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Abstract

The main objective of this study is to examine the sustainability of fiscal policy using a nonlinear model approach and a smooth transition autoregressive model (STAR), based on quarterly data ranging from 1964 Q4 to 2012 Q4 on the Algerian budget balance as a percentage of GDP. The results clearly show the existence of threshold effects in the Algerian budget deficit (nonlinear behavior and shift in fiscal policy regime) in the form of a Logistic model (LSTR) containing 2 regimes with one threshold, and depending on the third lag in oil price. Thus, the results support the active deficit and debt management hypothesis, when there is a deviation of the deficit ratio from its equilibrium. Moreover, government authorities intervene by cutting deficits and worsening debt only when they have reached a certain threshold (US $ 83.53 per barrel). On the other hand, nonlinear unit root tests accept the null hypothesis of the unit roots and reject the alternative hypothesis for the stationarity of the STAR nonlinear model. This means that the time series of budget balance is not stationary (not mean reverting characteristic), and therefore cannot sustain the budget deficit in Algeria over the long term. However, the effect of a shock with the same magnitude, but with different sign, will have the same effect on the speed of adjustment towards equilibrium. Moreover, the break dates coincides with the beginning of the sharp rise or a drop in oil prices, which confirms the results of the selection of transition variables in the nonlinear model.

JEL Classification: E62; H62; C22.

Keywords: Fiscal Policy; Sustainability; Threshold effects; STAR models; stationarity.

ملخص

الهدف الرئيسي من هذه الدراسة هو بحث مدى استدامة السياسة المالية باستخدام نهج نموذج غير الخطي ونموذجا الانحدار والانتقالية السلس ، استنادا إلى بيانات ربع سنوية تتراوح ما بين 1964 الربع الرابع إلى 2012 الربع الرابع على توازن الميزانية الجزائري كنسبة مئوية من الناتج المحلي الإجمالي . تظهر النتائج بوضوح وجود آثار العجز في الميزانية الجزائري (السلوك غير الخطي والتحول في نظام السياسة المالية) في شكل نموذجا لوجستية (LSTR) التي تحتوي على 2 من الأنظمة بحد واحد، وتبعا لتأخر الثالث في أسعار النفط . وهكذا، فإن النتائج تدعم فرضية إدارة النشاط العجز والديون، عندما يكون هناك انحراف لنسبة العجز من توازنه. وعلاوة على ذلك، فان السلطات الحكومية تتدخل عن طريق خفض العجز وتفاقم الديون إلا عندما تصل إلى حد معين (83.53 دولار أمريكي للبرميل). من ناحية أخرى، فبالنسبة للاختبارات غير الخطية لجذر الواحد هناك قبول لفرضية العدم من جذور الوحدة ورفض فرضية بديلة للسكون من الطراز غير الخطي. وهذا يعني أن السلسلة الزمنية من توازن الميزانية ليست ثابتة ، وبالتالي لا يمكن الحفاظ على عجز الميزانية في الجزائر على المدى الطويل. ومع ذلك، فإن تأثير صدمة من نفس الحجم، ولكن مع علامة مختلفة، يكون له نفس التأثير على سرعة التكيف نحو التوازن. وعلاوة على ذلك، تتزامن حدود التواريخ مع بداية الارتفاع الحاد أو الانخفاض في أسعار النفط، وهو ما يؤكد نتائج اختيار المتغيرات التي تمر بمرحلة انتقالية في النموذج غير الخطي.

1. Introduction

The topic of fiscal policy sustainability has received much attention during the last two decades, as budget deficits in developed and emerging countries have deteriorated. Questions have been raised by various commentators, investors and analysts whether public finances in the EU countries and in the US are on a sustainable track.

After the financial crisis of 2008-2009, the public debt of many countries has been on a steep upward trajectory due to implementation of various stimulus and relief packages directed to financial sector and the economy as a whole. A rising debt combined with long-term issues like the demographic change, which affects the balance between number of people in the labor force and number of retirees, have alerted fiscal authorities to the need to study the problem in detail. In fact, some European countries like Greece, Ireland, Portugal, Spain and Italy are currently in serious trouble with their public finances, which is reflected in the high yield demanded from the government bonds of these countries.

In less developed countries, the public sector is usually more fragile and prone to shocks than in developed countries. This is because the public sector of these economies is more vulnerable to exchange rate fluctuations, commodity price fluctuations (like the price of oil), changes in interest rate on government debt, sprees of high inflation and political turmoil.

In resource-rich countries, the fiscal framework should provide a set of tools to achieve two interrelated objectives: ensure long-term sustainability and intergenerational equity, and manage revenue volatility and uncertainty.

As far as Algeria is concerned, the transition from fiscal austerity policies under the structural adjustment program to expansionary fiscal policies has been expressed by the high volume of public spending, which has risen from 28.19% of GDP in 1996 to 43% in 2009 (the government has injected about $500 billion in public expenditure between 2004 and 2013). In this regard, government employment in Algeria remains a greater burden on the state budget, where wages increased three times over the last four year the average net monthly wage in the public sector in 2012 increased by 9.1 %, compared to 2011 (wages amounted to 26 thousand billion Algerian dinars, equivalent to 26 billion Euros). In addition, social transfers reached more than $156 billion during the period 1999-2012 (which is equivalent to 10 percent of GDP, and more than a quarter of the state's whole budget). Also, the levels of subsides multiplied 7.5 times since 1999 (30% of GDP in 2013). Furthermore, the value of Algeria's imports increased between 2001 and 2013 by 44.9 billion dollars, at a rate of 81.7%.

On the other hand, the Algerian financial authorities overlooked the other side of fiscal policy, so that it did not reflect their revenue collection capacity. We know that the state is losing about 100 billion Algerian dinars annually as a result of fraud and tax evasion, (which is equivalent to about 75% of the value of regular taxes collected). In addition, Algeria is expected to lose about $5 billion annually as a result of the abolition of the customs tariff in the case of the signing of the Convention on the Euro-Mediterranean Partnership, and its accession to the World Trade Organization, which will lead to a decline customs duties within the budget revenues, which represents more than 3% of GDP. Moreover, with the expected depletion of hydrocarbon resources over the next 50 years, gas and oil production decreased by 8% and 17% respectively, especially knowing that the Algerian economy is heavily reliant on hydrocarbons, which is exceeding 30 % of GDP, 95 % of export earnings and 60 % of budget revenues. As a result of higher spending and stable revenue, the fiscal deficit widened significantly during the last five years, as it moved from the surplus of 8.61 % in 2008 to a deficit of 6% in 2009, and from 1.2% of GDP in 2011 to 4.0% in 2012 (from 44.7 % to 45.3 % of NHGDP).

All of these challenges require us to ask the following important questions: First, are Algerian public finances meeting their intertemporal budget constraint? Second, is the sustainability of budget deficits robust to structural breaks and/or shifts in fiscal policy regimes? Third, is there any evidence of asymmetric and/or non-linear fiscal adjustment back to equilibrium? And what is the speed of the process of fiscal consolidation?

In this context, the aim of this paper is to analyze the technical basis of financial soundness and state solvency, and provide some evidence on the sustainability of budget deficits in Algeria, especially when fiscal policy is conducted as a nonlinear process. This has hardly been dealt with in the literature.

From a theoretical point of view, the traditional approach to the analysis of the sustainability of budget deficits has tested whether the government's intertemporal budget constraint (IBC) holds, that is, whether the current level of current debt to GDP should be equal to the total discounted current and expected future surpluses as expressed as percentages of the GDP, which means the stability of budget deficit. This is known as the transversality condition, which implies that no Ponzi games are allowed, or, in other words, the non-issuance of new debt to meet interest payments on old debts (snow ball effect).

Empirical tests on sustainability, however, do not provide a consensus on this issue because results vary with the theoretical framework, the sample period, the specification of the transversality condition, and the econometric methodology used. Several procedures to test for the IBC have been proposed in the literature, which mainly focus on the univariate properties (testing the stationarity) of the government deficit or debt, the presence of a long-run, linear, cointegration relationship between variables of the budget constraint, and examining the feedback from debt to deficit. Recent work provides evidence on threshold effects in public debt and fiscal deficit using: threshold autoregressive (TAR) models, smooth transition autoregressive (STAR) models, Markov switching model, and reveals nonlinearities in fiscal policy.

Descriptive analysis of fiscal sustainability in Algeria are based on IMF's new toolkit for designing fiscal rules that aim to smooth revenue volatility and ensure long-term fiscal sustainability in resource-rich countries. The toolkit includes intergenerational equity (permanent income Hypothesis PIH) and price-based rule models (a good approach for managing oil price volatility) (IMF 2012, 2014).

In the empirical study, our data consist of quarterly observations for Algeria over the period of 1964 Q4 to 2012 Q4. We will also use a smooth transition autoregressive (STAR) model and its unit root test, in order to detect the nonlinear behavior of the budget deficit. Our goal is to find a threshold value of transition variable that requires decision-makers to make an adjustment in Algerian fiscal policy, as well as calculate the speed transition from one regime to another, and estimate the transition function. For that matter, we have included some exogenous threshold variables dictated by economic reality or economic theory, such as dependency of fiscal policy on the oil price, the orientations of government's public spending, as well as lag of dependent variable (8 lags maximum for each transition variable).

The remainder of this paper is organized as follows: section one deals with the theoretical foundation of fiscal sustainability, whereas a descriptive analysis of fiscal framework considerations in Algeria is presented in section two. Detailed empirical evidence is presented in section three. Section four focuses on the methodology used, while section five includes a presentation of the main empirical results. The last section proposes some conclusions and recommendations for decision-makers

2. Theoretical Issues

In the literature, there is a lack of clear consensus among economists about the definition of public finance sustainability. In fact, many research papers in the area of sustainability introduce their own criteria for sustainability that are in many ways similar but not identical[1]. One definition is that a government should be able to meet its obligations if and when they arise in the future (i.e., can continue into the projected future without any changes in taxation or spending patterns).

Blanchard (1990) defines sustainable fiscal policy as a policy that ensures that the ratio of debt to GDP converges back towards its initial level. A similar definition is provided in Buiter (1985), who calls a fiscal policy sustainable if it maintains the ratio of government net worth to GDP at the present level.

The requirement of convergence of the debt ratio towards its initial level is only a special case of a more general definition, which states that fiscal policy is sustainable if the present value of future primary surpluses is equal to the current level of debt.

Consequently, to assess public finance sustainability there are seven different approaches[2]: summary indicators of sustainability, econometric tests, Value-at-Risk framework, fiscal limits and fiscal space, general equilibrium models, "Fan-Chart" Approach, and generational accounting. Each approach is described and analyzed based on research found in the literature [for more details see: Sarvi (2011)].

