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Are Exchange Rate, Exports and Domestic Investment in Tunisia Cointegrated? A Comparison of ECM and ARDL Model

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Abstract
The objective of the paper is to investigate the effect of the exchange rate, exports, and domestic investment by adopting a comparative approach between the ECM and ARDL procedure for the case of the Tunisian economy during the period of study1966-2017. Our insights of Error Correction Model recorded that the Domestic Investment and Exports have a negative impact on Exchange Rate. In accordance with the highlights of the ARDL model. Understanding these controversial nexus seems to be vitality, especially, for this current critical situation of the Tunisian economy.

Keywords: Exchange rate, Exports, Domestic investment, ECM, ARDL

JEL classification: E22, F13, F14, F15, F34

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1. Introduction

The exchange regime plays a crucial role in the determination of several macroeconomic aspects of an economy. Indeed, the exchange rate would double edged-weapon which can be the penalty or the reward of the tradable goods or services, supply or demand, foreign or domestic scale in the international markets.

Also, for the international policymakers, organizations, producers, and consumers, the bias of the exchange rate is the main factor which is taken in the core of exchange policies. Hence, this tool gives comparative advantages/disadvantages of the economy.

The first line of research which treats the relationship between exchange rate and exports has the topic of several studies (Ethier, 1973; DeGrauwe, 1988; McKenzie, 1999; Grier and Smallwood, 2007; Baak, 2008; Chit et al., 2010; Huchet-Bouron and Korinek, 2011; Caglayan et al., 2013;

Nishimura and Hirayama, 2013; Asteriou et al., 2016) which reflect conflicting and inconclusive results about the existence or not of significant relationships.

In addition, there is an impressive body of literature which analysis the nexus between the exchange rate and domestic investment (Hartman, 1972; Pindyck, 1988; Bertola, 1998; Wong, 2007; Bahmani-Oskooee and Hajilee, 2013) which reported the absence of any conclusive results about a negative of a positive significant impact of the exchange rate on domestic investment.

In this context, the Tunisian economy adopts a strategy of devaluating his domestic currency in order to gain momentum in terms of rewarding the exports through given competitive goods or services in the international markets through a competitive price compared to the other products. However, this strategy penalizes the domestic investment through the rise of the production costs (e.g. labor and capital), also, this strategy rewards the foreign investments in detrimental of the domestic ones.

Additionally, these challenging questions were rising and seriously taken attention especially after the revolution of the 14th January 2011. Hence, due to the importance of this controversial relationship, understanding these puzzling relationships is very important for the policymakers in order to take the right actions for the serenity of the Tunisian economy.

For this purpose, we attempt to examine the effect of the exchange rate, exports, domestic investment by adopting a comparative approach between the ECM and ARDL procedure for the case of the Tunisian economy over the period 1966-2017.

Our paper seeks to contribute to the literature in the following ways: We treated the impact of the exchange rate, exports, and domestic investment through a comparative approach between the ECM model and the ARDL procedure. Second, we take into consideration the possibility of the feedback effects of the domestic investment and exports on the exchange rate not only the effect of the exchange rate on exports and domestic investment.

The rest of the paper is organized as follow: Section 2 portrays the data and methods. Section 3 contains the empirical results. Concluding the paper is in Section 4.

2. Data and methodologies

This study investigates the effect of Exports and Domestic Investment on Exchange Rate in Tunisia by comparing the Error Correction Model and the ARDL Model. It used the annual time series data of the Tunisian economy from 1966 to 2017. Annual data used in this study includes Exchange Rate {Official exchange rate (LCU per US$, period average)}, Domestic Investment {Logarithm of Gross fixed capital formation (constant 2010 US$)} and Exports {Logarithm Exports of goods and services (constant 2010 US$)}. All variables are obtained from the World Bank's World Development Indicators.

To estimate the effect of Domestic Investment and Exports on economic in Tunisia, we specify the following equation of Exchange Rate:

$$TC_t = \beta_0 + \beta_1 DI_t + \beta_2 X_t + \varepsilon_t \quad (1)$$

Equation (1) can be written in the Error Correction Model form as:

$$\Delta TC_{(t)} = \sum_{(i-1)}^{k} \beta_0 \, \Delta TC_{t-i} + \sum_{(i-1)}^{k} \beta_{(1)} \Delta DI_{(t-i)} + \sum_{(i-1)}^{k} \beta_{(2)} \Delta X_{(t-i)} + Z_{(1)} ECT_{(t-1)} + \varepsilon_{(t)} \quad (2)$$

Where Δ is the difference operator; k is the number of lags, β_0, β_1 *and* β_2 are the short run coefficients to be estimated; $EC1_{t-1}$ is the error correction term derived from the long-run cointegration relationship; Z_1 is the error correction coefficients of $EC1_{t-1}$ and ε_{1t} is the error terms in equation.

