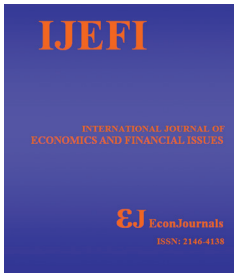

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Revisit of Tunisia's Money Demand Function: What About Oil Price and Exchange Rate Effects?

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ABSTRACT

This paper examines the long run and short run dynamic relationship between real broad money and macroeconomic factors in Tunisia for the period 2010M01 to 2019M07. We employ linear and NARDL bound testing approach for co-integration between the money demand measure and its determinants. Three real broader money demand variables (M2, M3, and M4) are considered to show that exchange rate have asymmetric significant effects once we introduce nonlinearity in the long run as well as in the short run association through partial sum concept. Then, by using the (Shin et al., 2014) NARDL approach, we show that currency appreciation and depreciation could affect the demand for money in an asymmetric manner. However, in the long run, it is only the oil price and Tunisian Dinar (TD) depreciation and appreciation which have significant effect out of the five considered macroeconomic factors (real income, interest rates, inflation, oil price, and the exchange rate). Besides, the CUSUMSQ stability tests results reveal that only real M3 money demand function which is clearly stable. In implementing monetary policy, the Tunisian central bank (TCB) should target the M3 monetary aggregate and take into account of the exchange rate changes stabilization. In addition, Tunisian government has interest to promote renewable energies production to face bad news of rising oil price which are one of the important causes of exchange rate fluctuations and high inflation.

Keywords: Tunisia, Demand for Money, Stability, Asymmetric Effects of Exchange Rate, Oil Price, NARDL Model
JEL Classifications: C33, E31, E41, E51, Q41, C22

1. INTRODUCTION

The question of the effects of monetary policy and its effectiveness has always been the subject of heated debate between practitioners and theorists for both emerging and developed countries. In an environment where the global economy is becoming increasingly complex, monetary authorities are facing major challenges. These authorities implement measures to ensure macroeconomic stability by preventing sharp fluctuations in economic activity and rising inflation. The considered actions are increasingly characterized by uncertainty about their consequences, which can profoundly affect the economy functioning.

A stable money demand function is a necessary condition for the adequate prediction of the impact of a given change in money supply on other macroeconomic variables fluctuations. The demand for money is the link between monetary policy and the rest of the economy. For large number of countries, Central Bank (CB) relays on money demand functions for at least two reasons. Firstly, it helps them to identify medium-term growth target for money supply. Secondly, it allows them to manipulate interest rates and the money reserve for the purpose of controlling total liquidity in the economy.

Traditionally, the money demand function depends on economic fundamentals such as real GDP (scale variable representing the economic activity) and interest rate and consumer price index (or inflation) representing the opportunity cost of holding money. However, exchange rates can play an important role in an economy, particularly in emerging ones (such as Tunisia) and are crucial to

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the success of economic reform programs. (Mishkin, 1996; Calvo, 2001) highlighted the economic challenge concerning the conduct of exchange rate policy in emerging countries.

The accurate specification of money demand function for Tunisia is a debated topic. Generally, the objectives consist in presenting the main determinants of the demand for money and checking the stability of the proposed function. In Tunisia, as elsewhere, the choice of the appropriate real equilibrium exchange rate is crucial to avoid negative effects on the internal and/or external balance of the economy. The depreciation of the Tunisian currency has caused an increase of the imported input prices as energy price that causing an increase in sales prices. In fact, inflation in Tunisia has been steadily rising since 2011 and it is characterized by a noticeable upward trend. Its rate reached in 2018 the record level of 7.7%, compared to 3.5% in 2011, the highest level since 1991 (IMF, 2018). Thus, as imported inflation has been added to domestic inflation, inflation has become a major concern for Tunisian economy. Moreover, the relationship between oil prices and exchange rates has received considerable attention in the literature since the 1980s. El Abed et al. (2016) suggested that policy makers of most MENA countries should consider exchange rate and oil price fluctuations on their macroeconomic policies and diversify more their economics. Then, it is clear that changes in oil prices affect macroeconomic balances and then may conduct the country's monetary policy [(Khalfaou et al., 2020) for the case of India, (Alsamara et al., 2017) for the case of Saudi Arabia, and (Naoyuki and Taghizadeh-Hesary, 2017; Naoyuki and Hesary, 2014; Mpofu, 2011)].

In this article, we propose to study the stability of the money demand function for the case of Tunisia which takes into account the oil price and the exchange rate alongside the usual arguments; namely income, inflation, and the domestic interest rate. Previous studies assumed that exchange rate has symmetric effect. Using a linear model, these studies do not find significant relation between the demand for money and the exchange rate. However, number of recent works demonstrated empirically that exchange rate changes could have significant asymmetric effects on the demand for money (Bahmani-Oskooee and Bahmani, 2015; Bahmani and Baek, 2016; Bahmani et al., 2019). By using a nonlinear model, we address the same issue asking if exchange rate changes do have significant long-run effects on the demand for money and do such effects are asymmetric or not for the Tunisian case.

Moreover, without a stable demand function, the central bank may not be able to predict the demand for money. Therefore it will not be able to determine how much to offer to meet the additional demand, and as a result, it will not be able to accomplish the goal of price stability. This paper attempt to add some fresh empirical evidence to the debate. It contributes to the existing monetary literature in many ways. First, it investigates a new specification of money demand equation by adding exchange rate appreciation and depreciation and oil price fluctuation to the money demand function. Secondly, it analyzes the demand for money by using NARDL bound testing approach for co-integration between the money aggregates measure and its determinants. Thirdly, it reconsider the stability question of the demand for money in Tunisia over time. To this end, we formulate the demand for money with real M2, M3 and M4 monetary aggregates.

The rest of the paper is structured as follows. In Section 2, we briefly survey the empirical money demand literature that focused on Tunisia and some other emerging countries. The model specification, data, and econometric issues are discussed in Section 3. Sections 4 present empirical findings. Finally, conclusions and some policy implications close the paper.

