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Testing Fiscal Reaction Function in Iran: An Application of Nonlinear Dickey-Fuller (NDF) Test

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Abstract

This paper is to convince the usage of the nonlinear unit root tests when dealing with a nonlinear model. To do so, the stationary test for variables in a model titles "Fiscal Reaction Function in Iran" has been applied according to both the ordinary and the Nonlinear Dickey-Fuller (NDF) tests. Results show that while variables under investigation are stationary in a nonlinear form, augmented Dickey-Fuller test indicates tendency to fail and reject the null hypothesis of a unit root in the presence of nonlinear dynamics. Therefore based on the results of Nonlinear Dickey-Fuller (NDF), the paper estimates the fiscal reaction function (FRF) in Iran. The estimated nonlinear regression supports a threshold behavior of two regimes in applying the fiscal reaction. Finally, findings confirm that fiscal policy in Iran is countercyclical though not sensitive in order to react to accumulation of the government debt.

Keywords: Unit Root Test, Nonlinear Dickey-Fuller (NDF) Test, STR Model, Fiscal Reaction Function, Iran.

JEL classification: C22, E32, H62, H63.

1. Introduction

Granger-Newbold (1974) firstly showed that when time series variables are non-stationary, the classical regression results may be misleading. Therefore, it is absolutely necessary, before estimating the regression equation, that stationary of the variables be examined using

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the unit root tests. Accordingly, a number of unit root tests got presented by several economists, to check stationary of time series variables. However, a few of these tests are used in most experimental studies. Lyocsa et al. (2011) in reviewing 155 papers from 17 journals, showed about 96.6% of these papers for stationary test used Augmented Dickey Fuller or Dickey Fuller (ADF and DF respectively), DF-GLS, Phillips-Perron, Ng-Perron and KPSS test. Whereas many of these papers used nonlinear models in their studies, these traditional unit root tests show tendency to fail rejecting the null hypothesis of a unit root in the presence of asymmetric dynamics; so results of these tests may be misleading. Hence, testing linearity against nonlinearity is necessary when researchers wish to consider a nonlinear modeling.

Accordingly to the low power of traditional unit root tests to reject the null hypothesis of a unit root in the presence of asymmetric dynamics, nonlinear stationary tests such as threshold autoregressive [TAR] models (Tong, 1990) or smooth transition autoregressive [STAR] models (Teräsvirta, 1994) have become quite popular in applied new time series econometrics (Demetrescu and Kruse, 2013: 42). Examining the results of studies by Sarantis (1999), Taylor et al. (2001), Sarno et al. (2004), He and Sandberg (2005), Li (2007), McMillan (2007) and Nobay et al. (2010) showed that smooth transition models are particularly successful in this respect. These studies indicated that time series variables such as real effective exchange rates of 10 major industrial countries [the G-10] (Sarantis, 1999), real exchange rates of the US, the UK, Germany, France, and Japan (Taylor et al., 2001), real money balances of the US (Sarno et al., 2003), France’s unemployment rate (Li, 2007), price-dividend ratios of several countries (McMillan, 2007), and inflation of US (Nobay et al., 2010) had nonlinear behavior and when the performance of the nonlinear unit root tests which accommodate a smooth nonlinear shift in the level, the dynamic structure, and the trend are compared to the classical unit root tests, it is found that these nonlinear tests are superior in terms of power.

Following the previous studies and according to the considerations mentioned, this paper examines variables stationary of “Fiscal Reaction Function in Iran” using a unit root test in the smooth transition autoregressive (STAR) framework. In other words, we try to investigate the necessity of using the nonlinear unit root tests when considering a nonlinear modeling. It should be mentioned that there already exists several unit root tests in the smooth transition autoregressive (STAR) framework, such as Enders and Granger (1998), Bec, Salem, and Carrasco (2002), Eklund (2003a), Eklund (2003b), Kapetanios, Shin, and Snell (2003), He and Sandberg (2005), and Li (2007). However, we use a Nonlinear Dickey-Fuller (NDF) test in a first order Logistic Smooth Transition Autoregressive model (LSTAR (1)) by Li (2007). Finally, according to the results of unit root tests, this paper examines "fiscal sustainability of government Policies" in the form of a nonlinear fiscal reaction function. For this purpose, a fiscal reaction function was estimated using a Smooth Transition Regression (STR) model in Iran for the period 1971-2014.

