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Exchange rate Pass-Through to domestic prices in Tunisia: a short and long run analysis

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Abstract

This study analyzes the impact of the exchange rate fluctuations in the short and long-runs in Tunisia under a pure commitment policy through two channels. The first is the Structural Vector Autoregression used to analyze the short run effects of the exchange rate on the industrial production index and on the consumer and import price indexes. The second is the Vector Error Correction Model used to examine the long run dynamic effects of the exchange rate upon the same variables relying on Tunisian monthly data during the period January 1993 to June 2011. Unlike several empirical studies, which show that the impact of the exchange rate movements on prices has been reduced over the past few years in the industrialized countries, the exchange rate is found to be a potential source not only of production but also of inflation reduction in Tunisia. Indeed, the direct channel of the exchange rate seems to have a significant impact on production and inflation in the long-run, whereas the indirect one has no effect on the money supply. These results strongly support the monetary policy of the central bank targeting the exchange rate because there is a strong correlation between this rate and prices.

Keywords: Exchange rate Pass-through; domestic prices; short and long run analysis; Tunisia.

JEL Classification: C32, E31, F31, F43.

1. Introduction

The issue of the optimal monetary regime for small open economies is still unanswered. There is no single optimal monetary regime that depends on the country's circumstances. In the developing countries, the exchange rate has often played a crucial role in the macroeconomic stability. From 1992 up to the end of 1995, the Tunisian government had not had a clear platform regarding the macroeconomic stability. For example, the Tunisian Central Bank (TCB) tried to stabilize the economy by means of the exchange rate, which adversely affected the budget.

Since 1993, the TCB has been following a strategy targeting the exchange rate. As a result, the exchange rate stabilization has been fully successful in reducing the inflation rate. Tunisia, in particular, which has been facing many systemic changes, such as the capital account liberalization in 2003, became in 2002, a member of the World Trade Organization. In such circumstances, researches on the monetary policy regime and the exchange rate should apparently be directed towards the incompatible threefold issue: the liberalization of the capital movement, the interest rates, and the independent monetary policy (Mishkin, 2003). Moreover, the research of Yeyati and Sturzenegger (2001) states that, for non-industrial economies, a long period is associated with a rate of inflation lower than that of the floats, but at the cost of a slower growth rate. Recently, the issue

of the exchange rate regime has become more apparent since the liberalization of the capital account occurred. Therefore, the exchange rate monetary policy could easily become alternately a speculative target and may lead to negative impacts on the real economic activity due to the rise and fluctuations of the interest rates and foreign currency holding.

Although the role of the exchange rate regime is limited to the economic impact on growth, the role of such regimes affecting the economic growth - particularly the costs and benefits of developing a different exchange rate regime- has increasingly drawn the attention of the Tunisian authorities. We concentrate on identifying the impact of the exchange rate regime on both the real GDP and prices in Tunisia. The main objective of this paper is to empirically analyze the impact of the short and long-run exchange rate on the real GDP and prices in Tunisia. Two econometric approaches are then applied: the Structural Vector Autoregressive (SVAR) and the Vector-Error-Correction Model (VECM). These methods are used to identify the impact of the exchange rate in the short and long run on the real GDP and import prices. We used monthly data from January 1993 to June 2011.
The rest of this paper is organized as follows. Section 2 briefly describes the theoretical and empirical analysis of the exchange rate regime in Tunisia. Section 3 deals with the data and analyzes the empirical results, while Section 4 provides some concluding remarks.

2. Literature revue of the theoretical and empirical aspect of the exchange rate regime in Tunisia

Between 1999 and 2006, the Tunisian monetary policy put the money supply and the real effective exchange rate targeting under control, Boughrara (2007). Actually, we can see that the results achieved, in terms of the inflation rate reduction, are irrevocable. The inflation general pace has known a downward trend since the early 90s. However, the evolution of the monetary aggregates being the main intermediate objectives, was inconsistent, mainly because of the remarkable evolution of these aggregates compared to those of the price levels, especially, after considering the effectiveness of the monetary approach.

The switching to inflation targeting policy, in Tunisia, is still a good opportunity to make benefits in terms of price stability. For this reason, the TCB links the inflation target with the exchange rate so as to improve the level of economic competitiveness in relation to the outside world. To achieve these objectives, the TCB had adopted, until 2006, a policy to track the growth of the money supply. It was actually committed, through this money targeting policy, to ensure price and exchange rate stability by taking action on short-term discretionary interventions in the money market. Besides, during the 1990s, Tunisia adopted a policy targeting the real effective exchange rate (REER) to preserve the competitiveness of its economy. This policy, which was to periodically adjust the nominal exchange rate to maintain the REER constant, was more or less efficient as the

country avoided the obstacles of the REER targeting, in other words, the continuation of a high inflation and an exchange rate misalignment.

In literature, there are several factors which may explain the reactions of the domestic and / or import price level to the movements in the exchange rate: "The Pass-Through". Taylor (2000) argues that the exchange rate changes reflected in the consumer price rise with the inflation level. He shows that a credible low inflation regime is suitable for a low impact, or conversely, the persistence of high inflation is positively correlated with the impact level.

