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Detecting and date-stamping unsustainability: The case of Tunisian Budget Deficit

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Abstract

This study shows the existence of unsustainability in the Tunisian budget deficit with a new recursive unit root test method. The result of the structural breaks unit root test seems to have been coarser for a period of 39 years, that is why we tried to find a finer result in the recursive tests by a technique of detection of explosiveness periodically collapsing, i.e. the dates of the exuberance of the Tunisian budget deficit. GSADF is a test that give more refined results since it detects the episodes of exuberance of the Tunisian deficit throughout the whole period. It goes without saying that these episodes are compatible with the events experienced in Tunisia such as Black Thursday, the bread riots, the subprime crisis, the 2011 Revolution, political instability, a lack of dynamism in economic activity, etc. The empirical findings provide evidence for the existence of exuberance in the Tunisian budget deficit over the period and date explosiveness and collapse. The implication for the conduct of sustainability of Tunisian budget deficit is that the Tunisian authorities should reduce the excess of fluctuations in explosive budget deficit and impose restriction policies to reduce public spending and increase investments in both public and private sectors.

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1. Introduction

Since the second half of the 1980s, the emergence of the notion of sustainability has considerably enriched the nature of the debate on the conduct of different economic policies. However, in budgetary matters, we must go back to the early 1920s to have the first attempt to analyze the sustainability of fiscal policy, for which we are indebted to Keynes (1923). Indeed, by focusing on the problem of the public debt encountered by France, Keynes has alerted the French government to the need for conducting a sustainable fiscal policy that satisfies its budget constraint.

In this context, in Tunisia during the last few years, external debt had risen sharply from 43 percent in 2011 to 68 percent at the end of 2019, due to a widening fiscal and current account deficit as a result of a series of external shocks and increasing social tensions. Adding to this, growth fell short of expectations again in 2016, after an already weak 2015. It began a recovery to 2.2% in 2017, driven by tourism and phosphates. As a result, Tunisia entered into a stand-by arrangement with the IMF for the first time in June 2013, for USD 1.75 billion. This arrangement ended in December 2015. A second IMF program under the Extended Fund Facility was launched in May 2016 for USD 2.9 billion over 48 months. (see appendix table I)

In Tunisia, the 2011 Revolution that overthrew an authoritarian regime, whose highlights were regional imbalance and unequal sharing of wealth, revealed a very fragile economic situation. Five years later, Tunisia's economic performance remained too low and insufficient to produce a substantial change that would have made it possible to alleviate the malaise set in the country and bring radical solutions to the problems of social inequalities, regional disparities and unemployment. The average loss of economic growth during the first three years after the revolution is estimated at 5.6% of GDP. According to the World Bank, this loss was due mainly to the significant decline in investment. This trend continued to decline during the following three years. Indeed, after a decline in GDP growth in 2015 compared to 2014, the year 2016 was particularly difficult and marked by a lack of dynamism in economic activity and a persistence of a worrying imbalance in the balance of payments. (Feki and Redzepagic, 2019)

Indeed, Tunisia has been facing several problems that could have seriously affected its budgetary deficit sustainability. Ever since, the Arab spring has erupted in several countries leading to even more serious challenges that need to be taken into consideration when assessing budgetary deficit sustainability. However, during the last ten decades, the study of sustainability has become an interesting issue for any analysis of public finance imbalances. This concept of sustainability, which finds its origin in the aggravation of budget deficit and the evolutionary accumulation of public debt, evokes a subject that deserves more and more importance. As one of the most used variables for measuring the economic situation of a country, budget deficit plays a vital role in the state budget. In recent decades, budget deficit has undergone radical fluctuations with ascending degradations.

The post-revolution period (2011-2019) has been characterized by increasing financial needs and by budget deficits exceeding critical threshold and by huge economic difficulties, such as a negative economic growth in 2011. Thus, the evolution of the

different Tunisian economic aggregates, such as budget deficit and public debt rate, would pose the problem of fiscal policy sustainability which is becoming increasingly serious and the problem of reviving economic activity for the next future. Moreover, despite the deterioration of country's economic and social situation and public finances imbalance since 2011, Tunisia is an exception and will remain a source of hope for countries in its neighborhood and in MENA region, because it has succeeded in establishing a democracy based on the respect of human rights and fundamental freedoms. Tunisia's economic failure will therefore put a definite stop to democracy in MENA region.

