Asymmetric behavior of exchange rate in Tunisia: a nonlinear approach

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Abstract

This paper employs the smooth transition autoregressive models (STAR) to analyze Tunisian exchange rate pass-through on quarterly data over the period 2011Q4 2019Q4. The non linearity tests suggest that the LSTAR specification describes better the behavior of exchange rate pass-through in Tunisia and our empirical results confirm its nonlinearity. We found evidence on high pass-through to inflation through external debt in both regimes.

Keywords: Exchange rate pass-through, Regime Change, LSTAR, Tunisia.

JEL classification: C24, E31, F31, H60

1. Introduction

The narrowing of foreign exchange reserves, the deficits of the trade and payment balances are among the main factors behind the depreciation of Tunisian national currency which lost much of its value in recent years. According to the International Monetary Fund report of July 2018, Tunisian public and external debt ratio reached 70% and 80% of GDP in 2017, and inflation accelerated reaching 7.7 % in May of 2018, while core inflation went up to 7.2 %, driven by the depreciation of the national currency.

In this context the growth of debt is inflationary according to the economic literature. Sargent and Wallace (1981), states that an increase in debt is inflationary in highly indebted countries. Reinhart and Rogoff (2009) and Reinhart and Rogoff (2010) find a relation between high government debt ratios and inflation among emerging economies who suffer from a growing debt ratio. But the reality is that while part of the debt is used to finance consumption, some of it goes directly to finance development projects of vital necessity for the country's economic transition.

In this paper we use Smooth Transition Autoregressive Models (STAR); we test for nonlinearity before estimating the exchange rate pass-through to inflation through external debt. Smooth transition autoregressive process was initially introduced by Bacon and Watts (1971), later popularized by Teräsvirta (1994, 1998) and knew a growing popularity in explaining fluctuations.

Many authors focused on the relation between debt and inflation, their finding support that increasing debt is inflationary, especially in developing and emerging countries, Tan (2006) for Malaysia, Kannan and Singh (2007) for India, Nouri and Samimi (2011) for Iran, Jalil, Tariq, and Bibi (2014) for Pakistan. To our knowledge, no work has been done on exchange rate pass-through to inflation by external debt using STAR models for the case of Tunisia.

The paper is organized as follows. Section 2 presents the model. Section 3 details the results, while Section 4 contains the concluding remarks.

2. The model

Smooth transition models (STR) are by definition nonlinear, where the dependent variable varies between two endogenously determined regimes.

$$y_t = \phi' z_t + \theta' z_t G(\gamma, c, s_t) + \varepsilon_t$$

$$= \{\phi + \theta G(\gamma, c, s_t)\}' z_t + \varepsilon_t$$

$z_t = (w_t', x_t')'$ is a vector of explanatory variables, where $w_t' = \left(1, y_{t-1}, \dots, y_{t-p}\right)'$, $x_t' = (x_{1t}, \dots, x_{kt})'$ a vector of exogenous variables and $\varepsilon_t \sim iid(0, \sigma^2)$. While $G(\gamma, c, s_t)$ is the transition function where γ and c are the slope and the value of the threshold. The latter is chosen with model selection techniques for a given list of candidate variables for s_t. The estimation of the regression parameters and the threshold values and slope is done via nonlinear least squares. The transition function is given by: Logistic (LSTR), Normal (NSTR or STR), Exponential (ESTR) and Logistic, second-order (L2STR). The choice between these function is done via a linearity test.

3. Empirical results

Data are extracted from the national institute of statistics, the central bank of Tunisia and the international monetary fund, and are, beside external debt growth, the evolution of: the consumer price index, the real effective exchange rate and the GDP growth. Next we test for stationarity by applying the Phillips-Perron (1988) unit root test.

Table n°1: Unit root test

	Level			1st difference		
	Intercept	Trend and intercept	None	Intercept	Trend and intercept	None
external debt	-1.944 (0.309)	-2.987 (0.153)	-0.133 (0.629)	-5.677 (0.000)	-5.719 (0.0004)	-5.534 (0.000)
inflation	-1.202 (0.660)	-1.535 (0.793)	0.686 (0.859)	-4.608 (0.001)	-4.550 (0.0059)	-4.462 (0.000)
reer	-0.430 (0.891)	-1.166 (0.899)	0.584 (0.837)	-3.281 (0.026)	-3.712 (0.038)	-3.316 (0.002)
gdp	-2.430 (0.143)	-2.500 (0.326)	-1.670 (0.089)	-6.925 (0.000)	-7.083 (0.000)	-6.925 (0.000)

The results in the table above show that all series are stationary processes in first difference. Now we determine the optimal lag length which minimizes the log likelihood (LogL).