2. SELECTED EMPIRICAL LITERATURE

Most of the works carried out on the study of the monetary targeting strategy in Tunisia has shown the failure of this strategy due to:

(i) The poor choice of the aggregate targeted by the TCB as an intermediate objective (Najeh and Bouaziz, 1990; Najeh and Kria, 1991; Zouari, 1991; Najeh, 1996; Boughrara, 2002);
(ii) Or the instability of the adopted currency demand functio (End et al., 2020) n.

2.1. Tunisia Money Demand Function Stability

Finding stable money demand functions, it broadly corroborates the choice of monetary aggregates as intermediate targets of monetary policy by the Tunisian Central Bank (TCB). In addition, interest rates and the reserve currency may be achievable operational targets and the Central Bank will further orient its monetary policy towards transparency operational targets.

Treichel (1997) proposed an empirical analysis to explain the conduct of monetary policy in Tunisia from 1962 to 1995 by examining the nature and stability of money demand and by discussing appropriate operating regimes for money supply control. He concluded that both interest rates and reserve money are feasible operating targets and suggested that the Central Bank orients its monetary policy more towards transparent operating targets.

Ben Salha and Jaidi (2013) examined the money demand function in Tunisia during the period 1981-2011. Using the ARDL bounds testing approach, their results reveal evidence of cointegration between broad money demand and its determinants, namely final consumption expenditure, expenditure on goods investment, export expenditure, and interest rate. They concluded that monetary policy in Tunisia should be based on a broad definition of money and the money demand function must take into account of the different expenditure components of real income.

Ghrissi (2013) used monthly data covering the period 1990-2011 to examine the stability of the money demand function in the case of the Tunisian economy through the test of Cumulative Sum of residues (SUMCU) and Chow's Forecast test. The results of this study indicate that the money demand function is not stable. Thus, he concluded that the Central Bank of Tunisia cannot accomplish the goal of price stability as monetary targeting regime currently applied, and then, the CBT should take steps towards the adoption of inflation targeting regime.

In a review of the Tunisian experience over the period 2000-2011, Lajnaf (2014) found that the money demand function in the sense of M3 shows some instability. It has some break points. The first is presented around the third quarter of 2002, which is the result of the crisis of September 2001. The second breaking point was the first quarter of 2004. It is justified by the increase in oil prices and by the sharp fluctuations in the exchange rate experienced during this year. The third breaking point is explained by the 2008 subprime crisis. Finally, the author say that the presence of these breaks in M3 attests the fragility of the Tunisian economy vis-à-vis the global shocks and international financial and monetary crises.

Mgadmi et al. (2016) presented an empirical investigation on the stability of money demand for the period 1973-2013 using the Smooth Transition Autoregressive models (STAR) which is characterized by switching regimes through continuous transition functions. The instability of the money demand is explained by the fragility of the Tunisian economy to world shocks and by the implementation of the IMF's Structural Adjustment Programs.

While inflation targeting remains the ultimate objective of Tunisia's monetary policy, the central bank shall in this case refer to a suitable currency demand function for the identification of medium-term monetary growth targets and for the manipulation of interest rates and reserve currencies in order to control the total liquidity of the economy. However, the utility of a money demand function depends crucially on its stability. This stability has major implications for the efficiency of monetary aggregates as intermediate objectives of monetary policy (Atkinson et al., 1984).

2.2. The Asymmetric Effect of Exchange Rate

(Mundell, 1963) is the first paper which predict that money demand depends on the exchange rate in addition to income and interest rates. The exchange rate seems to be related to the money demand function through the wealth effect or the substitution effect. Many studies show that currency appreciation or depreciation could affect the demand for money in an asymmetric manner. Arango and Nadiri (1981) argued that an appreciation of foreign currency increased the value, in local currency terms, of foreign assets held by domestic residents. If this increase led to consumption growth, along with an increase in wealth, then money demand could also increase. Bahmani and Pourheydarian (1990) argued that if further appreciation of foreign currency were expected, demand for foreign currency from domestic residents would increase.

Later, in estimating the currency demand in Iran, Bahmani-Oskooee and Bahmani (2015) explained the inability to find a significant relationship between the exchange rate and the demand for money under the assumption of a process of linear dynamic adjustment. However, once non-linearity is introduced from (Shin et al., 2014) side, they found that the movement of exchange rates has a significant effect on the demand for money. Thus, by separating the movements of appreciation from depreciation, they found that the appreciation and the depreciation have an asymmetrical effect on the demand for money. This is because post-revolutionary period, most Iranians cannot hold properties abroad due to the sanctions. And as a result, many Iranians in large cities take refuge to speculation by buying and selling dollars. As the dollar appreciates, Iranians expect a new appreciation and therefore hold more dollars and less national currency and vice-versa when the dollar depreciates, resulting in significant asymmetrical effects.

Addressing stability of the demand for money in Japan over the period 1973-2014, Bahmani-Oskooee and Baek (2016) explained that failure to find a cointegrating relationship is due to assuming a linear model in which exchange rate changes have symmetric effects. Once they adopt a non-linear ARDL approach, they found that exchange rate changes have asymmetric effects. In the long term, the appreciation of the yen has a significant positive effect. They also find stable monetary demand which not affected by the 2008 financial crisis.

Also, using quarterly data over the period 1973-2014, Bahmani-Oskooee and Baek (2017) examined the exchange rate elasticity of money demand in Korea by a non-linear ARDL model. In the short term, they find that the sign and magnitude of the effect differ for depreciation from appreciation. While, in the long run, only the size of the elasticities differs, and both of the appreciation and the depreciation leads to an increase in the demand for foreign currency. The effects of exchange rate changes on the demand for money is asymmetric as substitution effect is based on expectations and expectations change over time.

Using the NARDL bounds test for cointegration, Alsamara and Mrabet (2019) explored the impact of exchange rate shocks on the demand for money in Turkey from 1986:Q1 to 2014:Q4. They reveal that the response of money demand to a negative shock in exchange rate (appreciation) was stronger than its reaction to a positive shock (depreciation). In addition, the authors conclude that monetary policy makers should achieve more stable exchange rates to anchor price fluctuations.