Summary indicators[3] are the most commonly used practical tool in sustainability assessments. They are based on projections of future public debt and give the budgetary adjustment required to satisfy the IBC or reach a target debt level. Econometric tests are statistical tests for various theoretical sustainability criteria that can be used to determine whether a given criterion holds in the data[4]. Value-at-Risk framework uses stochastic simulations of the public sector balance sheet to study the degree of public sector solvency. It gives an estimate of a probability distribution for government's future net asset position[5]. Fiscal limits[6] and fiscal space[7] attempt to estimate a public debt ceiling for a country based on assumed constraints to government's fiscal policies. General equilibrium models[8] are detailed large-scale frameworks that assess sustainability based on comprehensive modeling of the whole economy. Generational accounting[9] analyses sustainability by comparing the net tax burden of current and future generations. Fan charts[10] summarize risks to debt dynamics by representing the frequency distribution of a large sample of debt paths generated by means of stochastic simulations, and derived from the "marriage" between the pattern of shocks on the one hand and the endogenous response of fiscal policy on the other.

[1] A good survey is provided in Balassone and Franco (2000), Krejdl (2006) and Sarvi (2011).

[2] See table 1 in appendix for strengths and weaknesses of each of the approaches.

[3] These indicators are: Finite and infinite horizon tax gap indicator (equivalent to the S1and S2 indicators used by the European Commission), Financing gap (Giammarioli et al. (2007)), Primary gap (Buiter et al. (1985)).

[4] See the following Empirical Literature.

[5] See Barnhill and Kopits (2003) and Sarvi (2011).

[6] This approach appears in Bi (2010), Cochrane (2010) and Leeper and Walker (2011a).

[7] This approach developed by Ostry et al. (2010).

[8] Three papers that analyse public finance sustainability by using: general equilibrium overlapping generations (GE-OLG) model by Moraga and Vidal (2004), application of applied GE-OLG model by van Ewijk et al. (2006) and application of computable GE-OLG model by Andersen and Pedersen (2006).

[9] See Auerbach et al (1991), Gokhale (2008), and Sarvi (2011).

[10] See IMF (2007).

The most straightforward way to assess the fiscal sustainability position is to start from a government's intertemporal budget constraint. The one-period government intertemporal budget constraint can be written in nominal terms as:

$$G_t - T_t + i_t B_{t-1} = \Delta B_t + \Delta M_t = -S_t \qquad (1)$$

Where G = government expenditure, T = tax revenue, B = government debt at the end of period t,

M = monetary base, S = total budget surplus, i = interest rate on government debt. The correct implementation of the budget constraint requires the use of the net market value of debt. Net debt

is defined as gross debt minus financial assets. Dividing each term in (1) by nominal GDP we obtain the budget constraint in terms of proportions of GDP:

$$g_t - \tau_t + (i_t - \pi_t - \eta_t) b_{t-1} = \Delta b_t + \Delta m_t + (\pi_t + \eta_t)\, m_{t-1} = -s_{t_t} \qquad (2)$$

where the lower-case letters g, τ, b, m, and s denote the ratio of the corresponding upper-case variables to nominal GDP, $\pi_t = (p_t - p_{t-1}) / p_{t-1}$ and $\eta_t = (Y_t - Y_{t-1}) / Y_{t-1}$ with P and Y standing for the price level and real GDP. Equation (2) says that the interest-inclusive government deficit is financed by new bond issues, base-money creation and seignoirage. Equation (2) can be written as:

$$d_t + \rho_t b_{t-1} = \Delta b_t \qquad (3)$$

Where $d_t = g_t - \tau_t - \Delta m_t - (\pi_t + \eta_t) m_{t-1}$ is the primary government deficit expressed as a proportion of nominal GDP, and $\rho_t = i_t - \pi_t - \eta_t$ is the real *ex post* interest rate adjusted for real output growth. Equation (3) is an identity which holds *ex post* in time t. If $\rho_t \langle 0$ for all t then equation (3) is a stable difference equation which can therefore be solved backwards. This implies that the debt-GDP ratio b_t

remains finite for any sequence of finite primary deficits d_t. For constant ρ_t and d, the steady-state value of $b = -d / \rho_t$. But if $\rho_t \rangle 0$ for all t, the debt- GDP ratio will eventually explode for $d_t \rangle 0$. To avoid this, primary surpluses are required (i.e. $d_t \langle 0$). In this case (3) must be solved forwards and the intertemporal budget constraint obtained in order to determine whether the sum of expected future discounted surpluses are sufficient to meet the current level of the debt-GDP ratio. For constant ρ_t and d ($d_t \langle 0$) again $b = -d / \rho_t$.

To obtain the intertemporal budget constraint, first we re-write the budget constraint for period $t + 1$ in *exante* terms as:

$$b_t = E_t \left[(1 + \rho_{t+1})^{-1} (b_{t+1} - d_{t+1}) \right] \qquad (4)$$

Where b_t is known in period t, and expectations are taken conditional on information at time t. Solving (4) forwards and successively substituting out the future compound discounted debt-GDP ratio gives the n-period intertemporal budget constraint:

$$b_t = E_t \delta_{t,n}\, b_{t+n} - E_t \sum_{i=1}^{n} \delta_{t,i}\, d_{t+i} \qquad (5)$$

Where $\delta_{t,n} = \int_{s=1}^{n} (1+\rho_{t+s})^{-1}$ is the time-varying real discount factor n periods ahead, adjusted for real GDP growth rate. $\delta_{t,n}$ can also be written as $\delta_{t,n} = \alpha_{t+n} / \alpha_t$ where $\alpha_t = \int_{i=1}^{t} (1+\rho_i)^{-1}$.

Normalizing $\alpha_t = 1$, and Defining $X_t = \alpha_t b_t$ and $Z_t = \alpha_t d_t$ as the discounted debt-GDP and primary deficit-GDP ratios, respectively, enables equation (5) to be written as:

$$\alpha_t b_t = E_t \alpha_{t+n} b_{t+n} - E_t \sum_{i=1}^{n} \alpha_{t+i} d_{t+i} \quad \text{or as} \quad X_t = E_t X_{t+n} - E_t \sum_{i=1}^{n} Z_{t+i} \qquad (6)$$

The one-period budget constraint, equation (3), can also be written in discounted terms as:

$$Z_t = \Delta X_t \qquad (7)$$

and equation (4) can be written as: $X_t = E_t (X_{t+1} - Z_{t+1})$.

A necessary and sufficient condition for sustainability is that as *n* goes to infinity, the discounted value of the expected debt-GDP ratio converges to zero. This is also known as the transversality condition, and implies that no Ponzi games (NPG) are allowed, meaning no new debt is issued to meet interest payments. This condition can be expressed as:

$$\lim_{n\to\infty} E_t \delta_{t+n} b_{t+n} = \lim_{n\to\infty} E_t X_{t+n} = 0 \qquad (8)$$

It then follows that the current debt-GDP ratio is offset by the sum of current and expected future discounted surpluses expressed as a proportion of GDP, implying that the government budget constraint holds in present value terms[11] with:

$$b_t = -\lim_{n\to\infty} E_t \sum_{i=1}^{n} \delta_{t,i} d_{t+i} \qquad (9)$$

$$X_t = -\lim_{n\to\infty} E_t \sum_{i=1}^{n} Z_{t+i} \qquad (10)$$

Two things are important to note. First, the transversality condition, equation (8), does not require that the debt-GDP ratio goes to zero, only that it does not grow faster than the growth-adjusted real discount rate. In principle, current debt can be sustained by any sequence of primary deficits or surpluses that satisfies equations (9) and (10), meaning that they offset the current level of debt. Second, if fiscal policy were not sustainable, a future policy change would be required in order to satisfy the transversality condition. Provided this change of policy is expected at time *t*, equation (9) can still hold even though the process generating the primary deficit would not then be structurally stable in the sense that the future policy change would cause a structural break (Uctum and Wickens (2002), P: 202).

In this regard, more recent work has emphasized the importance of non-linearity in fiscal policy. This nonlinearity may arise if we expect fiscal authorities to react differently to whether the deficit has reached a certain threshold deemed to be unacceptable or unsustainable (Statistically, this implies that the variable may behave as an I(1) process within the aforementioned threshold). Bertola and Drazen (1993) develop a framework which allows for trigger points in the process of fiscal adjustment, such that significant adjustments in budget

[11] Whether Z_t is a strongly or weakly exogenous process, a necessary and sufficient condition for the transversality condition given by (9) to be satisfied is that, if X_t is structurally stable, then it should be a zero-mean stationary process.

deficits may take place only when the ratio of deficit to output reaches a certain threshold[12]. This may reflect the existence of political constraints that block deficit cuts, which are relaxed only when the budget deficit reaches a sufficiently high level deemed to be unsustainable (Bertola and Drazen, 1993; Alesina and Drazen, 1991)[13].

3. Fiscal Framework Considerations in Algeria

For resource-rich countries, and with the expected depletion of hydrocarbon resources over the next years, a fiscal framework should provide a set of tools to achieve two interrelated objectives: (i) ensure long-term sustainability and intergenerational equity, and (ii) manage revenue volatility and uncertainty.

In this context, the IMF (2012) has developed a new toolkit for designing fiscal rules that aim to smooth revenue volatility and ensure long-term fiscal sustainability in resource-rich countries. The toolkit includes intergenerational equity and price-based rule models. The starting point of the long-term sustainability analysis is the permanent income hypothesis (PIH)[14]. Alternative approaches have been proposed in the literature to account for temporary investment needs—and thus lower accumulation of fiscal savings than the PIH, in at least some periods. In such cases, the PIH is combined with temporary escape clauses to accommodate temporary modifications of public spending. These are the Modified PIH (MPIH) and the Fiscal Sustainability Framework (FSF).

The Algerian economy is heavily reliant on hydrocarbons, which account for about 30 percent of GDP, 95 percent of export earnings and 60 percent of budget revenues. Fiscal policy is not on a sustainable trajectory while—with hydrocarbon resources[15] expected to be depleted within the next 50 years—it should be geared toward the preservation of wealth for future generations. The current section examines options and strategies for designing a fiscal framework for Algeria to achieve this objective, building on the recent IMF (2012) guidance papers on fiscal frameworks for resource-rich countries.[16]

Algeria's fiscal framework is based on a saving rule based on the current oil price: above the threshold of US$37 per barrel, oil revenue is saved into the oil stabilization fund (Fonds de Regulation des Recettes, or FRR). The FRR can be freely drawn upon for budget support, so that expenditure is disconnected from the saving rule. The framework lacks credibility in many respects. The effective price is more than twice the reference saving price; this, however, is not binding because of the uncapped annual drawdown from the FRR (Figure 1). Moreover, the FRR—which is housed at the central bank—yields low effective returns by international standards.

In this context, IMF (2014) Simulations indicate that the Algerian NHPD consistent with the PIH rule would be 11 % of NHGDP (Figure 2)[17]. This benchmark is derived by accounting for the actual saving in the FRR[18]. In fact, unless a country starts with a high level of debt, the PIH

[12] This state dependent two regime process will imply that the further the fiscal balance deviates from the equilibrium, the faster will be the mean reversion.