Also, Equation (1) can be written in ARDL Cointegration regression form of ARDL model can be expressed as:

$$\Delta \text{Log TC}_{(t)} = \mu_1 + \sum_{i=1}^{m} \beta_{1i} \Delta \text{Log TC}_{(t-i)} + \sum_{i=0}^{n} \beta_{2i} \Delta \text{Log DI}_{(t-i)} + \sum_{i=0}^{o} \beta_{3i} \Delta \text{Log X}_{(t-1)} + \delta_1 \text{Log DI}_{(t-1)} + \delta_2 \text{Log X}_{(t-1)} + \varepsilon_{(t)} \quad (3)$$

Where μ_1 is the intercept; m, n, and o are the lags order; Δ is the difference operator; and ε_{1t} is the error terms in the equation. The null hypothesis of no cointegration between is H0: δ1 = δ2 = 0 against the alternative hypothesis H1: δ1≠ δ2≠ 0.

3. Empirical Analysis

3.1. Analysis of stationarity

This subsection examines the stationarity properties of the variables included in the analysis. The stationarity of the series was further tested with two different unit root tests: the Augmented Dickey-Fuller (ADF)[1] test and the Phillips Perron (PP)[2] test.
In the case of the ADF test, two conditions must be spotted for the variables to be stationary:
- ADF statistical test > Critical test at the 1%, 5% or 10% levels;
- The probability value must be less than 5%.

Also in the case of the PP test, we must also respect two conditions, which are:
- PP statistical test > Critical test at the 1%, 5% or 10% levels;
- The probability value must be less than 5%.

[1] Dickey and Fuller (1979, 1981).
[2] Phillips and Perron (1988).

Table 1 - Tests for Unit Root

Tests for unit root	ADF		PP	
	Constant	Constant, Linear Trend	Constant	Constant, Linear Trend
TC	(3.258818) [3.873949]***	(0.255067) [4.578994]***	(2.437823) [3.807558]***	(0.168159) [4.561525]***
DI	(1.505853) [4.711695]***	(2.581698) [4.773396]***	(1.448929) [4.684403]***	(2.126674) [4.738362]***
X	(1.092962) [6.675659]***	(3.251754) [6.730737]***	(1.138280) [6.671060]***	(2.786312) [6.729282]***

Note: ***; ** and * denote significances at 1%; 5% and 10% levels respectively;
( ) denotes stationarity in level;
[ ] denotes stationarity in first difference.

The results in Table 1 show that all variables are stationary in first differences. The integration of the variables in the order 1, allows us to apply the Error Correction Model3 and the ARDL Model4.

3.2. Estimation of Error Correction Model (ECM)

3.2.1. Determination of the number of the lag

In Table 2, we used the Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) to select optimal lags of the Error Correction Model (ECM).

[3] Note: We can use the Johansen test (1991) when we have variables integrated of order (2), of order (1) and of order (0) provided that we have at least two variables are integrated of order (1).
[4] Note: The ARDL model makes it possible to test variables with different integration orders provided that they are not integrated of order 2.

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Table 2 - Lag Order Selection Criteria

Lag	Log L	LR	FPE	AIC	SC	HQ
0	156.9768	NA	2.48e-07	-6.694644	-6.575385*	-6.649969
1	170.0923	23.95008*	2.08e-07*	-6.873580*	-6.396543	-6.694879*
2	177.6659	12.84217	2.23e-07	-6.811562	-5.976747	-6.498835
3	181.1824	5.503989	2.86e-07	-6.573146	-5.380554	-6.126394
4	192.1148	15.68564	2.70e-07	-6.657164	-5.106794	-6.076386
5	197.4084	6.904723	3.32e-07	-6.496017	-4.587870	-5.781214

Note: * indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level);
FPE: Final prediction error;
AIC: Akaike information criterion;
SC: Schwarz information criterion;
HQ: Hannan-Quinn information criterion.

In order to choose the optimal lag length, we tested the general 5 lags system. The AIC and the HQ criteria suggested the same VAR order (one): this means that the number of optimal lags is equal to 1.

3.2.2. Johansen test

We are concerned in co-integration between variables using the Johansen test (Johansen, 1991). This test is founded on the Trace Statistic and the Maximum Eigenvalue Statistic.