However, Choudhri and Hakura (2001) found that the impact is positively correlated with the inflation rate in a large sample of countries and reported an incomplete Pass-through in most countries, including Tunisia. In this context, the work of Devereux and Yetman (2003) shows that the impact is positively associated with the average inflation rates, however, the relationship is not linear because the impact degree increases with inflation following a defective dynamics. Oladipo (2007), Oyinlola and Babatunde (2009), Nakamura and Steinsson (2010) and Raphael and Raphael's (2013) studies revealed a positive impact of the exchange rate on the domestic prices and production. On the basis of these few empirical evidence, we can conclude that, in the major developed countries, the exchange rate does not play a crucial role in the transmission of the dynamic effect of the monetary shock on the real economic activity, even if does not play such a role in small developed countries.

3. Empirical tests of the effect of the exchange rate regime: SVAR versus VECM

In this empirical research, we can identify two channels of the exchange rate impact. The first is a direct channel, which affects inflation through the pass-through effect of the import prices, for instance, the nominal exchange rate fluctuations which directly affect the import prices leading to the rise of the domestic prices. The second is the indirect channel of the exchange rate, which has an impact on the real GDP through the balance of payments. It is important to know the potential impact of the different exchange rate regimes, namely the costs and benefits of implementing a different exchange rate regime. The issue that arises is then whether the exchange rate is still playing an important role in maintaining the macro-economic stability in Tunisia.

3.1. Empirical research data

In this work, we simply used data about the period between January 1993 and June 2011, because if we had to use time series prior to 1993, our research would be of a lower quality due to the fact that, before 1993 , the inflation rate was very high because of the shortage of monthly data. Almost all the empirical researches involving the developing countries are a part of this initiative due to the short inherent periods of such an assessment.

The variables used for our model are the following: the industrial production index (IPI), the consumer price index (CPI), the money supply (MS), the real effective exchange rate (REER) and the import price index (MPI). All the data are expressed in a logarithmic form (denoted ln). Therefore, the coefficients on the stored levels measure the elasticity constants. The short-term interest rate was eliminated from the model since it does not reflect the behavior of the type of the Tunisian market. The data were collected mainly from the IMF (2012) and from the Tunisian Institute of Competitiveness and Quantitative Studies (TICQS).

Table 1: Descriptive analysis of the variables

Designations	LMS	LREER	LMPI	LIPI	LCPI
Mean	8.785	4.683	4.466	4.488	4.523
Median	8.812	4.734	4.281	4.542	4.519
Maximum	9.801	4.795	5.257	4.876	4.837
Minimum	7.832	4.511	3.844	3.952	4.193
Standard Deviation	0.542	0.095	0.431	0.229	0.175
Skewness	0.043	-0.465	0.501	-0.585	0.001
Kurtosis	1.976	1.521	1.922	2.309	2.082
Jarque-Bera	9.762	28.230	20.027	17.084	7.800
Probability	0.008	0.000	0.000	0.000	0.020
R	*24.74%*	*-5.06%*	*36.21%*	*17.67%*	*15.30%*
r	*0.10%*	*-0.02%*	*0.14%*	*0.07%*	*0.06%*

Source: Database of the World Bank 2014. Note: R: Global growth rate; r: Average annual growth rate.

This can result (see Table **1)** in a descriptive statistics of the basic variables and a clear growth of most of the aggregates, except with the REER where we can see an average annual drop of the order of 0.02%. All the series show a left-right asymmetry thinner than the normal distribution. In fact, we can consider these platykurtic series. Besides, we reject the hypothesis of the series normality through Jarque-Berra's test.

To begin, we will carry out a visual inspection of the time series. All of them, except the exchange rate which is characterized by fixed periods, show temporal trends. Figure **1** clearly shows cyclical movements, particularly, of the import price index. Whatever the series are stationary in level or in first difference and with a trend and a constant, we are interested in nothing but in conducting stationarity tests.

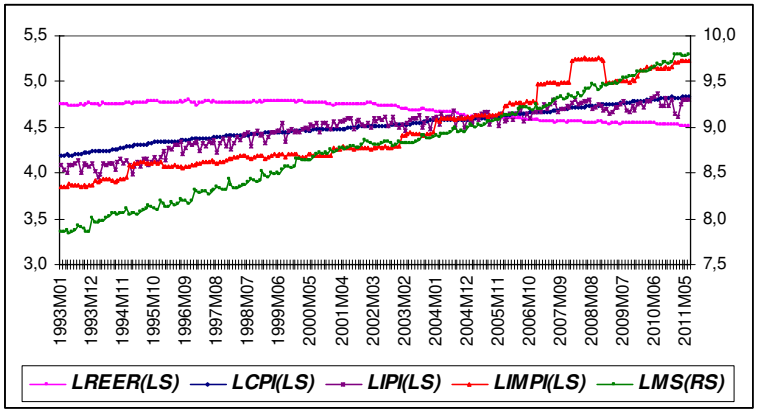

Figure 1: Evolution of the model variables in Logarithm

3.2. Short run effect of the real exchange rate: Structural Vector Autoregression (SVAR)

We start by identifying our model as a five-dimensional vector. In the above equation, vector x_t includes five variables: LREER, LIPI, LCPI, LMS and LMPI. v the vector of the constant. During the investigation period, there are significant structures of the monetary shocks and episodes of internal and external political turmoil. The structural model consists of five equations. The variables of the model are divided into two groups: non-political vectors, which include: log (IPI), log (CPI) and log (MPI), and strategic vectors, in which we find log (MS) and log (REER). ε_t is the structural error vector. The model specification is as follows:

$$x_t = \nu + A_1 x_{t-1} + \ldots + A_p x_{t-p} + \varepsilon_t$$

Before looking at the impulse response functions and the variance decomposition of the monetary disruption, we should select the VAR order by carrying out the diagnostic tests and those for Granger causality. We tested the VAR order on the basis of some criteria, such as the AIC and the SBC. As far as the in level SVAR model specification is concerned, while taking into account the nature of used variables and the sample, the optimum number of lags was set at 4. Figure **2** shows that the reciprocals of the roots are inside the unit disk. Therefore, we can say that the selected VAR is stationary.