[13] For more details, see: Chibi, Benbouziane and Chekouri (2014).

[14] The PIH assumes that a country maintains a constant ratio of the nonhydrocarbon primary balance (NHPB) to NHGDP, equal to the implicit return on the present value of future natural resource revenue plus accumulated net financial savings.

[15] For Hydrocarbon Proven Reserves in Algeria, see Figure 1 in appendix.

[16] This section is taken from the IMF Country Report No. 14/34, were prepared by Sampawende. A.-J. Tapsoba (FAD).

[17] For long-term sustainability analysis in resource-rich countries, the non-resource primary balance (NRPB) is a good measure of the macro-fiscal stance. The NRPB identifies the impact of government operations on domestic demand, because resource revenues typically originate abroad.

[18] The real rate of return on financial assets in dollar terms is assumed to be around 6.6 %. This is based on the typical breakdown of a savings fund, as follows: 91 % is invested in fixed-income assets, 5 % in cash holdings, and 4 % in global equities. The rate of return of each class of assets is as follows: 5.2 % for fixed-income assets, 1.8 % for cash-based assets, 7,5% for global equity, and 7 % for other assets.

exercise will deliver a deficit. Cumulative savings would stand at around 458 percent of NHGDP by 2050. Under the MPIH, the target for the NHPD-to-NHGDP ratio would temporarily be 15 percent, to accommodate an investment increase. This should be compensated by a long period of lower deficits until around 2040, and thereafter should stabilize at the PIH benchmark. In this case, cumulative savings would converge to the PIH level after 2040. Under the Fiscal Sustainability Framework (FSF), the NHPD-to-NHGDP ratio closely tracks with the MPIH outcome, though it would stabilize at 8 percent in the long term. Lower deficits reflect the positive impact of higher investment.

Moreover, the NHPD-to-NHGDP ratio in 2013 is estimated to be about 34 % higher than the PIH benchmark (Figure 3, Panel 1). The gap narrows to about 15.5 % by 2018. Significant fiscal consolidation, 20 % of NHGDP, would therefore be necessary to bring fiscal policy onto a sustainable footing. The PIH implied reference saving price rule could be between US$25 and US$21.5 more stringent levels than the current one (Figure 3, Panel 2). In addition, the application of the PIH-type rule would strengthen Algeria's financial position. As a result of a saving rule preserving resource wealth for future generations, the reserves coverage will increase significantly in the medium term and would surpass the current projections by almost 18 months of imports coverage (Figure 3, Panel 3).

As shown previously, the medium-term deficit remains far from the PIH benchmark, which would imply fiscal consolidation of an unrealistic magnitude; however, a price-based rule could provide a transitional anchor toward the PIH benchmark. Price-based rules are a good approach for managing price volatility. For Algeria, three smoothing rules are simulated: the price rule 5/0/0, the price rule 5/1/5, and the price rule 12/1/3[19]. Figure 4 shows a simulation of the realized oil price that Algeria would receive as well as reference prices implied by the three price rules. All three rules smooth prices. The price rule 5/0/0 tracks closely with the effective price. The rule 12/1/3, with its reliance on a long historical price series, provides for the most smoothing of prices.

Under all scenarios, the realized NHPD-to-NHGDP ratio converges to the PIH benchmark by 2022 (Figure 5). This contrasts with the current observed trend of Algeria's fiscal policy. Price-based rules lead to higher saving than the current projected FRR level. The price rule 12/1/3, with a longer backward-smoothing rule and the future price, performs well and generates the highest savings. The price rule 5/1/5, with short smoothing windows for both past and future prices, leads to higher volatility with lower but still sizeable financial savings. The price rule 5/0/0 yields somewhat similar volatility to that of the 5/1/5 formula but is consistent with financial savings. Backward-looking price rules tend to be adequate for Algeria from a practical standpoint. The price rule 5/0/0 presents the advantage of not requiring any forecasting exercise, contrary to the price rule 5/1/5, and incorporates changes in price trends with shorter lags than in the price rule 12/1/3. In particular, the price rule 5/0/0 scores well by reining in volatility and by leading to a strong financial position.

The price-based rule could be further supplemented with a structural balance (SB) rule. For Algeria, two different structural primary balance rules are simulated using the price rule 5/0/0, with the constraint of preserving the size of the FRR. Accordingly, IMF (2014) simulates a structural balance rule that preserves real wealth until 2033. This requires a structural surplus of 5 percent. In addition, it also displays in Figure 6 the previous 5/0/0 rule that corresponds to a structural equilibrium of the budget (strictly structural surplus). The realized NHPD-to-NHGDP ratio varies across different structural balance targets. The 5 percent SB rule would

[19] The numbers in the price rule refer, in order, to the number of years in the past, present, and future used to calculate the expenditure path. Thus, the 5/0/0 price rule uses oil prices for the past five years only to calculate the smoothed resource revenue. A 12/1/3 price rule uses prices for the past 12 years, the current price, and prices forecast for the following three years.

anchor fiscal policy to the PIH benchmark by 2026. With the end of oil, the target has to be adjusted to -1 percent to ensure smoothed spending profile. Cumulated financial saving will stand at comfortable levels at about 112 percent of NHGDP by 2050, with real wealth increasing after 2033. At the other extreme, a rule that targets a structurally balanced budget would delay the convergence toward the long-term anchor and lead to negative financial saving (about -52 percent of NHGDP by 2050). Real wealth tapers off and will be rapidly in a negative territory. Likewise, under the current policy course, the return to the long-term sustainability level is further delayed, which leads to financial dissaving and negative real wealth. This will lead Algeria to accumulate debt of about 88 percent of NHGDP by 2050.

4. Empirical Literature

The empirical studies on debt sustainability have been numerous in the last decade and have gained extreme importance after the last financial and debt crises occurred worldwide. However, empirical tests on sustainability do not provide a consensus on this issue because results vary with the used theoretical framework, sample period, specification of the transversality condition, and econometric methodology.

Three empirical frameworks have been used in the empirical literature. The first rests mainly on testing stationarity of the various fiscal variables (government deficit or debt), while the second employs cointegration techniques and explores the existence of a long-run equilibrium relationship between the fiscal variables of interest[20]. The third measures the feedback from debt to deficit[21].

Under the first framework, if the deficit series is non-stationarity, then it means that it is growing without bound over time, which means that subsequent debt will also grow without bound, rendering fiscal policy unsustainable. This will also violate Present Value Budget Constraint (PVBC) and the No-Ponzi-Game (NPG) constraints. A stationary deficit means that the series is reverting to a certain mean overtime being in general close zero. If that were the case, then obviously fiscal policy and debt would be sustainable, since deficits will be under control, oscillating between small deficits and surpluses overtime.

Within this context, empirical studies on developed economies are numerous and were initiated by the paper of Hamilton and Flavin (1986). Using yearly data for the US, covering the period 1962- 1984, they tested the validity of the PVBC, or equivalently the NPG condition, or the budget constraint. In their study, if the government deficit and debt series are stationary then debt is sustainable, which was the case for the US sample used. Also, using yearly data for the US economy over a larger sample covering respectively the periods: 1890-1983 and 1960-1984, Trehan and Walsh (1988, 1991) looked at the stationarity of public deficits and debt, and concluded that since they were stationary for both sample periods, then debt is sustainable. However, Kremers (1988) and Wilcox (1989) show that Hamilton and Flavin’s unit root tests suffer from the problem of serial correlation in residuals; once serial correlation is accounted for the findings of stationarity are reversed and the US primary surplus and debt become non-stationary.

However, these results may be biased since they do not take into account the possibility of regime shifts in fiscal policy. Another reason is that public debt and deficits present non-linear behavior, which is not taken into account in previous studies. Most of the studies that tested for the presence of these shifts, consider models with structural breaks or threshold effects in the

[20] For details, see: Haug, (1991); Smith and Zin, (1991); Hakkio and Rush,(1991); Ahmed and Rogers ,(1995); Quintos,(1995); Martin ,(2000). Other studies using a cointegration framework to test the validity of the IBC in Europe include Bravoand Silvestre (2002) and Afonso and Rault (2010) for eleven and teen EU countries respectively. Both studies reach mixed results with regards to the validity of the IBC in their sample countries.

[21] For details, see: Wickens and Uctum ,(1993); Bohn ,(1998); Feve and Henin, (2000); Uctum et. al.(2005).

behavior of the budget deficit, where the breakpoints are either chosen arbitrarily (e.g., they are exogenous) or are endogenously determined.

In this regard, Sarno (2001) examined the public debt sustainability through a nonlinear model approach, using data on the 1916-1995 US public debt as a percent of GDP and an exponential smooth transition autoregressive model (ESTAR). The results clearly showed that during the observed period, the US public debt as a percentage of the GDP had a nonlinear, mean-reverting characteristic, rejecting the null hypothesis of unit root and supporting fiscal sustainability.

Similarly, Chortareas, Kapetanios, and Uctum (2008) analyses the sustainability of government debt for Latin American and Caribbean countries employing unit-root tests that incorporate a nonlinear alternative in the form of an Exponential Smooth Transition Autoregressive (ESTAR) and self-exciting threshold autoregressive (SETAR) model with three regimes. They show that, in general, support for sustainability substantially improves when nonlinear mean reversion is taken into account. They also find that the results obtained from applying various tests with nonlinear alternatives, although broadly consistent, are not identical. This suggests that reliance on a single unit-root test for assessing fiscal policy sustainability may be misleading.

Using nonlinear stationary smooth transition autoregressive (STAR) process, Bahmani (2007) employ non-linear ADF test (KSS) and data from 28 countries, she fined support for stationarity of the deficits/GDP ratio in 50% of the countries in the sample.

Jibao et al., (2012), tested the asymmetry relationship between revenue and expenditure (i.e., making a distinction between the adjustment of positive (budget surplus) and negative (budget deficit) deviations from equilibrium). They used quarterly data on South Africa and an smooth transition autoregressive model (STAR). The authors found that fiscal policies were sustainable though the authorities in South Africa were more likely to react faster when the budget was in deficit than when in surplus and that the stabilization measures by government were fairly neutral at low deficit levels, that is, at quarterly deficit levels of 4% of GDP and below. They submitted that the increasing tension amongst local communities complaining about poor service delivery by the government could be a recipe for fiscal unsustainability.

Arghyrou and Luintel (2007) re-examine this issue on Greece, Ireland, Italy and the Netherlands by utilizing a new empirical approach and extended data sets. Issues of structural shifts and non-linear fiscal adjustment are tackled. They find that: (i) the fiscal path of these countries went through multiple shifts; (ii) most of these shifts correspond to important policy changes and/or external shocks; (iii) the government finances of all four countries satisfy the IBC across different time horizons; and (iv) fiscal disequilibrium adjusts non-linearly. They also find a clear positive Maastricht effect on the IBC of all countries.