The rest of the paper is organized as follows. In Section 2 the models are presented. This section includes two parts: 2-1- Nonlinear Dickey-Fuller (NDF) F test in the form of a LSTAR (1); 2-2- The basics of fiscal reaction functions. Estimates of unit root tests and fiscal reaction function in Iran are presented in Section 3. Finally, concluding remarks are given in Section 4.

2. The Model

This section includes two parts. In the first part, the Nonlinear Dickey-Fuller (NDF) test in the form of a LSTAR (1)[1] is introduced, where we believe in using nonlinear models, testing linearity against nonlinearity in the unit root test is a necessary. In the second part, the fiscal reaction function in the nonlinear form[2] is introduced.

2.1 Nonlinear Dickey-Fuller (NDF) Test

Consider the following two STAR models; the first equation does not have a constant term, whereas the second one does:

$$Case1: y_t = \pi_{11} y_{t-1} + \pi_{21} y_{t-1} F(t;\gamma,c) + \mu_t ; \quad \mu_t \approx iid(0,\sigma_u^2) \quad 0 < \sigma_u^2 < \infty \qquad (1)$$

1. See Li and He, 2007
2. See Burger et al., 2011

$$\text{Case2}: y_t = \pi_{10} + \pi_{11} y_{t-1} + (\pi_{20} + \pi_{21} y_{t-1}) F(t;\gamma,c) + \mu_t ; \quad \mu_t \approx iid(0,\sigma_u^2) \qquad (2)$$
$$0 < \sigma_u^2 < \infty$$

The transition function $F(t;\gamma,c)$ in (1) and (2) is defined as follows:

$$F(t;\gamma,c) = \frac{1}{(1+\exp\{-\gamma(t-c)\})} - \frac{1}{2} \qquad (3)$$

The resultant smooth transition regression [STR] model is discussed at length in Terasvirta (1998). The transition function $F(t;\gamma,c)$ is a continuous function that is bounded between 0 to1. The transition function depends on the transition variable (t), the slope parameter (γ) and the vector of location parameters (c). The transition variable is a linear time trend (t), which gives rise to a model smoothly changing parameters.

Our goal is to test the null hypothesis of a random walk without drift against the stable nonlinear LSTAR (1) model. The null hypothesis can be expressed as the following parameter restriction:

$$\begin{aligned} &Case1: \quad H_0^* : \gamma = 0, \pi_{11} = 1 \\ &Case2: \quad H_0 : \gamma = 0, \pi_{10} = 0, \pi_{11} = 1 \end{aligned} \qquad (4)$$

As $\gamma = 0$ implies that the transition function $F(t;\gamma,c) = 0$, then $\gamma = 0$ represents that the model is linear, $\pi_{10} = 0; \pi_{11} = 1$ represent a random walk without drift. However, $\gamma = 0$ will lead to an identification problem under the null hypotheses to remedy the problem, we follow the approach which Li and He (2007) use, and we apply Taylor expansion of γ around 0 in $F(t;\gamma,c) = 0$. The first and third order Taylor expansion is as follows:

$$\begin{aligned} &F_t(t;\gamma,c) = \frac{\gamma(t-c)}{4} + r_1(\gamma) \\ &F_3(t;\gamma,c) = \frac{\gamma(t-c)}{4} + \frac{\gamma^3(t-c)^3}{48} + r_3(\gamma) \end{aligned} \qquad (5)$$

Substituting the above equations into, after merging the terms, we get the following auxiliary regressions:

Where the parameters are defined as follows:

$$s_{1t}=(1,t)';\lambda_1=(\lambda_{10},\lambda_{11})',\varphi_1=(\varphi_{10},\varphi_{11})' \quad , \quad s_{3t}=(1,t,t^2,t^3)',$$
$$\lambda_3=(\lambda_{30},\lambda_{31},\lambda_{32},\gamma_{33})' \quad ,\varphi_3=(\varphi_{30},\varphi_{31,}\varphi_{32},\varphi_{33})' \tag{6}$$

Then the corresponding auxiliary null hypotheses are:

$$H^*_{0m}:\varphi_{m0}=1,\varphi_{mj}=0,j\geq 1;m=1,3$$
$$H_{0m}:\lambda_{mi}=0,\forall i;\varphi_{m0}=1,\varphi_{mj}=0,j\geq 1;m=1,3 \tag{7}$$

To investigate the null hypotheses of unit root test, we use the Nonlinear Dickey-Fuller (NDF) F test. We derive two theorems that are used to deduct the D-F F tests statistic distributions:

I) Nonlinear Dickey-Fuller (NDF) F that does not contain intercept: Consider models $y_t=(y_{t-1}s_{mt})'\varphi_m+u^*_{mt}$ hold, and assume that $(u^*_m)^{\infty}_{t=1}$ fulfills assumption $u_t\approx(0,\sigma^2)$ with $E(u^4_t)\prec\infty$, then for m=1, 3, such that:

$$\widehat{\Psi}^*_m-\widehat{\Psi}^*_m\overset{p}{\rightarrow}0,\Upsilon^*_m\left(\widehat{\Psi}^*_m-\psi^*_m\right)$$
$$\overset{d}{\rightarrow}\left(\Psi^*_m\right)^{-1}\Pi^*_m, \tag{8}$$

$$(s^*_m)^2\Upsilon^*_m\left(\sum x^*_{mt}\,(x^{*'}_{mt})\right)^{-1}\Upsilon^*_m\overset{L}{\rightarrow}\sigma^2(\Psi^*_m)^{-1}$$

Where the parameter restrictions are as follows:

$$\Upsilon^*_1=\mathrm{diag}\{T^*_1\},T^*_1=[T\quad T^2]\ ,\quad (r^{*'}_1)=[1\quad 0]$$

$$\Upsilon^*_3=\mathrm{diag}\{T^*_3\},T^*_3=[T\quad T^2\quad T^3\quad T^4],\quad (r^{*'}_3)=[1\quad 0\quad 0\quad 0]$$

$$\widehat{\Psi}^*_m(\widehat{\varphi}'_m),\quad \psi^*_m=(\varphi'_m),\quad x^*_{mt}=[y_{t-1}\quad s_{mt}]$$

$$\Psi^*_m=\sigma^2_u C_m\qquad \Pi^*_m=E_m$$

$$C_m=[c_{ij}]_{(m+1)^*\ (m+1)}\ ,\quad E_m=[e_i]_{(m+1)^*\ 1}$$

$$c_{ij}=\int_0^1 r^{i+j-2}W(r)^2\quad dr,\quad e_i=\frac{\left(W1^2-(i-1)\int_0^1 r^{i-2}W(r)^2\,dr-1/i\right)}{2}$$

Accordingly, we have Nonlinear D-F F test statistics as follows:

$$F^*_m=(\widehat{\Psi}^*_m-\psi^{*'}_m)(R^{*'}_m)\left\{(s^*_m)^2R^*_m\left[\sum x^*_{mt}\,(x^{*'}_{mt})\right]^{-1}(R^{*'}_m)\right\}^{-1}R^*_m(\widehat{\Psi}^*_m-\psi^*_m)/2 \tag{9}$$

$$= (\widehat{\psi}^*_m \acute{-} \psi^*_m)(R^{1*}_m)\acute{}\Upsilon^*_m * \left\{s^{*}_m{}^2\Upsilon^*_m R^*_m \left[\sum x^*_{mt}(x\acute{}^*_{mt})\right]^{-1}(R\acute{}^*_m)\Upsilon^*_m\right\}^{-1} * \Upsilon^*_m R^*_m(\widehat{\psi}^*_m - \psi^*_m)/2$$

$$\xrightarrow{L} [(\Psi^*_m)^{-1}\Pi^*_m][\sigma^2_u(\Psi^*_m)\acute{}^{-1}]^{-1}[(\Psi^*_m)^{-1}\Pi^*_m]/2 = (\Pi^*_m)(\acute{\Psi}^*_m)\Pi^*_m/2\sigma^*_u$$

II) Nonlinear Dickey-Fuller (NDF) F that contains both in intercept and dynamics: Consider models $y_t = s'_{mt}\lambda_m + (y_{t-1}s_{mt})'\varphi_m + u^*_{mt}$ hold, and assume that $(u^*_m)^\infty_{t=1}$ fulfills assumption $u_t \approx (0,\sigma^2)$ with $E(u^4_t) \prec \infty$, then for m=1, 3, such that:

$$\Upsilon_m(\widehat{\psi}_m - \psi_m) \xrightarrow{d} \Psi^{-1}_m, \widehat{\psi}_m - \psi_m \xrightarrow{p} 0,$$

$$s^2_m\Upsilon_m(\sum x_{mt}\acute{x}_{mt})^{-1}\Upsilon_m \xrightarrow{L} \sigma^2_u\Psi^{-1}_m$$