Recently, Elhassan (2021) examined the asymmetric impact of exchange rate fluctuations on Sudanian money demand for the period between1960 and 2018. Using the NARDL model, she founds that the impact of the exchange rate is asymmetric in the long and short terms. In the short term, a positive change in the exchange rate increases money demand, while a negative change in the exchange rate has no effect.

According to these studies, it becomes important to analyze the asymmetric effect of exchange rate on money demand in the case of Tunisian economy. To the best of our knowledge, no previous empirical research estimated the effects of the asymmetric effects of exchange rates and the effect of oil price on the Tunisian money demand function.

3. DATA AND ECONOMETRIC MODELS

3.1. Data Analysis

We employ monthly Tunisian data over 2010M01-2019M07 period to carry out the empirical analysis. This is the period for which data on real monetary aggregates M2, M3, and M4 variables are available (some are available till 2019M07, see detail given at Table A1 in Annex). Full definitions and sources of time series introduced in the empirical investigation are given at Table A1 (in Annex).

Table A2 (in Annex) presents descriptive statistics (average value, Median, Maximum, Minimum, standard deviation, Skewness, Kurtosis, Jarque and Bera (JB) statistic and its p-value) for considered variables. JB test statistics do not reject the normality assumption for LM2, LM3, LM4. Then these three series can have Gaussian distribution. Table A2 presents also correlation matrix. All considered variables are significantly correlated with money demand measures except Inflation rate. Association of real monetary aggregates M2, M3, and M4 is positive with real GDP, Exchange rate (LEXC), Inflation rate (INF) and interest rate (INT) and negative with oil price (LPO).

As starting point for NARDL model, it is imperative to verify if all considered variables are not integrated of order two I(2). If not, the linear and NARDL framework are not appropriate. Hence, we use PP test to examine the stationarity of the considered variables. Unit root test results are given at Table A3 in Annex. No series can be considered as I(2) process. All series are I(1) except Inflation which can be considered as I(0) process.

Since all considered macroeconomic time-series variables are either I(1) or I(0), we'll investigate cointegration question from NARDL models. Results from Table 1 confirm the existence of long run equilibrium relationship between considered variables and Tunisian demand for money (Since all F_{PSS} statistics are greater than the upper bound critical value at 5% level of significance).

The bound critical values reported in this Table are given by Eviews 10. Fr²om (Pesaran et al., 2001, p. 300) Table CI, Case III, the upper bound critical value of the F-test for cointegration when there are 5 [6] exogenous variables is 3.35 (3.79) [3.23 (3.61)] at the 10% (5%) level of significance (critical values are computed via stochastic simulations using T = 1000 and 40,000 replications).

3.2. Models and Useful Technics

The long-run static specification of money demand in this section follows the literature but also oil price and the exchange rate are incorporated as independent variables:

$$LMj_t = \alpha + \beta\, LEXC_t + \gamma\, LGDP_t + \delta\, INF_t + \xi\, INT_t + \phi\, LOP_t + u_t \quad (1)$$

The asymmetric linear model separating depreciations from appreciations can be as follow:

$$LMj_t = \alpha + \beta^- LEXC_t^- + \beta^+ LEXC_t^+ + \gamma\, LGDP_t + \delta\, INF_t + \xi\, INT_t + \phi\, LOP_t + ut \quad (2)$$

Table 1: Cointegration FPSS test results for real monetary aggregates M2, M4, and M3

Aggregates	F-statistic	k	Significant	I (0)	I (1)	Result
Real M2	4.95390	6	10%	1.99	2.94	Cointegration
Real M4	5.39829		5%	2.27	3.28	Cointegration
Real M3	5.319323		2.5%	2.55	3.61	Cointegration
-			1%	2.88	3.99	

Where $LEXC_{t-i}^+$ (depreciations) and $LEXC_{t-i}^-$ (appreciations) are the partial sum process of the positive and negative changes in $LEXC_t$ defined as:

$$LEXC_{t-i}^+ = \sum_{j=1}^{t} \Delta LEXC_j^+ = \sum_{j=1}^{t} \max(\Delta LEXC_j, 0) \quad (A)$$

and

$$LEXC_{t-i}^- = \sum_{j=1}^{t} \Delta LEXC_j^- = \sum_{j=1}^{t} \min(\Delta LEXC_j, 0) \quad (B)$$

j = 2, 3, 4, LMj = log(Mj)-log(CPI) is a measure of real quantity of monetary aggregate j held by the public and LGDP = log(GDP)-log(CPI) is the scale variable measured by the real GDP in Tunisia. Two measures of opportunity cost of holding money are included in (1). The interest rate denoted by INT is a measure of opportunity cost against financial assets and inflation rate denoted by INF = Log (CPI_t/CPI_{t-1}) is the opportunity cost of holding money against real assets (CPI is the consumer price index). The nominal effective exchange value of Tunisian Dinar (TD) that is denoted by LEXC = log (EXC) is included to account for currency substitution. Finally oil price is denoted by LOP to account for world economic conjuncture.

Following the literature on the transaction demand for money we expect an estimate of γ to be positive and those of ξ and δ are expected to be negative, while estimate of β is expected to be positive or negative.

Thus, a negative estimate of ξ and δ will reflect the opportunity cost to holding money. A negative estimate of β will support the wealth effect and a positive estimate support the expectation or substitution effect. If a grow in exchange rate (EXC), i.e., a depreciation of Tunisian Dinar do decrease the demand for domestic currency due to relatively stronger substitution effect, an estimate of β could be negative. Otherwise, if wealth effect is relatively stronger, an estimate of β could be positive (Arango and Nadiri, 1981; Bahmani-Oskooee and Pourheydarian, 1990). ϕ the coefficient of oil price is expected to be positive or negative.