Table n°2: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-70.56417	NA	16.80939	5.658783	5.803948	5.700585
1	-56.86043	23.19096*	6.335425	4.681571	4.875125	4.737308
2	-54.60550	3.642568	5.766188*	4.585039*	4.826980*	4.654709*
3	-54.07702	0.813061	6.000825	4.621309	4.911639	4.704913
4	-54.07388	0.004589	6.512480	4.697990	5.036709	4.795529

* indicates lag order selected by the criterion

The final prediction error (FPE), the Akaike information criterion (AIC), the Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ) indicates that two lags is the optimal choice. Before estimating the model we make sure that a short run cointegration exists in our sample, therefor we run the Granger (1969) causality test.

Table n°3: Granger causality test

Null Hypothesis	F-Stat	Prob	Null Hypothesis	F-Stat	Prob
INF does not cause REER	0.047	0.954	REER does not ause INF	3.221	0.058
GDP does not cause REER	0.080	0.924	REER does not cause GDP	0.055	0.946
DEBT does not cause REER	0.533	0.594	REER does not cause DEBT	0.484	0.623
GDP does not cause INF	0.311	0.736	INF does not cause GDP	0.245	0.785
DEBT does not cause INFL	1.791	0.189	INF does not cause DEBT	0.683	0.515
DEBT does not cause GDP	0.848	0.441	GDP does not cause DEBT	2.354	0.118

The Granger Causality test with two lags shows the existence of causality at 5% significance for all variables. In order to estimate STAR model we need to determine the value of the constant and the delay parameters. Teräsvirta (1998) states that the delay parameter is chosen by the smallest *p-value* of LM statistic.

Table n°4: Linearity Tests

Null Hypothesis	F-statistic	p-value
H04: b1=b2=b3=b4=0	20.43680	0.0003
H03: b1=b2=b3=0	20.43680	0.0003
H02: b1=b2=0	20.43680	0.0003
H01: b1=0	2.098093	0.1237
	Terasvirta Sequential Tests	
H3: b3=0	20.19146	0.0004
H2: b2=0 | b3=0	20.19146	0.0004
H1: b1=0 | b2=b3=0	2.098093	0.1237
	Escribano-Jorda Tests	
H0L: b2=b4=0	1.785603	0.3967
H0E: b1=b3=0	14.21089	0.0675

Linearity tests shows that the LSTAR specification fits the data better. In fact tests based on the third-order Taylor expansion (b4=0) reject the linear specification at the 5% level using H03, and the recommend the first-order logistic as Pr(H3) <= Pr(H2). the fourth-order Taylor expansion also reject the linear specification at the 5% level using H04, and the recommend the first-order logistic with nonzero threshold as Pr(H0L) >= Pr(H0E) with Pr(H0E) >= .05.