When conducting the diagnostic tests, the JB test result shows that the null hypothesis for the normal distribution cannot be accepted for all the variables at a significance level of 5%. There are problems with these variables, particularly, with the short-term time series because it contains monthly data with a lot of noise. As to the non-significant LB test of the autocorrelation residues, there are neither statistically significant residual autocorrelations nor visible patterns. Moreover, the ARCH test strongly rejects the heteroscedasticity hypothesis of the VAR residuals. Finally, we can say that, despite an unstable VAR, due to the inclusion of non-stationary time series in the model, the diagnostic tests are satisfactory and comply with the hypothesis of white noise with constant variance over time.

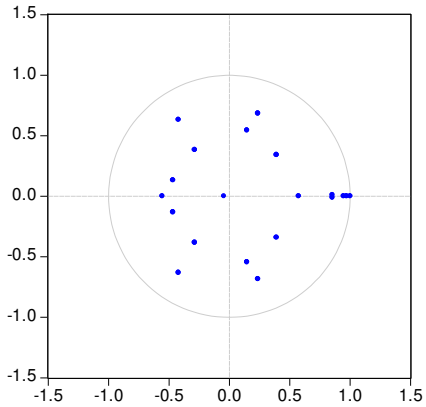

Figure 2: The unit root inverse for all the VAR variables

In order to identify the shocks or their respective impulse response functions via the Cholesky decomposition, the variables should be given a plausible order. Following McCarthy (2000) and Campa and Goldberg (2004), we assume a recursive sequence with some minor changes, mainly due to the different characteristics of the national economy. The authors mentioned above assume that the shocks of international offers are exogenous shocks of the exchange rate through the import prices. Shocks in the exchange rate will instantly be on the consumer price index and on that of the industrial production, whereas the reaction of the central bank through the money stock is listed at the end of the order of the variables (Cîtu, 2003).

It is assumed that an unexpected change in the exchange rate instantly affects the industrial production index, whereas the CPI instantly affects the MPI. Since the central bank's final objective is to stabilize the prices through the exchange rate, it instantly reacts to the variations of the exchange rates and price indices for its business objectives.

Based on the theoretical hypothesis, and as Sims (1980) mentioned, we assume that MS instantly affects the real output through the IPI. Therefore, the IPI could be affected through two channels: the exchange rate and the money stock. Moreover, the new Keynesian approach says that the money stock instantly affects the IPI, whereas the prices are sticky in the short run. Therefore, the Wald order of the variables is as follows: $REER \rightarrow MPI \rightarrow CPI \rightarrow MS \rightarrow IPI$. As a result, the recursive approach (Cholesky decomposition) is built in the following way:

$$x_t = \begin{bmatrix} REER \\ MPI \\ CPI \\ MS \\ IPI \end{bmatrix} \text{ and } B_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix}$$

The effects of a shock in the real exchange rate are shown in Figure **3**. The vertical axis is the response of the LMPI, LCPI, LSM and LIPI to a shock of 1% of the REER during the initial period. The horizontal axis represents time in months. The dynamic effect of a 1% shock to the exchange rate generates a permanent decline in the MPI and in the CPI, while the responses of the money supply and of the IPI are not significant. The impact of the exchange rate leads to: (*i*) a depreciation of the exchange rate, (*ii*) a decline of the CPI and MPI from the fourth period following a small growth, and (*iii*) an almost negligible effect on MS and the IPI. The import price index reacts during the first month, then it grows permanently at a slow pace by about 1.3% after 10 months. The consumer price index shows a significant response and continues to record a permanent growth of about 0.98% after 11 months. Money supply shows a significant impact in the fourth month and a

permanent increase of about 0.83% after 13 months. The effect of the industrial production index is low and constant, at around 0.5%.