Where the parameters are defined as follows:

$\Upsilon_1 = \text{diag}\{T_1\}, \quad T_1 = [T^{1/2} \quad T^{3/2} \quad T \quad T^2]\ , \quad \acute{r}_1 = [0 \quad 0 \quad 1 \quad 0]$

$\Upsilon_3 = \text{diag}\{T_3\}, T_3 = [T^{1/2} \quad T^{3/2} \quad T^{5/2} \quad T^{7/2} \quad T \quad T^2 \quad T^3 \quad T^4],$

$\acute{r}_3 = [0 \quad 0 \quad 0 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0]$

$\acute{\psi}_m = \left(\hat{\acute{\lambda}}_m, \hat{\acute{\varphi}}_m\right), \ \psi_m = (\acute{\lambda}_m, \acute{\varphi}_m), \ x_{mt} = \begin{bmatrix} s_{mt} \\ y_{t-1}s_{mt}\end{bmatrix}$

$\Psi_m = \begin{bmatrix} A_m & u_m B_m \\ \sigma_u \acute{B}_m & \sigma^2_u C_m\end{bmatrix} \qquad \Pi_m = \begin{bmatrix}\sigma_u D_m \\ \sigma^2_u E_m\end{bmatrix}$

$A_m = [a_{ij}]_{(m+1)*(m+1)} \quad , \quad B_m = [b_{ij}]_{(m+1)*(m+1)} \quad , \quad C_m = [c_{ij}]_{(m+1)*(m+1)}$

$D_m = [d_i]_{(m+1)*1} \quad , \quad E_m = [e_i]_{(m+1)*1}$

$a_{ij} = T^{-(i+j-1)} * \sum_{t=1}^{T} t^{i+j-2}\ , b_{ij} = \int_0^1 r^{i+j-2}W(r)dr\ , c_{ij} = \int_0^1 r^{i+j-2}W(r)^2 dr$

$d_t = W(1) - (i-1)\int_0^1 r^{i-2}W(r)dr, \quad e_i = \dfrac{(W(1)^2 - (i-1)\int_0^1 r^{i-2}W(r)^2 dr - 1/i)}{2}$

Accordingly, we have Nonlinear D-F test statistics as follows:

$$F_m = (\widehat{\psi}_m - \acute{\psi}_m)\acute{R}_m\{s^2_m R_m(\sum x_{mt}\acute{x}_{mt})^{-1}\acute{R}_m\}^{-1}R_m(\widehat{\psi}_m - \psi_m)/2 \qquad (10)$$

$$F_m = (\widehat{\psi}_m \acute{-} \psi_m)\acute{R}_m\Upsilon_m * \left\{s^2_m\Upsilon_m R_m\left(\sum x_{mt}\acute{x}_{mt}\right)^{-1}\acute{R}_m\Upsilon_m\right\}^{-1} * \Upsilon_m R_m(\widehat{\psi}_m - \psi_m)/2$$

$$\xrightarrow{L} \left(\widehat{\psi}_m \acute{-} \Pi_m\right)\{\sigma^2_u\Psi^{-1}_m\}^{-1}(\Psi^{-1}_m)/2 = \acute{\Pi}_m\Psi^{-1}_m\Pi_m/2\sigma^2_u$$

2.2 Fiscal Reaction Function (FRF)

The issue of "fiscal sustainability" has taken on special importance in the aftermath of the global financial crisis. Although for fiscal sustainability is provided several definitions, almost all of these definitions are associated with fiscal policy. In a comprehensive definition, fiscal sustainability can be considered as a measure of fiscal dependence on the government's recent behaviors, compared to the last fiscal developments and changes in the macro-economic level. To empirically assess fiscal sustainability, the concept of "fiscal reaction function" can be used. Fiscal reaction functions usually specify, for annual data, the reaction of the primary balance/GDP ratio to changes in the one-period lagged public debt/GDP ratio, controlling for other influences. In other words, if the public debt/GDP ratio increases, government should respond by improving the primary balance, to arrest and even reverse the rise in the public debt/GDP ratio (Bohn, 1995, 2007). According to Burger et al. (2011), the basic fiscal reaction function is in the following form:

$$(B/Y)_t = \alpha_1 + \alpha_2 (B/Y)_{t-1} + \alpha_3 (D/Y)_{t-1} + \alpha_4 (\hat{y})_t + \varepsilon_t \tag{11}$$

