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# The Effect of Central Bank Intervention on the Exchange Rate of the Tunisian Dinar in Relation to the European Currency

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## Abstract

*The aim of this paper is to specify a modelling procedure which uses simultaneous equations system to assess exchange rate, conditional volatility and a reaction function of the Central Bank in order to take into account the interdependence prevailing these variables. To this effect, we use a Generalised Method of Moments on high frequency data for the period spreading over 1999-2006. During this period, we find that the interventions of the Central Bank of Tunisia record a significant effect on the return of the rate, yet accompanied with a high tendency of exchange rate fluctuations persistency, which measured by the volatility of the exchange rate.*

***Key words:*** Central banking intervention, exchange return and exchange rate volatility.
**JEL classification:** E 58; G15; C22; C32; F31.

## Introduction

The debate over the efficiency of Central Banks' interventions over exchange rate dynamics has been developed into a rich literature, which concerned itself with the significance of these interventions on exchange rate movements and on the anticipations of interventions over the exchange market. During the 1960s, under the fixed exchange regime, the interventions of the Central Bank over the exchange market integrate themselves in the popular spirit as a condition to maintain the exchange rate within fixed limits. Since the collapse of the Bretton-Woods system and the emergence of the administered floating regime, the rate of intervention has increased. It is at the beginning of the 1980s that economists started to multiply techniques used to test the efficiency of the Central Bank's interventions.

Several studies (Aguilar and Nydahl 2000; Hillebrand et al. 2009), use linear modelling approaches which relate exchange rate movements and interventions of Central Banks. These authors believe that these interventions are neither efficient for the exchange rate movements nor for future anticipations of the exchange rate. Failure of these interventions may be attributed to the linearity of the different modelling approaches used to test the efficiency of the Central Banks' interventions on exchange markets. Indeed, there is a certain asymmetry in these interventions due to the high weight given to depreciations operations. Moreover, the reaction function of the Central Bank is characterised by the convexity of its curb. This convexity is in fact the result of the deviation between the exchange rate and its target. The more the deviation is large, the more the intervention is desirable. In practice, Central Bank intervene in order to support a stable exchange rate system and consequently to contain uncontrollable situations on exchange markets. Besides, volatility and the persistent fluctuation of the exchange rate and speculative attacks and uncertainty force banks to frequently intervene in favour of the exchange market.

In order to test interventions on the exchange rate, the majority of the developed analyses seek to attest for the effect of the interventions of the Central Bank on the returns of the exchange rate and its volatility as well. However, these studies do not focus the link between the reaction function of the Central Bank and exchange rate movements (Richard 1997, Beine et al. 2002, Christopher 2008, Hillebrand et al. 2009, Giannellis and Papadopoulos 2010, Bauwens and Sucarrat, 2010). Fatum and Pedersen (2009) suggest that only when the direction of intervention is consistent with the monetary policy stance that intervention exerts a significant influence on exchange rate returns. Hillebrand et al. (2009) find that over the 1998-2004 period, central bank interventions did not have a significant impact on returns but reduced realized exchange rate volatility. Nikkinen and Vähämaa (2009) examine the effects of the foreign exchange market interventions by the Bank of Japan on the ex ante correlations between the JPY/USD, EUR/USD, and GBP/USD exchange rates. Authors find that interventions tend to temporarily increase the ex ante correlations among the major exchange rates. According to Goyal and Arora (2010), Indian Central Bank communication has a large potential on exchange rate volatility but was not effectively used. Using high frequency data from 1993 to 2010, and a GARCH model of the peso/US dollar exchange rate return. Rincón and Toro (2010) indicate that neither capital controls nor central bank intervention used separately were successful for depreciating the exchange rate.

The aim of this study is to specify a modelling procedure which uses simultaneous equations system to assess exchange rate returns, conditional volatility and the reaction function of the central bank in order to take into account the non-linear interdependence between behaviour of the central bank, conditional variance and the mean of exchange rate returns.

The paper is organized as follows. Section 2 recalls the effect of central bank intervention on exchange rate. Section 3 presents the data, model specification about the effects of central bank interventions for the DT/Euro and results and refining their economic interpretation. Section 4 concludes.

