ERF Working Papers Series

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ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

Working Paper No. 1540
February 2022

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We are grateful to Professor Nada O. Eissa for helpful comments and language editing.

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First published in 2022 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

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. It is no coincidence that the sustainability of public debt became a specific research agenda in macroeconomics and public economics at around the same time. However, the literature lacks a clear consensus about the definition of public finance. In fact, many research papers introduce their own criteria for sustainability, with many similar (but not identical) elements. In this context, the concept of a debt ceiling, limit, or threshold complements debt sustainability analysis (DSA) exercises and gives a better sense of fiscal sustainability. It could be used as a starting point for determining the level at which it would be desirable to stabilize debt. Regardless of how the debt limit is derived, the debt anchor should not be set at this limit; instead, it should be utilized as a mechanism for self-insurance that provides a buffer against adverse macroeconomic and fiscal shocks (Eyraud et al., 2018). Those buffers should reflect the distribution of risks around the predicted debt trajectory (Fournier and Fall, 2015; Debrun et al., 2019).

Accordingly, this study focuses on two main aspects of fiscal sustainability in Algeria. In the first essay, we use Ostry et al.'s (2010) "fiscal space and public debt limits" approach to analyze fiscal sustainability. We use Fully Modified Least Squares and threshold models to estimate the fiscal reaction function for Algeria between 1990-2020. Despite the efforts made to rearrange spending and income priorities, the descriptive and econometric results provide clear evidence of the fiscal fatigue state (loss of control of the debt growth) and the decrease in the fiscal space available in Algeria. The results also show the existence of a threshold level in the debt ratio (debt ceiling or fiscal cliff), approximately equal to 61.1 percent, above which Algerian fiscal policymakers are concerned with corrective actions to avoid insolvency.

The second essay aims to analyze the relationship between public debt and economic growth and investigate whether a unique debt turning point (threshold) exists for Algeria. For this purpose, we use an innovative methodology: a regression kink with an unknown threshold (Hansen, 2017). The empirical results show a debt-to-GDP threshold of 31.9 percent for 1970-2020. Our estimated threshold suggests that, in Algeria, debt-to-GDP ratios below 32 percent would boost economic growth by 0.13 percent, while any debt ratios above that threshold would harm economic growth by 0.06 percent.

Keywords: Fiscal sustainability, fiscal space, fiscal reaction function, fiscal fatigue, public debt, economic growth, regression kink, non-linearity, threshold effects.
JEL Classifications: H62, H63, H74, C13, C15, C23, O57.