Several critics can be stated on static linear model (1). First, linear equation (1) is a contemporaneous relation, which may not be plausible theoretically and inadequate empirically owing to the omission of short-run dynamics. Following (Laidler, 1993, pp. 175-76), we can consider the dynamic linear ARDL model. Second, the static linear model (1) is a weak modification of the (Mundell, 1963, p. 484) model since there is no any consideration for asymmetries. Then, a nonlinear long run asymmetric augmented regression model can be written as:

$$\Delta LMj_t = \alpha + \rho LMj_t + \beta^- LEXC_t^- + \beta^+ LEXC_t^+ + \alpha_2\, LGDP_t + \alpha_3\, INF_t + \alpha_4\, INT_t + \alpha_5\, LOP_t + \sum_{i=0}^{m} \theta_i^- \Delta LEXC_{t-i}^- + \sum_{i=0}^{m} \theta_i^+ \Delta LEXC_{t-i}^+ + \sum_{i=0}^{m} \theta_i \Delta LMj_{t-i} + \sum_{i=1}^{m} \delta_i \Delta INF_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta LGDP_{t-i} + \sum_{i=1}^{m} \xi_i \Delta INT_{t-i} + \sum_{i=0}^{m} \phi_i \Delta LOP_{t-i} + \varepsilon_t \quad (3)$$

where ΔLMj_t represents real broad money demand growth, Δ is the first difference operator, ε_t is disturbance term ρ, β^+ and β^-, α_2 α_3, α_4, α_5 are the long run parameters, $\varepsilon_t \sim WN(0,\sigma^2)$, θ_i^+ and θ_i^- are the asymmetric short run parameters. The error correction model (ECM) associated with the asymmetric cointegration form can then be written as the so known NARDL model:

$$\Delta LMj_t = \alpha + \rho u_{t-1} + \sum_{i=0}^{m} \theta_i^- \Delta LEXC_{t-i}^- + \sum_{i=0}^{m} \theta_i^+ \Delta LEXC_{t-i}^+ + \sum_{i=0}^{m} \theta_i \Delta LMj_{t-i} + \sum_{i=1}^{m} \delta_i \Delta INF_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta LGDP_{t-i} + \sum_{i=1}^{m} \xi_i \Delta INT_{t-i} + \sum_{i=0}^{m} \phi_i \Delta LOP_{t-i} + \varepsilon_t, \quad (4)$$

where

$$u_t \equiv ECM_t = LMj_t - (\beta^- LEXC_t^- + \beta^+ LEXC_t^+ + \alpha_2 LGDP_t + \alpha_3 INF_t + \alpha_4 INT_t + \alpha_5 LOP_t)/\rho, \; j = 2, 3, 4,$$

and $\theta^+ = -\beta^+/\rho$ and $\theta^- = -\beta^-/\rho$ are the asymmetric long run parameters.

All the symmetry tests are based on the standard Wald tests (W_{LR} for long run and W_{SR} for short run). The long run symmetries can be examined by testing H_0: $\theta^+ = \theta^-$, while the short run symmetries can be examined by testing individual H_0: $\theta_i^+ = \theta_i^-$ (for all i = 0..., m-1), or summative version; $H_0 : \sum_{i=0}^{m-1} \theta_i^+ = \sum_{i=0}^{m-1} \theta_i^+$.

4. THE EMPIRICAL RESULTS

Using Tunisian monthly data over 2010M01-2019M07 period, linear static regression (1) yields a significant positive relationship between real monetary aggregates M2 (M3 or M4) and LGDP and LOP and a negative relationship with LEXC, INT and INF (insignificant only for INF). For the asymmetric linear static regression results from equation (2), we see that there is significant positive relationship between real monetary aggregate M2 (M3 or M4) and LOP and $LEXC_t^+$ and negative relationship with $LEXC_t^-$, LGDP, INF and INT (insignificant only for INT). Each situation is coupled with high coefficient of determinations, lower DW statistics than R^2, and high Student t-statistics (upward biased). All of these indicate a case of spurious regressions. In addition, all of these regressions suffer from structural breaks (instability) as indicated by CUSUMSQ statistic test. Low DW statistics indicate positive correlation in the residuals, hence we should consider dynamic models to get more accurate results.

In the following sub-section, we estimate the NARDL models outlined by equation (4) for real monetary aggregates M2, M4, and M3 using monthly data over 2010M01-2019M07 period to carry out the empirical analysis and particularly to determine which monetary aggregate yields stable relationship with income, interest rates, inflation, oil price, and the exchange rate for Tunisian economy. Following the literature, we then use Akaike's Information Criterion (AIC) to select the optimum lags.

Based on an ARDL models, we found that the nominal effective exchange rate had no long-run effects on the demand for money in Tunisia (These results are available upon request). The estimates of the NARDL model (in Table 2 for short run effects and Table 3 for long run effects) show that introducing nonlinear adjustment of Exchange rate can change the outcome. The diagnostic investigation are documented at Table 4.

4.1. Short-Run Estimates

The results from NARDL model for short run effects are given in Table 2. The results of the estimates for real monetary aggregates M2, M3 and M4 indicate that the changes in inflation (ΔINF) has significantly negative coefficients. We note that the changes in the real M2 and real M3 aggregates are very similar. In addition, in order to assess short-term currency demand for real M2 and M3, changes in previous inflations (that can be used as a measure of expected inflation (Ghrissi, 2013), ΔINF_{-1} and ΔINF_{-2}, are associated with decreasing coefficients as we go back in time (respectively -1,087 and -0,44 for real M2 and -0,88 and -0,57 for real M3). Thus, our results show that an accelerated increase in inflation would lead to a decrease in demand for the currency. This is because the inflation rate is a measure of the opportunity cost of holding money. Thus, the expected inflation affects the opportunity cost of holding money and would encourage Tunisian households to substitute real assets for money.

The results of estimations for real M3 indicate also that only ΔINT_{-2} carries significantly positive coefficient. Higher interest rates favor short-term liquid savings (Savings accounts, deposit certificates (CDs), foreign currencies, money market accounts, marketable securities, and Treasury) and contractual savings (Savings in housing accounts, Investment savings account). This means that liquid assets are generally preferred investments by Tunisian households. Particularly, deposit contracts offered by the banking sector are the main investment formula and provide to individuals a liquidity insurance.