Where:

B/Y= Primary Balance/GDP

D/Y= Government Debt/GDP

$\hat{y}$ =Output Gap

According to Terasvirta (1994) and with the aim of considering the asymmetric effects of debt level and macroeconomic fluctuations over government decisions, for equation (11) is considered a non-linear structure based on the smooth transition regression (STR) model:

$$(B/Y)_t = \varphi'\omega_t + (\theta'\omega_t).G(\gamma, c, s_t) + u_t \tag{12}$$

$$G(\gamma, c, s_t) = \left(1 + \exp\left\{-\gamma \prod_{k=1}^{K} (s_t - c_k)\right\}\right)^{-1}, \gamma > 0$$

Where:

ω_t = vector of explanatory variables ($(B/Y)_{t-1}; (D/Y)_{t-1}\, and\, (\hat{y})_t$).

$\phi' = (\phi_0, \phi_1, ..., \phi_p)'$ = The parameter vectors of the linear and the nonlinear part.

$\theta' = (\theta_0, \theta_1, ..., \theta_p)'$ = The parameter vectors of the linear and the nonlinear part.

$G(\gamma, c, s_t)$ = Transition Function.

s_t = Transition variable.

γ = Slope parameter.

$c =$ Vector of location parameters.

Government Debt/GDP is three types[1]:

Debt to the central bank/GDP (DCY)

Debt to domestic banks and non-bank financial institutions/GDP (DOY)

Foreign debt/GDP (DXY)

3. Empirical Results

This section is to convince the usage of the nonlinear unit root tests when dealing with a nonlinear model. To do so, the stationary properties for the variables in a model titles "Fiscal Reaction Function in Iran" has been tested using both the ordinary as well as the Nonlinear Dickey-Fuller (NDF) tests for the period 1971-2014.

In the first step, the stationary of variables has been tested, using the ordinary Augmented Dickey-Fuller test. The results are presented in Table 1. According to Table 1, the output gap (GAP) is only stationary in level [I (0)] and other variables are integrated of order 1 [I (1)]. Based on Augmented Dickey-Fuller test results, non-stationary variables should be differenced before being used in estimating equation (12). However, it should be noted that the differencing processes lead to loss of valuable information regarding the variable level.

1. It should be noted as mentioned by a distinguished referee that the official government debts are not a good and real representation of the actual government debts due to the so-called hidden government debts. In another words, the actual government debts are much higher than the official ones. However, due to the fact that one of the objective of the present paper was to deal with the impacts of different government debts and also due to lack of viable data regarding hidden debts for the estimation purpose during the period under consideration, the present research concentrated on the above 3 kinds of government debts.

Table 1: Augmented Dickey-Fuller F Test

Variable	Intercept	Intercept and Trend	t-Stat	Prob
BY		▪	-3.36	0.07
D(BY)	▪		-8.38	0.00
DCY		▪	-1.78	0.69
D(DCY)	▪		-4.66	0.00
DOY	▪		-2.73	0.08
D(DOY)	▪		-5.95	0.00
DXY	▪		-2.70	0.08
D(DXY)	▪		-4.02	0.00
GAP	▪		-4.47	0.00

*Critical Values: 1% level: -3.60; 5% level: -2.93 and 10% level: -2.60

This section deals with tests the stationary properties of the variables using Nonlinear Dickey-Fuller (NDF) approach in the form of a LSTAR (1). To do so, the following steps should be done:

1. Testing Linearity against STR Model and Model Specification

Towards building up the LSTAR model, the first step is to carry out a Lagrange Multiplier (LM)-type test to test linearity against STAR models alternatives. Based on the probability values of F test statistics reported in table 2, it can be concluded that linearity of the model has been rejected. Therefore, the next step is to find a suitable nonlinear model for transition variable (trend). As seen from table 2, the results regarding different nonlinearity tests shown by F2, F3 and F4 probabilities the estimate STR model is LSTR1 for the transition variables.

Table 2: Testing Linearity against STR Model and Model Specification

Variable Under Test	Transition Variable	p-value F	p-value F2	p-value F3	p-value F4	Suggested Model
BY	Trend	0.006	0.012	0.62	0.011	LSTR1
DCY	Trend	0.004	0.006	0.032	0.357	LSTR1
DOY	Trend	0.033	0.142	0.182	0.053	LSTR1
DXY	Trend	0.044	0.162	0.390	0.027	LSTR1
GAP	Trend	0.027	0.482	0.172	0.033	LSTR1

***Note**: Teräsvirta (1998) advises choosing the LSTR2 or the ESTR model if the rejection of the null hypothesis of F3 test is the strongest. In case of the strongest rejection of the null hypotheses of F2 or F4, LSTR1 is chosen as the appropriate model.

