance. It is recognised that most economic and financial series present non-linear dynamics, regime change phenomena, asymmetries, multimodal distributions. So must we necessarily use non-linear models when seeking to make forecasts in economics and finance? The answer to this question depends fundamentally on the form of non-linearity chosen (choice of the non-linear model) and the definition of the forecast we wish to use (construction of the forecast).

It is in this perspective of analysis that this article was written. The aim was to explain the asymmetry of the impact of the exchange rate on economic growth for all the Maghreb countries during the period 1980-2019. This work also sought to measure the rate of adjustment of the exchange rate towards equilibrium levels, which justifies the use of nonlinear modeling.

The main purpose of this article was, therefore, to test the various hypotheses on the relationship between the exchange rate regime and economic growth. We tried to find out whether the type of exchange rate regime influences economic development. However, the sign of the parameters relating to the exchange rate regime remains unclear, as mentioned above. We thus tried to find out whether the exchange rate regime approved by the nominal anchor is important in terms of development.

To answer all these questions, we organized the remaining of this paper as follows. The second section dealt with the theoretical aspects of the exchange rate through the main empirical applications, their problems and their limitations. The third section was devoted to the methodology of applying the used nonlinear model to the Panel data. The penultimate section dealt with the achieved estimates and their interpretations. Finally, we revealed the main conclusions.

2. Theoretical overview

The real effective exchange rate (REER) is undeniably the most important determinant of economic activity. Indeed, the exchange rate volatility influences the economic performance by acting on agents' behaviour. In addition, the currency fluctuations disrupt investment decisions by affecting production costs. As a result,

they compromise both of the foreign trade and foreign direct investment.

The instability of the exchange rate, due to its risk rate increase, would have a negative effect on exchange in general. Greater fluctuations in the exchange rate cause producers to shift their interests from activities related to foreign demand to the benefit of domestic activities. Chowdhury argue that the variability of the real exchange rate has a negative effect on the trade growth rate (Chowdhur, 1993; Chudhary, 2005). On the other hand, if domestic producers are highly risk-sensitive, increased currency risk reduces the exports' marginal utility. This decline in the exports' relative utility to the benefit of domestic activities (less risky) causes the decline of foreign trade (Aljandali, 2018).

There is no single definition of REER (Edwards, 1989) yet, taking into account its definition as the ratio between the price of exchangeable and non-exchangeable goods (Dornbusch, 1987; Edwards, 1989; Blanchard & Quah, 1998; Burda & Wyplosz, 2013; Affandi & Mochtar, 2013) the previously described fact implies the existence of a negative correlation between the relative wealth and TCER. However, the question that arises in the case of a rich country is why one should expect to see higher prices of non-exchangeable goods.

The main purpose of this section was to study the impact of asymmetry, persistence and non-linearity defining the exchange rate movements. Regarding the foreign exchange market, several recent studies have suggested that the dynamics of the exchange rate adjustment is characterized by non-linearity. Researchers highlighted the existence of a non-linearity between the real and nominal exchange rates. These authors showed that the exchange rate dynamics can be characterized by different nonlinearity sources (Dumas, 1992; Krager & Kugler, 1993; Sercu et al., 1995; Obstfeld & Taylor, 1997; Michael et al., 1997; Coakleyc & Fuertes, 2001; Bec et al., 2006).

Based on the Dornbusch exchange rate model (1976), Sarantis (1999) pointed out that the heterogeneity of investors in the foreign exchange market is the major source of non-linear exchange rate dynamics. As for De Grauwe and Dewachter (1993),

they showed that the interaction between these different categories of operators leads to a rise or fall of the volatility of the exchange rate as well as a delay in the adjustment of the stock prices to their equilibrium value.

On the other hand, Peters (1994) studied the behaviour of investors in the foreign exchange market. By focusing on the differences in expectations, time horizons and degrees of risk aversion, Lardic et al. (2003) show that a heterogeneous set of investors will respond distinctly to new information, which may generate nonlinear dynamics of the exchange rate.

The empirical studies of Dumas (1992) and Sercu et al. (1995) on the dynamics of the real exchange rate adjustment in relation to the purchasing power parity (PPP) show that the exchange rates return to equilibrium follows an exponential function. They also perceive the presence of transaction costs and the causes of the non-linearity of the exchange rates. In fact, these authors developed a model that explains the effects of the transaction costs caused by international merchandise trade on the nominal exchange rates. Moreover, the authors suggest that the presence of the transaction costs, which may lead to unadjusted imbalances, may justify a non-linear adjustment of the exchange rates to equilibrium.