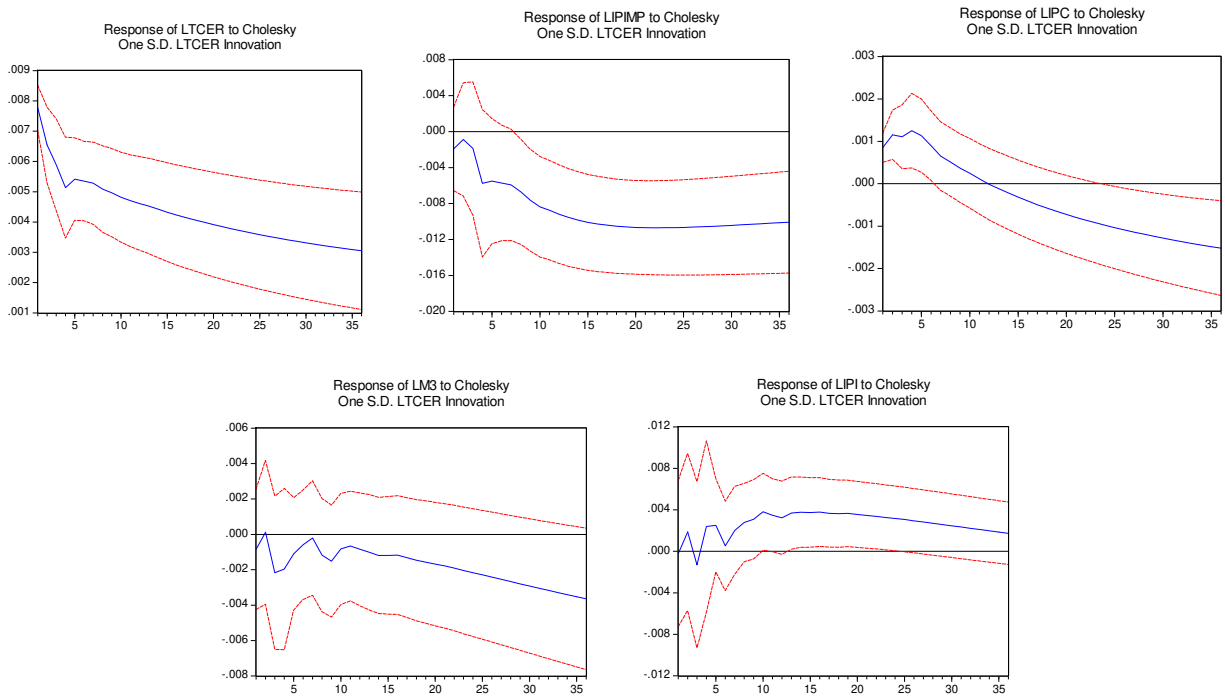

Figure 3: Impact of the real effective exchange rate on prices and money supply - Cholesky

The results of the empirical research suggest that the direct exchange rate channel has a strong pass-through effect on prices, whereas the indirect channel has no effect on the IPI. Figure **3** illustrates this potential of the strong pass-through of the exchange rate effect on prices in Tunisia. There is a high transmission of the effect of the exchange rate fluctuations through the import prices on those of the economy. Consequently, a depreciation of the domestic currency leads to an increase in the price levels by about 1.3%. Even during the first month, the import prices react to the real exchange rate developments, which means that there is a high pass-through effect of the exchange rate changes on the domestic prices via the import prices. On the other hand, a depreciation of the national currency showed a significant effect on the industrial production index in Tunisia.

This result is in line with the evidence that money, and through it, the money supply throughout the study period is a predetermined endogenous variable. In order to bring back the price level to the equilibrium compatible with the pass-through of the money supply with an exchange rate target, one should use quick endogenous adjustments to the money supply (see Figure **4**) which is an endogenous variable set prior to inflation and to the exchange rate changes due to the TCB's intervention in the currency market.

What seems clear when evaluating the characteristics of Tunisia, as a small open economy with a high degree of devaluation and a significant share of imports (especially raw materials), is that it cannot impact the world economy. Moreover, many prices, mainly of consumer goods and durables

are somehow indexed to the exchange rate. Wages are indexed to the same exchange rates in some economic sectors. Finally, this result shows that any change in the current monetary strategy targeting the exchange rates has a probable risk of financial instability due to the increase in dollarization. Such changes would impede the ability of the TCB to control the inflation caused by the increase of the pass-through effect of the variations in the exchange rate regime on prices.

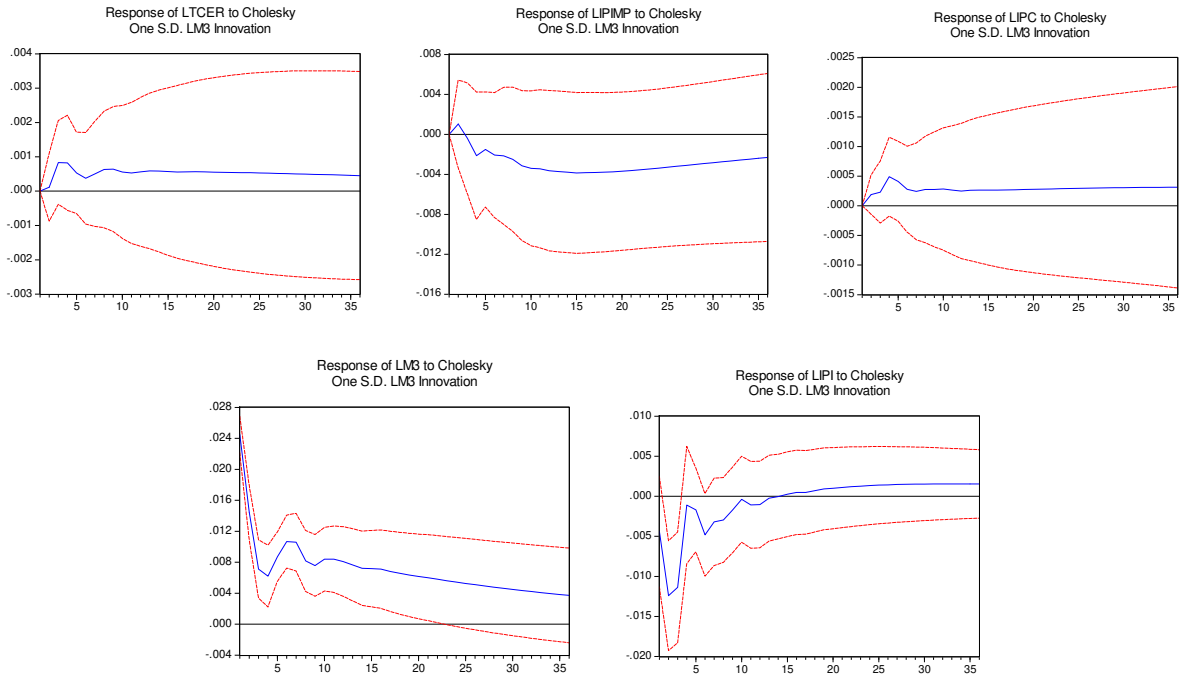

Figure 4: Effect of the money supply on the effective exchange rate and on prices - Cholesky

To be able to compare the obtained result through Cholesky's decomposition, we use the decomposition of Bernanke-Sims in which the plausible range of the variables is not important. However, we should carry out the LR test proposed by Sims as such both channels of the exchange rate effect on the economy are analyzed by Sims and Zha (1998) and Uhling (2005) using the Bernanke-Sims's decomposition.