Piergalliniy and Postigliolaz (2013) investigate the sustainability of Italy's public finances from 1862 to 2012, adopting a non-linear perspective. Specifically, they employ the smooth transition regression (STAR) approach to explore the scope for non-linear fiscal adjustments of primary surpluses in response to the accumulation of debt. Their results show the occurrence of a significantly positive reaction of primary surpluses to debt when the debt-GDP ratio exceeded the trigger value of 110 percent. The after threshold positive response implies that the path of Italy's fiscal policy is sufficiently consistent with the intertemporal budget constraint.

Juan Carlos Cuestas and Karsten Staehr (2011) analyze the time series properties of the fiscal balance in the 10 Central and Eastern European countries. The persistence of shocks in the variable has been analyzed by means of unit root tests that account for the possibility of non-linearities (ESTAR process) and structural changes. The results of the linear and non-linear unit root tests find only mild evidence in favor of the stationarity hypothesis, with asymmetric effects present in a few cases. After controlling for structural changes in the data generation process, the results point to stochastic stationarity of the series. Thus, in spite of relatively steady headline figures, the public balance processes exhibit substantial instability in the EU countries from Central and Eastern Europe.

Considine and Gallagher (2008) assess whether the UK public finances were sustainable for the period 1919 to 2001 using a nonlinear representation of the debt to GDP ratio and thus provide a more robust test of debt sustainability. Empirical evidence supports debt sustainability. Moreover, the ESTAR representation is evidence that sustainability is the result of active debt management rather than tax-smoothing. The results strongly support the active debt management hypothesis for the UK.

Chiung-Ju Huang (2006) examines the Taiwan public debt sustainability for the period of 1967:1 to 2006:4 using the public debt as a percentage of GDP. The results of linearity tests suggest that the debt-GDP ratio has nonlinear characteristics. But when applying a nonlinear model, the result of model selection shows that the debt-GDP ratio is better represented by the ESTAR than LSTAR. In addition, the estimation results of liner and nonlinear models indicate that nonlinear modeling could be used to calculate the adjustment behaviors better than the linear modeling. However, there is no strong evidence of nonlinear mean reversion in the debt-GDP ratio. That is there is no strong evidence to support the Taiwan public debt sustainability. Chiung-Ju Huang (2014) re-examines this issue, but he used an unrestricted two-regime threshold autoregressive (TAR) model with an autoregressive unit root. The empirical results show that Taiwan's public debt appears as a nonlinear series and is stationary in regime 1 but not in regime 2. This result implies that while Taiwan's public debt was mostly sustainable over the 1996 to 2013 period examined in the study, it may no longer be sustainable in the most recent two years as the public debt ratio has increased cumulatively to 3.618%.

5. Methodology

This empirical study uses the budget balance -GDP ratio (deficit or surplus) to examine the fiscal sustainability. We will use a smooth transition autoregressive (STAR) models in order to detect the nonlinear behavior of the budget deficit. Our goal is to find a threshold value of transition variable that require decision-makers to make an adjustment in Algerian fiscal policy, as well as calculate the speed transition from one regime to another, and estimate the transition function. Then, we examine the persistence of shocks in the variable, which will treat them by means of unit root tests that account for the possibility of non-linearities and structural changes.

5.1 Model specification

In time series analysis, there are many nonlinear time series models in the literature. Before introducing the Smooth Transition Autoregressive model, we will first look at a simple one: Threshold Autoregressive (TAR) model. The Threshold Autoregressive model can be considered as an extension of autoregressive models, allowing for the parameters changing in the model according to the value of an exogenous threshold variable s_{t-k} . If it is substituted by the past value of *y*, which means $s_{t-d} = y_{t-d}$, then we call it Self-Exciting Threshold Autoregressive model (SETAR). Some simple cases are shown as follows:

TAR model:

$$Y_t = \begin{cases} \phi_{10} + \phi_{11} y_{t-1} + \varepsilon_{1t} & if \quad s_{t-d} \leq c \\ \phi_{20} + \phi_{21} y_{t-1} + \varepsilon_{2t} & if \quad s_{t-d} \rangle\, c \end{cases}$$

Where *d* is the delay parameter, triggering the changes between two different regimes. These models can be applied to the time series data which has a regime switching behavior. However, the threshold value in the model here is discontinuous[22]. By replacing the threshold value with a smooth transition function, the TAR model could be generalized to the Smooth Transition Autoregressive (STAR) model. Now the observations y_t switch between two regimes smoothly in the sense that the dynamics of y_t may be determined by both regimes, with one regime having more impacts at some times and the other regime having more impacts at other times. Another interpretation is that STAR models actually allow for a "continuum" of regimes, each associated with a different value of $F(s_t)$. The smooth transition model is theoretically more appealing than the simple TAR models that impose an abrupt switch in parameter values. An abrupt switch only happens if all agents act simultaneously[23].

The smooth transition autoregressive model for a univariate time series of order p is defined as follows:

$$Y_t = \left(\phi_{10} + \sum_{j=1}^{p_1} \phi_{1j}\, x_{t-j}\right)\left[1 - F(s_t;\gamma,c)\right] + \left(\phi_{20} + \sum_{j=1}^{p_2} \phi_{2j}\, x_{t-j}\right) F(s_t;\gamma,c) + \varepsilon_t \quad ,\gamma\rangle 0 \tag{1}$$

x_t is the vector of explanatory variables containing lags of the endogenous variable and the exogenous variables (or the time trend). The transition variable s_t may be a delayed value of y as in SETAR models, but also an exogenous variable or function of exogenous variables. c is the threshold value, and γ determines the speed and smoothness of the transition. F stands for a continuous transition function usually bounded between 0 and 1. Because of this property, not only can the two extreme states be explained by the model, but also a continuum of states that lie between those two extremes.

The most popular functional forms of the transition function specified by Teräsvirta (1994) are as follows:

Logistic transition function: $L(s_t;\gamma,c) = \left[1 + \exp(-\gamma(s_t - c))\right]^{-1}$ (2)

The resulting model is referred to as logistic STAR or LSTAR model,

Exponential transition function: $E(s_t;\gamma,c) = 1 - \exp(-\gamma(s_t - c)^2)$ (3)

The resulting model is referred to as exponential STAR or ESTAR model.

If γ is small, both transition functions switch between 0 and 1 very smoothly and slowly; if γ is large, both transition functions switch between 0 and 1 more quickly (see Figure 2 in appendix). As $\gamma \to \infty$, both transition functions become binary. However, the logistic function approaches the indicator function $F(s_t > c)$ and the LSTAR model reduces to a TAR model; while the exponential function approaches the indicator function $F(s_t = c)$ and the model does not nest the TAR model as a special case.

[22] Although the TAR models allow for detecting non-linearity and was able to give a good economic explanation through some mechanism and observable transition variable, it suffers from some shortcomings, most notably, the transition variable value get away from the threshold does not change the explanatory variables parameters in a single system, but these transactions are affected only when the transition variable is larger or smaller than the threshold value.

[23] Change at the aggregate level will be adequately represented by a STAR model if the economy is made up of a large number of individuals or companies, each changes regime abruptly but at different dates. This non-simultaneity of individual behavior can indeed be justified by the fact that some individual or institutional agents can anticipate government action and begin their transition before the change of economic policy, while costs of information or adjustments may lead other agents to react with a delay to the action of the authorities. This justification can be expanded to include even some cases where the reactions of the individual agents are in themselves gradually and to varying degrees, caused by agent's behavioral myopia, which may be due to the presence of the costs of the transition, or stuck to habits. Add to that the uncertainty factor which imparts gradual property to the transition, since the economists agents do not trust in the continuation of the new economic policies, and therefore do not adjust their behavior immediately with the new system, but converge and adapt gradually with it after getting more information and skills across time.

The decision rules of choosing between LSTAR and ESTAR models are suggested by Teräsvirta (1994).

Once the transition variable s_t and the transition function $F(s_t;\gamma,c)$ have been selected, the next stage in the modeling cycle is estimation of the parameters in the STAR model. Estimation of the parameters in the STAR model is a relatively straightforward application of nonlinear least squares (NLS). Otherwise, the NLS estimates can be interpreted as quasi-maximum likelihood estimates (Franses and van Dijk (2003). P: 90). The estimation can be performed using any conventional nonlinear optimization procedure. Issues that deserve particular attention are the choice of starting values for the optimization algorithm, concentrating the sum of squares function and the estimate of the smoothness parameter γ in the transition function. It immediately follows that sensible starting value for the nonlinear optimization can be easily obtained by a two-dimensional grid search over γ and c. Therefore, a grid search is performed to pin down the starting values for the estimation that minimize the residuals sum of squared.

5.2 STAR unit root tests

We consider whether Y_t or its discounted version is stationary using unit-root tests that incorporate a nonlinear alternative. The first test, due to Kapetanios, Shin, and Snell (2002) henceforth KSS and Eklund (2003), considers the null hypothesis of a unit root against the alternative of a STAR model in a context similar to DF test[24].

The nonlinear form of an ADF equation corresponding to the class of STAR models is:

$$\Delta Y_t = \rho_1 Y_{t\text{-}1} + \rho_2 Y_{t\text{-}1} F(s_t;\gamma,c) + \varepsilon_t \tag{4}$$

KSS further impose the assumption that $\rho_1 = 0$. The reason is that in some economic contexts it is reasonable to assume that the variable displays a mean reverting behavior towards an attractor when it is sufficiently far away from it, but a random walk representation in the neighborhood of the attractor. In this case, we have that:

$$\Delta Y_t = \rho_2 Y_{t\text{-}1}\left[1 - \exp\left(-\gamma Y_{t\text{-}1}^2\right)\right] + \varepsilon_t \tag{5}$$

The test for the *joint* null hypothesis of linearity and a unit root can be achieved by testing $H_0 : \gamma = 0$ against $H_1 : \gamma > 0$. Using a first order Taylor series approximation to (4), we can obtain[25]:

$$\Delta Y_t = \delta Y_{t-1}^3 + error \tag{6}$$

The unit root test is based on the t-statistic for the null $H_0 : \delta = 0$ against the alternative $H_1 : \delta < 0$ from the OLS estimate of δ. The asymptotic distribution of this test t_{NL} ($NLADF = \dfrac{\widehat{\delta}}{s.e.(\widehat{\delta})}$) is non-standard and KSS derive it and provide asymptotic critical values.

In the presence of constants and trends, the data are first detrended/demeaned. The 1%, 5%, and 10% critical values for the detrended and demeaned data are –3.93, -3.40, and -3.13, respectively.

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[24] We refer to this test as the nonlinear augmented Dickey–Fuller (NLADF) test.