Several empirical studies, notably those of Ramey and Ramey (1995), suggest that the volatility of the GDP indicator is generally detrimental to economic growth and that this effect is very much pronounced, especially for the least developed countries. Some of these studies analyzed the role of the exchange rate volatility. On the other hand, some other empirical studies Bosworth et al. (1995) raised a strong negative relationship between the exchange rate variability and economic growth. This relationship has long-run effects that exceed by far those of the short run.

Aghion et al. (2009) studied the effect of real exchange rate volatility on the long-run economic growth. They found that a 50% increase in real exchange rate volatility is translated as a 0.3% decrease in economic growth. They also found a negative effect of the overvaluation of the exchange rate regime on economic

development. In addition, an overvaluation of the exchange rate by 20% reduces economic growth by 0.2%. However, it is questionable whether this last finding is not simply cyclical in nature, since such overvaluation can only be temporary.

Similarly, Goyal and Sahay (2006) confirm that economic growth is weak when it is more volatile. Schnabel (2008), however, studied the volatility of the nominal exchange rate in the peripheral countries of the Euro zone. He showed that this volatility is lower than that of other countries. This result is rather due to the adopted parity policy.

The empirical results of Selimi and Selimi (2017) indicate that the real exchange rate positively affects economic growth. In fact, they found out relevant arguments that support the fix exchange rate regime which ensures the country's macroeconomic stability.

Cheikh and Zaied (2020) recent article investigated the exchange rate pass-through (ERPT) for a set of economies in transition, i.e. for 10 new EU Member States (NMS) for the period 1996-2015. The authors used a nonlinear panel smooth transition regression (PSTR) approach, in which transition factors related to EU membership are correctly captured from the data. Indeed, their empirical results suggest that the inflation regime is the main macroeconomic driver of the magnitude of the ERPT. When inflation levels exceed the 4.56% threshold, that is, in an environment of high inflation, the level of transmission is higher and reaches a full ERT. However, with the transition to a stable and low inflation regime, i.e. when inflation levels are below the 4.56% threshold, the magnitude of the pass-through decreases significantly in the NMS group.

The various empirical proofs cited above have shown that there is an unstable relationship between exchange rate and economic growth, which made us opt for the regime-change models in order to ensure the desired type of relationship.

3. Empirical methodology

The threshold regressions in panel data models allow modeling the heterogeneity of the slope parameters. These models give a

parametric approach of the heterogeneity which is associated to an economic story. The first panel-based regime change approach (Panel Threshold Regression model, PTR) was developed in 1999 by Bruce Hansen. Moreover, that type of non-linearity is currently known as an indispensable feature of the dynamics of the macroeconomic indicators. The question that deserves an answer here is how to fill in this gap. On the other hand, the regime change or the non-linearity are somewhere "omitted" in this assembly phenomenon of time series and panel issues, if one faces those of non-stationarity and cointegration.

3.1. Panel Threshold Regression model with brutal transition

The Panel Threshold Regression (PTR) model category was developed by Hansen (1999). In these models, the endogenous variable y_{it} is determined through several different non-dynamic relationships. Therefore, the process (y_{it}, $t \in Z$ and $i \in Z$) satisfies a two-regime PTR model, if and only if:

$$y_{it} = \mu_i + \beta_0' X_{it} + \beta_1' X_{it} \mathrm{I}(q_{it} > c) + \varepsilon_{it} \quad (1)$$

where μ_i is the vector of individual fixed coefficients, $X_{it} = \left(X_{it}^1, ..., X_{it}^k\right)$ is the matrix of the k exogenous variables containing no endogenous delayed variables, $\beta = \left(\beta_1, ..., \beta_k\right)$ and ε_{it} is $iid\left(0; \sigma_\varepsilon^2\right)$. The index $i = 1$, then N refers to the individual dimension and the index $t = 1, ..., T$ to the temporal dimension. The transition from one regime to another requires comparing the situation of a transition factor q_{it} with respect to the value of a threshold c. Regarding the choice of this transition variable, no new hypothesis seems to exist apart from the STAR model. It is therefore possible to rewrite equation (1) in the following form:

$$y_{it} = \begin{cases} \mu_i + \beta_0' x_{it} + u_{it} & \text{if } \ q_{it} \le c \\ \mu_i + \left(\beta_0' + \beta_1'\right) x_{it} + u_{it} & \text{if } \ q_{it} > c \end{cases} \quad (2)$$

The originality of this modeling lies in the exposure of a panel through several different regimes, each determined by linear dynamics. In this case, there is a brutal change since a unit can switch from one plan to another at a date. In fact, if the change indicator is greater than the threshold variable $q_{it} \le c$ even very

insensibly, the process is described by the first defined regime using the slope coefficients β_0' (in return if $q_{it} > c$, the process is described by the second regime where the coefficients are $(\beta_0' + \beta_1')$.