## Theory of Interventions on the Exchange Rate

When the Central bank intervenes on the exchange market, it does it by buying or selling foreign assets in order to stabilize the exchange rate and reduce its volatility. Such behaviour turns around the efficiency of interventions undertaken on the exchange rate. However, these proposals seek to determine the effect of interventions of the Central Bank on the exchange returns as well as on its volatility. Likewise, these proposals do not suggest any reaction function of the central bank. There are essentially two sources of interventions to influence the exchange rate: the purified/sterilized and the non-purified/non-sterilized interventions (Richard 1997, Beine et al.2002, Christopher 2008, Hillebrand et al. 2009, Fatum and Pedersen 2009, Bauwens and Sucarrat 2010, Kumhof 2010, Giannellis and Papadopoulos 2010, Goyal and Arora 2010, Rincón and Toro 2010).

A non-sterilized intervention is a purchase of foreign currencies which leads to an increase in (a diminution) net foreign assets and consequently an increase (a diminution) equivalent to money supply, mainly domestic loans. A sterilised intervention takes place when the bank compromises between net foreign assets and net domestic assets. In fact, non-sterilized interventions lead to variation in the interest rate (cost of the opportunity to retain funds) and thus in exchange rates. There is a difference between these two interventions. Several economists have attempted to determine the objectives which motivate monetary authorities to intervene. Different hypotheses have been suggested in a way that they target to reach a target exchange rate and to diminish irregular movements of the exchange rate. Such interventions are considered efficient if they allow bringing the exchange rate to its target level and if they allow reduction of the risk threatening exchange markets (Goyal and Arora 2010, Rincón and Toro 2010).

Portfolio balance, signaling and noise-trading are the three channels through which sterilized intervention may be practiced. According to the theory, as long as foreign and domestic assets are considered outside assets and are imperfect substitutes for each other in investor's portfolios. Investors allocate their portfolios to balance exchange rate risk against expected rate of return so intervention could lead to a change in the value of the exchange rate When the central bank sells foreign currency assets for domestic currency assets, other things being equal, this creates an excess supply of foreign currency assets, and an excess demand for domestic currency assets. This is likely to result in a change in the exchange rate, which need a higher expected return on foreign currency assets and so an appreciation of the domestic currency. (Dominguez and Frankel, 1993, Coeurdacier et al. 2007, Devereux and Sutherland 2007, Tille and Van Wincoop 2008, Engel and Matsumoto 2009). The second channel through which sterilized intervention can affect the level of exchange rates is known as the signalling channel, (Mussa, 1981). This model assumes asymmetric information between market participants and the central bank. Sterilized intervention then operates through the signalling channel by causing private agents to alter their exchange rate expectations. If market participants judge the foreign exchange operations of the central bank to be credible, then even though today's fundamentals do not change when interventions occur, expectations of future fundamentals will change (Tille and Van Wincoop 2008, Engel and Matsumoto 2009, Kumhof 2010). Goodhart and Hesse (1993), Hung (1997) and Behera et al. (2006) consider the third channel namely the noise-trading channel. A central bank can use sterilized interventions to induce noise traders to buy or sell currency. So it can manipulate the exchange rate by entering in a relatively thin market. As a consequence, the exchange rate is determined by marginal demand and supply flow in the foreign exchange market.

## The Empirical Study

In our study, we do not take into account the systematic difference which characterises the sterilized and non-sterilized interventions. We will specify a system $Y_t = (r_t, \sigma_t^2, I_t)$.Where:

$r_t$ is the return of the daily Tunisian dinar in relation to the Euro

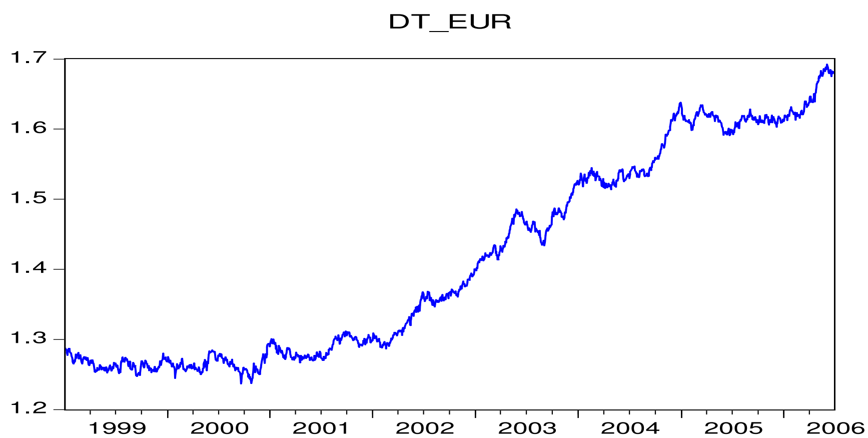
$\sigma_t^2$ is the conditional volatility of the exchange rate

$I_t$ is the intervention practiced by national Tunisian authorities through buying and selling currencies. If $I_t \geq 0$ ($I_t \leq 0$), it specifies buying currencies (currency selling).

## The Data

The following graphs illustrate the respective evolution of the exchange rate, returns on exchange and conditional volatility.

**Graph 1:** Closing quota on the Tunisian exchange market between April 01 1999 and June 29 2006.




In general terms, it is not very interesting to only see the nominal exchange rate of the Tunisian Dinar in relation to the Euro. In fact, returns on the exchange rate is more interesting because the intervening actor in the exchange market is more interested in the related profits achievable than in nominal rate of the currency. Besides, the returns used as currency change index rates allow for comparison between currencies. There are two definitions of exchange rate return. The first stipulates that a return on exchange is an arithmetic return rate, defined as follows:

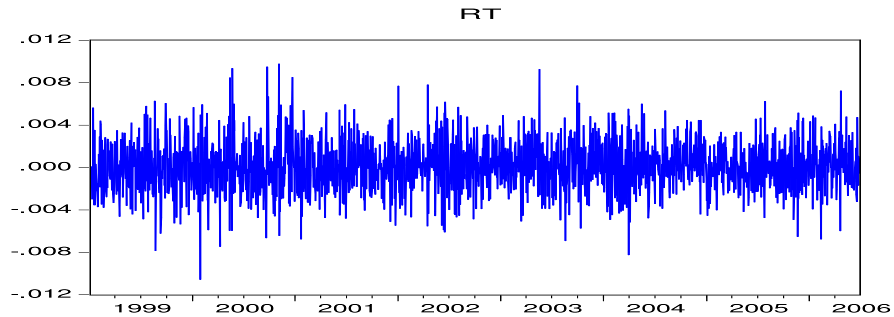
$$R_{1,t} = \frac{S_t - S_{t-1}}{S_{t-1}}$$

The second definition stipulates that the return on exchange is a geometric return rate, defined as follows:

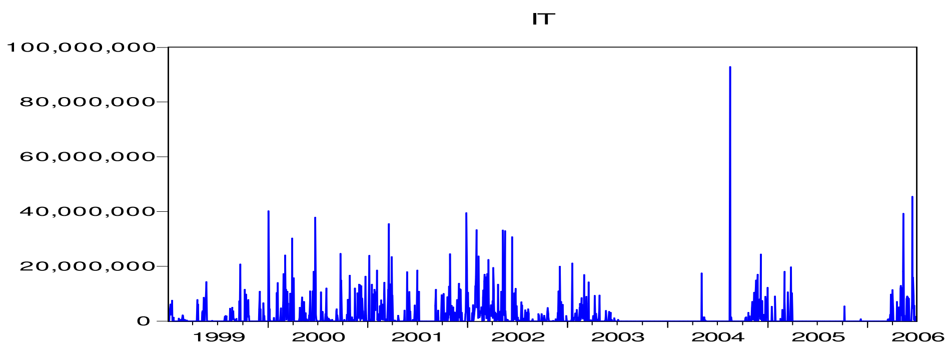
$$R_{2,t} = Log(\frac{S_t}{S_{t-1}})$$

Where $S_t$ is the nominal quotation of the exchange rate. We retain the second definition since it is the most used one in the relevant literature. Besides, the geometric return allows for linking time-discrete models and time-continued models.