Moreover, unlike the developed economies, the financial markets outside the commercial banks were rudimentary before the reform period. Individual ability to trade money for financial instruments are very limited. Furthermore, The Tunisian Central Bank (TCB) actively influences the level of interest rates. These differences between the less developed and developed nations will have pronounced influence on the money basic demand function and hence on the monetary policy efficiency (Boughrara, 2001). Thus, measuring the opportunity cost in the case of Tunisian money demand is miss-leading as interest rate fluctuation is controlled by TCB.

Results for real monetary aggregates M2 and M4 indicate that ΔLGDP carries negative significant coefficients at 1% level. A 1% increase in the GDP would decrease the demand for money by 0.61% for real M2 and 0.63% for real M4, implying that the demand was inelastic in the short term. The negative coefficient of GDP growth implies that in bad economic conditions (over 2010-2021 period of negative GDP growth trend, post 2011 Tunisian revolution, and between 2019 Covid crisis, individuals make pessimistic expectations and reduce their consumption

Table 2: Short-run coefficient estimates

Real variable	M2			M4			M3		
	Coefficient	t-statistic	Probability	Coefficient	t-statistic	Probability	Coefficient	t-statistic	Probability
Δ $LEXC_t^+$							−0.009714	−0.129579	0.8972
Δ $LEXC_{t-1}^+$							0.036048	0.453377	0.6513
Δ $LEXC_{t-2}^+$							−0.019752	−0.251577	0.8019
Δ $LEXC_{t-3}^+$							−0.190536	−2.749832	0.0072
Δ $LEXC_t^-$	−0.336845	−2.871759	0.0050	−0.324869	−2.939779	0.0041			
ΔLGDP	−0.607380	−3.309915	0.0013	−0.627953	−3.566164	0.0006			
ΔINF	−1.741669	−5.926591	0.0000	−1.631250	−6.636435	0.0000	−1.419437	−5.472568	0.0000
Δ INF_{-1}	−1.087438	−4.213012	0.0001	−0.657921	−3.184432	0.0019	−0.881171	−3.305288	0.0014
Δ INF_{-2}	−0.440617	−1.673287	0.0975				−0.572372	−2.159204	0.0334
Δ INT							−0.002754	−0.500047	0.6182
Δ INT_{-1}							−0.003825	−0.678214	0.4993
Δ INT_{-2}							0.015832	2.917354	0.0044
ECM_{-1}*	−0.493776	−6.516290	0.0000	−0.479557	−6.797750	0.0000	−0.499159	−6.767011	0.0000

NARDL model is based on ARDL (1, 0, 1, 1, 0, 3, 0) for M2, ARDL (1, 0, 1, 1, 0, 2, 0) for M4, and ARDL (1, 4, 0, 0, 3, 3, 0) for M3. *P-value incompatible with t-Bounds distribution. From (Pesaran et al., 2001, pp. 303, Table CII, Case III), the appropriate critical value for significance of ECM_{-1} is−4.04 (−4.38) at the 10% (5%) level when k=6. ECM: Error correction model, INF: Inflation rate, INT: Interest rate

Table 3: Long-run coefficient estimates

Real variable	M2			M4			M3		
	Coefficient	t-statistic	Probability	Coefficient	t-statistic	Probability	Coefficient	t-statistic	Probability
$LEXC_t^+$	0.185812	3.036183	0.0031	0.184839	3.159282	0.0021	0.204100	3.298182	0.0014
$LEXC_t^-$	−0.268649	−2.696433	0.0083	−0.258818	−2.759453	0.0069	−0.253555	−2.314979	0.0228
LGDP	−0.095018	−0.623024	0.5347	−0.100870	−0.702264	0.4841	−0.169338	−1.084412	0.2810
INT	−0.005454	−1.268568	0.2076	−0.008237	−1.947570	0.0543	−0.004883	−1.385405	0.1693
INF	−0.709896	−0.538682	0.5913	−1.580863	−1.364128	0.1756	−1.294093	−0.997315	0.3212
LOP	0.036974	3.628069	0.0005	0.037598	3.770527	0.0003	0.031593	3.492273	0.0007
C	6.457754	3.869492	0.0002	6.588253	4.188694	0.0001	7.355513	4.306233	0.0000

INF: Inflation rate, INT: Interest rate

Table 4: Diagnostic statistics

Real	M2		M4		M3	
	t-statistic	Probability	t-statistic	Probability	t-statistic	Probability
Adjusted R^2 (%)	97.8092		97.708		97.6343	
F-statistic	364.5994	0.0000	387.5496	0.0000	223.3508	0.0000
LM	0.098694	0.9519	0.859045	0.6508	0.048139	0.9762
ARCH	0.327236	0.5673	0.326236	0.5679	0.493138	0.4825
W_{SR}	33.53531	0.0000	38.96166	0.0000	27.70792	0.0000
W_{LR}	3.841988	0.0500	7.639133	0.0057	1.057395	0.3038

LM is the statistic to test for autocorrelation (Breusch-Godfrey Serial Correlation LM). It is distributed as χ^2 with 2 degrees of freedom. Heteroskedasticity ARCH test is distributed as χ^2 with 1 degrees of freedom. W_{SR} is the Wald statistic for the test of symmetry hypothesis in SR while W_{LR} is the Wald statistic for the test of symmetry hypothesis in LR. LR: Long run, SR: Short run, LM: Lagrange multiplier

and investment spending and consequently money constitute a precautionary saving in the form of monetary assets (quasi-currency or negotiable debt securities).

By examining the effects of exchange rate changes on the demand for money, we get coefficient estimates of the variable $\Delta LEXC_t^-$ (representing the appreciation of the Tunisian dinar (TD)), and of the variable $\Delta LEXC_t^+$ (representing the depreciation of TD). Based on the results obtained at Table 2, coefficient for real M3 indicates that dinar depreciation carries significantly negative coefficient at 1% level. A 1% increase in the $\Delta LEXC_{t-3}^+$ would decrease the demand for money by 0.19 % for real M3. Also, results indicate that dinar appreciation carries significantly negative coefficient at 1% level. A 1% decrease in the $\Delta LEXC_t^-$ would increase the demand for money by around 0.34% for real M2 and by around 0.32% for real M4. The negative sign proves the existence of wealth effects linked to changes in the exchange rate.