The process (y_{it}, $t \in Z$ and $i \in Z$) satisfies a PTR model with r regimes, if and only if:

$$y_{it} = \mu_i + \beta_0 X_{it} \mathrm{I}(q_{it} \le c_1) + \beta_1 X_{it} \mathrm{I}(c_1 < q_{it} \le c_2) + \ldots + \beta_r X_{it} \mathrm{I}(c_{r-1} < q_{it}) + \varepsilon_{it} \quad (3)$$

where $c_1 < c_2 < \ldots < c_{r-1}$. In practice, the number of regimes r is roughly low.

In order to present the estimation procedure of the slope and threshold parameters, we started by developing a PTR model with r regimes:

$$y_{it} = \mu_i + \beta' x_{it}(c) + u_{it} \quad (4)$$

where $x_{it}'(c) = [x_{it}\mathrm{I}(q_{it} \le c_1) x_{it}\mathrm{I}(c_1 \le q_{it} < c_2) \cdots x_{it}\mathrm{I}(q_{it} > c_{r-1})]$, $\underset{(kr,1)}{\beta}' = [\beta_2' \beta_2' \cdots \beta_r']$, μ_i denotes the individual effects, x_{it} is a vector of k exogenous variables and u_{it} is $i.i.d(0, \sigma^2)$.

From the above equation, two difficulties arise. The first is the estimation of the individual effects, which are common for the different regimes, while the second is the estimation of the slope and threshold parameters. Being similar to the development in time series, the attached formulation does not help directly estimate through the OLS because the exogenous variables are directly related to thresholds. Therefore, the evaluation procedure has to be carried out in two stages.

Some researchers (Chan, 1993; Hansen, 1999; Dong et al., 2011) support the idea maintaining optimal threshold estimators as optimal coefficient estimators $\hat{c} = (\hat{c}_1, \cdots, \hat{c}_{r-1})$, which reduces the sum of squared residuals (SSR):

$$\hat{c} = \arg \min_{c \in \Lambda} SSR(c) \quad (5)$$

where $SSR(c) = \sum_{i=1}^{N}\sum_{t=1}^{T} u_{it}^{2*}$.

The slope parameters $\hat{\beta}(c)$ are again estimated using the OLSs evaluated in $\hat{c}$; besides, it is possible to derive the residual empirical variance:

$$\hat{\sigma}^2 = \sum_{i=1}^{N}\sum_{t=1}^{T} \frac{1}{n(T-1)} \hat{u}_{it}^{*}\hat{u}_{it}^{*} = \frac{1}{n(T-1)} S(\hat{c}) \quad (6)$$

It is also possible to follow the PTR model testing strategy. Its first phase consists in testing (*i*) the linearity, in case the null hypothesis is accepted, the test strategy stops or has to be repeated with a new alternative hypothesis, for example a new transition variable. On the other hand, if the linearity assumption is not accepted, two tests have to be carried out continuously: (*ii*) the detection test of the number of regimes, (*iii*) the slope parameter significance test (*iv*) and it is a good idea to generate a confidence interval on the coefficient of interest.

The linearity test consists in examining the different regimes parameters equality. In equation (1), the absence of a threshold effect is indicated by the following hypothesis: $H_0 : \beta_1 = 0$ versus $H_1 : \beta_1 \neq 0$. The linearity test has therefore to be performed considering this coefficient equal to its evaluated value.

$$F_1 = \frac{S_0 - S_1(\hat{c}_1)}{\hat{\sigma}^2} \text{ where } \hat{\sigma}^2 = \frac{1}{N(T-1)} S_1(\hat{c}_1) \quad (7)$$

with S_0 and $S_1(\hat{c}_1)$ the sum of squared residuals of the linear and non-linear models, respectively.

3.2. Presentation of the sample variables

The purpose of this sub-section was to describe the sample and the variables analysis of each country in the sample. In fact, our panel comprises N=5 Maghreb countries, namely Algeria, Morocco, Mauritania, Libya and Tunisia, between 1980 and 2019, that is 40 observations per country. Indeed, and based on the statistics presented in Table 1 below, we described the main characteristics

of the main variables used in this study. The data are collected from the latest World Bank database. It is quite clear that all the variables reject the null hypothesis of normality because the probability of the Jarque-Bera test is well below 5%.

Gross domestic product per capita (GDPC) is the indicator of the level of economic activity employed. It is more effective than GDP in measuring the development of AMU countries. In Solow's model (1956), the increase in the production factors (labor and capital) accounts for some of the growth. It is thanks to the increase in paid employment (labor factor) and domestic investment (capital factor) that there is growth. However, most of the growth is not explained by these two, but rather through a residual factor. In other words it is the technical progress, which origin is not really known. The causes of growth (population increase and technical progress) are therefore exogenous: the model does not explain their origin.