**Graph 2:** Daily exchange return series of TND/ Euro

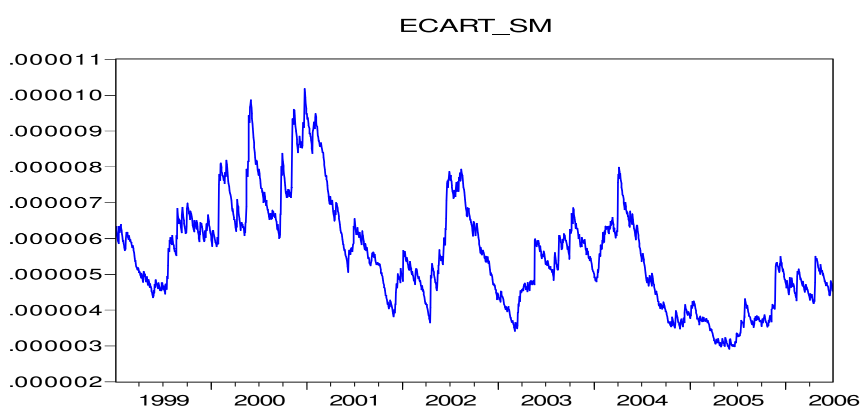



**Graph 3 :** Intervention process of the central bank over exchange market




During this period, the sign of interventions is positive. This indicates that the operations of the Central Bank in the exchange market are operations of currency purchase.

**Graph 4 :** Conditional volatility of the exchange rate



**Specification of the Model**

We consider the following simultaneous equations system:

(1) $r_t = a_1 I_1 + \varepsilon_t$

(2) $\sigma_t^2 = \beta_1 \varepsilon_{t\_1}^2 + \beta_2 \sigma_{t\_1}^2 + \beta_3 I_t + v_t$

(3) $I_t = \chi_1 I_{t\_1} + \lambda_2 \sigma_t^2 + \lambda_3 r_t + \omega_t$

Where $r_t$ = Log ($S_t$) – Log ($S_{t-1}$) with $S_t$ is the nominal exchange rate of TND/Euro, $\sigma_t^2$ is the volatility of the exchange rate measured by a variable window (Rolling Sample) and $I_t$ represents the interventions of the Central bank on the exchange market. In this system, the first equation (1) models the effect of the interventions of the Central Bank on the level of the TND /Euro return. Indeed, the purchasing operations of the Euro tend to depreciate the TND in relation to the Euro. The second equation (2) specifies conditional volatility as a function of the previous observations, of its own delays and of the interventions of monetary authorities. Thus, this specification is inspired by Garch (1.1) model, taking into account the effect of the interventions and it implies a non-linear relationship between the two equations (1) and (2), and subsequently a non-linear dependence between $\varepsilon_t$ and $v_t$. The third equation (3) is a function of the reactions of the interventions of national authorities. We admit that the previous interventions record an impact on current interventions and that the authorities adopt a policy of targeting the level of exchange rate's volatility in their intervention decisions.

**Estimation approaches**

**The simultaneous equations model of exchange rate moments and interventions**

The vector of the parameters to be estimated is:

$$\theta = (\alpha_1, \beta_1, \beta_2, \beta_3, \gamma_1, \gamma_2, \gamma_3)$$

Given that the series of interventions of the Central bank is equal to zero over a long period, it will not be possible to attribute a specific probability distribution. It is in these lines that we use the generalised method of moments which does not require information about an exact distribution of the shocks. A GMM-based estimation is uniquely based on the hypothesis that the shocks of the equations of the system must be orthogonal to the set of instrumental variables. In fact, GMM-based estimations select the estimated parameters in a way that the correlations between instruments and the shocks are close to zero as it is defined by the criterion function. Using the weighted matrix of the criterion function, GMM is a robust method of estimation at whatever form of heterocedasticity or autocorrelation relationship, even if the correlation between shocks is non-linear.