2. Estimation of Nonlinear Dickey-Fuller (NDF) F Test Statistic Value

In this section, we estimate equation (2) and Nonlinear Dickey-Fuller (NDF) F in the form of a LSTAR (1) that contains both intercept and dynamics [equation (10)]. The results of these estimates are presented in Table 3. According to the Nonlinear Dickey-Fuller (NDF) F statistic reported in Table 3, the null hypothesis of a random walk without drift is rejected against the stable nonlinear LSTAR (1) model. So, variables under investigation are stationary in a non-linear form. According to Nonlinear Dickey-Fuller (NDF) test results and unlike the Augmented Dickey-Fuller test results, the value of variables level can be used to estimate the equation (12).

The results of Augmented Dickey-Fuller test and Nonlinear Dickey-Fuller (NDF) test showed that testing linearity against nonlinearity is necessary when researchers wish to consider a nonlinear modeling; because traditional unit root tests such as the Augmented Dickey-Fuller test show a tendency to fail rejecting the null hypothesis of a unit root in the presence of asymmetric dynamics.

Table 3: Nonlinear Dickey-Fuller (NDF) F

Variable Under Test	Nonlinear Regression	(NDF) F
BY	$-5.29+0.36BY_{t-1}+(3.22-0.36BY_{t-1})\left[\frac{1}{(1+\exp\{133.87\ (t-17.94\}}-\frac{1}{2}\right]$	15.5**
DCY	$-5.29+0.36DCY_{t-1}+(-0.23BY_{t-1})\left[\frac{1}{(1+\exp\{105.90(t-17.88\}}-\frac{1}{2}\right]$	183.35***
DOY	$1.52+0.99DOY_{t-1}+(-0.21DOY_{t-1})\left[\frac{1}{(1+\exp\{272.23(t-9.89\}}-\frac{1}{2}\right]$	21.87***
DXY	$1.59DXY_{t-1}+(1.85-0.96DXY_{t-1})\left[\frac{1}{(1+\exp\{44.72(t-22.76\}}-\frac{1}{2}\right]$	115.8***
GAP	$0.71GAP_{t-1}+(-2.76-0.71GAP_{t-1})\left[\frac{1}{(1+\exp\{44.25(t-40.94\}}-\frac{1}{2}\right]$	12.61*

*Critical Values: 1% level: 16.09; 5% level: 13.11 and 10% level: 11.86

Note: * Significant at 10%; ** Significant at 5% and *** Significant at 1%

According to the results of unit root tests, the value of variables level is used to estimate fiscal reaction function (FRF) in Iran. The first step is specification in the estimation of a STR model.

Specification involves testing for nonlinearity, choosing s_t and deciding whether LSTR1 or LSTR2 should be used. Those results of the estimations are presented in Table 4. According to probability values of F test statistics reported in table 4, the null hypothesis of this test, based on the linearity of the model, is rejected for transition variables $(DX/Y)_{t-1}$ and $(DC/Y)_{t-1}$. For selecting the optimal transition variable, the variable that the null hypothesis is rejected stronger is selected. According to probability values of F reported in Table 4, $(DX/Y)_{t-1}$ is selected as an optimal transition variable. Selection of a suitable model for variable transition ($(DX/Y)_{t-1}$) based on the tests statistic F2, F3 and F4, is the next step at STR model specification. Consistent with the results reported in Table 4, the suitable proposed model is LSTR1 for variable transition.