Other than labor (salaried employment, POP) and capital (Gross Fixed Capital Formation, GFCF as a percentage of GDP), the other explanatory variables can be presented in three groups. On the one hand, they are different in nature and act differently on growth. Still, this step is obligatory to carry out the estimation.

Our approach was to use three groups of variables and carried out our estimation over the data collected between 1980 and 2019. What made our estimation technique effective was the use of such criteria as absence of autocorrelation of residues and individual and temporal heteroskedasticity. Indeed, the first group of explanatory variables forms those related to the economic policy, namely: First, the consumer price index (CPI), second, public spending relative to real GDP (GOV), then, foreign direct investment relative to real GDP (FDI) and finally, trade openness in relation to real GDP (TRADE).

In fact, the inflation (CPI) risk is not to be discarded in case of flexible exchange. If an inflationary spiral is unlikely to settle, following a negative external shock, via a salary indexing mechanism as this is often lacking in developing countries, it can still be triggered by imported inflation which magnitude depends only on the rate of penetration and the import price elasticity and /

or the low productivity that characterizes the economies of these countries.

In addition, public spending (GOV) has traditionally been seen as a stimulus for economic growth (Nubukpo, 2007). Indeed, according to the Keynesian logic, public spending can exert a significant counter-cyclical influence on the economies fundamental variables, especially on consumption and investment. Moreover, in monetary unions, the fiscal policy is the main instrument for responding to the various asymmetric shocks that may affect economies in the absence of a fiscal federalism, since the monetary policy is common to all the countries.

The Foreign Direct Investment (FDI) is another internal characteristic to be considered when assessing the ability of a particular exchange rate regime to generate growth but received very little attention in the economic literature. The FDI variation would theoretically have two opposite effects on real output, depending on the flexibility degree of the exchange rate regime: on the one hand, a net FDI inflow into a flexible regime leads, ceteris paribus, to an appreciation of the exchange rate and a mastery of the imported inflation favorable to consumption and therefore to growth; on the other hand, if the Marshal-Lerner condition is checked, this exchange rate appreciation ultimately reduces production by undermining cost competitiveness. In fixed exchange, the adjustment is made by the interest rate which reacts to decline and consequently favours investment.

Trade openness (TRADE) has been defined in the economic literature by several authors in various ways. However, the most agreeable definition considers trade opening as the progressive reduction of customs duties and the elimination of other restrictions on the free movement of goods and services. In order to estimate it, most international organizations (IMF, World Bank, among others) use the trade opening rate measured by the ratio of the sum of exports and imports to gross national product.

The second group of explanatory variables is formed by the monetary variables related to GDP, namely: The monetary aggregate (M3) and the private credit (CREDIT), which represents

the development degree of the financial sector whose effects are expected to be positive on growth.

The first and most widely used indicator M3 is the ratio of the monetary aggregate or liquid liabilities of the economy to GDP, i.e. M3/GDP (Jung, 1986; Berthélemy & Varoudakis, 1996; Arestis & Demetriades, 1999; Bakhouche, 2007). This ratio reflects the size of the financial system vis-à-vis the overall size of the economy, i.e. financial deepening. Several authors like (Levine, 1997; Roubini & Sala-i-Martin, 1992) show that there is a strong positive correlation between this indicator and the per capita GDP. The higher the value of this ratio, the more the financial system is developed, notably through the expansion of savings mechanisms, the increase in the size of the banking sector, the improvement of the provision of financial services, and the increase of liquidity in the economy.

The second indicator CREDIT measures the financial intermediation and is equal to the ratio between the amount of credit granted to private enterprises and GDP. Excluding the public sector, this indicator illustrates how funds are channelled to private investors. Levine (1997) finds a statistically significant positive correlation between real GDP per capita and the way credit is directed to the private sector. This indicator isolates credits to the private sector from credits allocated to the government and public enterprises. However, it is often influenced by directed credit policies or government grant programs.

The third group of the explanatory variables forms the exchange rate variables, namely: The real effective exchange rate (REER). As for the risk of financial instability inherent to the exchange rate volatility in a flexible regime and its negative impact on the real economy, Aghion et al. (2009) think of it as dependent on the firms' ability to finance and invest in order to improve their productivity. The authors clearly differentiate the case of developing countries with a shallow financial market and the risk-averse financing institutions in developed countries. Aghion et al. (2009) show that productivity is negatively related to the degree of flexibility of the exchange for a group of countries and consider it preferable to the adoption of a fixed regime.

