Economics Bulletin

Volume 42, Issue 4

The determinants of EURO/TND exchange rate volatility in Tunisia

Nadia Dridi
High School of Economics and Commerce of Tunis

Fathi Ayachi
High School of Economics and Commerce of Tunis

Abstract

This paper aims to study the different determinants of nominal exchange rate volatility of the Tunisian Dinar (TND) against the Euro (EURO), principal money of the commercial and financial partners of Tunisia and, particularly, the most volatile money relative to other international currencies as Dollar. We used monthly data from January 2006 to March 2016. In this study, EURO/TND exchange rate volatility is measured employing EGARCH (1,1) approach. For this purpose, we identify relevant variables that influence exchange rate volatility (net assets in foreign currency, current account, debt service average ratio, average money market interest rate, consumer price index family, Tunindex) which were included in our model estimation. The cointegration analysis reveals the presence of a long-run equilibrium relationship between exchange rate volatility and its various determinants and shows that only the current account and debt service ratio have significant negative effects on exchange rate volatility during the study period. At the short-run, the VECM indicate the presence of positive significant relationship among all the explanatory variables and exchange rate volatility with exception of average money market interest rate that has a significant negative effect.

Citation: Nadia Dridi and Fathi Ayachi, (2022) "The determinants of EURO/TND exchange rate volatility in Tunisia", *Economics Bulletin*, Volume 42, Issue 4, pages 1981-1997
Contact: Nadia Dridi - nadiadridi75@yahoo.fr, Fathi Ayachi - fethi_ayachi2@yahoo.fr.
Submitted: June 11, 2022.   **Published:** December 30, 2022.

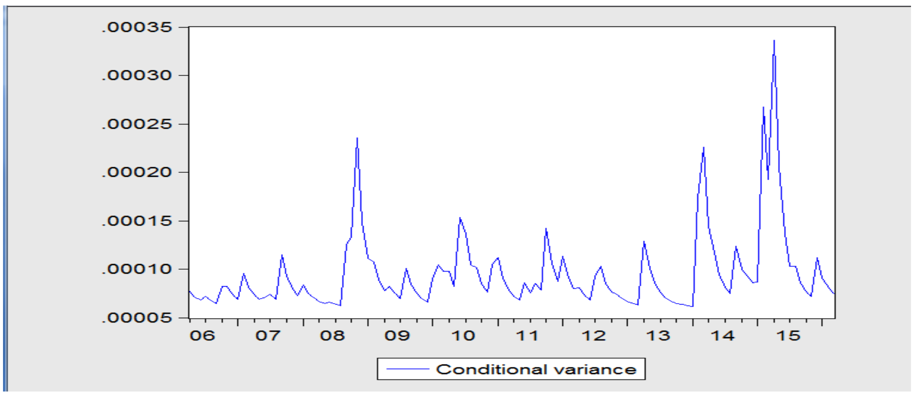
1.Introduction

The risk of the volatility of the Tunisian currency is prejudicial to trade, especially since the market for hedging derivatives is not developed in Tunisia. In addition, volatility promotes and encourages the parallel market for foreign currency and speculation.

In this context, it is interesting to determine the factors explaining the volatility of nominal exchange rate of the Tunisian Dinar (TND) against the Euro (EURO)[1] in order to reduce this volatility. Nevertheless, there is an absence of studies examining the determinants of exchange rate volatility in Tunisia because the majority of the existing empirical literature concentrates mainly on volatility itself and investigates the effect of exchange rate volatility on various macroeconomic variables (such as economic growth, exports, domestic and foreign investments…), leaving the question of its determinants unresolved. Thus, the goal of this paper is to analyze the determinants of euro exchange rate volatility in Tunisia using monthly data covering the period January 2006 to March 2016. The methodology used in this study incorporates various econometric methods, namely cointegration and error correction model, which may help uncover the determinants of exchange rate volatility, generalized impulse-response functions and variance decomposition analysis that are carried out in order to determine the dynamic effect of variables on exchange rate volatility.

The results of this study, aim at showing that the volatility tends to decrease, as the current account is balanced and as the country has an easy access to the international financial market to refinance, i.e. to manage its long-term debt. Indeed, debt service ratio becomes sustainable at the long term.

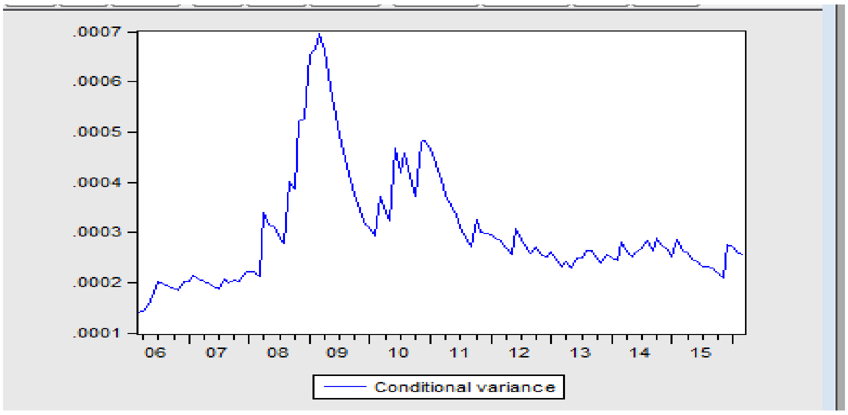
Figure 1: Conditional volatility of nominal exchange rate EURO/TND calculated from EGARCH(1,1) (Vltxch)