Otherwise, since 2011 revolution, Tunisia has been facing a slowdown in economic activity and increasingly serious public finance problems. This is due to the necessary readjustment of the economy after the regime change. Notably, the state of public finances has deteriorated over the years, mainly due to increases in spending (especially on wages), which have not been sufficiently offset by revenue growth due to tax reforms implemented since 2016. These reforms help make fiscal policy more sustainable and help close the financing gap. The table II shows the objectives of these reforms.
Tunisia does not meet the eligibility criteria for the use of grants in MFA operations. (see table II in appendix)

Additionally, the importance of the problem of structural changes stems from the fact that the presence of such changes in the series can influence the interpretation of certain economic theories. Thus, not taking these changes into account can lead to biases in more elaborate models and subsequently to less precise decisions in terms of economic policies, particularly fiscal and monetary policies.

In empirical literature, most studies have employed traditional unit root tests such as the ADF, PP and KPSS tests when testing for stationarity. These traditional tests have been largely criticized in particular when the series understudies are affected by structural breaks. Thus, we use Perron (1989) unit root tests that have the advantage of taking into consideration the presence of structural breaks. Perron [1989, 1990] points out that if the true process has structural changes in the linear trend function, the power of unit root tests decreases.

Some recent studies have already noted that the deficit process may be unsustainable. For instance, Kustepeli and Onel (2004) examine the sustainability with and without structural breaks of government deficits in Turkey with the intertemporal budget constraint (IBC) approach initiated by Hamilton and Flavin (1986) in the 1970-2003 period in which Turkish budget balance has been in deficit, with an exception in 1970. The results of the empirical analysis without structural breaks show that Turkish fiscal deficits are weakly sustainable. Neaime (2015) examines empirically models of the sustainability of public debt and exchange rate policies as well as the relationship between current account and budget deficits in the emerging small open economy of Lebanon. The empirical results point to unsustainable debt and exchange rate policies. Other empirical results support the existence of a unidirectional causal relationship, in the short run, between budget and current account deficits, indicating that rising fiscal deficit have started to put even more pressure on current account deficits and on Lebanon’s public debt.

In the Tunisian context, there is a number of studies that considered the issue of debt and budgetary deficit sustainability by using several methods. Neaime (2010)

analyzed the sustainability of public debt in the Middle East and North Africa (MENA) in the post US financial crisis period. He uses time series econometric tests and the "*NPG constraint*"; the empirical results show strong evidence of sustainability of fiscal policies in Tunisia, given the country's fiscal discipline. Additionally, the weak sustainability in Egypt is explained by the successful privatization plan introduced during the 1990s. Morocco's mixed results are explained by the recently introduced fiscal recovery reforms. The results show the unsustainable debt and fiscal policies of Jordan and Turkey.

When assessing the sustainability of budget deficits, it is standard practice to test for stationarity. For instance, Gouasmi and Haffoudhi (2018) test for the stationarity of Tunisian budget deficit, assuming that government expenditure and revenue are I(1), because their difference constitutes a budget deficit. In a univariate analysis, they apply a variety of unit root tests to the deficit, which would lead them to conclude that the budget deficit is unsustainable when it is found to be not stationary.

We can mention other empirical studies that have used cointegration techniques to test whether debt is sustainable. These cointegration techniques were used to test whether a long-run relationship exists between government revenues and expenditures. If such a relationship is proved to be true, then we can conclude that debt is sustainable (see for instance, Tanner and Liu, 1995; Haug A.A, 1991; Quintos, 1995; Ahmed and Roger,1995; Payne, 1997; Crowder, 1997; Athanasios and Sidiropoulos, 1999).

It appears, however, that the application of unit root tests over an aggregate period of a budget deficit series has been overlooked in the discussion of its sustainability. In this study, we argue that this technique could be generating misleading results when standard unit root tests are applied. However, volatile budget deficit may heavily deteriorate economic stability and spark political unrest, which highlights the necessity of exploring the features of budget deficit movements and the existence of a periodically collapsing component in the deficit.