From the above, the final model to be estimated, after linearization by natural logarithm, can be written as follows:

$$Ln\_GDPC_{it} = \beta_0 + \beta_1 Ln\_POP_{it} + \beta_2 Ln\_GFCF_{it} + \beta_3 Ln\_FDI_{it} + \beta_4 Ln\_REER_{it} + \beta_5 Ln\_CPI_{it} + \beta_6 Ln\_TRADE_{it} + \beta_7 Ln\_M3_{it} + \beta_8 Ln\_GOV_{it} + \beta_9 Ln\_CREDIT_{it} + u_{it} \quad (8)$$

where "*Ln*" represents the natural logarithm. We present a summary of the main descriptive statistics in table 1 below.

According to the left side of figure 1, it is clear that the GDP per capita (GDPC) is characterized by an upward trend for all the countries, but with a great difference between Libya and the other 4 countries. For example, during the 1980/2019 period, Libya has an average of 8014.3 with a standard deviation of 1914.1. All of its values are between 4539.0 and 12064.8 with a strong concentration around 7755.5. In addition, the sample distribution of GDPC is skewness spread on the right (Skewness = 0.603) and leptokurtic (Kurtosis = 2.58). In total, this variable shows an overall growth of 28.8% with an annual growth of 0.71%.

Table 1: Overall descriptive analysis of basic variables

Designation	GDPC	POP	GFCF	FDI	REER	CPI	TRADE	M3	GOV	CREDIT
Average	3778.201	4681021	28.932	1.295	122.437	72.926	67.010	58.249	18.701	38.046
Median	3217.435	3199585	27.162	0.140	103.021	76.884	64.809	54.033	17.214	26.474
Maximum	12064.780	12303926	93.547	37.166	449.523	155.325	138.898	251.618	51.975	95.507
Minimum	1295.495	439159	8.949	-1.564	30.008	6.156	30.816	12.423	9.943	3.907
Standard Deviation	2481.775	3895701	11.306	4.138	68.338	36.209	20.898	34.887	6.528	25.365
Skewness	1.424	0.647	1.406	5.725	2.488	0.017	0.578	1.724	2.447	0.613
Kurtosis	4.503	1.946	8.601	41.135	10.490	2.132	3.240	8.802	10.603	2.015
Jarque-Bera (JB)	86.396	23.199	327.363	13211.2	673.768	6.292	11.607	379.653	681.296	20.626
JB p-values	0.000	0.000	0.000	0.000	0.000	0.043	0.003	0.000	0.000	0.000

FDI relative to GDP is very noticeable in Mauritania compared to the other countries. In fact, the right-hand side of figure 1 shows a significant increase of FDI for Morocco at the start of the study period and a considerable growth for Mauritania between 2010 and 2019. In fact, for the case of Mauritania, the FDI evolution is characterized by an average of 2,952 with a too large standard deviation of 6.76 which makes its coefficient of variation is too high greater than 1 (= 2.29). All values for this country are between 0.01 and 37.17. The FDI sample distribution is asymmetrically spread on the right (Skewness = 3.93) and also strongly leptokurtic (Kurtosis = 18.91). Overall, this variable shows significant overall growth of 49.72% with annual growth of 1.13%.