[25] Hence, Sollis (2009) proposes a KSS-type test, which distinguishes between asymmetric or symmetric effects under the alternative hypothesis (i.e., the speed of mean reversion will be different depending on the sign of the shock and not only its size). He proposes to test for unit roots in this non-linear framework using the auxiliary equation:

$$\Delta Y_t = \beta_1 Y_{t-1}^3 + \beta_2 Y_{t-1}^4 + error$$

The null hypothesis of symmetric STAR versus the alternative of asymmetric STAR.

5.3 Unit root tests allowing for structural breaks

The previous nonlinear unit-root test allows for structural change in a smooth process. But, a superficial visual inspection of the budget balance or other macroeconomic series suggests the presence of potential structural breaks, which reflect shocks rather than smooth change. For example, an economic series that conforms to a stationary process around a fixed mean, which undergoes a one-time shift, will appear to conform to a nonstationary process, unless one incorporates the shift in the mean. Following the seminal work of Perron (1989), we recognize that the presence of structural change can substantially reduce the power of unit-root tests. Zivot and Andrews (1992) propose a unit-root test that allows for an endogenous structural break. Lumsdaine and Papell (1997) extended the endogenous break methodology to allow for two endogenous breaks in the trend function. They find more evidence against the unit root hypothesis than Zivot and Andrews (1992), but less than Perron (1989). Lee and Strazicich (2003a) propose a one break Lagrange multiplier (LM) unit root test as an alternative to the Zivot and Andrews (1992) test, while Lee and Strazicich (2003b) suggest a two break LM unit root test as a substitute for the Lumsdaine and Papell (1997) test. In contrast to the ADF test, the LM unit root test has the advantage that it is unaffected by breaks under the null. In such situations, it is necessary to test for the possibility of a break using tests that account for these breaks. If there is a shift in the level of the DGP (data generating process), it should be taken into account in testing for a unit root because the ADF test may be distorted if the shift is simply ignored. In doing so, we use the unit root tests proposed by Saikkonen and Lütkepohl (2002). Therefore, a shift function may be added to the deterministic term of the DGP.

6. Empirical Results

To ensure efficient use of the statistical tests carried in the analysis, we need a sufficient number of observations. Thus budget balance quarterly data[26] are employed in this study. The data period is from the fourth quarter in 1964 to the fourth quarter in 2012 (193 observations). The data is compiled from national office of statistics, Ministry of Finance, WDI and IFS. The budget balance is measured as the ratio of central government budget balance (*overall* budget balance) to GDP. The use of the overall budget balance is consistent with previous studies of budget deficit sustainability[27].

The nonlinear model for the budget balance -GDP ratio (D), include some exogenous threshold variables dictated by economic reality or economic theory, such as dependency of fiscal policy on the oil price (O) in Algeria (see figure 3 in appendix), and also the orientations of governments public spending (G), as well as lags of dependent variable (8 lags maximum (2 years) for each transition variable). The next step in the specification phase is to run the linearity test[28]. The results are shown in Table 2.

As can be seen from Table 2, the linearity test results reject a linear model, and the selected transition variable is the third lag of oil price $O(t\text{-}3)$ (smallest F), with the suggested model is LSTR with one threshold as either F4 and F2 having the strongest rejection. These results show that the budget deficit (surplus) rate can be modeled with a smooth transition regression model containing two regimes (shift in fiscal policy regime), and the nonlinear dynamic process is governed by the third lag of oil price. Furthermore, the results support the active deficit and debt management hypothesis, when there is a deviation of deficit ratio from threshold.

Remarkably, the model is linear in the parameters when (γ; c) are fixed in the transition function. Therefore, a grid search is performed to pin down the starting values for the

[26] We converted the annual data to quarterly using a cubic transformation.

[27] Trehan and Walsh (1988) argue that the assessment of budget sustainability should be based on the time series properties of the value of the overall budget balance, inclusive of interest payments and seigniorage revenue.

[28] The results in this part were obtained with the JMulTi econometric package.

estimation that minimize the residuals sum of squared. The obtained starting values in Figure 7 are: γ = 8.1334, c = 72.7612, and SSR= -148.9428.

Table 3 reports the estimation results of linear and nonlinear models for deficit-GDP ratio D. The STAR obtains the higher R^2, lowest estimated variance. Most of the regression coefficients were significant and in both part at 5 and 10 percent level. The threshold value was estimated at US $ 83.53 per barrel, as the speed of transition (adjustment) from one regime to another was estimated at 6.82. Accordingly, The estimated Logistic transitional function will be: $L(s_t;\gamma,c)=\left[1+\exp(-6.82(O_{t-3}-83.53))\right]^{-1}$.

Figure 8 shows the transition function versus the transition variable. The vertical axis is the transition function and the horizontal axis is the transition variable. When the transition variable is less (higher) than 83.53 US Dollars per Barrel, and thus the transition function is less (higher) than 0.5, the economy is in low deficit (high deficit) regime.

Results of linear unit root tests (Table 4) showed that the budget balance time series is stationary as the calculated statistical values are smaller than the critical values (the null of a unit root can be rejected in favor of stationarity), However, this result may be misleading in the nonlinear unit root tests. Since the calculated statistical values are greater than the critical values, we accept the null hypothesis of the unit roots and reject the alternative hypothesis for the stationarity of the STAR nonlinear model. This means that the time series of budget balance is not stationary (not mean reverting characteristic), and therefore cannot sustain the budget deficit in Algeria over the long term. However, Sollis (2009)'s test shows that the effect of a shock with the same magnitude, but different sign, will have a same effect on the speed of adjustment towards equilibrium (acceptance of the null hypothesis of symmetric STAR).

This result was confirmed by using unit root tests with structural breaks (Table 5), as we reject the alternative hypothesis for the stationarity at the 1% level of significance for all tests. What can be seen is that each of the break dates coincide with the beginning of the sharp rise or a drop in oil prices, which confirms the results of the selection of transition variable in nonlinear model. As for the 1994 period, it has coincided with the application of the structural adjustment imposed reduction of the budget deficit.

7. Conclusion

The aim of this study is to analyze the technical basis of financial soundness and state solvency, and provide some evidence on the sustainability of budget deficits in Algeria, especially when fiscal policy is conducted as a nonlinear process, which has been hardly treated in the literature. Our goal is to find a threshold value for a transition variable that pushes decision-makers to make an adjustment in Algerian fiscal policy, as well as calculate the speed of transition from one regime to another, and estimate the transition function.

Descriptive analysis of fiscal sustainability in Algeria is based on the IMF's new toolkit for designing fiscal rules that aim to smooth revenue volatility and ensure long-term fiscal sustainability in resource-rich countries. IMF (2014) simulations indicate that the Algerian NHPD consistent with the PIH rule would be 11 % of NHGDP. The price rule 5/0/0 presents the advantage of not requiring any forecasting exercise, restraining volatility and leading to a strong financial position.

The results of empirical study clearly showed the existence of the threshold effects in the Algerian budget deficit (nonlinear behavior and shift in fiscal policy regime) in the form of a Logistic model (LSTR) containing 2 regimes with one threshold, and depending on the third lag in oil price. Thus, the results support the active deficit and debt management hypothesis, when there is a deviation of deficit ratio from its equilibrium. More specifically, government authorities would intervene by cutting deficits and worsening debt only when they have reached a certain threshold (US $ 83.53 per barrel). On the other hand, nonlinear unit root tests accept the null hypothesis of the unit roots and reject the alternative hypothesis for the stationarity of the STAR nonlinear model. This means that the time series of budget balance is not stationary (not mean reverting characteristic), and therefore cannot sustain the budget deficit in Algeria over the long term. However, the effect of a shock with the same magnitude, but different sign, will have a same effect on the speed of adjustment towards equilibrium. Moreover, the break dates coincide with the beginning of the sharp rise or a drop in oil prices, which confirms the results of the selection of transition variable in nonlinear model.

Based on these results, the Algerian fiscal framework should be:

- Managing oil price volatility by applying the price-based rules, which protect the budget from volatility. With this approach, windfall revenues are saved and drawn upon during difficult times.
- Managing resource funds for future generations (the FRR should be transformed into a full-fledged sovereign wealth fund SWF), and needs to be supported by an adequate institutional arrangement (Fiscal Responsibility Law, Organic Budget Law, Extractive Industries Transparency Initiative). On the other hand, the oil fund should be managed on a market basis. A SWF scheme could be explored and the reserve management capacity of the central bank should be strengthened.
- Extending the time horizon for hydrocarbon production, and increasing exports, will improve the prospects for Algeria’s oil wealth. This will require more foreign investment in the oil and gas industry, together with steps to rationalize domestic hydrocarbon consumption.
- Scaling up investment domestically in line with the Algeria’s need to build its capital stock to overcome infrastructure gaps and help support the diversification of the economy and the growth of a robust private sector. Such policies are also able to raise potential non-resource growth and create a virtuous cycle of increased fiscal space.

Finally, we note a limitation of our analysis. Compared to the quantiles AR approach (QAR), the non-linear methods such as the smooth transition autoregressive (STAR), threshold autoregressive (TAR) or Markov switching are not able to estimate conditional quantiles since they were originally proposed to estimate nonlinear models for conditional means (or variance). A second remark is that reliance on single types of unit-root tests when assessing fiscal policy sustainability may turn out to be misleading and therefore an array of tests should be used in order to obtain a confident result. Of course, a comprehensive assessment of fiscal policy sustainability would require the use of various other theoretical criteria in addition to further tests (cointegration test and feedback from debt to deficit).