Therefore, we may claim the existence of asymmetrical effects of $\Delta LEXC_t^+$ and $\Delta LEXC_t^-$-and we observe that the depreciation effect is smaller than the appreciation impact in the short run. This result indicates that individuals respond to currency appreciation more than currency depreciation by holding more of their domestic currency in the short run.

This implies that the appreciation of domestic currency lowers the domestic currency value of foreign currencies held by Tunisian oversea residents. As this is perceived as an opportunity for wealth increase, the demand for money should increase (Arango and Nadiri, 1981). On the other hand, and for the same reasons, when the national currency appreciates, domestic residents may hold more foreign currencies and reduce their demand for domestic currency.

In the nonlinear model (Table 2), ECM_{-1} is also highly significant (which was also the case in the linear model). This provides not just additional support for cointegration but also supports nonlinear adjustment and convergence toward long-run equilibrium. That, for real monetary aggregates M3 (M2 and M4), almost 49.9159% (49.3776% and 47.9557%) of the adjustment takes place within one months since data are monthly (convergence towards long run equilibrium takes about 2 months).

4.2. Long-Run Estimates

Long run coefficient estimates are reported in Table 3. Even no specification problem was detected, in addition to exchange rate, only oil price seems to have positive significant effect on Tunisian long run money demand equilibrium. Inflation, interest rate, and real GDP have no significant effects on money demand in long-run for the three Tunisian considered money aggregates over 2010M01-2019M07 period. These findings contradict the previous findings of (Haider et al., 2017; Mahmood and Alkhateeb, 2018; Bahmani-Oskooee and Baek, 2016; Bahmani-Oskooee and Baek, 2017; Suliman and Dafaalla, 2011).

Concentrating on the effects of exchange rate changes on real monetary aggregates M2, M3 and M4, it is clear that at the 1% significant level, we may claim the existence of asymmetrical effects of $LEXC_t^+$ and $LEXC_t$- in the long run. Further, the coefficients of $LEXC_t^+$ and $LEXC_t$- have different signs. A 1% increase in the $LEXC_t^+$ (depreciation of TD) would lead to a (0.19%, 0.20%, 0.18% respectively) increase in demand for TD, while a 1% decrease in the $LEXC_t$- (appreciation of TD) would lead to a (27%, 0.25%, 0.26% respectively) increase in demand for TD in the long run. This result is corroborating the different direction of effects of the depreciation and the appreciation on the Iran's money demand reported by (Bahmani-Oskooee and Bahmani, 2015) and Saudian's money demand reported by (Mahmood and Alkhateeb, 2018).

Again, in long run, result indicates that individuals respond to currency appreciation more than currency depreciation by holding more of their domestic currency. The depreciation of domestic currency, or the appreciation of foreign currency, raises the domestic currency value of foreign assets held by Tunisian oversea residents. Since this is perceived as an increase in wealth, the demand for money increase (Arango and Nadiri, 1981).

However, historically and due to inflation and high budget and current deficits in Tunisia, dinar has frequently depreciated. And, even there is a belief that the trend of the dinar is continually declining, any short-lived appreciation of the dinar was well exploited. Consequently, these findings reveal that an appreciation of TD is reflected in the demand for money more than depreciation in the long run, inferring that individuals are willing to absorb the adverse shocks in foreign exchange rate when depreciation occurs. That explains why, in the long run as in short run, appreciation leads to more demand for money and then exchange rate changes have an asymmetric impact on money demand in Tunisia.

Moreover, our findings indicate that oil price has a positive long run effect on the demand for money, the elasticity coefficients of LOP were significant at the 1% level (0.03% for real monetary aggregates M2, M3 and M4). The fact that the demand for money depend on oil price gives a great importance to the international environment in the conduct of Tunisian monetary policy. Indeed rising of oil price is bad news for Tunisia since oil price fluctuations are one of the main causes of economic downturns, trade deficits, high inflation, and exchange rate changes. The deterioration of the energy balance could lead to a depreciation of the national currency and the individuals need more TD to purchase commodities, and thus, demand for domestic currency will rise. These positive signs are expected and they reflect that domestic residents need more money to achieve a higher level of transaction. As a matter of fact, any policy taken by monetary authority have to take into account of the oil price fluctuations.

Even no specification problem was detected for the three models (for real monetary aggregates M2, M3 and M4), in addition to exchange rate, only oil price seems to have positive significant effect on Tunisian long run money demand equilibrium. The domestic interest rate fails to indicate any significant results in the long run supporting the fact that the interest rate has no role in capturing the opportunity cost of holding money in Tunisia. This outcome supports the previous findings of (Pham and Bui, 2018) for Vietnam economy.

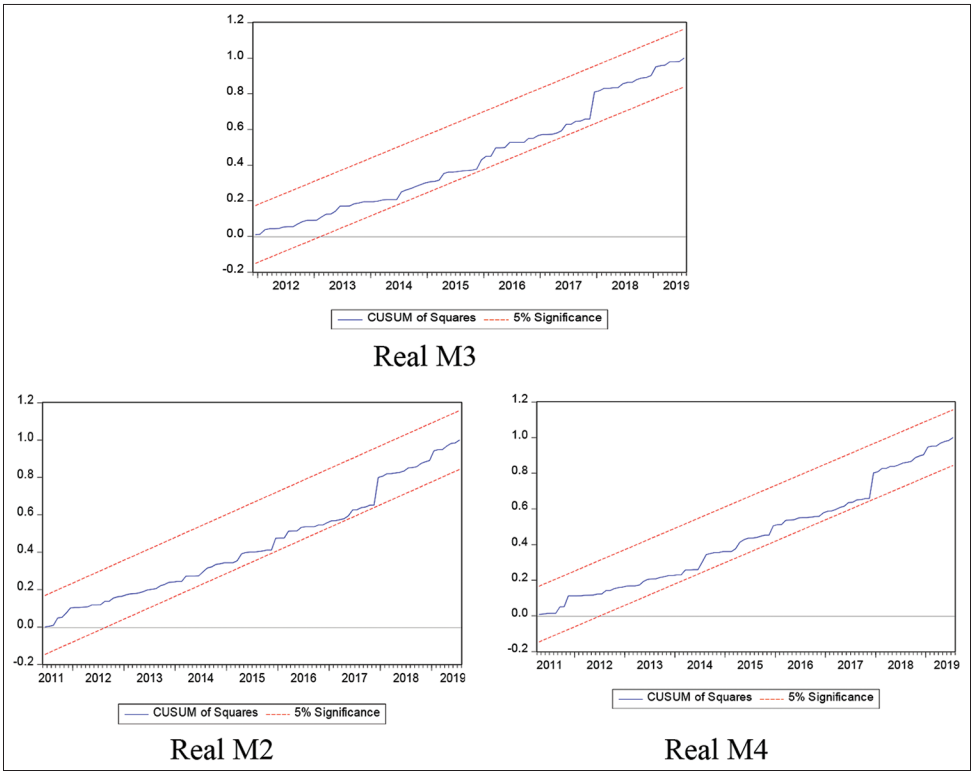
In addition, Inflation and real GDP have no significant effects on money demand in long-run for the three considered real money aggregates (M2, M3 and M4). These findings contradict the previous findings of (Haider et al., 2017; Mahmood and Alkhateeb, 2018; Bahmani-Oskooee and Baek, 2016; Bahmani-Oskooee and Baek, 2017; Suliman and Dafaalla, 2011).