The analysis of the sustainability of fiscal policy has been at the forefront of researchers' concerns in recent years, as it helps explain a country's economic situation. Our study is at the heart of this topic, as Tunisia has been undergoing a major upheaval since 2011. We present new evidence that the Tunisian budget deficit is explosive in nature. Despite attempts by successive governments to reduce budget deficits, it may contain a component that periodically collapses, making standard unit root tests biased. We apply a new recursive unit root test, which is known to be powerful in detecting the periodically collapsing component of the deficit.

The originality of this work lies in the study of the sustainability of budget deficit by a technique of detection of periodically collapsing components, i.e. we acknowledge the existence of episodes of exuberance in budget deficit. (the dates of the exuberance of the Tunisian budget deficit).

With structural break unit root tests, we actually find that the Tunisian budget deficit had been stationary from 1970 to 2019 after allowing for a structural break at 2011. In this study, we claim that this conclusion could be true and lead to misleading policies based on the belief that the budget deficit is stationary and sustainable. To confirm our

results herein, we utilize a new unit root test for explosiveness, proposed by Phillips et al. (2015a, PSY), and re-examine the unsustainability of the Tunisian budget deficit.

In addition, the recursive test is known to have greater improved power for the periodically collapsing components than the standard augmented Dickey–Fuller [ADF] test. We found some evidence, with this new test, to suggest that the post-revolution Tunisian budget deficit was explosive. Besides, Yoon (2012) presented new evidence that the postwar U.S. federal budget deficit was explosive in nature. He applies a newly proposed recursive unit root test for explosiveness, which is known to be powerful to the periodically collapsing component. Although the evidence for explosiveness he found in his study is not overwhelming, this study should at the very least serve as a warning against a blind application of standard unit root tests to budget deficits, which may harbor components that periodically collapse.

Since the discussion on the dynamics of unsustainability of budget deficit via the approach of PWY (2011) and PSY (2015) has not been studied so far in Tunisia, this paper seeks to study this technique on the existence of a periodically collapsing component in the budget deficit. This study investigates whether episodes of exuberance exist in the budget deficit on the basis of the SADF[1] and the GSADF[2] approach. This technique delivers date stamping strategies for the emergence of periodically collapsing components in budget deficit and is best suited for a practical application to time series.

The aim of this paper is to use the approaches developed by PSY (2015) in order to detect periodically collapsing substantial components of budget deficits, and to detect the beginning and the ending of episodes of exuberance in budget deficit during the period extending from 1970 to 2019. To our knowledge, this document is the first research that implements the date-stamping strategy developed by PSY (2015) in the Tunisian budget deficit.

This paper is divided into three sections. The first section is devoted to the introduction and the literature review. The second section is devoted to the methodology of sustainability of fiscal deficit. The second section consists in the study of sustainability by detecting periodically collapsing components. We study the sustainability of fiscal deficit by GSADF approaches. We show the results and discussion of this approach in the third section and then, we come to our conclusion.

2. Methodology: SADF and GSADF Approach

On the basis of the theoretical analysis of identifying single explosiveness from the founders (Philips et al. (2011)), this study further implements the unsustainability of budget deficit with SADF[3] and GSADF[4] techniques to measure periodically collapsing

[1] Supremum Augmented Dickey-Fuller (SADF)

[2] Generalized Supremum Augmented Dickey-Fuller (GSADF)

[3] For more information, the SADF test depends on repeated estimation of the ADF model on a forward expanding sample sequence and this test is obtained as the sup value of the corresponding ADF statistic sequence.

[4] The GSADF approach is also based on the idea of sequential right-tailed ADF tests, but the test extends the sample sequence to a more flexible range. Instead of fixing the starting point of the sample, the GSADF test changes the starting and ending points of the sample over a feasible range of windows.

components of budget deficits. More precisely, this new recursive unit root test proposed by Philips et al. (2011) is quite similar to the standard ADF test, except that the new test is recursively applied to the samples with increasing observations.