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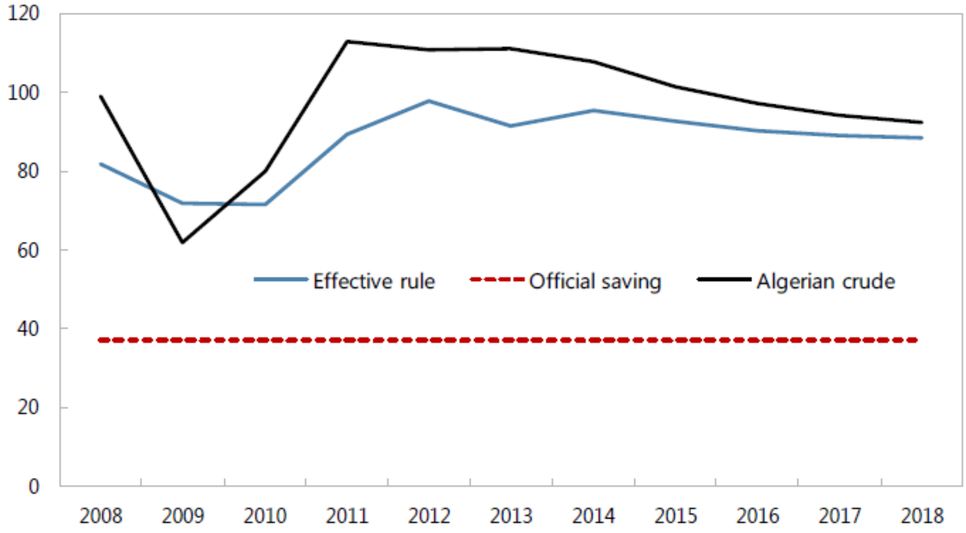
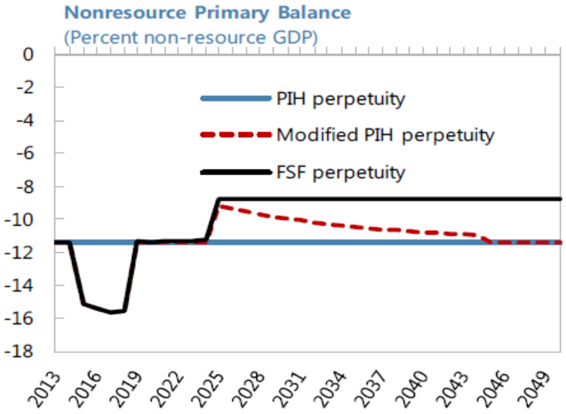
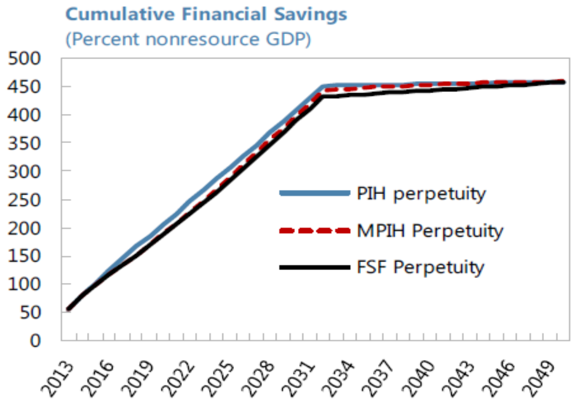
Figure 1: Algeria: Price Rules in the Actual Fiscal Framework, 2008–18



Sources: IMF Country Report No. 14/34. P: 27.

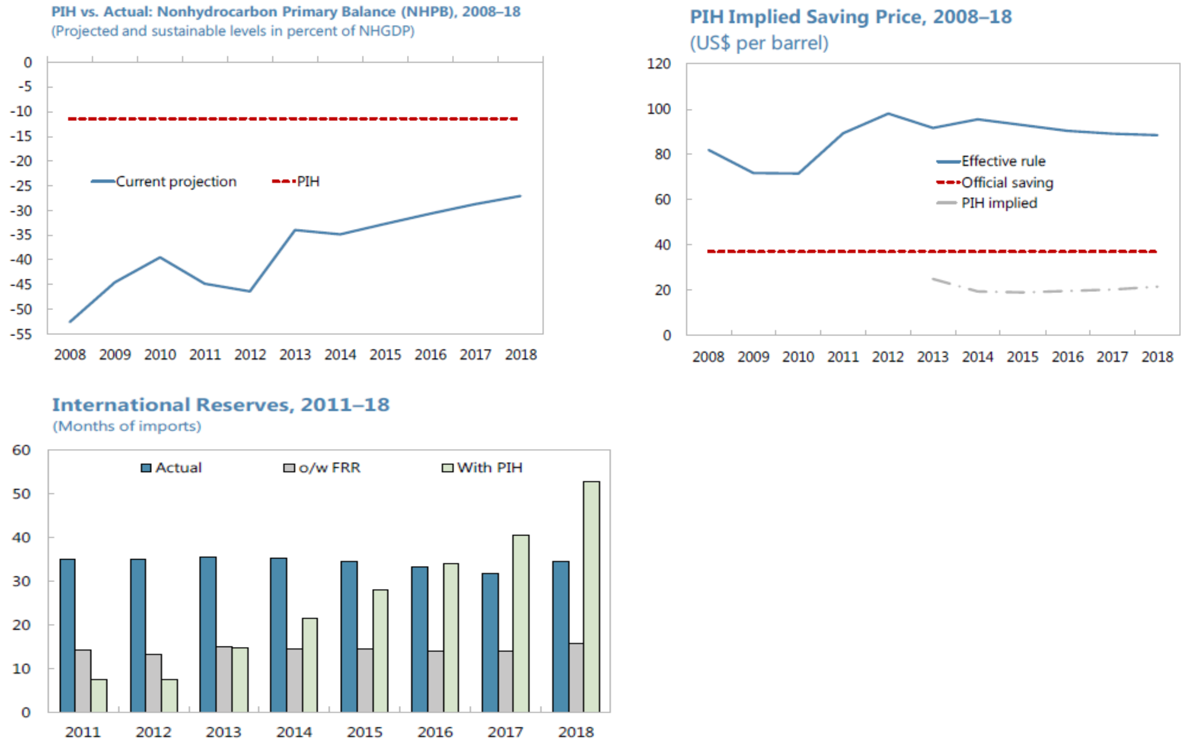
Figure 2: Algeria: Sustainability Assessment Indicators, 2013–50





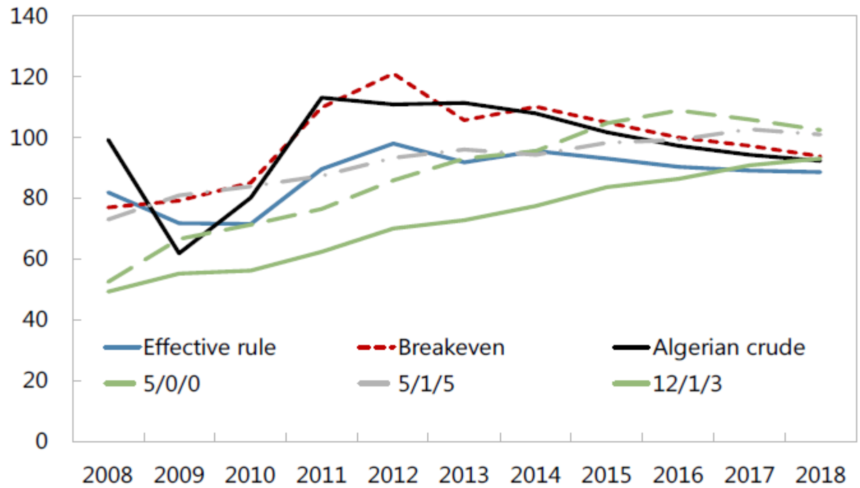
Sources: IMF Country Report No. 14/34. P: 32.

Figure 3: Algeria: Macroeconomic Implications of the PIH Rule



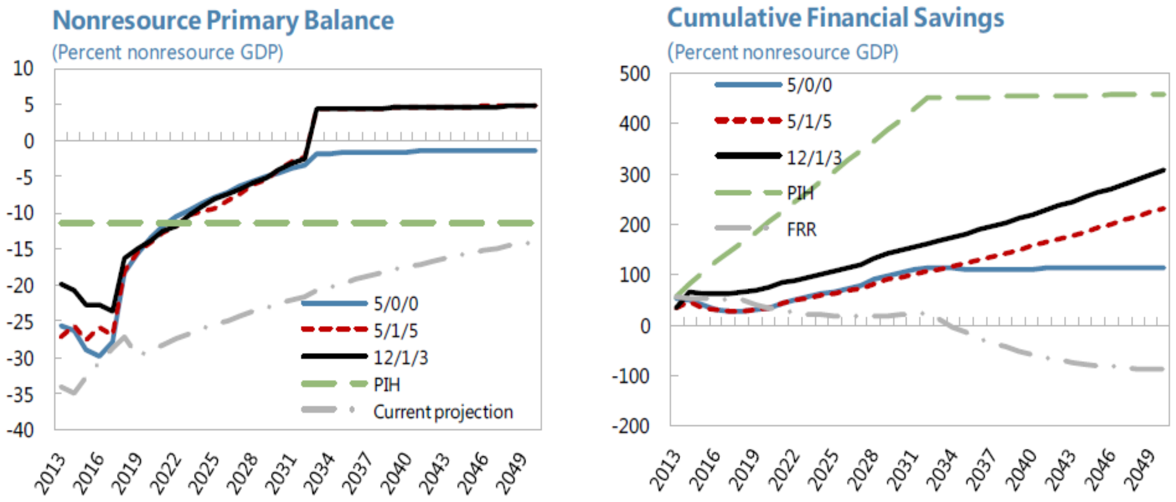
Sources: IMF Country Report No. 14/34. P: 33.

Figure 4: Algeria: Oil Price, 2008–18 (US$ per barrel)



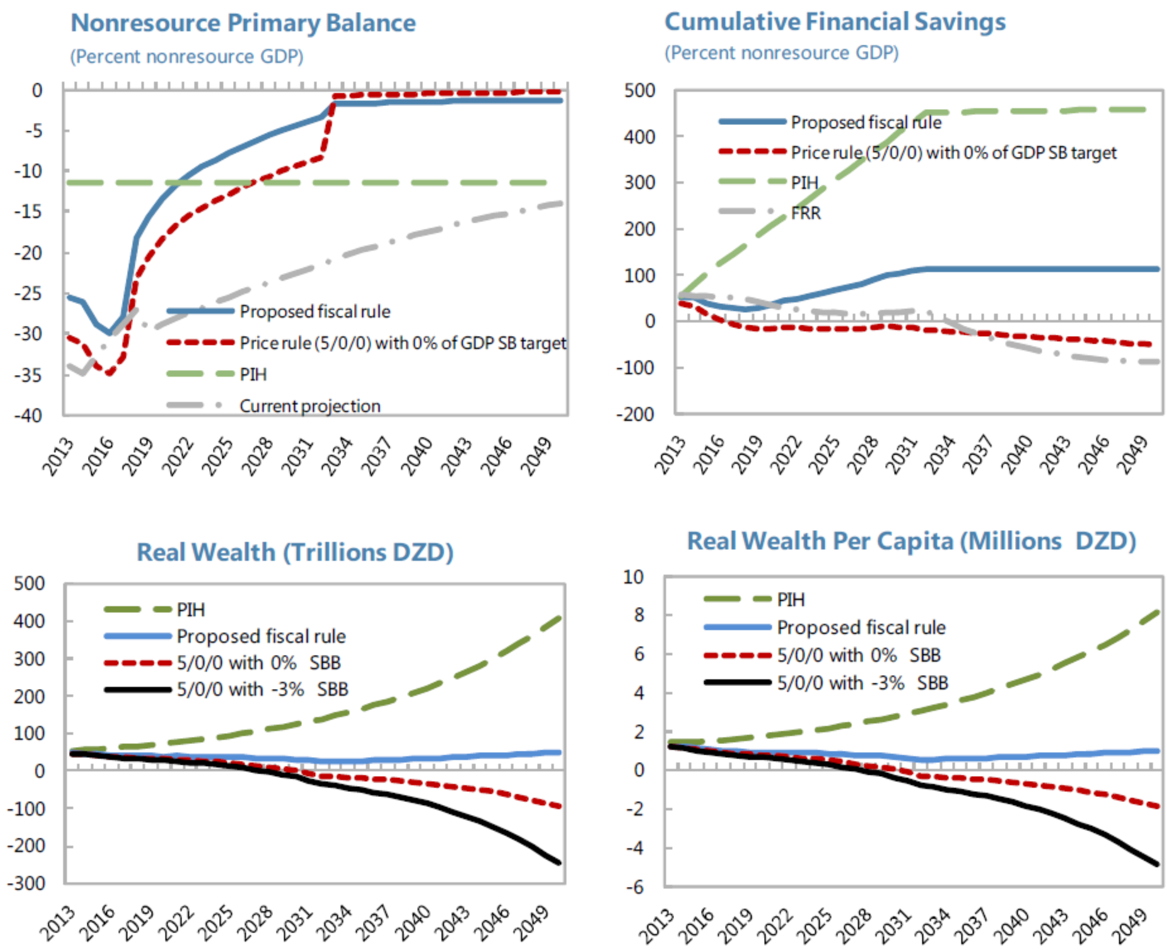
Sources: IMF Country Report No. 14/34. P: 35.