4.3. Diagnostic and Stability Analysis

Wald test statistic suggested by (Shin et al., 2014) which is denoted by W_{LR} (W_{SR}) for long run (short run) is significantly not rejecting (rejecting) long-run (short run) symmetry effects (Table 4) for real M3. Hence, we may conclude that exchange rate adjustments exhibit only short-run asymmetry for real M3. However, looking at Table 4, in long run, we get for real M2 and M4 almost similar results to those obtained for real M3 except that from Wald test our calculated statistic W_{LR} and W_{SR} for respectively long run and short run reject in both long-run and short symmetry effects.

In addition, the stability of money demand function is very crucial element to implement an efficient monetary policy, therefore, it is important to examine whether the coefficients of the estimated NARDL model are stable over time. To this end, our empirical analysis carries out a further stability tests by using the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ). Stability tests indicate that all the coefficients of estimated models are stable as they fall within the critical bounds (see Figure 1).

Figure 1: Plots of CUSUM of squares from NARDL models



A few other diagnostic statistics of the nonlinear model support free of autocorrelation and Heteroscedasticity model are also reported in Table 4. The model enjoys a good global fit by the adjusted R^2 and the significance of F-statistic. All estimated coefficients are stable for real M3. It is clear that both parameters estimates from real M2 and M4 demand functions are likely to experience some instability occurred towards the end of 2017 and the early of 2018 for both real M2 and M4.

5. CONCLUSION

Our study aims to improve the understanding of real monetary aggregates which play a crucial role in the conduct of the monetary policy in Tunisia. In addition to (Mundell, 1963)'s proposition saying that money demand could depends upon the exchange rate in addition to the level of income and the interest rate, we add oil price as a world economic conjecture factor.

Although there is a vast empirical literature on the subject, no existing empirical study has yet examined the asymmetric impact of exchange rate changes in Tunisia under an inflation targeting regime. This paper is based on the demand of Tunisian real monetary aggregates M2, M4 and M3 over the period 2010M01 to 2019M07 covering post 2011 TUN revolution crisis.

Our empirical investigations try to improve the literature on the determinants of money demand for the Tunisian economy. We contribute to the existing literature in different ways. First, we investigates a new specification of money demand equation by adding oil price to the money function for Tunisia. Second, we take into account of the exchange rate appreciation and depreciation to highlight the asymmetrical effects of exchange rate. Third, we use a Non-linear dynamic model (NARDL) to get the stability that unshaved by the static money demand function.

In the short run, our results show that an accelerated increase in inflation would lead to a decrease in the currency demand. This is because the inflation rate is a measure of the opportunity cost of holding money. Thus, the expected inflation affects the opportunity cost of holding money and would encourage Tunisian households to substitute real assets for money. TCB seems to want to combat inflation by increasing the key interest rate, at the risk of negatively influencing investment. However, the source of inflation in Tunisia today is not really monetary. An examination of the liquidity ratio of the economy, as measured by the M3/GDP ratio, shows that the money supply has been established at compatible levels with the activity development (in average this ratio is around 72% post 2011 TUN revolution), which supports the absence of monetary inflationary pressures. In addition, it seems that this inflation is more a result of a mismatch between supply and demand of goods and services and of the international environment situation (due to exchange rate and oil price) than of monetary origin. Indeed, the depreciation of the dinar against the euro or the dollar, the rise of oil price, the disruptions in distribution channels, plus the delayed effect of the exceptional rise in wages, have without doubt an impact on the inflation rate.

Also, the results of estimation for real M3 indicate that only 2 past interest rate change (ΔINT_{-2}) which carries significantly positive coefficient. Higher interest rates favor short-term liquid savings (Savings accounts, deposit certificates (CDs), foreign currencies, money market accounts, marketable securities, and Treasury) and

contractual savings (Savings in housing accounts, Investment savings account). This means that liquid assets are generally preferred investments by Tunisian households. Particularly, deposit contracts offered by the banking sector are the main investment formula and provide to individuals a liquidity insurance.

Our findings suggest that the response of money demand to a negative shock in exchange rate (appreciation) was stronger than its reaction to a positive shock (depreciation) in the short and long run. In the long run, our results indicates that the wealth effect has a stronger impact on the demand for money rather than expectation effect. The individuals will hold more domestic currency in case of depreciation and appreciation. Besides, these findings reveal that an appreciation of TD is reflected in the demand for money more than depreciation in the long run, inferring that individuals are willing to absorb the adverse shocks in exchange rate when depreciation occurs. The findings of this study propose then that the exchange rate fluctuations should be within the ambit of monetary policy in Tunisia, and decision makers should adopt policies that can achieve exchange rate stability. However, to achieve stability in the exchange rate target, a stable political and economic climate must be created to encourage new investments, increase exports, and reduce imports.