Source: EVIEWS treatment

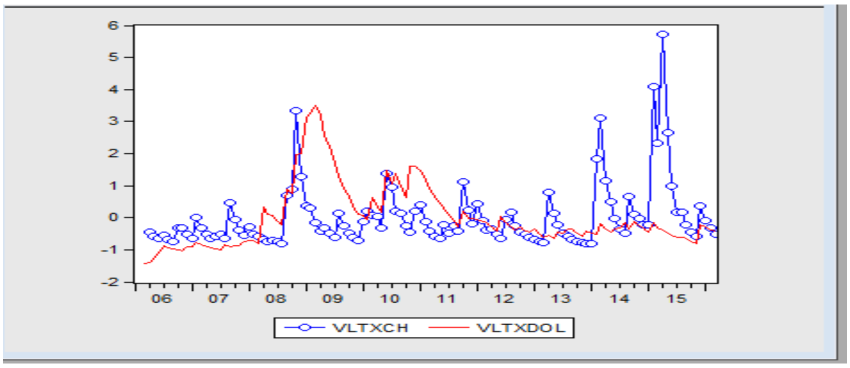
[1] Euro(EURO) is the principal money of the commercial and financial partners of Tunisia and, particularly, the most volatile money relative to other international currencies as Dollar (Figs. 1,2 and 3), with the exception of the period of the American financial crisis (subprime mortgage crisis) that began in 2008, in which the dinar remained stable against the Dollar.
Fig. 1 shows remarkable depreciation in the national currency against the euro, characterized by very high volatility.

Figure 2: Conditional volatility of nominal exchange rate DOL/TND calculated from GARCH(1,1) (VLTXDOL)



Source: EVIEWS treatment

Figure 3: The conditional volatility of nominal exchange rates DOL/TND and EURO/TND



Source: EVIEWS treatment

This study differs from some of the previous studies investigating the determinants of exchange rate volatility in few ways. First, this paper extends the extant literature, by further incorporating relevant variables that influence nominal exchange rate volatility (net assets in foreign currency, current account, debt service average ratio, average money market interest rate, consumer price index family, Tunindex (stock index in dinar)). Second, several previous literatures show that a simple GARCH(1,1) model is parsimonious for measuring volatility. However, the GARCH model has a major drawback because the variance conditional is only symmetric. For that reason, we employ the EGARCH(1,1) model for modeling the volatility of exchange rate because it allows for an asymmetry information of the conditional variance.

The study is structured as following: the next section presents previous literature about exchange rate volatility. The model specification is presented in the section 3. The methodology and data are explained in section 4. Following section reports empirical results, while the final section provides the conclusion and policy implications.

2. Previous literature about exchange rate volatility

In this section we will present some empirical studies dealing with the determinants of exchange rate volatility.

Jabeen and Khan (2014) undertook an analysis of modelling exchange rate volatility in Pakistan. They used monthly data on Pak Rupee exchange rates in the terms of major currencies (US Dollar, British Pound, Canadian Dollar and Japanese Yen) and macroeconomics fundamentals from April, 1982 to November, 2011. The conditional volatilities of these macroeconomic variables were measured through GARCH models. The results showed that the PKR-USD exchange rate volatility is influenced by real output volatility, foreign exchange reserves volatility, inflation volatility and productivity volatility. While the PKR-GBP exchange rate volatility is influenced by foreign exchange reserves volatility and terms of trade volatility. As far the PKR-CAD exchange rate volatility, it is influenced by terms of trade volatility. The findings revealed that exchange rate volatility in Pakistan results from real shocks than nominal shocks.

Kilicarslan (2018) determined the factors affecting exchange rate volatility in Turkey for a period from 1974 to 2016. The author used the GARCH model to calculate the real effective exchange rate volatility. The Johansen cointegration test was used to determine whether there is a long-term relationship between variables. The coefficients of the long-run relationship between the variables were estimated by the FMOLS method. The results showed that the rise in domestic investment (LGFCF), money supply (LMONEY) and trade openness (LTRADE) increases the real effective exchange rate volatility, while the rise in foreign direct investment (LFDI), output (LGDPC) and government expenditures (LGGEXP) also reduces the real effective exchange rate volatility.

A study conducted by Ajao, and Igbekoyi, (2013) analyzed the determinants of real exchange rate volatility in Nigeria from 1981 to 2008 employing the GARCH (1,1) techniques to generate a measure of the volatility. Using the co-integration test and the error correction model, the results showed that openness of the economy, government expenditures, interest rate movements as well as the lagged exchange rate are among the major significant variables that influence REXRVOL during this period.

Oaikhenan and AigheyisiF(2015) examined the factors explaining the volatility of the bilateral exchange rate of the Nigerian currency, the naira to the U.S. dollar, using data for 1970-2013 period. The EGARCH(1,1) modeling technique revealed that increase in net capital flows, the level of financial development, the level of external reserves, the degree of integration of the Nigerian economy with the global economy, increase in crude oil price as well as economic growth can help to mitigate the volatility of the Naira exchange rate. The results found also that external indebtedness (external debt) and monetary expansion have the potential to exacerbate volatility in exchange rate.