Table 4: Testing Linearity against STR Model

Transition Variable	p-value F	p-value F2	p-value F3	p-value F4	Suggested Model
B/Y(t-1)	0.76	0.46	0.58	0.72	Linear
GAP(t)	0.19	0.01	0.86	0.23	Linear
DC/Y(t-1)	0.05	0.06	0.73	0.06	LSTR1
DO/Y(t-1)	0.044	0.162	0.390	0.027	Linear
DX/Y(t-1)*	0.027	0.482	0.172	0.033	LSTR1

*see notation in table 1

Table 5: STR Estimation and Tests for Misspecification

	estimate	t-stat	p-value
Linear Part			
CONST	-0.83	-3.28	0.04
GAP(t)	0.51	1.79	0.08
DC/Y(t-1)	-0.18	-2.25	0.03
DO/Y(t-1)	-0.53	-1.75	0.09
DX/Y(t-1)	2.83	3.73	0.01
Nonlinear Part			
B/Y(t-1)	0.59	2.88	0.01
DC/Y(t-1)	0.20	2.24	0.03
DO/Y(t-1)	0.64	2.03	0.05
DX/Y(t-1)	-2.76	-3.58	0.00
R2:0.70	AIC:2.08	SC:2.54	HQ:2.25
Tests for Misspecification			

The second and third steps in the estimation of an STR model involve finding appropriate starting values for the nonlinear estimation and estimating the model, and evaluation of the model usually includes various tests for misspecification such as error autocorrelation, parameter non-constancy, remaining nonlinearity, ARCH and non-normality. Estimation results of this step are presented in Table 5. According to tests of misspecification, the estimated non-linear model is evaluated as acceptable in terms of quality.

In the model section, the transition function $G(\gamma, c, s_t)$ said to be a continuous function that is bounded between 0 to1. The transition function depends on the transition variable (s), the slope parameter (γ) and the location parameter (c). The estimated final amounts for slope parameter and location parameter are equal to 21.3 and 3.90. Therefore, the transition function is as following:

$$\mathrm{G}\left(21.03, 3.90, (\mathrm{DX}/\mathrm{Y})_{t-1}\right) = \left(1 + \exp\left\{-21.03\left((\mathrm{DX}/\mathrm{Y})_{t-1} - 3.90\right)\right\}\right)^{-1} \quad (13)$$

Since transition function is 0 (G=0) in the first regime, the first regime equation is as follows:

$$(B/Y)_t = -0.83 + 0.51GAP_t - 0.18(DC/Y)_{t-1} - 0.53(DO/Y)_{t-1} + 2.83(DX/Y)_{t-1} \quad (14)$$

And transition function is 1 (G=1) in the second regime; so, we have for the second regime:

$$(B/Y)_t = -0.83 + 059(B/Y)_{t-1} + 0.51GAP_t + 0.04(DC/Y)_{t-1} + 0.11(DO/Y)_{t-1} + 0.07(DX/Y)_{t-1} \quad (15)$$

The estimated nonlinear regression support a threshold behavior of two regimes in the fiscal reaction functions. The positive coefficient of the variable DX/Y and the negative coefficient of the variables DC/Y and DO/Y, in the first regime (when the ratio of government foreign debt to GDP is below 3.90%), indicates that government reaction to foreign debt is sustainable, while government reaction to debt to the central bank and domestic banks and non-bank financial institutions are not sustainable. In addition, the positive coefficient of the variables DX/Y, DC/Y and DO/Y in the second regime (when the ratio of government foreign debt to GDP is above 3.90%) shows government reaction to all three type of debt (debt to the central bank, domestic banks and non-bank financial institutions and foreign debt) is sustainable. However, the small regression coefficients indicate a weak sustainability. In other words, fiscal policy was not sensitive to react to accumulation of the government debt. Finally, the positive coefficient of the variable GAP in both regimes confirms the hypothesis "counter-cyclical response of the government fiscal policies" in Iran.

4. Concluding Remarks

In this paper, it was investigated the necessity of using nonlinear unit root tests, when it was considered a nonlinear modeling. Accordingly, variables stationary of “Fiscal Reaction Function in Iran” were examined using the Augmented Dickey-Fuller and Nonlinear Dickey-Fuller (NDF) test. Results showed that traditional unit root tests such as the Augmented Dickey-Fuller test have tendency to fail, rejecting the null hypothesis of a unit root in the presence of asymmetric dynamics. Therefore, testing linearity against nonlinearity is necessary when a nonlinear modeling is considered.

In the second part and according to the results of Nonlinear Dickey-Fuller (NDF), the value of a variable level was used to estimate fiscal reaction function (FRF) in Iran. The estimated nonlinear regression support a threshold behavior of two regimes in the fiscal reaction function. Findings confirmed that fiscal policy was not sensitive to react to the accumulation of the government debt. Therefore, due to the impact of public debt on long-run economic growth through various channels, it is necessary that "debt sustainability" be considered as a main variable in the objective function of fiscal policies in Iran. Finally, the results showed that fiscal policy in Iran is countercyclical.

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