We estimate the following standard autoregressive model for $\boldsymbol{y_t}$ using the least squares method:

$$\boldsymbol{y_t = \mu + \vartheta y_{t-1} + \sum_{i=1}^{L} \psi_i \Delta y_{t-i} + \epsilon_t} \quad \textbf{(1)}$$

where $\boldsymbol{y_t}$ denotes the time series, $\boldsymbol{\mu}$ is the intercept, $\boldsymbol{\vartheta}$ is the autoregressive coefficient, $\boldsymbol{L}$ is the maximum number of lags, Δ is the difference operator, the differenced lags coefficients for $\boldsymbol{\psi_i}$ are i=1,…,L and the error term appears as $\boldsymbol{\epsilon_t}$.

Unit root tests are commonly used to determine whether a time series is stationary, using an autoregressive model as given by the **Eq.1**. The latter is used to test the hypothesis of existence of a unit root against the hypothesis of stationarity, i.e. H0 against H1. In contrast, the Supremum Augmented Dickey-Fuller (SADF) test, proposed by PWY (2011), is the test of a right-tailed unit root where the hypothesis of the existence of a unit root against the hypothesis of the existence of mildly explosive behavior in $\boldsymbol{y_t}$. Formally in the test, the null hypothesis of unit root test is $\boldsymbol{H0: \vartheta = 1}$ (absence of periodically collapsing components of budget deficits), while the alternative hypothesis is $\boldsymbol{H1: \vartheta > 1}$ (presence of periodically collapsing components of budget deficits).

Some notation is needed, before proceeding to a description of the tests included in ***Rtadf*** (right-tail augmented Dickey-Fuller). To make the exposure simpler, we will use a sample interval **[0, 1]** (To make things clear, we normalized the original sample by T). The Eq.1 estimated the coefficients $\boldsymbol{\vartheta_{\tau 1,\tau 2}}$ and $\boldsymbol{ADF_{\tau 1,\tau 2}}$ and the ADF statistic over the sample $[\boldsymbol{\tau_1, \tau_2}]$. Furthermore, we defined the $\boldsymbol{\tau_w = \tau_2 - \tau_1}$ the window size of the regression and the fixed initial window that is set by the user us $\boldsymbol{\tau_0}$. Given that, the difference between the tests relates to the manner of setting $\boldsymbol{\tau_1}$ and $\boldsymbol{\tau_2}$.

The ***Rtadf*** test shows that the simple version of the standard ADF is the first type of this test. With the first and last observations of the whole sample are $\boldsymbol{\tau_1}$and $\boldsymbol{\tau_2}$. However, we can consider that, $\boldsymbol{\tau_w = \tau_0 = 1}$. In addition, since we now need the right-tail of the statistics of ***Rtadf*** test, we used not the critical values of the usual standard ADF test for testing the null hypothesis, but some new critical values for this test.

The second type of test ***Rtadf*** is the rolling ADF (RADF) test. With this ADF statistic is calculated over a rolling window of ***fixed size*** specified by the user, with $\boldsymbol{\tau_w = \tau_0}$ for all estimations, i.e. same value in $\boldsymbol{\tau_0}$ for all estimations. For each step of the procedure of this test, the window's start and end points are incremented one observation at a time. Each estimation yields an ADF statistic, indicated as $\boldsymbol{ADF_{\tau 1,\tau 2}}$. The RADF statistic is defined as the *supremum* $\boldsymbol{ADF_{\tau 1,\tau 2}}$ statistic among all possible windows.

PWY (2011) suggested SADF test based on recursive estimations of the ADF statistics with a fixed initial point and an expanding window size, or the initial size of the window is set by the user. The estimation procedure is as follows:

Firstly, $\boldsymbol{\tau_1}$ is the first observation in the sample, that is set as the starting point of the estimation window, i.e., $\boldsymbol{\tau_1 = 0}$. Next, $\boldsymbol{\tau_2}$ is the end point of the initial estimation window, that is set according to some choice of minimal window size, $\boldsymbol{\tau_0}$, such that the initial window size is $\boldsymbol{\tau_w = \tau_2}$ (again, in fraction terms). Finally, the regression is recursively estimated, while considering the window size τ_2 that belongs to an interval $[\tau_0,\ 1\ ]$ (i.e., $\tau_2 \in [\tau_0,\ 1\ ]$), at a time we can add one additional observation. In addition, ADF_{τ_2} is a statistic given to each estimation. It is very interesting to know that in the last step, estimation will be based on the whole sample (i.e., $\boldsymbol{\tau_2 = 1}$ and the statistic will be $\boldsymbol{ADF_1}$). In summary, the SADF statistic is obtained as the *supremum* value of the $\boldsymbol{ADF_{\tau_2}}$ sequence for $\boldsymbol{\tau_2 \in [\tau_0, 1]}$**:**