Hassan et.al. (2017) studied the sources of exchange rate volatility in Nigeria from 1989Q1 to 2015Q4. The measure of volatility of exchange rate was obtained through the Autoregressive Conditional Heteroscadasticity (ARCH) model. Employing two techniques, namely Autoregressive Distributed Lag (ARDL) model and Granger Causality test, the findings revealed that net foreign asset and interest rate have positive and statistically significant impact on exchange rate volatility while fiscal balance, economic openness and oil price have positive and statistically insignificant impact on exchange rate volatility.

Insah and Chiaraah (2013) used annual data covering the period 1980 to 2012 to determine the sources of real exchange rate volatility in Ghana. The GARCH (11) model was used to determine the measure of exchange rate volatility. Estimation results based on the Autoregressive Distributed Lag (ARDL) model revealed that there exist positive relationship between government expenditure and real exchange rate volatility, while, both domestic and external debts were negatively related to real exchange rate volatility. The effect on the economy is that an increase (decrease) in domestic and external debts will lead to a decrease (increase) in real exchange rate volatility. As a policy move, an increase in external debt is not problematic if real exchange rate volatility management is the macroeconomic policy objective of the government.

Alagidede and Ibrahim (2017) utilized Johansen cointegration test and VECM model to analyze the causes of real exchange rate volatility in Ghana using annual data spanning 1980 to 2013. The real exchange rate volatility measured using the conditional variance from a GARCH(1,1) process. The study found that in the short run output is the main driver of exchange rate fluctuations in Ghana. In the long run, however, exchange rate volatility is significantly influenced by government expenditure growth, money supply, terms of trade shocks, FDI flows and domestic output movements.

Mpofu(2021) investigated the determinants of exchange rate volatility in South Africa(ZAR/US dollar) employing monthly time series data for the period 1986-2013 using GARCH(1,1) and EGARCH(1,1) models. The study indicated that switching to a floating exchange rate regime has a significant positive effect on ZAR volatility. The results also indicated that trade open-ness significantly reduces ZAR volatility only when bilateral exchange rates were used, but founds the opposite when multilateral exchange rates were used. The study also showed that volatility of output, commodity prices, money supply and foreign reserves significantly influence ZAR volatility.

Calderon and Kubota (2018) focused on the factors driving RER volatility. The study employed panel regression analysis for a sample of 82 countries from 1974 to 2013.The results showed that trade in manufacturing helps reduce RER volatility while non-manufacturing trade may contribute to higher RER volatility. Financial openness mitigates (amplifies) RER volatility in a country with higher (lower) share of foreign equity vis-à-vis foreign debt liabilities.

Cevik et.al. (2015) introduced a neglected set of “soft power” factors capturing a country’s demographic, institutional, political and social underpinnings to uncover the “missing” determinants of exchange rate volatility over time and across countries. Based on a balanced panel dataset comprising 115 countries during the period 1996–2011, the empirical results showed a high degree of persistence in exchange rate volatility, especially in emerging market economies. They found also that the “soft power” variables—such as an index of voice and accountability, life expectancy, educational attainment, the z-score of banks, and the share of agriculture relative to services—have a statistically significant influence on the level of exchange rate volatility across countries.

3. Econometric model

Many studies analyzed the determinants of exchange rate volatility by considering the exchange rate volatility as a function of variables such as: the openness of an economy, interest rate, inflation, the exchange rate regime, productivity index, the domestic and foreign money supplies, income, government expenditure. This paper extends the extant literature, by further incorporating relevant variables that influence nominal exchange rate volatility (net assets in foreign currency, current account, debt service average ratio, average money market interest rate, consumer price index family, Tunindex). These determinants variables are found to play a theoretical key role in explaining the movement of nominal exchange rate. The degree of the impact of each of these factors varies and depends on a particular country's economic.

In this context, we perform the actual analysis of the impact of these factors by estimating the following long-run relationship between exchange rate volatility and its various determinants[2]:

$$Lvltxch_t = \alpha_0 + \alpha_1 \; Lcoef\_det_t + \alpha_2 \; Lav\_dev_t + \alpha_3 LIP_t + \alpha_4 \; LTMM_t + \alpha_5 \; Sol\_co_t + \alpha_6 \; LTunin_t + e_t \, . \qquad (1)$$

where, $vltxch_t$ denotes nominal exchange rate volatility measured by EGARCH(1,1) model, $coef\_det_t$ represents debt service average ratio; av_dev_t represents net assets in foreign currency; IP_t represents consumer price index family; TMM_t represents average money market interest rate; Sol_co_t is the current account; $Tunin_t$ represents Tunindex (stock index in dinar) and e_t represents an error term.

4. Data and methodology

4.1. Data and measuring exchange rate volatility

The empirical analysis employs monthly data for the period January 2006 to March 2016. The taking into account of data before 2006 would not have changed the results because the trend to depreciation has already begun since 2001 with the advent of the euro. The data stopped in 2016, because the BCT has inaugurated from 2017 a new exchange rate regime that of an administered exchange rate regime in place of a regime "crawling peg". The variables used in the model and their explanations are presented in Table 1. The series of nominal exchange rate volatility denoted as **vltxch**[3] in the model is not a directly observable variable. In this paper, conditional variance estimated from EGARCH(1,1) model, based on an autoregressive

[2] All variables are transformed into logarithm except the variable current account. L denotes natural logarithm

[3] The volatility graph resulting from EGARCH(1,1) estimation is depicted in Fig. 1.

model of order 2 (AR(2)), is the appropriate measurement of nominal exchange rate volatility of the EURO/TND.