Table 3 - Johansen Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.438928	52.23865	29.79707	0.0000
At most 1 *	0.352009	23.92128	15.49471	0.0021
At most 2	0.052863	2.661264	3.841466	0.1028
Trace test indicates 2 cointegrating equations at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.438928	28.31737	21.13162	0.0041
At most 1 *	0.352009	21.26001	14.26460	0.0034
At most 2	0.052863	2.661264	3.841466	0.1028
Max-Eigenvalue test indicates 2 cointegrating equations at the 0.05 level				

* denotes rejection of the hypothesis at the 0.05 level;
**MacKinnon-Haug-Michelis (1999) p-values.

The Johansen cointegration test, presented in Table 3, marks that Trace Statistic and the Maximum Eigenvalue Statistic indicate that there are 2 cointegrating equations at the 0.05 level. Therefore, we can estimate an Error Correction Model (ECM).

3.2.3. Determination of the equation of long-term equilibrium of Error Correction Model

The attainment of the estimation by the maximum likelihood method reports the sequent cointegration relation. The long-term equilibrium relation is introduced as follows:

$$TC = 0.1107 - 0.9902\,DI - 0.5772\,X \quad (4)$$

The equation of the long- run relationship of Error Correction Model shows that domestic investment (DI) has a negative effect on Exchange Rate (TC); that is, a 1% increase in Domestic Investment leads to a 0.9902% decrease in Exchange Rate. Also, this equation shows that Exports (X) has a negative effect on Exchange Rate (TC); that is, a 1% increase in Exports leads to a 0.5772% decrease in Exchange Rate.

To warrant the validity of these results and to prove the existence of the long-term relationship, we must test the significance of the coefficients of these variables. For this reason, we will apply the Error Correction Model (ECM).

3.2.4. Empirical results of ECM

In this step, we estimate the equation of the long run equilibrium relationship in the following form as an error correction model. The results of the estimation yield the pursuant equation:

$$D(TC,2) = C(1) * (D(TC(-1)) + 0.990216958319 * D(DI(-1)) + 0.577215715023 * D(X(-1)) - 0.11074088474) + C(2) * D(TC(-1),2) + C(3) * D(D(DI(-1))) + C(4) * D(D(X(-1))) + C(5) \quad (5)$$

Table 4 shows the results of estimating the equation. If the coefficient of the variable C (1)[5] is negative and possesses a significant probability. This means that the long-run equilibrium relationship is significant.

Table 4 - Estimation of ECM by using Method: Least Squares (Gauss-Newton/Marquardt steps)

Dependent Variable: TC				
C(1)	-0.341644	0.120789	-2.828435	0.0070
C(2)	-0.185935	0.143608	-1.294735	0.2022
C(3)	0.091517	0.146410	0.625073	0.5352
C(4)	0.024185	0.122253	0.197823	0.8441
C(5)	0.006325	0.010994	0.575287	0.5680

In our case, the correction error term is significant and has a negative coefficient. These prove that, in the long run, Domestic Investment and Exports have a negative impact on Exchange Rate. According to the results of the estimation of the error correction model, Domestic

[5] Note : C(1) is the coefficient of the Error Correction Term (ECT)

Investments and Exports are fundamental factors for the appreciation of Tunisian Dinar in the long-run.

3.3. Estimation of Autoregressive Distributed Lag approach model (ARDL Model)

3.3.1. Bounds test

Unit root tests (ADF and PP) confirm that none of the series is integrated of I(2); therefore, we may apply ARDL bounds testing procedures for establishing the long-run relationship between Exchange Rate, Domestic Investment, and Exports.

Table 5 - Bounds test

ARDL Bounds Test		
Test Statistic	Value	k
F-statistic	5.187160	2
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Our results of the ARDL bounds testing are reported in Table 5. Indeed, our calculated F-statistic is more than the upper critical bound at 5% and 10% levels of significance following Pesaran et al. (2001). One may conclude that there prevails a cointegration between Exchange Rate, Domestic Investment, and Exports, which make it possible to look into the impact of Domestic Investment and Exports on Exchange Rate in the long run.

3.3.2. Determination of the equation of long-term equilibrium of ARDL model

The long-term equilibrium relation is presented as follows:

$$\mathrm{TC} = 0.0759 - 0.2629\,\mathrm{DI} - 0.3427\,\mathrm{X} \quad (6)$$

The equation of the long- run relationship of ARDL Model shows that domestic investment (DI) has a negative effect on Exchange Rate (TC); that is, a 1% increase in Domestic Investment leads to a 0.2629% decrease in Exchange Rate. Also, this equation shows that Exports (X) has a negative effect on Exchange Rate (TC); that is, a 1% increase in Exports leads to a 0.3427% decrease in Exchange Rate. To attest that this long-term relationship is equitable or not, we must test the significance of these variables by estimating the ARDL Model.