Thus, the SADF test is defined as follows:

$$\boldsymbol{SADF\ (\tau_0) = \ sup_{\tau_2 \in [\tau_0,\ 1]} ADF_0^{\tau_2}} \qquad \textbf{(2)}$$

The SADF test, having a dating strategy, can be inconsistent when the sample contains more than one episode of exuberance. To surmount this weakness, PSY (2015) propose a generalized version of the SADF, named the generalized supremum Augmented Dickey-Fuller (GSADF) test. This test studies explosive behavior in the series, date-stamping the origination and collapse when they may be multiple explosiveness in the data. It is also based on the recursive tests; however, the estimation extends the sample sequence to a more flexible range[5]. (see table III and table IV in appendix)

PSY (2015) define the GSADF statistic as the supremum value of ADF statistic over all feasible ranges of τ_1 and τ_2. Formally, this statistic is defined as:

$$\boldsymbol{GSADF(\tau_0) = \underbrace{sup}_{\substack{\tau_2 \in [\tau_0, 1\ ] \\ \tau_1 \in [0, \tau_2 - \tau_0]}} ADF_{\tau_1}^{\tau_2}} \qquad \textbf{(3)}$$

3. Data and Results

According to the data of the Ministry of Finance, the evolution of the Tunisian budget deficit during the period (1970-2019) is represented by graph Fig.1 (see appendix). Our series is annual with 50 observations. It is necessary to recall first that, by definition, the gross budget deficit is the excess of total government expenditure over its own resources, and is therefore the overall deficit. The net budget deficit is determined by deducting the principal of the public debt as a component of public expenditure, so it is the gross deficit minus the principal of the debt.

In fig.1, the deficit, which is the difference between the expenditure and revenue, is plotted. Except for the lower budget deficit during the 1970–1990 period, the Tunisian budget deficit has been increasing in deficit since the 1990s until the peak in 2013 and the severe peak in 2017. We are interested, in this study, in the time series behavior of the

[5] Unlike the SADF test which fixes the starting point, τ_1, as the first observation of the sample, the GSADF allows the starting point to vary within the range $[0, \tau_2 - \tau_0]$. PSY have shown that the modified version of SADF test, which cover more subsamples, is more efficient than the SADF test in detecting explosive behavior when multiple bubbles occur in the data.

budget deficit. Clearly, it is unclear as to whether the deficit contains a substantial component that collapses periodically.

This study can serve as a warning to policy makers against blindly applying standard unit root tests, which can hide components of budget deficit that periodically collapse.

We started our empirical study with the descriptive statistics is represented by Table V in Appendix. The Perron (1989) test with structural breaks and the empirical findings for this test are reported in Table VI. It shows the test statistic is -9,840618. The test statistic is lower than critical value for all significance level and in this case, we reject the null hypothesis of the presence of unit root. According to the results of the Perron test, therefore, we may conclude that the budget deficit is stationary at the 10%, 5% and 1% significance level, after allowing for a structural break in 2011 and considering that the budget deficit is sustainable. (see appendix)

We use the GSADF test to detect periodically explosive components of budget deficits and to estimate the origination and termination dates of explosive components of Tunisian budget deficits for the period extending from 1970 to 2019, with 50 observations. PSY (2015) argue, when there may be multiple explosiveness in the data, the SADF strategy may suffer from reduced discriminatory power and then fails to detect the existence of the collapsing component of budget deficits. The application of the PSY (2015) method allows us to overcome the weakness associated with the SADF procedure. These critical values are derived by Monte Carlo simulation with a number of replications of 2000. The initial window was fixed at 6 observations that correspond to approximately 10% of the sample size.