The variables in the model are classified into two groups: the non-strategic vectors, which include the LIPI, LMPI and LCPI, and the strategic vectors, which include the LREER and LMS. To identify the political impact in the structural VAR, we assume that the vector of non-political variables cannot instantly react to the vector of the political variables. Moreover, as shown by Sims and Zha (1998), a non-recursive identification system provides a simultaneous interaction between the exchange rate and the money stock. Actually, the important question about the estimation of the structural VAR is the normalization coefficients of the dependent variable. As a consequence, we first need to make restrictions on the B_0 matrix, then, we re-estimate the model by standardizing its coefficients. We suggest the following restriction on the B_0 matrix:

$$x_t = \begin{bmatrix} REER \\ MPI \\ CPI \\ MS \\ IPI \end{bmatrix} \text{ and } B_0 = \begin{bmatrix} 1 & b_{12} & b_{13} & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & b_{32} & 1 & 0 & 0 \\ b_{41} & 0 & 0 & 1 & b_{42} \\ 0 & b_{52} & b_{53} & 0 & 1 \end{bmatrix}$$

In fact, the fourth line can be interpreted as the response of the monetary policy to the fluctuations in the exchange rate regime and, therefore, we will go with an instant response from the money supply shock to an exchange rate shock. On the other hand, the political variables in the second, third and fifth lines do not instantly react on themselves. Finally, the exchange rate instantly reacts to innovations triggered by the import price index, whereas imports and industrial production index do not instantly react to the innovations caused by the exchange rate or the money supply.

In order to check the significance of the identification restriction, it is necessary to perform the likelihood ratio test. The LR test returns meaningful results so that our identification restriction is accepted ($\chi^2(9) = 4353.26,\ pvalue = 0.000$). It can be seen that the level of p significance is below 0.05, therefore, we cannot reject the hypothesis that the restrictions are binding. As a result, we can accept the restrictions imposed in the identification of the B0 matrix. Consequently, the result obtained by means of Bernanke-Sims's decomposition is quite similar to the one obtained by Cholesky's. This similarity between both decompositions suggests that the model is robust.

The dynamic effect of the exchange rates on prices and on industrial production is shown in Figure **5** above. This graph shows that the exchange rate has the same pattern in its impulse response function as seen in Cholesky's previous decomposition. Once again, this similarity between the results confirms that the model is robust.

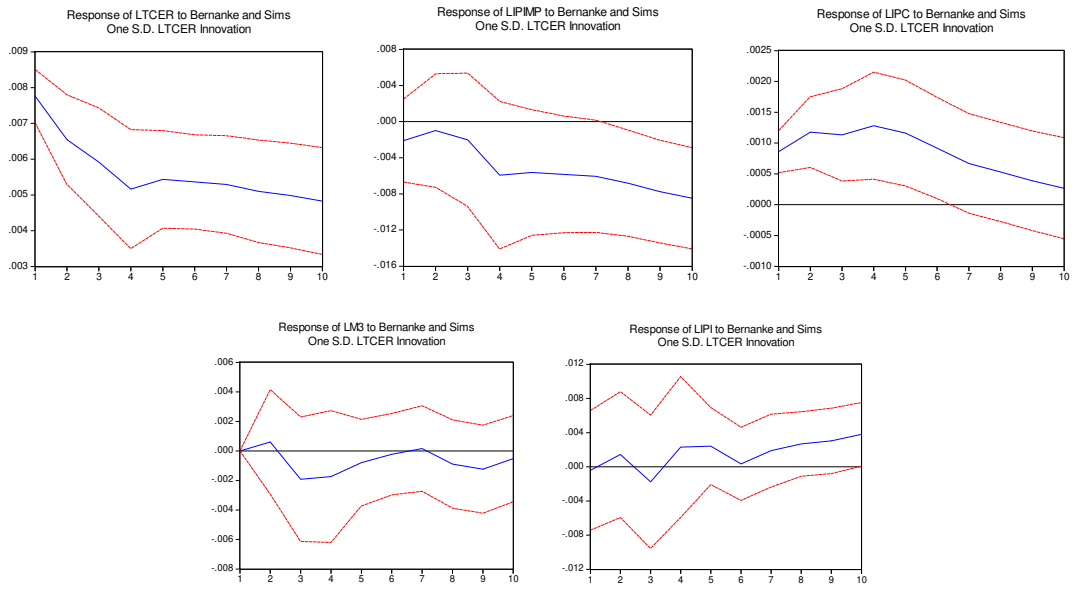

Figure 5: Exchange rate impact on prices and money supply - Bernanke-Sims

This decomposition also shows that the exchange rate plays an important role in Tunisia; however, it is convergent with almost all the findings about the developing countries. Figure **6** shows that Bernanke and Sims's decomposition identifies a high Pass-through potential effect of the exchange rate on prices but generates no significant effect on the potential output. Since the results obtained through Bernanke and Sims's decomposition are close to those of Cholesky's, they will be interpreted the same way as was done in the previous decomposition.