3.3.3. Empirical results of ARDL model

We can say that the equilibrium cointegration equation is significant and that there is a long term relationship between the variables when the Error Correction Term has a negative coefficient and a negative probability.

Table 6 - Estimation of ARDL Model

ARDL Cointegrating And Long Run Form Dependent Variable: D(TC) Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(DI, 2)	0.196317	0.139793	1.404337	0.1671
DLOG(X, 2)	-0.183406	0.162828	-1.126382	0.2660
CointEq(-1)	-0.535148	0.141406	-3.784470	0.0005
Cointeq = D(TC) - (-0.2629*DLOG(DI) -0.3427*DLOG(X) + 0.0759)				

Table 6 shows that the error correction term has a negative coefficient (-0.535148) and a probability less than 5% (0.0005) in this case, we can say that the equilibrium cointegration equation is significant and that there is has a long-term relationship between the variables. So we can prove that Domestic Investment and Exports have a negative effect on Exchange Rate in the long run. According to the results of the estimation of the ARDL model, Domestic Investments and Exports are also essential factors for the appreciation of Tunisian Dinar in the long-run.

3.4. Stability of models

Brown and al. (1975) have suggested that the parameter stability can be examined with a CUSUM Test. This last indicates the stability of long-run parameters (Figure 1).

Stability of Error Correction Model | Stability of ARDL Model

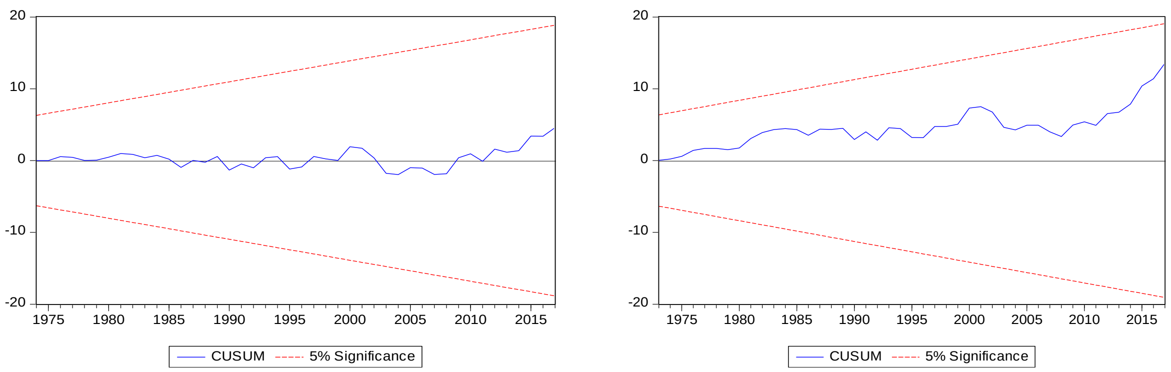

Figure 1 - Stability of models

Figure 1 shows the results of the CUSUM Test, which indicates that the error correction model and ARDL model used in the study are well established. Consequently, the two models are stable and estimated results are well respected for policy practices.

4. Concluding remarks

With the reemergence of the exchange rate's incidence on the exports level and domestic investment as a stylized fact in the Tunisian context, especially after the revolution when the economy struggles about critical scenarios and serious problems (e.g. unemployment, inflation, stagnation, corruption, public debt's sustainability, syndical and social claims ...). Also, these controversial issues created a challenging perspective for the economy and the misunderstanding and misinterpretation of this nexus constitute the topic of several discourses and debates at the political, social, and economic scales. For this purpose, we attempt to investigate this nexus by adopting a comparative approach between the ECM and the ARDL procedure over the period 1966-2017.

With respect to the long- run relationship of Error Correction Model, we pointed out that the Domestic Investment and Exports have a negative impact on Exchange Rate. With respect to the ARDL model, our findings prove that Domestic Investment and Exports have a negative effect on Exchange Rate in the long run.

Based on our findings, the Tunisian authority should take seriously the competitiveness issue based on the devaluating manner of the domestic currency. Also, they are invited to preserve the domestic investment and minimizing the high dependence on the foreign investment through devaluating the domestic currency and gained a comparative advantage in terms of attractiveness of the foreign investments in detriment of the domestic ones.

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