Table VII displays the results from the GSADF test. The statistic of the test is 7.20, which exceeds their 5% and 10% right-tailed critical values, respectively. According to the results, the null hypothesis is rejected, which reveals that the Tunisian fiscal deficit is affected by the presence of periodically collapsing components of budget deficits for the period between 1970 to 2019. (see appendix)

On the basis of GSADF technique, we conclude that exuberance exists in the fiscal deficit, which allows us to investigate the possible existence of collapsing components of budget deficits episodes. Figure 2 displays results to date-stamp the episodes of exuberance in budget deficit, and the GSADF statistics sequence is compared to the 95% GSADF critical values sequence. Figure 2 displays graphically the results from the GSADF test over the sample period. The graph shows five periods of explosivity and identifies their starting and ending points. (see appendix)

Figure 2 displays results for the date stamping strategy from 1970 to 2019. Overall, the GSADF test statistics provide strong evidence of explosive behavior in the Tunisian budget deficit. The identified exuberance and collapse periods include Black Thursday in January 1978 episode (1975-1978), the bread riots (1983-1984), the subprime crisis (2007), the Tunisian Revolution (2012-2014) and political instability (2016-2017). The durations of those episodes are greater than or equal to one year.

Table VIII allows us to identify from periodically collapsed short duration. Then, we can add that the unsustainability of fiscal deficit in Tunisia can account for the origin of these periodical collapses. (see appendix)

4. Conclusion

In this article, we have studied the time series of Tunisia's budget deficit over the period 1970-2019. When using the structural breaks unit root test, which would lead us to conclude that the budget deficit is sustainable when it is found to be stationary. Furthermore, we are able to account for the presence of structural breaks in the data series, which should have been induced by the changes in budget deficit, we conclude that the deficit had been sustainable throughout the whole period. This result seems to have been coarser for a period of years, that is why we tried to find a finer result in the recursive tests by a technique of detection of explosiveness periodically collapsing, i.e. the dates of the exuberance of the Tunisian budget deficit. Actually, the budget deficit is periodically unsustainable. Indeed, if we apply the recursive GSADF test, we obtain periods of budget drift that are in line with the facts (Black Thursday in January 1978 episode (1976-1977), the bread riots (1984), the subprime crisis (2007-2008), the revolution (2011) and the political instability that followed). This study should serve as a warning against a blind application of the unit root test with structural breaks, the result of which is the stationarity of the Tunisian budget deficit throughout the whole period. According to the GSADF test, newly proposed by PSY15, the budget deficit series possibly has components that have collapsed periodically. In other words, the Tunisian budget deficit seems to have been explosive at times, and draconian restrictive policies were necessary to bring it back on a sustainable path. (Structural Adjustment Program, (1986)).

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Appendix:

Table I: The main macroeconomic stance and developments in Tunisia over the last decade

	2011	2012	2013	2014	2015	2016	2017	2018	2019
GDP growth (annual %)	-2.04	4.21	2.42	3.09	0.96	1.11	2.23	2.62	1.32
Unemployment, total (% of total labor force) (national estimate)	18.32	17.63	15.93	14.26	15.16	15.56	15.33	15.46	15.13
Foreign direct investment, net (BoP, current US$)	-432666011.57	-155426912 8.78	-105862258 2.18	-102475444 3.57	-970521888.74	-622569482.16	-810936482.84	-98894290 1.04	-810173457.68
Budget deficit* (in % of GDP)	-3.1%	-5.2%	-6.6%	-4.8%	-4.5%	-5.8%	-5.9%	-4.5%	-3.3%
Public debt (in % of GDP)	42.5%	42.5%	44.2%	48.1%	52.3%	58.7%	66.5%	73.0%	68.0%
Total Foreign Exchange Reserves (Claims in U.S. dollars, Allocated Reserves)	3538078.25	3741924.82	3813459.55	4430862.28	4873915.47	5501929.9	6280659.97	6624672.11	6725710.82
Exchange rate, Nominal Effective Exchange Rate, Index	97.46	93.63	88.78	86.05	86.84	80.83	71.55	64.10	60.54

*** Deficit by international standards (excluding Privatization and External Grants) and excluding confiscated revenues and including debt principal collection and loans.**
Source: Ministry of Finance; IFS, IMF, WDI

Table II: The IMF and the European Union's Macroeconomic and Financial Assistance programs

Program	The main objectives
AMF (*Assistance macro-financière*)	To maintain macroeconomic stability, partly through the implementation of structural reforms and the selective recapitalization of banks; To support inclusive growth; To reduce external vulnerabilities; To strengthen investor and donor confidence.