ملخص

حظي موضوع استدامة السياسات المالية باهتمام كبير خلال العقدين الماضيين، حيث تدهور عجز الميزانية في البلدان المتقدمة والنامية. وليس من قبيل المصادفة أن في نفس الوقت تقريبًا أصبحت استدامة الدين العام ضمن جدول أعمال بحثي محدد في الاقتصاد الكلي والاقتصاد العام. ومع ذلك، تفتقر الأدبيات الاقتصادية إلى رأي موحد وواضح حول تعريف المالية العامة. في الواقع، تطبق العديد من الأوراق البحثية معاييرها الخاصة للاستدامة، مع وجود العديد من العناصر المتشابهة ولكن غير المتطابقة. في هذا السياق، فإن مفهوم سقف أو حد أو عتبة للدين يكمل تمارين تحليل القدرة على تحمل الدين (DSA)، ويقدم توضيحًا أفضل للاستدامة المالية. ويمكن استخدامه كنقطة انطلاق لتحديد المستوى حيث يستحسن تثبيت الديون. وبغض النظر عن طريقة تحديد حد الدين، لا ينبغي تثبيت الدين عند هذا الحد. بدلًا من ذلك، ينبغي استخدام حد للدين كآلية للتأمين الذاتي يفصل بين الصدمات الاقتصادية الكلية والصدمات المالية السلبية (ايرود (Eyraud) وأخرون، 2018). يجب أن تعكس هذه الفواصل المؤقتة توزيع المخاطر حول مسار الدين المتوقع (فورنييه وفول (Fournier and Fall)، 2015؛ ديبرون (Debrun) وأخرون، 2019). وبناءً عليه، تركز هذه الدراسة على جانبين رئيسيين للاستدامة المالية في الجزائر. في المقال الأول، استخدمنا نهج أوستري وآخرون (Ostry et al) (2010) المسمى "الحيز المالي وحدود الدين العام" لتحليل الاستدامة المالية: فقمنا باستخدام نماذج المربعات الصغرى المعدلة بالكامل ونماذج الحد لتقدير وظيفة رد الفعل المالي في الجزائر ما بين أعوام 1990- 2020. وعلى الرغم من الجهود المبذولة لإعادة ترتيب أولويات الإنفاق والدخل، تقدم النتائج الوصفية ونتائج الاقتصاد القياسي دليلًا واضحًا على حالة الإرهاق المالي (فقدان السيطرة على نمو الدين) وتقلص الحيز المالي المتاح في الجزائر. كما أظهرت النتائج وجود مستوى للحد الأقصى لنسبة الدين (سقف الدين أو المنحدر المالي)، يساوي تقريبًا 61.1٪، وهو ما يتعدى الحد الذى يمكن أن يثير قلق صناع السياسات المالية الجزائريون فيما يتعلق بالإجراءات التصحيحية لتجنب الإعسار. يهدف المقال الثاني إلى تحليل العلاقة بين الدين العام والنمو الاقتصادي والتحقيق في ما إذا كانت هناك نقطة تحول فريدة للديون (السقف) في الجزائر. لهذا الغرض، استخدمنا منهجية مبتكرة، وهي الانحدار ذو السقف غير المعروف (هانسن (Hansen)، 2017). تظهر النتائج التجريبية أن سقف الدين نسبة إلى إجمالي الناتج المحلي يبلغ 31.9% للفترة 1970-2020. كما يشير الحد الذي وصلنا له إلى أن في الجزائر نسب الدين إلى إجمالي الناتج المحلي التي تقل عن 32% تعزز النمو الاقتصادي بنسبة 0.13%، في حين أن أي نسب دين أعلى من هذا الحد تضر بالنمو الاقتصادي بنسبة 0.06%.

Essay 1: Fiscal Space and Public Debt Limits: The Case of Algeria

"*For a long time to come, one of the priorities of macroeconomic policy will be to slowly but steadily return debt to less dangerous levels, to move away from the dark corners*."

Olivier Blanchard (2014)

"*Absent adequate fiscal space, financial instability will be worse and may lead to price instability or sovereign default, which will further impair the functioning of financial markets, at a great cost to the broader economy."*

Maurice Obstfeld (2013)

1. Introduction

The issue of public debt is important within the context of public finances, as it represents one of the means available to finance the public budget deficit and policies to recover from economic crises over time. Usually, governments resort to internal or external borrowing, but they are keen to ensure that the public debt moves at sustainable levels and reduces its risks in the medium and long term.

With the COVID-19 fiscal response in full swing, the global debt burden is set to rise dramatically in 2020; gross government debt issuance soared to a record high of over USD 2.1 trillion in March 2020, more than double the 2017-19 average of USD 0.9 trillion. Global debt is now 40 percentage points (USD 87 trillion) higher than at the onset of the 2008 financial crisis. In developing countries, public debt has exceeded 70 percent of GDP in one-fifth of emerging economies. At the same time, 40 percent of low-income countries face difficulties in servicing public debt. In developed countries, current public debt ratios are still higher than before the global financial crisis in nearly 90 percent of these countries. (Global Debt Monitor. April 2020). In light of the upward curve of public debt in developed and developing countries alike, the issue of fiscal sustainability is receiving more attention from governments and regional and international financial institutions.

In developed countries, rising debt – combined with long-term trends like demographic change – has alerted fiscal authorities to evaluate different reforms. As of 2015, around 70 countries worldwide had an explicit debt ceiling in place, restricting their ability to enact reform. The majority of debt ceilings were clustered at around 60-70 percent of GDP, including most EU countries (Eyraud et al., 2018).

In less developed countries, the public sector is usually more fragile and prone to shocks compared to developed countries. This fragility is due to exposure 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.