Table 1: Data sources and definition

Variable	Definition	Source
Tc Euro	Nominal exchange rate (EURO/TND)	Central Bank
(vltxch)	Nominal exchange rate volatility measured using EGARCH (1,1) model	EVIEWS
(av_dev)	Net assets in foreign currency (as number of import days)	Central Bank
TMM	Average money market interest rate	Central Bank
(IP)	Consumer price index family (base 100=2005)	Central Bank
(Tunin)	Tunindex (Stock Index in Dinar)	Investing.com*
(Sol_co)	Current account (as a percentage of GDP)	Central Bank
coef_det	Debt Service average ratio (as % of current revenues)	Central Bank

Several previous literatures showed that a simple GARCH(1,1) model, proposed by Bollerslev(1986), is parsimonious for studying volatility. However, although the GARCH model is able to capture the volatility clustering phenomenon, it has a major drawback because the variance conditional is only symmetric and it requires restriction of non negativity of coefficients to be positive. Therefore, in the GARCH model a big negative shock will have exactly the same effects on the volatility as a big positive shock of the same magnitude. For that reason, the paper further applies the Exponential GARCH (EGARCH) model proposed by Nelson(1991). The model is able to explain the asymmetry information of the conditional variance and is also able to make the conditional variance positive regardless of the plus or the minus sign of parameter in the model by applying logarithm to the conditional variance.[4]

The specification of the conditional variance in the EGARCH (1,1) model is as follows:

$$log\sigma_t^2 = \theta + \gamma \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| + \lambda \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \rho \, log(\sigma_{t-1}^2) \ . \qquad (2)$$

In equation (2), ρ measures the persistence in conditional volatility. λ presumes the existence of asymmetry information. σ_t^2 is the conditional variance.

[4] Despite the existence of another model with asymmetry namely TGARCH(1,1) (Threshold GARCH), introduced by Zakonian(1994), we used in this study the EGARCH(1,1) because TGARCH(1,1) does not guarantees the estimates of the conditional variance to be positive.

EGARCH model does not have to restrict the parameters to obtain stationary estimation. Consequently, the study report in Table 2 the parameters estimates and their corresponding p-values of AR(2)-EGARCH(1,1) model for the nominal exchange rate studied. The model satisfied the stationarity condition as the absolute value of ρ is less than one, ($|\rho| < 1$). In addition, the relatively large value of the parameter ρ suggests that exchange rate volatility is persistent for the sample period. Essentially, the leverage effect term is negative (-0.176) and statistically different from zero indicating the existence of asymmetry information and leverage effects in exchange rate volatility for the sample period.

Table 2: Estimation results of AR(2)- EGARCH(1,1) model for exchange rate (EURO/TND)

Dependent variable: D(LOG(TC_EURO))
LOG(GARCH)=C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) +C(6)*(RESID(-1)/@SQRT(GARCH(-1)) + C(7)* LOG(GARCH(-1))

Variable	coefficient	Std.Error	z-Statistic	Prob.
C	0.002627	0.001125	2.334528	0.0196
AR(1)	0.235083	0.122074	1.925746	0.0541
AR(2)	-0.202540	0.098809	-2.049812	0.0404
		Variance Equation		
C(4)	-3.258716	2.409856	-1.352245	0.1763
C(5)	0.187745	0.135809	1.382427	0.1668
C(6)	-0.176420	0.093225	-1.892414	0.0584
C(7)	0.665482	0.254859	2.611176	0.0090
R-squared		0.0964		
Adjusted R-squared		0.0485		

The diagnostic statistics reveal that EGARCH(1,1) model is well specified. Given the insignificant p-values[5], the Box-Ljung(Q) statistic for standardized residuals at 36 lags shows that there is no serial correlation, and the ARCH-Lagrange multiplier (LM) test indicates that there is no remaining ARCH effects in the standardized residuals.

4.2. Methodology

In order to solve the spurious regression problem and violation of the assumptions of the classical regression model (1), cointegration analysis is used to establish whether there is a long-run equilibrium relationship among the variables. The cointegration approach requires testing the times-series properties of variables in equation (1) for stationarity using ADF to test for unit roots. If all variables under consideration are integrated of the same order (e.g. I(1)), then the long-run relationship among the variables will be estimated using multivariate cointegration methodology developed by Johansen(1988) and Johansen and Juselius (1990).

[5] Q(36)=25.556, p-v= 0.851; ARCH-LM= 4.179, p-v= 0.123

In this method, the number of cointegration relations is tested on the basis of Trace statistics and Maximum Eigenvalues statistics.

According to the Engle and Granger (1987) Representation Theorem, once the presence of cointegration is established we will estimate an error correction model (ECM)that includes both long-run(static) and short-run (dynamics) relationship between exchange rate volatility and others variables. Besides, the purpose of ECM model is to indicate the speed of adjustment from the short run to long run equilibrium state.