Figure 5: Algeria: Managing Volatility Indicators, 2013–50



Sources: IMF Country Report No. 14/34. P: 36.

Figure 6: Algeria: Proposed Fiscal Rule, 2013–50



Sources: IMF Country Report No. 14/34. P: 37.

Figure 7: STR Grid Search to find Starting Values

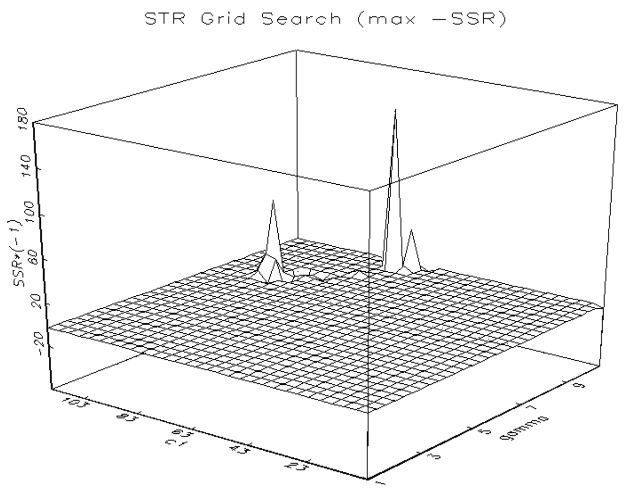


Figure 8: The Transition Function vs. the Transition Variable

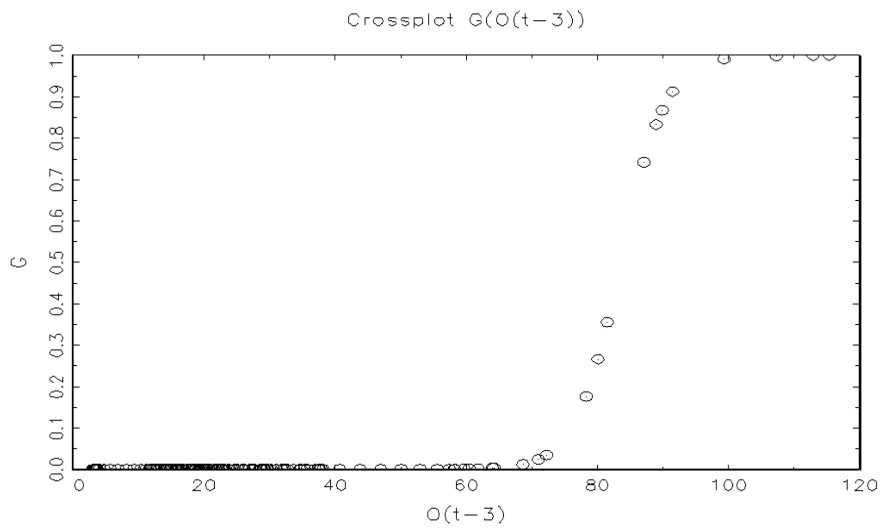


Table 1: Descriptive Statistics for Variables

Variable	Mean	Min	Max	Std. Dev
D	2.44E+00	-1.20E+01	1.97E+01	7.11E+00
G	2.36E+01	3.41E+03	4.51E+06	1.14E+06
O	7.37E+05	3.03E+00	9.15E+01	1.91E+01

Table 2: Testing Linearity against STR and Model Selection

Transition Variable	F	F4	F3	F2	Suggested Model
D(t-1)	2.61E-02	1.81E-02	8.58E-02	8.01E-01	LSTR
D(t-2)	6.26E-01	5.15E-01	2.76E-01	9.12E-01	Linear
D(t-3)	6.65E-01	6.70E-01	1.36E-01	9.66E-01	Linear
D(t-4)	5.93E-01	5.71E-01	1.45E-01	9.56E-01	Linear
D(t-5)	8.04E-01	3.33E-01	8.77E-01	8.78E-01	Linear
D(t-6)	4.78E-01	3.45E-01	4.24E-01	7.14E-01	Linear
D(t-7)	1.04E-01	5.33E-01	1.67E-02	4.04E-01	Linear
D(t-8)	5.90E-03	2.62E-01	1.58E-03	1.79E-01	ESTR
G(t)	NaN	NaN	7.21E-01	5.67E-01	Linear
O(t)	1.8305e- 02	2.67E-03	2.85E-01	8.18E-01	LSTR
G(t-1)	8.98E-01	9.00E-01	6.95E-01	5.18E-01	Linear
O(t-1)	2.63E-02	1.21E-03	5.49E-01	8.68E-01	LSTR
G(t-2)	9.94E-01	1.00E+00	6.53E-01	4.80E-01	Linear
O(t-2)	1.78E-02	2.58E-04	7.25E-01	9.08E-01	LSTR
G(t-3)	NaN	NaN	5.69E-01	4.56E-01	Linear
O(t-3)*	1.15E-17	2.04E-22	6.85E-01	9.26E-01	LSTR
G(t-4)	9.98E-01	1.00E+00	5.94E-01	4.44E-01	Linear
O(t-4)	2.18E-02	1.11E-03	3.97E-01	9.38E-01	LSTR
G(t-5)	9.93E-01	1.00E+00	6.80E-01	4.42E-01	Linear
O(t-5)	6.63E-03	2.15E-03	5.68E-02	9.50E-01	LSTR
G(t-6)	1.00E+00	NaN	6.75E-01	4.50E-01	Linear
O(t-6)	2.28E-11	7.66E-12	3.10E-03	9.40E-01	LSTR
G(t-7)	9.73E-01	9.98E-01	1.41E-06	6.23E-01	Linear
O(t-7)	3.06E-02	2.18E-01	1.44E-03	9.03E-01	ESTR
G(t-8)	9.07E-01	9.61E-01	5.61E-01	5.02E-01	Linear
O(t-8)	3.88E+00	1.92E-04	3.57E-02	8.34E-01	LSTR
TREND	NaN	NaN	6.08E-01	4.69E-01	Linear

Table 3: STR Estimation

Variable	Linear Part					Nonlinear Part				
	Start	**Estimate**	**Sd**	**T-Stat**	**P-Value**	**Start**	**Estimate**	**Sd**	**T-Stat**	**P-Value**
CONST	0.05643	0.06185	0.0302	2.0486	0.0425	39406.62	210083.59	0.8085	0.7031	0.4833
D(t-1)	3.46243	3.45848	0.0674	51.2955	0	-5020.9127	16070.849	0.1545	1.1122	0.2681
D(t-2)	3.55711	-4.90226	0.2272	-21.5748	0	6905.8931	-62813.104	0.5309	-3.5567	0.0005
D(t-3)	-4.9119	3.55052	0.3612	9.8298	0	492.96704	81322.891	0	0	0
D(t-4)	-2.1238	-2.12636	0.4004	-5.311	0	-4398.8832	-46535.596	0.8158	-2.6713	0.0085
D(t-5)	2.96121	2.97107	0.3997	7.4327	0	2392.191	-3847.2251	0.9663	-0.2755	0.7834
D(t-6)	-3.7557	-3.76867	0.3591	-10.4944	0	-2148.212	34618.052	0.482	2.5018	0.0136
D(t-7)	2.44632	2.45568	0.2242	10.9533	0	-454.50061	-38078.194	0.0947	-5.3676	0
D(t-8)	-0.6452	-0.6482	0.0655	-9.9022	0	3.10645	10325.076	0.8271	0.9832	0.3274
G(t)	-0.0003	-0.00003	0	-3.0639	0.0027	0.0064	-0.03102	0.1943	-0.1597	0.8734
O(t)	0.59246	0.59848	0.1217	4.9191	0	-355.7632	-914.11116	0.8985	-0.1792	0.858
G(t-1)	0.00013	0.00013	0	3.123	0.0022	-0.085848	0.59845	0.2949	2.0294	0.0445
O(t-1)	-2.091	-2.10972	0.456	-4.627	0	3800.9049	-18411.816	0.9966	-1.647	0.102
G(t-2)	-0.0002	-0.0002	0.0001	-3.0188	0.0031	0.12849	-1.66901	0.2879	-5.7976	0
O(t-2)	-1.5622	3.04683	0.7342	4.14981	0.0001	-5300.9121	60493.635	0.2084	6.3979	0
G(t-3)	0.00016	0.00016	0.0001	-3.0915	0.0179	0.04326	2.13514	0.1896	11.26	0
O(t-3)	-2.1784	-2.19386	0.7096	-2.4118	0.0024	-1091.187	-76638.411	0	-3.2167	0
G(t-4)	-0.00009	-0.00009	0.0001	1.7262	0.1604	-0.11666	-1.18598	0.4444	-2.6686	0.0086
O(t-4)	1.16292	1.14397	0.6627	1.6028	0.0055	3443.6043	39378.009	0.4664	3.0775	0.0026
G(t-5)	0.00011	0.00011	0.0001	-1.989	0.1114	0.11398	-0.28377	0.3714	-0.7641	0.4462
O(t-5)	-0.0001	-1.52518	0.7668	-2.1575	0.0488	-1362.9797	-2336.868	0.3455	-0.5093	0.6114
G(t-6)	0.38113	-0.00015	0.0001	2.621	0.0328	-0.13281	1.5211	0.1038	14.6496	0
O(t-6)	2.07738	2.06638	0.7884	2.447	0.0098	1105.6104	-11122.477	0.2812	-2.0769	0.0398
G(t-7)	0.00011	0.00011	0	-2.8491	0.0157	-0.01377	-1.80961	0	0	0
O(t-7)	-1.406	-1.42074	0.4987	-2.5437	0.0051	-209.59216	11390.28	0	0	0
G(t-8)	-0.00003	-0.00003	0	2.8237	0.0121	0.03931	0.66646	0.1734	3.8424	0.0002
O(t-8)	3.02087	0.39016	0.1382	2.3976	0.0867	384.97357	-1547.2555	0.1519	-0.332	0.7404
γ						8.13343	6.82656	0.6857	2.5418	0.0122
C						72.76122	83.53325	0.1164	6.3686	0
AIC:				-3.87E+00						
SC:				-2.89E+00						
HQ:				-3.47E+00						
R^2:				1.00E+00						
adjusted R^2:				0.9998						
SD of residuals:				0.128						
variance of residuals:				0.0164						
SD of transition variable:				23.1379						

Table 4: Linear and Non-linear Unit Root Tests

Linear unit root tests	lags	Statistic	Nonlinear unit root tests	lags	Statistic
ADF	3	-3.1751	**KSS (2003)**	3	0.95206
PP	3	-2.6529	**Sollis (2009)**	3	0.35289
KPSS	3	0.2816			

Notes: ADF and PP: Critical values are: -2.56, -1.94 and -1.62 at 1%, 5% and 10% respectively. KPSS: Critical values are: 0.739, 0.463 and 0.347 at 1%, 5% and 10% respectively. KSS (2003): Critical values for the detrended and demeaned data are: –3.93, -3.40, and -3.13 at 1%, 5% and 10% respectively. Sollis (2009): Critical values are: 4.886 and 4.009 at 5% and 10% respectively.