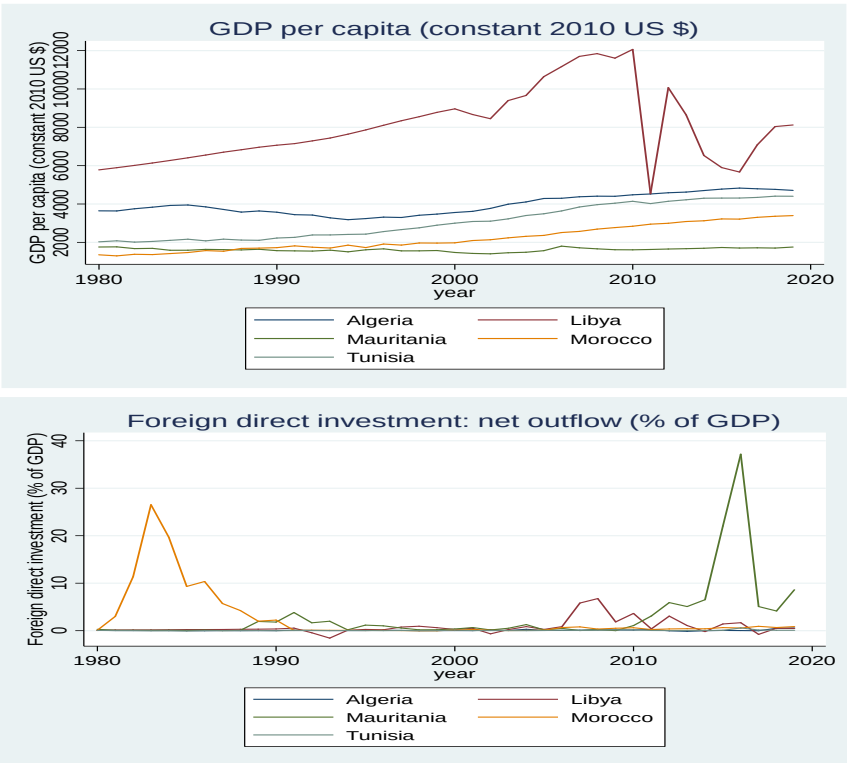

Figure 1: Trend evolution of the GDP per capita and the net outflow FDI by country

Regarding the real effective exchange rate (REER), the evolution of the 5 countries in the left-hand side of figure 2 shows a clear difference until the beginning of the 1990s. Moreover, we observe the stability of rates around 100%. For the case of Tunisia, the evolution of the REER is characterized by an average of 132.1 with a standard deviation of 42.1. All values are between 78.3 and 221.0. The sample distribution of the REER is asymmetric spread to the right (Skewness = 1.11) and largely leptokurtic (Kurtosis = 3.20). In total, this variable shows a significant overall decrease of -56.82% with an annual decrease of -2.31%.

Trade openness (TRADE) increased considerably from the 2000s in all countries and reached record rates like Libya in 2012 of 138.9% relative to GDP. According to the right-hand side of Figure 2, and for the case of Morocco, the evolution of TRADE is characterized by an average of 47.2 with a standard deviation of 12.3. All values are between 30.8 and 67.8. The sample distribution is asymmetric spreading slightly to the right (Skewness = 0.40) and leptokurtic (Kurtosis = 1.73). In total, this variable shows a significant global growth of 282.2% with an annual growth of 3.44%.

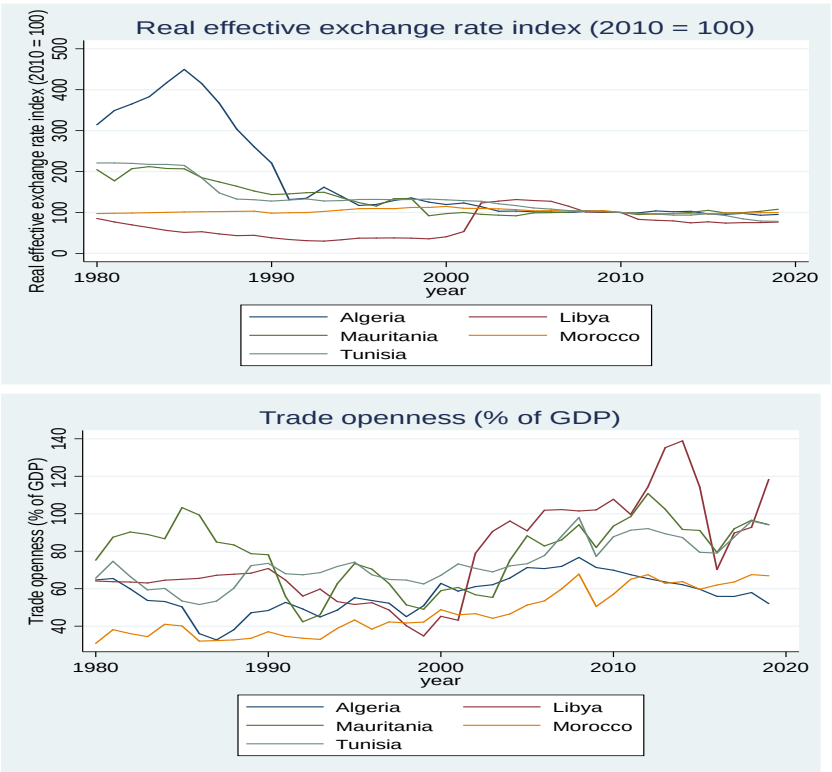

Figure 2: Trend evolution of the REER and the TRADE by country

On the whole, we found that the majority of the series are on average unstable in mean or in variance. In addition, they showed a strong divergence from one country to another, which proves once again the strong heterogeneity and dependence between them.

4. Estimation and interpretation

In this section, we developed the estimation of the model coefficients at a threshold of a brutal change. This procedure is very similar to the one used in time series, with the exception of the suppression phase of individual fixed effects. Indeed, the simulation was then carried out using the iterative maximum likelihood method.