Considering our base equation (1), the ECM model is specified as follows:

$$\begin{aligned}\Delta \text{ Lvltxch}_{\text{t}} = \beta_0 &+ \sum_{j=1}^{p-1} \beta_{1j} \Delta \text{ Lvltxch}_{\text{t}-\text{j}} + \sum_{j=1}^{p-1} \beta_{2j} \Delta \text{ Lcoef\_det}_{\text{t}-\text{j}} + \sum_{j=1}^{p-1} \beta_{3j} \Delta \text{ Lav\_dev}_{\text{t}-\text{j}} \\ &+ \sum_{j=1}^{p-1} \beta_{4j} \Delta \text{ LIP}_{\text{t}-\text{j}} + \sum_{j=1}^{p-1} \beta_{5j} \Delta \text{ LTMM}_{\text{t}-\text{j}} + \sum_{j=1}^{p-1} \beta_{6j} \Delta \text{ sol\_co}_{\text{t}-\text{j}} \\ &+ \sum_{j=1}^{p-1} \beta_{7j} \Delta \text{ LTunin}_{\text{t}-\text{j}} + \gamma\, EC_{t-1} + \varepsilon_t \,. \qquad (3)\end{aligned}$$

where, Δ is the first difference operator, p is the optimal lags based on the AIC, SBC and HQC criteria, ε_t is the error term.

EC_{t-1} is the lagged error correction term obtained from the cointegration equation(1) $and\ \gamma$ measures the speed of adjustment towards the long run equilibrium level.

In addition to these analyses generalized impulse-response functions (GIRFs)[6] and variance decomposition analyses are carried out in order to determine the dynamic effect of variables on exchange rate volatility. Therefore, the effect of one standard deviation shock occuring in net assets in foreign currency, current account, debt service coefficient, average money market interest rate, consumer price index family, Tunindex on the current and future value of exchange rate volatility may be determined.

5. Empirical results

5.1. Cointegration analysis

We start the analysis by examining the unit root properties of the variables. The ADF test results are presented in Table 3. The results show that all variables of the study are non-stationary at level but stationary at first difference and depict the same order of integrated (I(1)). Thus, the cointegration test is used to determine whether the long run relationship among the variables depicted in equation(1) exists (Engle and Granger (1987))[7].

[6] In this study we used GIRFs proposed by Pesaran and Shin(1998) because it is not sensitive to the order of the variables in Choleski decomposition contrary to the orthogonalized impulse-response function analysis, introduced by Cristopher A. Sims(1980), which depends on the order of the variables and leading to different impulse-response results.

[7] VAR analysis is used to determinate the optimum lag length. Then, the suitable lag order for the unrestricted VAR and cointegration analysis is three according to the criteria test (AIC, SBC, HQC).

Table 3 Unit root tests: ADF test statistics

Variables	Levels (T-statistic)	First differences (T-statistic)
LTc Euro	-1.277(I)	-7.783*(I)
Lvltxch	-0.155(N)	-6.351*(N)
Lav_dev	-0.156(N)	-10.723*(N)
LIP	5.517(N)	-4.721*(I)
Sol_co	1.184(N)	-3.597*(N)
LTMM	-2.154(I)	-5.636*(N)
LTunin	-2.822(I)	-9.769*(I)
Lcoef_det	0.053(N)	-3.383*(N)

Notes: * means that the variables are stationary at 1% significant level. I and N figures in parentheses expresses a non-trend model with intercept and non-trend model without intercept. respectively. In no-trend model with intercept and without intercept, the critical values of ADF statistic at 1% level of significance are -3.485 and -2.584 respectively.

The results of the cointegration tests are presented in Table 4 while the normalized cointegrating vectors are presented in Table 5. Maximum Eigenvalues and Trace tests indicate that null hypothesis of no cointegration is rejected but that of at most cointegration vector is accepted. This indicates the presence of one cointegration relationship at the 5% level.

Table 4: Results of Johansen cointegration tests

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.343290	139.6213	125.6154	0.0053
At most1	0.251727	90.84179	95.75366	0.1038
At most2	0.183224	57.20319	69.81889	0.3311
At most3	0.137210	33. 72589	47.85613	0.5169
At most4	0.079966	16.60621	29.79707	0.6689
At most5	0.057306	6.938209	15.49471	0.5849
At most6	0.000798	0.092644	3.841466	0.7608

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**Mackinnon -Haug-Michells(1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob**
None*	0.343290	48.77956	46.23142	0.0262
At most1	0.251727	33.63860	40.07757	0.2217
At most2	0.183224	23.47730	33.87687	0.4943
At most3	0.137210	17. 11968	27.58434	0.5697
At most4	0.079966	9.668001	21.13162	0.7752
At most5	0.057306	6.845565	14.26460	0.5076
At most6	0.000798	0.092644	3.841466	0.7608

Max- eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level.
**Mackinnon-Haug-Michells(1999) p-values

Table 5: Normalized cointegration vector

1 Cointegrating Equation (s):	Log likelihood	1032.699				
Normalized cointegrating coefficients (standard error in parentheses)						
Lvltxch	Lav_dev	LIP	Sol_co	LTMM	LTunin	Lcoef_det
1.000000	-0.03349	0.850842	0.081584	-0. 019728	-0.212391	0.626299
	(0.33334)	(0.85746)	(0.03222)	(0.46589)	(0. 37661)	(0.15144)