Table **2** shows the contribution of the exchange rate and money supply on the MPI, CPI and IPI fluctuations. This information is obtained through the decomposition of the error foreseeable variance of the endogenous variables generated by the innovations of the exchange rates and the money supply. The real variables are accounted for according to the median value and at 95% of probability intervals for the decomposition of the forecast errors for an h horizon in months. The result of this test is consistent with the identification of the impulse response functions. Table **2** shows that the contribution of the exchange rate to the fluctuation of the import price indices is 4.1% and 1.97%, respectively. Regarding the variance decomposition of the forecast IPI error, the contribution of the IPI fluctuating exchange rate is negligible (about 0.4%).

Table 2 Decomposition of the forecast error variance by innovations

Horizon	Decomposition of the LREER variance			Decomposition of the LMS variance		
	LMPI	LCPI	LIPI	LMPI	LCPI	LIPI
1	0.00	0.00	0.00	2.52	2.20	0.00
12	1.71	0.93	0.55	2.07	4.67	14.06
24	3.19	0.66	0.57	1.63	10.61	12.81
36	3.73	0.87	0.49	1.46	15.86	12.13
48	3.97	1.34	0.43	1.46	19.74	11.46
60	4.09	1.97	0.41	1.59	22.27	10.68

Source: Authors' estimates from the data source.

Table **2** also shows that the contributions of the monetary stock to the fluctuation of import indices and consumer prices are 1.6% and 22.3%, respectively. The variance decomposition of the industrial production error and money supply to the fluctuation of the IPI are close to 11%. These results are consistent with those obtained in the impulse response function through both decompositions. Similarly, Table **2** shows that the exchange rate plays a more important role in the price fluctuation than the stock changes of the money supply do. Both channels of the monetary transmission mechanism have no significant effect on the change of industrial production. Altogether, the results indicate that the exchange rate identifies a strong Pass-through effect on the domestic prices. Besides, the money supply channel seems weak as an independent instrument of the monetary policy.

Moreover, the results indicate that the exchange rate identifies a strong Pass-through effect on the domestic prices, whereas the money supply channel seems weak as an independent instrument of the monetary policy.

3.3. The dynamic effect and the test of long run stability of the real exchange rate: Vector error correction model (VECM)

In this section, we will apply a vector error correction model (VECM) to examine the long run dynamic effects of the exchange rate on the industrial production index, the consumer and the import price indices.

First, we test the integration properties of the variables - through an increased Dickey-Fuller test or Philips Perron's (ADF or PP) – so as to check if the time series are stationary in difference or with trend and whether they are integrated of order one or zero. After applying the unit root tests, we will perform co-integration tests to find out about the properties of the variables and the presence of long term links between REER, MS, CPI, MPI and IPI. Thus, we will follow the methods used by Johansen (1995), Enders (2004) and Lutkepohl (2005). From Table **3**, it seems that all the variables are not stationary in level as they failed to pass both the ADF and PP stationarity tests because they are integrated of order 1. Similarly, when we take the first difference that has a constant as a deterministic component for all the variables (with the exception of the industrial production index), the null hypothesis is strongly rejected at all levels of significance. Therefore, we can conclude that the time series are stationary.

The co-integrating relationship between the variables can be studied if the variables are stationary in first difference, i.e., integrated of first order. Since the time series have to be integrated of order 1, we also include error correction terms in the VAR standard so as to examine the time series co-integration. We therefore have to try to examine if there is a linear combination of the variables in long-term equilibrium. We will begin by specifying tests of maximum delay, polynomial trend, co-integration ranks, stability parameters, and hypothesis testing for a model I(1). The maximum lags are based essentially on the AIC and SBC criteria. Actually, all the criteria showed that the optimal number of lags is four; therefore, we will use them in our model.

Table 3: Unit root test in level and in first difference

Variables	Integration order		In level				In first difference			
	ADF	PP	ADF		PP		ADF		PP	
			Stat.	*k*	*Adjust*	*L.B*	*Stat.*	*k*	*Adjust*	*L.B*
LREER	1	1	-2.02	0;T	-1.88	15;T	-16.5[a]	0;C	-16.8[a]	10;C
LMS	1	1	3.55	12;_	-4.3	-1;T	-3.72[a]	11;C	-43.8[a]	24;C
LCPI	1	1	-2.25	1;T	11.3	4;_	-10.2[a]	0;C	-10.2[a]	3;C
LIPI	1	1	-2.5[a]	13;C	-7.88[a]	7;T	-4.57[a]	12;T	-28.4[a]	79;_
LMPI	1	1	-2.21	0;T	-2.26	4;T	-15.4	0;C	-15.4 [a]	2;C

Source: Authors' estimates from the data source. Note: *k* is the number of the optimum lags in which the *t*-statistics is significant in the regression, *L.B.* represents the bandwidth using Bartlett kernel in the PP test, *C* is a significant constant, *T* is a significant constant and trend and (_) is neither a constant nor a trend. (a) significance at 1%.

In the next step, we will examine the statistics of the trace test and the maximum intrinsic value for the co-integration rank. Using the critical values of Johansen and Nielsen (1993) for the λ_{trace} statistics of the dummy variables included in the system, we can see, in Table 4, that under the null

hypothesis, r = 0 is rejected because the λ_{trace} statistics is greater than the critical value at 95% significance. On the other hand, the alternative hypothesis of the existence of one or more co-integration vectors is admitted. Since 44.65 are less than 47.86, we cannot reject the null hypothesis at this significance level. Based on the results of the trace test, we will accept a rank r = 1, which implies that we have to find a co-integrating vector of long-term relationships between variables.