In so far as the identification condition is concerned, for each equation the number of excluded exogenous variables is superior or equal to the number of introduced endogenous variables. In this way the identification condition is met for the three equations. Indeed, the unit f the matrix coefficients of the reduced form admits a range equal to one. The results show that the interventions of the Central bank have significant effects over the return of the exchange. This positive effect indicates that the interventions practised by national authorities through purchasing currencies tend to depreciate the exchange rate of the TND in relation to the Euro.

**Table 1:** The GMM-based estimation

| Systems equations | Coeff | Explanatory variables | Estimation | Standard deviation | t-student | P value |
|---|---|---|---|---|---|---|
| $r_t$ | $\alpha_1$ | $I_t$ | 6.61 E-11 | 2 .07 E-11 | 3.19** | 0.014 |
| $\sigma_t^2$ | $\beta_1$<br>$\beta_2$<br>$\beta_3$ | $\varepsilon_{t-1}^2$<br>$\varepsilon_{t-2}^2$<br>$I_t$ | 0.0977<br>0.89<br>3.83E-14 | 0.074<br>0.08<br>4.03 E-14 | 1.30<br>11.2**<br>0.95 | 0.192<br>0.000<br>0.342 |
| $I_t$ | $\gamma_1$<br>$\gamma_2$<br>$\gamma_3$ | $I_{t-1}$<br>$\sigma_t^2$<br>$r_t$ | 0.644<br>8.05 E-10<br>1 .15 E-09 | 0.11<br>3.85 E-10<br>8.83 E-08 | 5.83**<br>2.09**<br>1.29 | 0.000<br>0.035<br>0.194 |

Thus, the politics of Tunisia is a politics of exchange depreciation and it is in this line of thinking that the process of interventions on the exchange rate is efficient. In fact, such interventions allow for bringing the exchange rate to the desired target. In the second equation, the significance of the volatility delay coefficient as well as the value close to the sum's unit ($\beta_1, \beta_2$) show a persistence of exchange volatility shocks. However, the interventions on exchange rate do not admit significant effects on the reduction of uncertainty in the exchange market ($\beta_3 \geq 0$). For the third equation, the function of the reaction of interventions significantly depends on the one hand on interventions delayed by a period and on the other hand on exchange volatility. This shows that the national authorities adopt a policy of targeting volatility to guide their movements of interventions.

Else, the obtained results show that this policy of interventions of the Central Bank is not efficient given the positive and non-significant effect of interventions over the conditional exchange volatility. In this regard, we raised questions over the reasons of the Central Bank exchange volatility interventions inefficiency. Is it because of the different measures of volatility? Is it because of the disruption dates which were not taken into account in our model?