Therefore, the equilibrium exchange rate volatility could be written as long-run steady state relationship[8] as the following:

$$Lvltxch_t = - 0.626\ Lcoef\_det_t + 0.0334\ Lav\_dev_t - 0.85LIP_t$$
$$+ 0.019\ LTMM_t - 0.081Sol\_co_t + 0.212\ LTunin_t . \quad (4)$$

The long-run analysis presented in Table 5 shows that current account and debt service average ratio have negative statistically significant effects on exchange rate volatility at 5% level, while net assets in foreign currency, average money market interest rate, consumer price index family and Tunindex are not a statistically significant determinants of exchange rate volatility during the study period. Debt service average ratio influences negatively exchange rate volatility implying that a unit-percentage increase in debt service ratio reduces significantly exchange rate volatility by 0.626%. The negative effect of debt on exchange rate volatility is explained by perpetual and efficiently debt at the long-run.

Similarly, current account is negatively related to exchange rate volatility. It means that a one percent increase in current account will lead to a 0.081% decrease in exchange rate volatility. In other words, the volatility decreases with the attenuation of the current account deficit at the long-run.

According to the regression results, exchange rate volatility decreases over time with the improvement of the current account, i.e. with the attenuation of the current account deficit and the perpetual and efficiently debt service ratio at the long-run. Indeed, debt becomes sustainable at the long term. As regards the magnitude of the effects, the debt service average ratio has higher magnitude of influence compared to current account in the long run. The results indicate that debt service average ratio has an effect more substantial than current account on exchange rate volatility.

5.2. Vector error correction model

The short run dynamics of the long run exchange rate volatility can be examined by estimating error correction model[9]. The results of ECM as presented in Table 6 show that the

---

[8] Obtained from the normalized cointegration equation

[9] The result of ECM as given in Table 6 indicates that the model seems to be good as it satisfies the diagnostic test. Box-Ljung(Q) statistic for standardized residuals at 36 lags shows that there is no serial correlation (Q(36)=23.186, p-v= 0.951), and the ARCH LM test is sufficient to justify the absence of the heteroskedasticity in the standardized residuals (ARCH-LM (obs*R^2)= 0.244, p-v= 0.621).

coefficient of error correction term is negative with a value of -0.104 and is statistically significant. This signifies that the long run relationship of the estimated model is stable and any disequilibrium created at the short run will be temporary and will get corrected over a period of time. Additionally, the speed of adjustment term indicating that 10.4% adjustment of exchange rate volatility towards long run equilibrium level occurs per month. Then, this result confirms the validity of an equilibrium relationship among the variables in the cointegrating equation.

Table 6: Error correction model results

Lag	EC_{t-1}	Δ(Lvltxch)	Δ(Lav_dev)	Δ (LIP)	Δ (Sol_co)	Δ(LTMM)	Δ(LTunin)	Δ (Lcoef_det)
1	-0.104* (-5.368)	-	-	-	0.054* (4.539)	-	1.126** (1.99)	0.148*** (1.85)
2		-	-	24.07* (2.626)		-1.275*** (-1.816)	-	0.21* (2.453)
3		-	0.64*** (1.757)	-	0.04* (2.492)	-	-	-

Notes: The figures in parentheses are t-statistics; *,**,*** denote statistical significance at the 1%; 5% and 10% levels respectively.

The short-run analysis shows the presence of positive significant relationship among net assets in foreign currency, current account, debt service ratio, consumer price index family, Tunindex and exchange rate volatility. While, there is also a significant and negative short-run relationship between exchange rate volatility and average money market interest rate.

Debt service ratio influences positively the exchange rate volatility, implying that a unit-percentage increase in debt service ratio, at the first and the second month lag, increases significantly the exchange rate volatility by 0.148% and 0.21%, respectively. These effects are also statistically significant at 10% and 1% level respectively. This indicates that the volatility increases with debt service at the short-run. Similarly, current account is positively associated with exchange rate volatility and statistically significant at least at the 1% level. This indicates that a unit-percentage increase in current account, at the first and the third month lag, increases significantly the exchange rate volatility by 0.054% and 0.04% respectively. In other words, the volatility raises with the excavation of the current account deficit (with increasing current account deficit) at the short-run.

In addition, the elasticity of a two-month lag in consumer price index family is 24.07 and statistically significant at least at 1% level. It means that a one percent increase in consumer price index family will lead to a 24.07% increase in exchange rate volatility. This indicates that the volatility increases with inflation at the short-run because it is a depreciation factor of the exchange rate.

Furthermore, results reveal that the Tunindex is positively associated with exchange rate volatility (i.e. 1.126) and is statistically significant at 5% level implying that a one percentage increase in Tunindex at the first month lag increase exchange rate volatility by 1.126%. The economic optimism explained by the increase in the Tunindex leads to the volatility on the exchange market.

However, average money market interest rate is negatively associated with exchange rate volatility and statistically significant at 10% level. This indicates that a unit-percentage increase in average money market interest rate at the second month lag significantly reduces exchange rate volatility by 1.275%. It means that an increase in the interest rate (restrictive monetary policy) reduces the volatility at the short-run.