Based on equation 1 above, it was estimated using the abrupt transition threshold model based on Panel data. We also applied Hansen's (1999) test procedure to identify the number of

REER thresholds that test the linear model null hypothesis against the alternative two-speed model hypothesis. The asymptotic thresholds tests results obtained by 1000 bootstrap repetitions are reported in table 2. At this point of the study, we tested the logarithm of REER (Ln_REER) threshold on the logarithm of GDP per capita (Ln_GDPC) of the five countries.

Table 2: PTR results of the REER threshold test

Hypothesis test	LM Statistic	Bootstrap p-value	Threshold estimate	95% confidence interval
H_0: no threshold	431.2^{***}	0.000	4.519	[4.502 ; 4.521]
H_0: one threshold	166.8	1.000	4.676	[4.658 ; 4.810]

Notes: The null hypothesis test has no threshold in relation to the alternative hypothesis of a threshold. The threshold is obtained by minimizing the sum of the squared residues. *** which represent 1% significance.

According to table 2, the regime change test in a sample of 200 observations using the Bootstrap procedure, leads to the rejection of the null hypothesis of no threshold at a 5% risk when the Ln_REER variable is selected as the threshold variable. This result confirms the existence of a critical threshold conditioning the impact of the exchange rates on economic growth. Our test results show that the threshold variable is equal to 4.519 (i.e. REER=91.743) with a confidence interval [4.658; 4.810] at the 5% threshold (i.e. REER ϵ [90.197; 91.927]).

The same approach was then applied in order to test the possibility of obtaining a second division in the sub-sample of 154 observations. The second-level threshold effect test then allows us to accept the null hypothesis H_0 of the absence of two thresholds. However, the new obtained threshold variable is 4.676 (i.e. REER=107.339). This variable is not statistically significant over a confidence interval of [4.658; 4.810] at a 5% threshold.

Once the search for the effects of the exchange rate threshold for the Maghreb countries has been achieved, we proceeded to study the relationship (3) between the exchange rate and economic growth under different REER regimes. Table 3 summarizes the estimation results. Under different exchange rate regimes, the exchange rate-economic growth nexus varies due to a structural break in of the data.

Using Hansen's (1999) approach, table 3 shows that the PTR estimation generates two regimes: A first regime, consisting of 46 observations showing a log of REER less than 4.519, reveals that the REER elasticity has a significant and negative impact of around 0.8% on economic growth. A second regime, consisting of 154 observations, shows a significant and positive impact on economic growth. Thus, the REER has a favorable and significant effect on economic growth.

Table 3: Results of REER regimes Estimates on the GDPC

LGDPC	**Regime 1: LREER < 4.519**		**Regime 2: LREER > 4.519**	
Variable	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Ln_POP	0.520	3.573***	0.021	0.864
Ln_GFCF	0.068	2.037**	0.112	3.408***
Ln_REER	-0.796	-5.569***	0.068	3.029***
Ln_FDI	-0.008	-1.923*	0.001	2.142**
Ln_CPI	-0.981	-5.986***	0.145	3.442***
Ln_TRADE	0.082	0.612	0.242	6.601***
Ln_M3	0.603	5.601***	0.335	4.698***
Ln_GOV	0.556	3.040***	0.052	0.764
Ln_CREDIT	0.759	-4.066***	0.040	1.347
Number of Observation	46		154	

Notes: ***, ** and * represent 1%, 5% and 10% of significance, respectively.

Figure 3 shows the normalized sequence statistics of the likelihood ratio (γ) according to the logarithm exchange rate threshold (Ln_REER) which proves the significance of the first threshold 4.519 (i.e. REER=91.743).

The nonlinear modeling of the PTR model led to the detection of an exchange rate logarithm threshold of 4.519 significant at 99%. To avoid the negative impact exerted by the exchange rate hampering economic growth, the Ln_REER must not exceed the threshold beyond 4.519 despite the economic differences of the five countries.

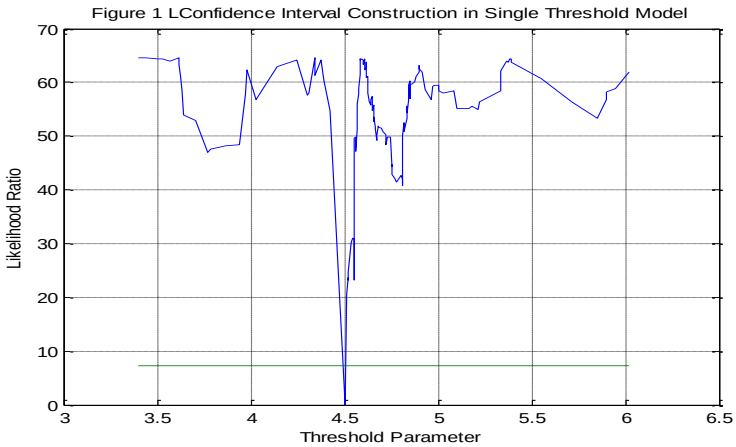

Figure 3: Normalized sequence statistics of the likelihood ratio: function of the Log(REER)