Table III: A summary of the three tests ADF, SADF, GSADF for our research

Test	Null hypothesis	Alternative hypothesis
ADF	Existence of unit root	Absence of unit root
SADF	Existence of unit root	Single episode of exuberance in budget deficits
GSADF	Existence of unit root	Multiple episodes of exuberance in budget deficits

Table IV: Difference between SADF and GSADF tests

SADF Test	GSADF Test
Window widths not flexible	Window widths flexible
τ_1 are the starting point fixes as the first observation of the sample	The starting point to vary within the range $[0, \tau_2 - \tau_0]$
Single episode of exuberance	Multiple explosiveness

Table V: Some descriptive statistics of the budget deficit, 1970–2019

Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
-1257.246	-604.5	-42	-5986.8	1623.364	-1.720039	4.624326

Table VI: The Perron test with structural breaks of the Budget deficit (sample: annually data 1970 –2019)

	Level	
	t-statistic	**Break date**
DEFICIT	-9,840618	2011

Critical values of Perron test are: -5,92 -5,23 -4,92
Source: author calculate

Table VII: The GSADF test of the Budget deficit (sample: annually data 1970 – 2019)

		Critical value		
		99% level	95% level	90% level
GSADF	7.20455	7.427711	3.992450	3.057068

Source: author calculate

Table VIII: Explosiveness periods in the budget deficit: the GSADF test

Starting Date	Ending Date	Duration
1975	1978	2 years
1983	1984	3 years
2007	2007	1 year
2012	2014	3 years
2016	2017	1 year

Source: author calculate

Figure 1. Tunisian Budget Deficit: 1970-2019

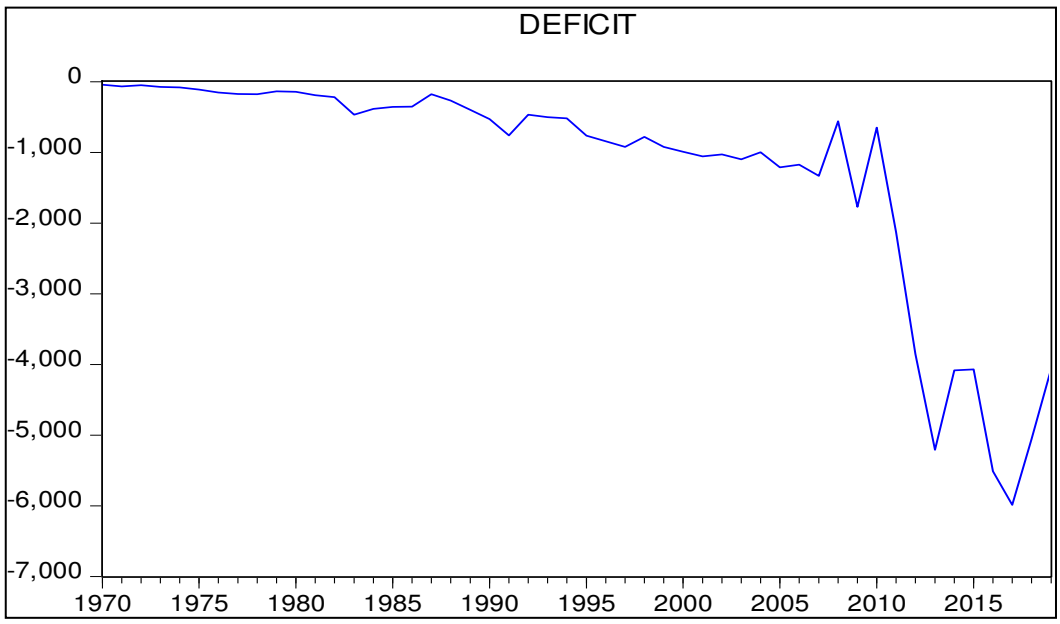

Figure 2. Date-stamping explosiveness periods in the Budget Deficit: the GSADF test