Table 4: Rank co-integration test

Null hypothesis	Alternative hypothesis	Intrinsic value	Trace statistics	Critical value at 5%	p-value
$r = 0$	$r > 0$	*0.114*	*70.867*	*69.819*	*0.041*
$r \leq 1$	$r > 1$	0.088	44.647	47.856	0.097
$r \leq 2$	$r > 2$	0.073	24.562	29.797	0.178

Source: Authors' estimates from the data source.

The parameter stability was assessed using the co-integrating vector stability test. The reverse unit root (Figure **6**) shows that the co-integrating vector is stable during all the observation periods. The development of the VECM model different residues (Figure **7**) shows a stable co-integrating vector during the study period. At the interpretation level, a value greater than 1 means that the hypothesis is rejected, while a value smaller than 1 means that the hypothesis cannot be rejected. Co-integration r rank is stable if the rank r-1 is rejected for any sample size and r rank is not rejected for any sample size.

Next, we will examine model I(1) using the tests of stationarity, weak pass-through and variables exclusion from the model. The likelihood ratio test (LR) for each of these hypotheses is asymptotically distributed according to the χ^2 rule, with r as a degrees of freedom under the null hypothesis with a significance level of 5%. Table **5** contains a descriptive analysis of the VAR model residuals. Besides, the results of weak pass-through tests are presented in Table **6**.

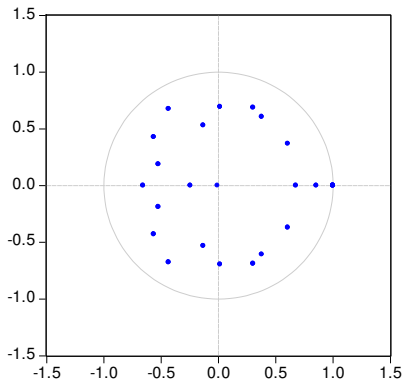

Figure 6: Unit root of the VECM model characteristic polynomial

The exchange rate shows a weak pass-through, i.e. this variable is not affected by the long-term co-integration of the variables – but affected only by short-term relationships. However, the other variables are affected by long-term co-integration. Since the money stock does not have this feature, we can say that the TCB has applied monetary rules. Moreover, during the period under review, the

money supply was endogenous to inflation and to the changing TCB interventions on the foreign exchange market. This is consistent with our conclusion that the money supply is endogenous to the exchange rate target which is strongly determined by changes in the currency market.

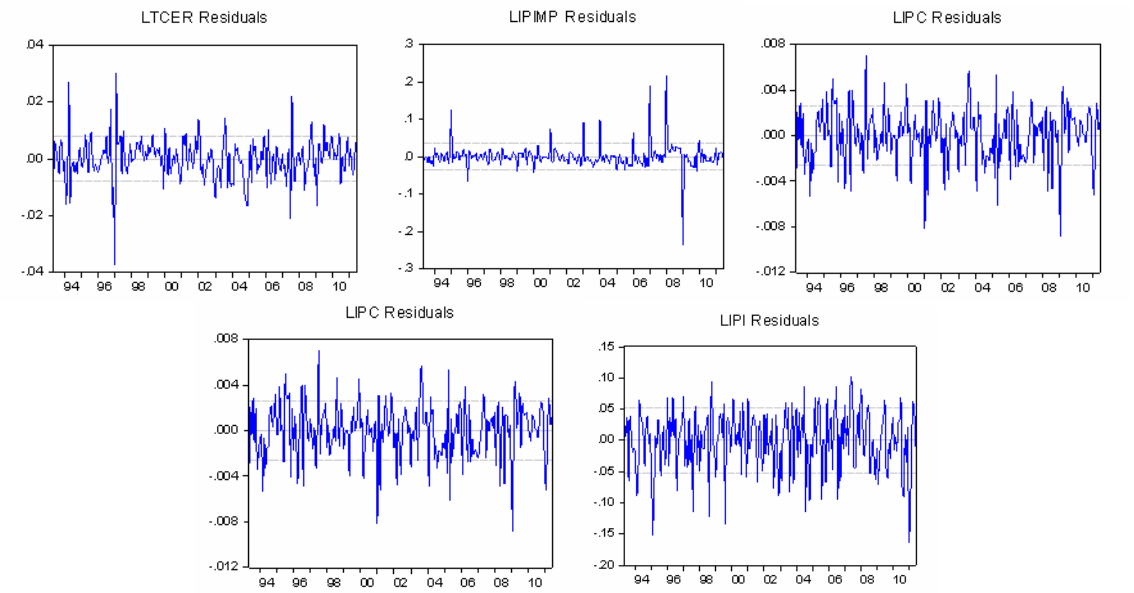

Figure 7: Evolutions the different VECM model residuals

Finally, the result of the exclusion of the co-integrating vector variables is shown in Table **7**. The analysis shows that not all the variables are excluded. Therefore, there is only one stable long-term linear combination relationship between the exchange rate, the import prices, the consumer price index, the money supply and even the industrial production index. Moreover, all the variables, with the exception of the exchange rate, react to this equilibrium, whereas the exchange rate does not respond to such equilibrium because of its weak pass-through. This result is consistent with evidence that the exchange rate is endogenous in the Tunisian monetary policy, which is a part of the administered exchange rate regime.