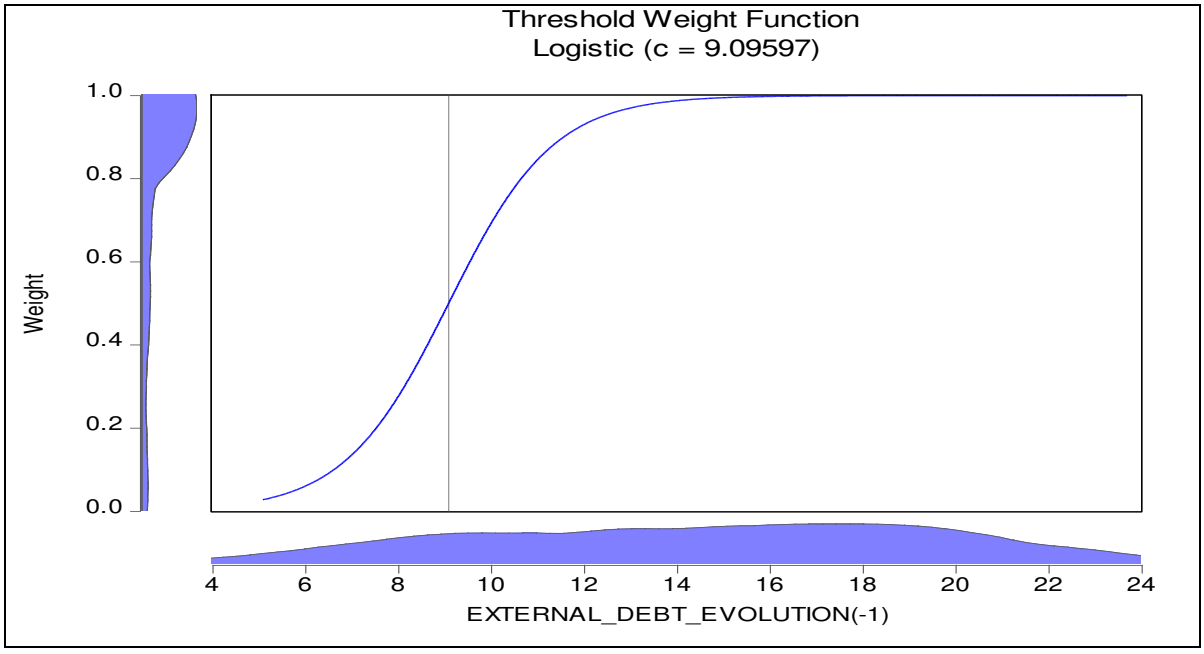
The estimation of the model is carried with HAC (Newey West) covariance method using observed Hessian to overcome serial correlation and heteroskedasticity. The result of the table below shows two regimes, linear and non linear. The transition between them is through the threshold variable external debt evolution (-1) which has significant impact at 5% in both regimes. .

Table n°5: Smooth Threshol Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
	linear part			
GDP_GROWTH	0.789010	0.122546	6.438472	0.0000
EXTERNAL_DEBT_GROWTH(-1)	0.936207	0.090400	10.35625	0.0000
EXTERNAL_DEBT_GROWTH(-2)	-0.575857	0.047758	-12.05793	0.0000
REER(-1)	-0.740040	0.110913	-6.672258	0.0000
	nonlinear part			
GDP_GROWTH	-0.351729	0.206217	-1.705628	0.1161
EXTERNAL_DEBT_GROWTH(-1)	-0.823357	0.100382	-8.202270	0.0000
EXTERNAL_DEBT_GROWTH(-2)	0.661447	0.069824	9.473028	0.0000
REER(-1)	0.803262	0.132484	6.063097	0.0001
SLOPE	0.888457	0.237442	3.741791	0.0033
THRESHOLD	9.095975	0.399602	22.76256	0.0000

The transition lag and the fluctuations in each regime are determined via the sum of squared residuals. The estimation has a R-squared of 0.9 and an Adjusted R-squared of 0.79. The persistence level is the sum of the threshold lag's coefficients in both regimes. The results in the table above shows that the transition occurs when external debt's growth is over 9,1% as shown in Figure 1.

Figure n°1: Threshold weight function with kernel density



The slope γ or speed of transition between both regimes is 0,89, while the persistence level is 0,11. The second regime has a higher level of fluctuations with a sum of squared residuals of 0,51 while it is only 0,37 in the first one. The pass-through is 94% in the first regime and 82% in the second one.

4. Conclusion

Tunisian economy suffers not only from a continuous depreciation of the national currency pushing inflation upward but also from external debt. The Granger Causality test with two lags shows the existence of causality at 5% between inflation, GDP growth, real effective exchange rate and external debt growth. We used quarterly data in a sample from 2011Q4 2019Q4 to test for asymmetry in exchange rate behavior and to estimate its pass-through to inflation in Tunisia through external debt, using a Smooth Transition Autoregressive Model

(STAR). The non linearity tests based on the fourth-order Taylor expansion suggested that the LSTAR specification fits better the data and the choice of the threshold is based on the sum squared residual. Our main findings are a high pass-through of 94% in the first regime and 82% in the second one but with higher fluctuations, the transition starts at a growth of 9.1% in external debt.

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