Table 5: Unit Root Tests with Structural Break

			One structural break	
		lags	**Statistic**	**Break date**
Zivot and Andrews (1992)		7	-3.8218	1998 Q1
	shift dummy $f_t^{(1)}$	3	-3.4265	2009 Q1
Saikkonen and Lütkepohl (2002)	exponential shift $f_t^{(2)}$	3	-3.4710	2009 Q1
	rational shift $f_t^{(3)}$	3	-3.4725	2009 Q1
	Two structural breaks			
	lags	**Statistic**	**Break date I**	**Break date II**
Lumsdain and Papell (1997)	3	-4.3321	1971 Q1	1994 Q1
Lee and Strazicich (2003)	5	-6.1445	1967 Q4	1971 Q1

Notes: Zivot and Andrews (1992): Critical values are: -5.57, -5.08 and -4.82 at 1%, 5% and 10% respectively. Saikkonen and Lütkepohl (2002): Critical values (T=1000) are: -3.48, -2.88, and -2.58 at 1%, 5% and 10% respectively. Lumsdain and Papell (1997): Critical values are: -7.34, -6.82 and -6.49 at 1%, 5% and 10% respectively. Lee and Strazicich (2003): Critical values: -6.33, -5.71 and -5.33 at 1%, 5% and 10% respectively.

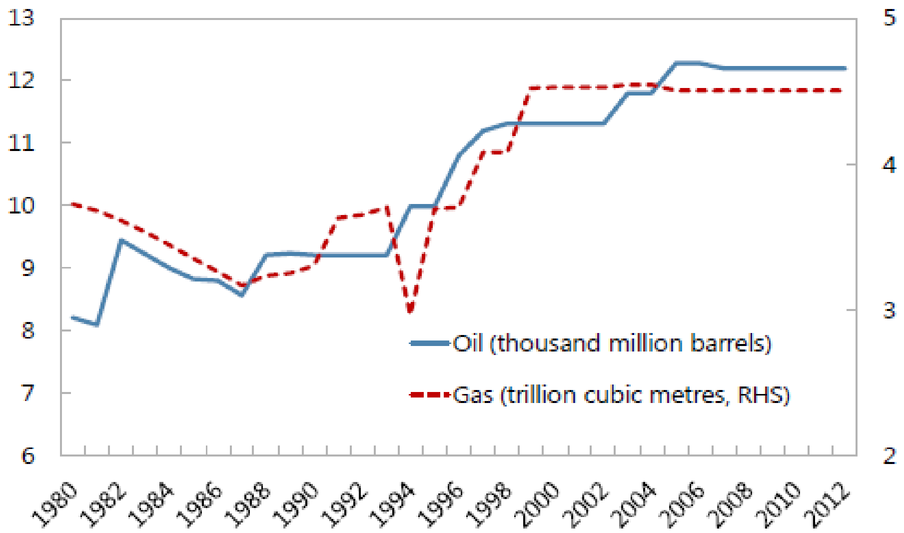
Appendix

Table 1: Summary of Strengths and Weaknesses of the Six Approaches

Approach	Strengths	Weaknesses	Key references
Summary indicators	- simple to use - good first approximation - can be used with different modelling frameworks - easy to communicate - results between studies easy to compare	- require inputs from other models - do not explicitly account for uncertainty - do not explicitly account for interactions between variables	Buiter et al. (1985), Blanchard et al. (1990)
Econometric tests	- derived directly from theory - useful in study of past policies	- mostly retrospective; hard to conduct prospective analysis - no quantitative measure of sustainability (answer either accept or reject)	Hamilton and Flavin (1986), Bohn (1998;2005)
Value-at-Risk approach	- explicitly accounts for interactions and uncertainty - public sector balance sheet is analysed as a whole - can be used with different modelling frameworks	- a lot of data needed (public sector balance sheet etc.) - large effort to build the model needed - long-run analysis hard	Barnhill and Kopits (2003)
Fiscal limits and fiscal space	- different perspective - explicitly accounts for interactions and uncertainty - easy to communicate	- very model-dependent (fiscal limits in Bi 2010) - a broad sample of data needed (fiscal space in Ostry et al. 2010)	Bi (2010), Cochrane (2010), Leeper and Walker (2011a), Ostry et al. (2010)
General equilibrium models	- explicitly accounts for interactions - structurally detailed and accurate description of the economy - country-specific features can be modelled	- very large effort to build a model - a lot of parameter values need to be calibrated - predictive accuracy of the model not guaranteed	van Ewijk et al. (2006), Andersen and Pedersen (2006)
Generational accounting	- different perspective - inter-generational equity also considered	- do not explicitly account for interactions or uncertainty - hard to allocate benefits of expenditures accurately to age groups	Auerbach et al.(1991), Gokhale and Smetters (2003)

Source: Sarvi, T. (2011). P: 50.

Figure 1: Hydrocarbon Proven Reserves, 1980–2012



Source: British Petroleum Statistical Review of World Energy (2013).

Figure 2: Logistic and Exponential Transition Functions of Varying Values of Gamma (γ).

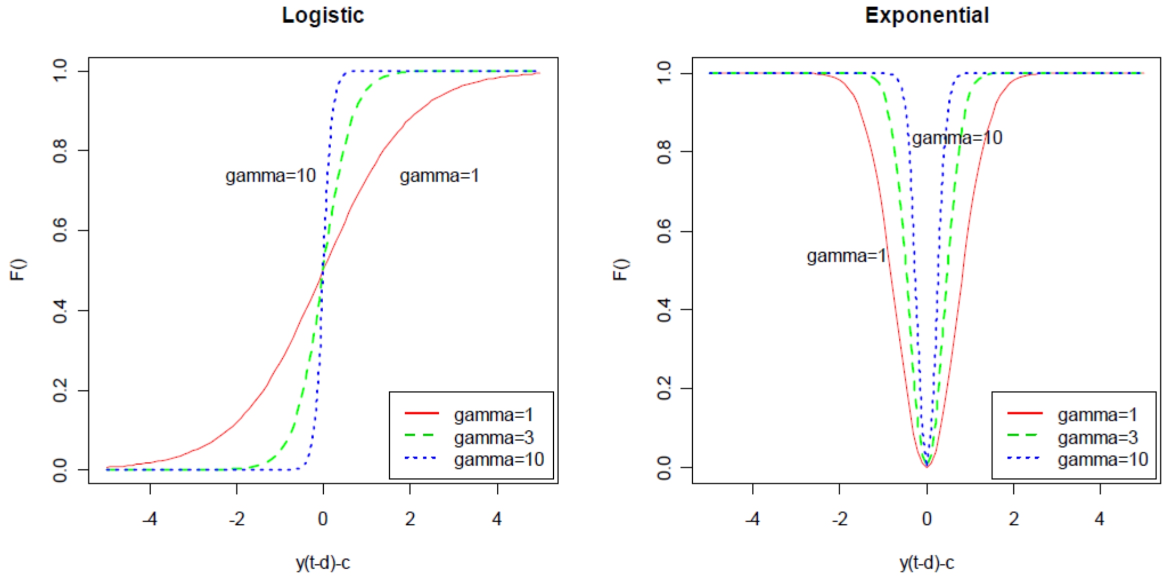
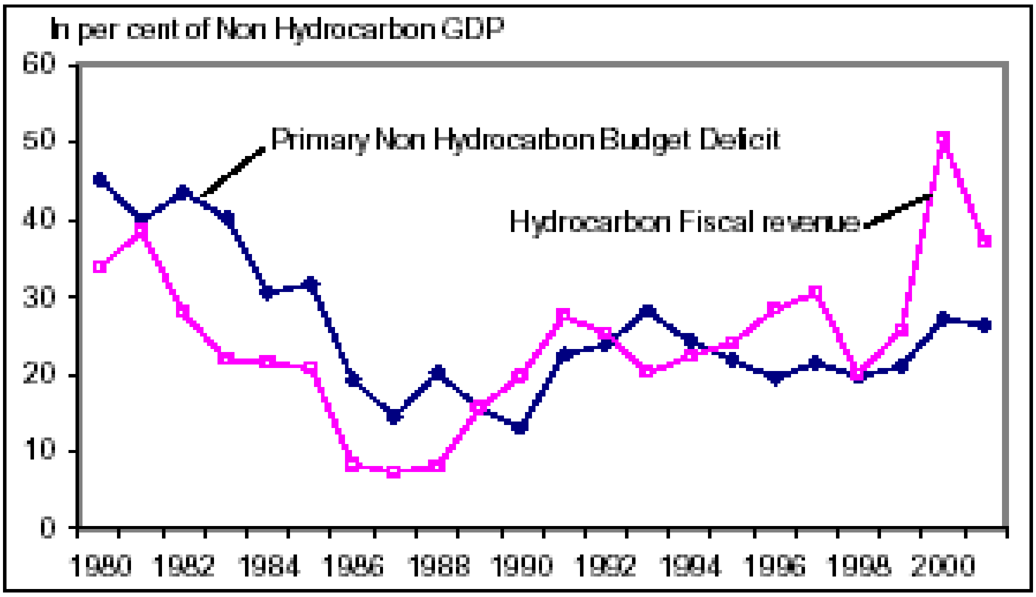


Figure 3: Primary Non Hydrocarbon Budget Deficit and Hydrocarbon Fiscal Revenue in Algeria



Source: Document of The World Bank Group Rapport No. 25828-AL. (2003). P: 4.

Plot of Time Series 1966.4-2012.4, T=185