Table 5: Descriptive analysis of the VAR model residuals

Designations	LREER	LMPI	LCPI	LMS	LIPI
Mean	4.683	4.466	4.523	8.785	4.488
Median	4.734	4.281	4.519	8.812	4.542
Maximum	4.795	5.257	4.837	9.801	4.876
Minimum	4.511	3.844	4.193	7.832	3.952
Standard deviation	0.095	0.431	0.175	0.542	0.229
Skewness	-0.465	0.501	0.001	0.043	-0.585
Kurtosis	1.521	1.922	2.082	1.976	2.309
Jarque-Bera	28.230	20.027	7.800	9.762	17.084
Probability	0.000	0.000	0.020	0.008	0.000

Source: Authors' estimates from the data source.

In what follows, we will examine the linear restriction on the charge and the co-integration vector matrices. Consequently, we will normalize LREER to 1. To help with this process, we will use the LR test for this hypothesis where the chi-square statistics with 1 degree of freedom is 0.108, whereas the significance level is 0.74. As a result, the linear restrictions on α and β are accepted

because the significance level is 0.74, which shows that it exceeds 0.05. In other words, the LR test shows that the restrictions of over-identifying two matrices are accepted. Finally, we can say that not all the estimated coefficients are statistically significant but have the expected sign.

Table 6: Tests of weak exogeneity

Variables	Chi-square	DL	p-value
LREER	14.52	16	0.560
LMPI	26.80	16	0.044
LCPI	34.09	16	0.005
LMS	61.61	16	0.000
LIPI	48.93	16	0.000

Source: Authors' estimates from the data source.

To simplify the co-integrating vector interpretation, we can rewrite the long-run equilibrium relationship as follows:

$$\hat{LREER}_t = -\underset{(1.11)}{0.083}\,LMPI_t - \underset{(2.17)}{1.23}\,LCPI + \underset{(0.39)}{0.06}\,LMS_t + \underset{(4.59)}{0.608}\,LIPI_t$$

The long run relationship between the exchange rate, the consumer price index and the industrial production index is statistically significant at 5% at least. However, the money supply and the import price index did not show their long-term significant effects on the exchange rate. Therefore, this justifies once again the pass-through of the money supply to the inflation movement and to the change of the central bank's interventions on the foreign exchange market.

The co-integration vector may be taken as a causal model having the price level as the dependent variable. Therefore, this model shows that the price indices are negatively correlated with the exchange rate. If we standardize the exchange rate coefficient to 1, the long run relationship can be written as follows:

$$\hat{LIPI}_t = \underset{(0.62)}{0.65}\,LCPI_t + \underset{(1.79)}{0.35}\,LMPI_t + \underset{(2.75)}{1.43}\,LREER_t + \underset{(0.36)}{0.11}\,LMS_t$$

Consequently, the exchange rate coefficient shows a strong Pass-through effect of the real effective exchange rate on the price levels in Tunisia. Moreover, this coefficient could be interpreted as a long term elasticity (due to lags) indicating that a 1% devaluation (depreciation) of the results in the national currency implies an increase of 1.43% in the level of the industrial production in Tunisia. In other words, the exchange rate has a long-term coefficient of 1.43, which means that 1.43% of the exchange rate evolution is a part of the production level.

We can say that the exchange rate is not a potential source of production but also of inflation reduction in the short and long-run in Tunisia. Therefore, the direct channel of the exchange rate seems to have a significant impact on production and inflation in the long-run, whereas the indirect channel of the exchange rate has no effect on the money supply. These results strongly support the

monetary policy of the central bank in targeting the exchange rate, because there is a strong correlation between the exchange rate and the prices in Tunisia.

Table 7: Wald exclusion tests for the VAR lags

Lag	LREER	LMPI	LCPI	LMS	LIPI	Joint
1	149.24	156.37	381.89	91.48	23.02	796.49
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	1.85	1.96	12.04	17.08	15.30	54.76
	(0.87)	(0.86)	(0.03)	(0.00)	(0.01)	(0.00)
3	0.30	2.80	10.81	9.09	35.12	59.83
	(1.00)	(0.73)	(0.06)	(0.11)	(0.00)	(0.00)
4	3.77	4.85	7.81	46.58	1.96	72.03
	(0.58)	(0.43)	(0.17)	(0.00)	(0.86)	(0.00)
df	5	5	5	5	5	25

Source: Authors' estimates from the data source. Note: P-value between (**.**). df: degree of freedom.

4. Conclusion

The short-and long-term effects of the exchange rate on the real output and prices in Tunisia are examined using the SVAR and VECM methods and the decompositions of Cholesky, Bernank and Sims during the period between 1993:01 and 2011:06. The empirical research result indicates that the exchange rate direct channel has a strong pass-through impact on prices, whereas the indirect one has no effect on the output on the basis of the industrial production and money supply indices. This emphasizes the potentially strong pass-through impact of the exchange rate on the prices in Tunisia. More precisely, it shows, through the import prices, the strong effect of the nominal value transmission or the effective exchange rate on the domestic prices, that is, the depreciation of the domestic currency which generates an increase in the price level.

Undoubtedly, changing the type of the exchange rate system is likely to cause a risk of financial instability due to the increase of dollarization. These changes will also affect the ability of the Central Bank to control inflation due to the strong effect of the pass-through following the exchange rate changes in the domestic prices. Probably, a flexible exchange rate can do it because the stabilization high cost is once again caused by people. The exchange rate indicates a potential effect on the price level. The results show that giving up this system or depreciating the national currency would not be wise to promote economic growth as it is economically inefficient, however, macroeconomic instability will obviously have a negative effect on economic growth.

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