Finding gives a great importance to the international environment in the conduct of monetary policy. It says that in the long run, demand for money depend only on exchange rate and on oil price. In addition, our findings indicate that oil price has a positive long run effect on the money demand. The increase of oil price leads to a deterioration of the energy balance that could lead to a depreciation of the national currency, and then individuals need more TD to purchase commodities. Thus, demand for domestic currency will rise. Actually, under the impetus of the IMF, the Tunisian government is going towards the alleviation of the compensation fund. With the reduction of compensation for high fuel prices, the authorities hope to reduce chronic budget deficits and a large public sector debt. However, with such reform, subsidy system will lose its principal objective mainly the inflation reduction. We propose then that, before going to the harmful effect of the compensation subsidies reduction on the economy, the State has interest to put in place some tools like rationalization of the consumption of fuel and urgent promotion of the renewable energies production.

We have also tried to use the domestic interest rate as a determinant of the demand for money, but we failed to indicate any significant results in the long run. This result support the fact that interest rate has an unimportant role in capturing the opportunity cost of holding money in Tunisia.

In order to determine which monetary aggregate yields stable relationship with income, interest rates, inflation, oil price, and the exchange rate changes, we rely on CUSUM and CUSUMSQ tests. Real M2 and M4 demand functions have experienced some instability while real M3 demand function is found to be stable. Thus, for an effective monetary policy in Tunisia, although either monetary aggregates could be manipulated, it is important to pay more attention to M3. This result is extremely important to policy makers in order to conduct and implement an effective monetary policy that can ensure exchange rate stability and support economic growth.

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ANNEX

Table A1: Data description and sources

Notation	Definition	Frequency	Span of time	Source
Mj, j=2, 3, 4	Nominal money demand	Monthly	2010m01-2021m02	TCB
Real LMj, j=2, 3, 4	Real money demand in log*	Monthly	2010m01-2019m07	
GDP	Real GDP**	Yearly	2010-2019	INS
INT (TMM)	Nominal interest rate (money market rate)	Monthly	2010m01-2021m05	TCB
CPI (base2000)	Consumer price index	Monthly	2010m01-2019m07	INS
INF	Inflation=log (CPI/CPI_{-1})	Monthly	2010m01-2019m07	
EXC	Nominal exchange rate	Monthly	2010m01-2021m06	Investing.com
OP	Oil price	Monthly	2010m01-2019m07	EIA

*Nominal monetary aggregate (Mj) is deflated by CPI index to obtain real monetary aggregate; LMj = log (Mj)-log (CPI), j = 2, 3, 4. **This variable is constructed by dividing the nominal GDP by the CPI index. GDP series is converted to monthly data by quadratic technic provided by Eviews 10 package. M2 = M1 + Quasi-money, where M1 = Fiduciary money + Credit balance of checking accounts + Current accounts opened next to the CCP and next to registered intermediaries. M3: Broad money is the sum of M2, repurchase agreements, money market fund shares/units and debt securities up to two years. M4 is the sum of M3 and treasury bills in the hands of the public. TCB: Tunisian central bank, INS: Institut National de Statistique, EIA: Energy Information Administration, GDP: Gross domestic product, CPI: Consumer price index, OP: Oil price, LM: Lagrange multiplier, EXC: Exchange rate, INF: Inflation rate, INT: Interest rate

Table A2: Descriptive statistics and correlation matrix

Descriptive statistics								
Statistic	**LM2**	**LM3**	**LM4**	**LEXC**	**INF**	**INT**	**LOP**	**LGDP**
Mean	5.684876	5.725785	5.731179	0.698910	0.004284	5.196277	4.326657	11.30818
Median	5.683290	5.723741	5.730633	0.676408	0.004349	4.750000	4.336810	11.31353
SD	0.066157	0.060995	0.061346	0.266768	0.003282	1.302951	0.356712	0.180576
Jar-Bera	2.396597	2.975433	3.691633	12.75631	1.673353	15.94047	7.147709	6.114811
Probability	0.301707	0.225888	0.157896	0.001698	0.433148	0.000346	0.028048	0.047010
Correlation matrix								
Variable	**LM2**	**LM3**	**LM4**	**LGDP**	**LEXC**	**INF**	**INT**	**LOP**
LM2	1.000000							
LM3	0.999378	1.000000						
LM4	0.998535	0.999076	1.000000					
LGDP	0.958490	0.951192	0.949135	1.000000				
LEXC	0.917503	0.907666	0.905772	0.978000	1.000000			
INF	0.14574^{+}	0.14661^{+}	0.14331^{+}	0.15971^{+}	0.16406^{+}	1.000000		
INT	0.675191	0.657440	0.642969	0.747730	0.760396	0.141739	1.000000	
LOP	−0.487267	−0.475506	−0.491201	−0.593483	−0.636566	0.075255	−0.209494	1.0000

$^{+}$Correlation is not significant at 5% level. LM: Lagrange multiplier, SD: Standard deviation, INF: Inflation rate, INT: Interest rate, LEXC: Exchange rate in log, LOP: oil price in log, LGDP:GDP in log.

Table A3: PP unit root test results

Model	LM2	LM3	LM4	LEXC	INF	INT	LOP	LGDP
				At level				
With C	−1.3475	−1.5403	−1.6240	−1.0515	−9.748*	−1.1095	−1.3062	1.8836
With Ct and T	−4.392*	−4.325*	−4.31*	−1.6048	−9.943*	−1.7474	−1.9649	−1.9698
Without C and T	6.9665	5.9710	4.3498	2.1245	−4.922*	0.4753	−0.2555	11.4793
				At first difference				
With C	−17.639*	−17.284*	−16.45*	−7.74*	−47.405*	−8.729*	−7.909*	−11.936*
With C and T	−18.626*	−17.928*	−17.87*	−7.719*	−47.879*	−8.698*	−7.867*	−12.331*
Without C and T	−12.842*	−12.997*	−12.86*	−7.335*	−47.073*	−8.705*	−7.951*	−7.786*

*Significant at 1% level. Similar results are obtained from ADF test. LM: Lagrange multiplier, INF: Inflation rate, INT: Interest rate