Theoretically, although academics and researchers have not reached a consensus on the influence that an exchange rate regime might have on economic growth, this empirical study confirms that there is a relationship between the two variables. However, as far as the meaning of this relationship is concerned, everything depends on the economy under study. Moreover, some studies confirm that a fixed exchange rate regime is rather advantageous for less open countries to international competitiveness and with a less developed capital market, while other studies showed that countries with a flexible exchange rate regime display the same performances as those with an adjustable fixed exchange rate regime (Selimi & Selimi, 2017). On the other hand, other research works have come to the conclusion that it is the existence of a robust monetary policy status, rather than the exchange rate per se that matters for economic growth. Consequently, this debate between supporters of fixed exchange and flexible exchange rate regimes still persists.

This implies that there is a generally strong relationship between the exchange rate regime and the GDP per capita. Admittedly, the choice of an exchange rate regime does not seem neutral, but its impact appears to be relatively small. This relationship is mainly due to the impact of the FDI flows and particularly external trade.

Notwithstanding, in the event that the economies of the southern Mediterranean would opt for adapting a Euro anchoring in order to minimize domestic inflation or to provide a monetary presumption, the choice of techniques of this approach would be identical from the point of view of economic development.

5. Conclusion

In this article, we chose to study the dynamics of the REER of the Maghreb countries in a framework of nonlinear models with a sudden transition. In fact, the brutal change approach PTR developed by Hansen (1999), showed us that the REER has significant non-linear effects on economic growth in the different studied countries.

We have already shown that the REER shows opposite effects before and after the estimated threshold. This highlights the asymmetric effect of unforeseen shocks on exchange rate volatility. Similarly, the REER dynamics of the five countries is non-linear and asymmetrical regardless of the exchange rate regime applied. In addition, trade openness, through foreign exchange or foreign investment, has become a well-known growth trigger according to several theoretical and empirical studies.

The predictions generally suggest the existence of a significant trade potential in the AMU. For countries with a limited potential, this could mean that they either had a naturally low potential (which would likely to be the case of Mauritania given the small volume of its exports), or provided enormous efforts in the conquest of the sub-regional market and then reached the potential level in view of their very large share in the exports of the zone (case of Tunisia). In particular, it appears that the choice of an exchange rate regime has little influence on growth performance, probably because of its interaction with other variables, such as a weak financial market.

The article concludes that there is a lack of exchange rate neutrality in the case of the Maghreb countries and that the exchange rate regime is performing strongly compared to a weak one. The estimated results show that the strong exchange rate regime is more conducive to economic growth in the case of

countries experiencing positive terms of trade shocks, benefiting from FDI inflows and significant trade openness.

Another interesting result is that, in the Tunisian and Moroccan cases, a lower degree of openness and a depreciation of the effective exchange rate negatively influence economic growth. However, a misalignment (i.e. an overvaluation) of the real exchange rate, affects it positively. In fact, this result is not commonly accepted, which could be explained by the fact that for more than three decades, Tunisia and Morocco have pursued a development strategy focused on the external market. Nevertheless, this does not seem to have been accompanied by a structural change in the specialization that remains inter-branch around products which are more competitive and which added value is getting weaker and weaker. In this context, the appreciation of the real exchange rate, which may be conducive to growth, would promote growth by making imports of capital goods cheaper. Conversely, depreciation in the exchange rate, which protects inefficient sectors and increases inputs, lowers productivity. In the case of Algeria, which is largely dependent on oil and the world market, neither the change in the real exchange rate nor the nature of the exchange rate regime has an effect on economic growth. On the other hand, the Tunisian and Moroccan cases are characterized by a negative effect due to the overvaluation of the real exchange rate on growth.

According to the results found, the nature of the exchange rate system adopted by Mauritania can affect its economic growth in two ways in the medium term: either directly through its impact on adjustments to shocks, or indirectly through its effect on other important factors of economic growth such as foreign direct investment and international trade.

Libya is also experiencing a strong foreign exchange crisis. Foreign exchange restrictions imposed on operators have led to a surge in the Libyan dinar's price on the black market. The outlook remains bleak due to rising geopolitical tensions and civil unrest.

Indeed, to extend the empirical analysis, one can focus on the non-linear link that may have existed between economic growth and inflation in the AMU countries, and the role and

weight of exchange rate policy in this equation. This will provide more answers on the short- and long-term relationship between economic growth and exchange rate developments and the optimal regime to be pursued in this region.

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