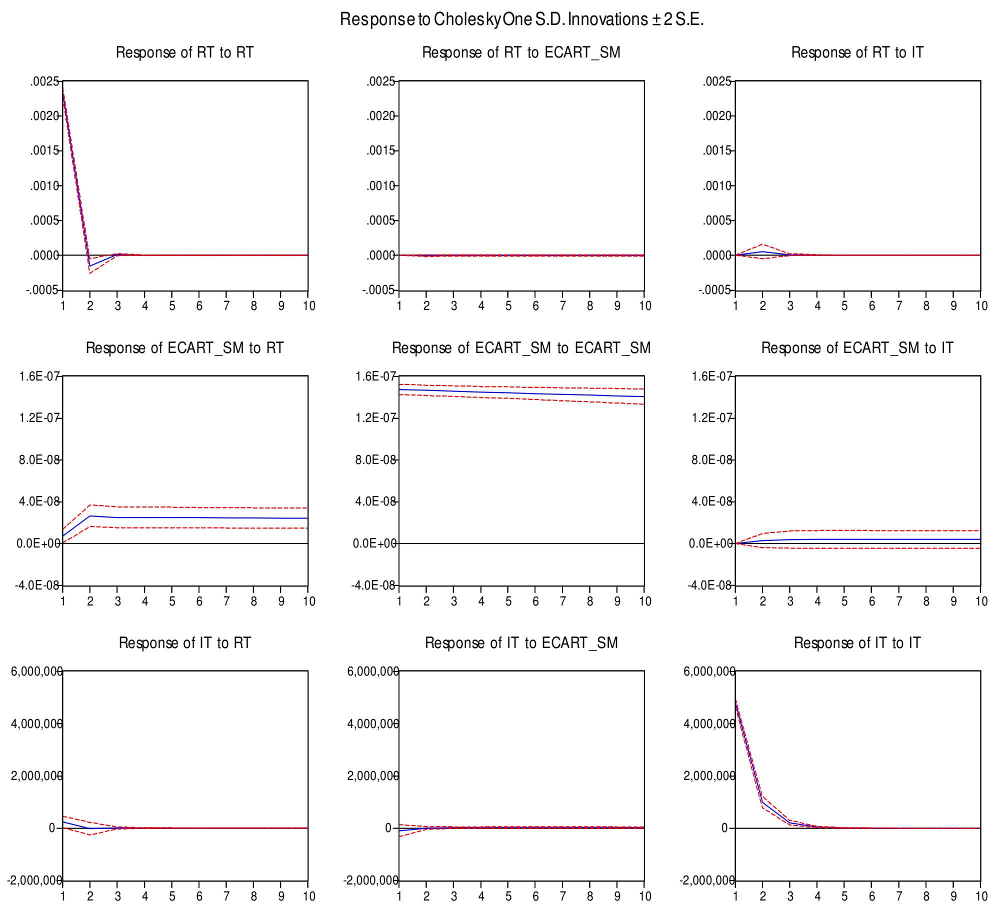
## VAR Model Approach

In this section, we use a non-constrained VAR model. It is possible that the obtained results depend on the equations system's structural form of equation (1) and equation (3), of the GMM estimation or of the choice of instruments. In order to take into account this possibility, we estimate an autoregressive vector specification. The system might be written as a structural VAR model:

$$Ay_t = \omega + \phi_1 y_{t-1} + \varepsilon_t$$

Where $y_t = (r_t, \sigma_t, I_t)$ and $\varepsilon_t$ is three-dimensioned vector with a null mean and with a variance-covariance matrix $\delta$. Graph 5 determines the response of exchange return impulsions to volatility shocks, to the Central bank's different interventions shocks with a delay of 10 periods. The graph shows that exchange returns react in a significant negative way to returns delayed by two periods, which proves that for a positive shock exchange return reacts positively whereas for a negative shock it react positively. This shows the existence of an adjustment dynamic. Moreover, the interventions have only a positive effect on conditional volatility. Indeed, exchange interventions positively depend on previous interventions delayed by two periods. The results confirm what we find in the previous analysis.

**Graph 5:** Implulsional response functions




## Conclusion

The majority of the relevant studies use linear intervention models without taking into account the existing interdependencies between the interventions of the Central bank, the level of exchange return and conditional volatility. In this study, we have used a simultaneous equations system in which we applied a generalised moments method. The first equation characterises the mean of the stochastic process which generates the series of the exchange rate returns in function of the interventions variable representing buying or selling of foreign currencies. If the Central

Bank of Tunisia undertakes a purchase (selling) of foreign currency, then domestic money depreciates. The shocks of exchange return are supposed to follow a conditional Gaussian distribution with a null mean and a conditional variance $\sigma_t^2$ It is in these lines that equation (2) allowed for variance $\sigma_t^2$. In fact, volatility at date t is a function of the squares of the deviations of the observed mean in the recent past. If the coefficients of shocks are close to the unit, then there is an alternation between lull and euphoria periods. Finally, equation (3) determines the reaction of the Central Bank of Tunisia in terms of conditional volatility and in terms of returns level.

The results of the estimation using the GMM have shown that the interventions of the Central Bank of Tunisia are efficient at the level of exchange returns, yet they are inefficient at the level of volatility. Indeed, purchasing (selling) of currency tends to depreciate domestic currency. Thus, the policy followed by national authorities is a policy of depreciation of domestic currency along with a volatility persistency. These results are different from the exchange policy followed by the Central Bank of Tunisia which has as objective exchange risk reduction in the exchange market.

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