Finally, a third month lag of net assets in foreign currency has a coefficient of 0.64 and statistically significant at 10% level. It means that a one percentage increase in net assets in foreign currency leads to about 0.64 percentage increase in exchange rate volatility.

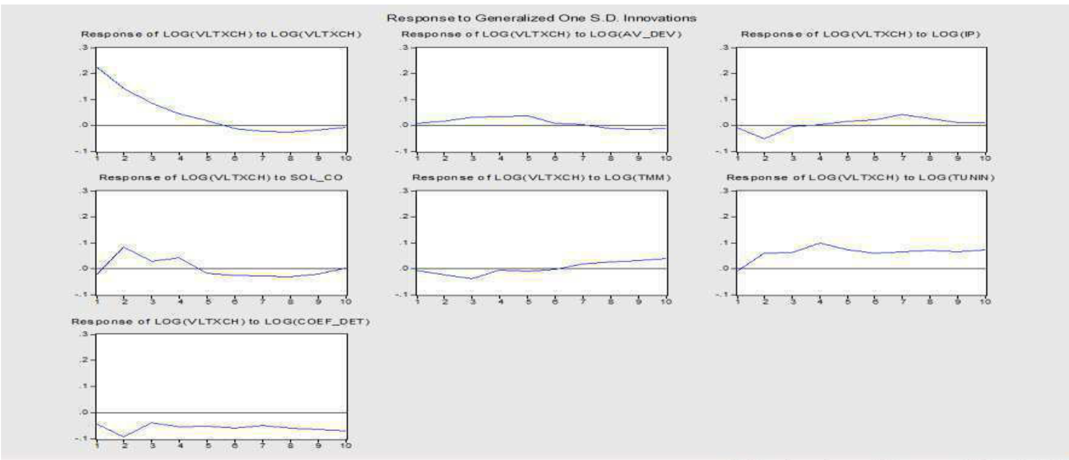
The results indicate that exchange rate volatility is very important at the short-run rather than at the long-run.

5.3. Generalized impulse-response functions and variance-decomposition analysis

In addition to analyzing both long run and short run relationship by using cointegration methodology and VECM, generalized impulse response functions (GIRFs) are used to examine the dynamic link between exchange rate volatility and its determinants.

The responses[10] of exchange rate volatility to one standard deviation shock or innovation in other variables over ten months are presented in Fig.4. From this Fig, it can be concluded that the debt service ratio has persistent negative effect on exchange rate volatility. The empirical results also suggest that the shock from current account restrains the volatility of exchange rate after the fifth month. This emphasizes the persistent negative effect of current account on exchange rate volatility at the long run.

Figure 4: Impulse response functions for exchange rate volatility for 10 months



*S*ource: EVIEWS treatment

[10] Optimum lag length is found to be 3 for the ECM on the basis of AIC criterion and SBC.

Besides, the decomposition of forecast-error variance for ten months forecasting horizon for exchange rate volatility is presented in Table 7. The results indicate that the variation in exchange rate volatility is largely explained by itself 41.97% while 2.3% 2.26% 2.83% 6.79% 22.64% and 21.162% are explained by changes in net assets in foreign currency, consumer price index family, average money market interest rate, current account, Tunindex and debt service ratio respectively. According to the results of variance decomposition, the shock to current account has a small effect on exchange rate volatility at the end of the tenth month compared to debt service ratio. Although debt service ratio explains 5.887% of exchange rate volatility in the first period, it reaches 21.162% in the tenth month. The variance decomposition and the (GIRFs) results also verify the robustness of the empirical results of the long run exchange rate volatility model.

Table 7: Variance-Decomposition analysis results

Variance Decomposition of LOG(VLTXCH)

Period	S.E.	LOG(VLTX...	LOG(AV_D...	LOG(IP)	SOL_CO	LOG(TMM)	LOG(TUNIN)	LOG(COEF...
1	0.222495	92.86517	0.152486	0.126477	0.803072	0.066614	0.098698	5.887486
2	0.291474	76.88864	0.360278	1.692056	8.440676	0.815531	3.561566	8.241253
3	0.315002	72.94240	1.238410	1.458916	8.038101	2.026503	6.601914	7.693753
4	0.337824	64.95251	2.152370	1.288358	8.567722	1.762406	13.35091	7.925727
5	0.352913	59.53385	3.035279	1.348913	8.112053	1.618427	16.17437	10.17711
6	0.368518	55.33235	2.828820	1.565940	7.937965	1.484280	17.61980	13.23085
7	0.386153	51.50164	2.581127	2.476053	7.809654	1.671058	18.92329	15.03718
8	0.406515	47.77158	2.421733	2.573667	7.648613	1.956079	20.36118	17.26715
9	0.423441	44.80085	2.389605	2.400830	7.295344	2.337935	21.31370	19.46173
10	0.438843	41.97402	2.330377	2.264001	6.794245	2.830873	22.64431	21.16217

Cholesky Ordering: LOG(AV_DEV) SOL_CO LOG(TMM) LOG(TUNIN) LOG(COEF_DET) LOG(IP) LOG(VLTXCH)

6. Conclusion and policy implications

The main goal of this paper is to investigate the different determinants of nominal exchange rate volatility of the Tunisian dinar (TND) against the Euro(EURO) using monthly times series from January 2006 to March 2016. As a measure of volatility, we used the estimated conditional variance of the nominal exchange rate generated from EGARCH(1,1) model. The empirical results of the Johansen cointegration test show that there is a long-run equilibrium relationship between exchange rate volatility and its determinants, while the estimated error correction model, used to determine the short-run dynamics, show reasonable speed of adjustment towards the long-run equilibrium.

The results of the cointegration test indicate that only the current account and debt service ratio have negative and statistically significant effects on the exchange rate volatility, indicating the two variables as the key variables that restrain the volatility of exchange rate at the long-run.

According to the regression results, exchange rate volatility decreases over time with the improvement of the current account, i.e. with the attenuation of the current account deficit and the perpetual and efficient debt service ratio at the long-run. Therefore, the results of this study aim at showing that the volatility tends to decrease, as the current account is balanced and as the country has an easy access to the international financial market to refinance its long-term debt. Indeed, debt becomes sustainable at the long term.

As regards to the magnitude of the effects, the debt service ratio has higher magnitude of influence compared to current account at the long run. The VECM results indicate that net assets in foreign currency, current account, debt service ratio, consumer price index family and Tunindex have a significant positive impact on the exchange rate volatility, whereas significant negative relationship exists between exchange rate volatility and average money market interest rate during the period 2006-2016. The variables have different magnitude of influence on the volatility at the short-run. The results indicate that the exchange rate volatility is very important at the short-run rather than at the long-run.

Additionally, GIRFs and variance decomposition analyses are carried out for investigating the dynamic effects of variables on exchange rate volatility. The results indicate that debt service ratio has a persistent negative effect on exchange rate volatility, and that the shock to debt service ratio has a substantial effect after ten months compared to current account, supporting the results obtained from the long-run relationship.

Given the remarkable volatility in the Tunisian currency against the Euro (EURO), we believe that the findings presented in our paper will appeal to Tunisian policymakers to reduce current account deficit by limiting imports and promoting exports of local products, while ensuring openness to new markets. In particular, investment incentives are among the measures that the government must undertake, as well as the recourse to indebtedness to finance its foreign currency funding requirements.

References

Ajao, M.G., and Igbokoyi, O.E. (2013) "The Determinants of Real Exchange Rate Volatility in Nigeria", Academic Journal of Interdisciplinary Studies, 2(1): 459-471.

Alagidede, P., and Ibrahim, M. (2017) "On the Causes and Effects of Exchange Rate Volatility on Economic Growth: Evidence from Ghana", *Journal of African Business,* 18(2):169-193.

Bollerslevt. (1986) "Generalized Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics*, 31(3): 307-327.

Calderon, C., and Kubota, M. (2018) "Does Higher Openness Cause More Real Exchange Rate Volatility?", Journal *of International Economics,* 110(C):176-204.

Cevik, S., Harris, R., and Yilmaz, F. (2015) "Soft Power and Exchange Rate Volatility", *IMF Working Paper*, 1-34.

Engle, R.F., and Clive Granger, W. J. (1987) "Co-integration and Error Correction: Representation, Estimation and Testing", *Econometrica*, 55(2): 251-276.

Hassan, A., Abubakar, M. and Dantama, Y. U. (2017) “Determinants of Exchange Rate Volatility: New Estimates from Nigeria”, *Eastern Journal of Economics and Finance*, 3(1): 1-12.

Insah, B. and Chiaraah, A. (2013) “Sources of Real Exchange Rate Volatility in the Ghanaian Economy”, *Journal of Economics and International Finance*, 5(6): 232-238.

Jabeen, M., and Khan, S. A.(2014) “ Modelling Exchange Rate Volatility by Macroeconomic Fundamentals in Pakistan”, *International Economertric Review*, 6(2): 58-76.

Johansen, S. (1988) “*Statistical* Analysis of Cointegration Vectors”, *Journal of Economic Dynamics and Control,* 12(2): 231- 254.

Johansen, S., and Juselius, K. (1990) “Maximum likelihood estimation and inference on cointegration with application to money demand”, *Oxford Bulletin of Economics And Statistics,* 52(2):169-210.

Kilicarslan, Z. (2018) “Determinants of exchange rate volatility: Empirical evidence for Turkey”, *Journal of Economics, Finance and Accounting* (JEFA), 5(2): 204-213.

Mpofu, TR. (2021) “The Determinants of Exchange Rate Volatility in South Africa”, *The World Economy,* 44 (5): 1380-1401.

Nelson D. B. (1991) “Conditional Heteroskedasticity Asset Returns: A New Approach”, *Econometrica*, 59(2): 347 - 370.

Oaikhenan, H. E., and Aigheyisi, O. S.(2015) “ Factors Explaining Exchange Rate Volatility in Nigeria: Theory and Empirical Evidence”, *Economic and Financial Review*, 53(2): 47-77.

Pesaran, M. H, and Yongcheol ,S. (1998) “ Generalized Impulse Response Analysis in Linear Multivariate Models”, *Economics Letters*, 58(1): 17-29.

Zakoian, J.M.(1994) “Threshold Heteroskedastic Models”, *Journal of Economic Dynamics and Control*, 18(5): 931-955.