Regarding oil-exporting countries, since early 2020, demand for oil has plummeted as the COVID-19 pandemic threatens to bring the global economy to a standstill. The slump in demand is coinciding with a rise in supply, as major oil producers announced an expansion in production. As a result, international crude oil price benchmarks fell from about USD 50 a barrel on March 6 to USD 20-35 since mid-March. Thus, oil exporters are facing a triple macro-fiscal shock: a sharp revenue loss from the collapse in global oil prices, the negative economic impact on domestic non-oil activity, and increased spending pressures arising from the policy response to the effects of COVID-19. In many oil-exporting countries, a large share of government revenue is provided by the resource sector. Many oil exporters currently have limited fiscal space, making maintaining – let alone increasing – spending extremely challenging as oil revenues drop. Rising fiscal pressures are likely to result in higher public debt, gross or net, as even countries with public financial assets will need to dig deep into them. The weakening fiscal position and growth slowdown could affect investor confidence and increase the cost of borrowing due to higher risk premia, further limiting the fiscal space and potentially prompting concerns over debt sustainability for countries with already high debt.

In Algeria, the dual shock of falling oil prices and COVID-19 plunged the economy into recession. As a result of higher spending and lower general government revenue, the fiscal and external balances have deteriorated significantly. The general government overall balance widened significantly during the last year, as it moved from –5.6 percent in 2019 to -13.6 percent in 2020. General government gross debt increased from 38.2 percent GDP in 2018 to 61.96 percent in 2020. The projected interest rate–growth differential (2020–2025) is -2.2 percent.

With this background in mind, several macroeconomic questions arise:

- To what extent did the COVID-19 pandemic reduce fiscal space in Algeria, and what is the likelihood of a sovereign debt crisis?
- What is the available fiscal space for the Algerian economy, and what factors pose significant threats to the existing fiscal space during the post-COVID-19 recovery?
- Is there evidence of fiscal response to rising debt levels in the form of a fiscal reaction function? Which factors determine the fiscal stance at the country level?
- Is there an optimal debt threshold for Algeria beyond which debt can be harmful to growth?

In this context, the aim of this paper is to analyze the technical basis of financial soundness and state solvency and provide evidence on the sustainability of public debt in Algeria. The evidence allows fiscal policy to be conducted as a nonlinear process, which has not been addressed adequately in the existing literature.

The remainder of this paper is organized as follows: Section 2 presents the theoretical foundation of fiscal space and several approaches to measure it. Detailed empirical evidence is presented in section 3. Section 4 describes fiscal space indicators in Algeria. The model

specification and empirical results are discussed in sections 5 and 6. The final section offers conclusions and recommendations for decision-makers.

2. Theoretical issues

While fiscal space is recurrent in macroeconomic policy discussions, a clear consensus on its definition and measurement is lacking. Fiscal space reflects the availability of budgetary resources to conduct effective fiscal policy. As simple as that sounds, fiscal space is a complex concept that researchers have defined and measured differently.

Definition

One approach has defined the concept as the budgetary room to create and allocate funding for a particular purpose without threatening a sovereign's financial position or the stability of the economy (Heller 2005; Ley 2009). In this case, the notion of fiscal space is closely linked to the concept of fiscal sustainability, which in turn is related to the capacity of a government to finance its operations, serve its debt obligations, and ensure its solvency. A second approach focuses more on countries' potential to expand their financing capacity. For example, Roy (2009) interprets fiscal space as: "the financing that is available to a government as a result of concrete policy actions for enhancing resource mobilization, and the reforms necessary to secure the enabling governance, institutional, and economic environment for these policy actions to be effective, for a specified set of development objectives." Steuerle (2014) evaluates the extent to which past policy decisions tie the hands of current politicians. Many policymakers understand fiscal space precisely in this sense. Ódor (2016) defines fiscal space as: "a room for maneuver for fiscal policy to absorb fiscal risks without triggering substantial increases in sovereign risk premia." By "absorb," he means stabilizing net worth/net debt after a negative shock without urgent fiscal adjustment.

In this context, the concept of a debt ceiling, limit, or threshold[5] is promising to complement debt sustainability analysis (DSA) exercises and give a better sense of fiscal sustainability. It could be used as a starting point for determining the level that would be desirable to stabilize debt. From the technical side, fiscal space is defined as the difference between a government's actual debt and the theoretical debt limit[6] implied by the historical behavior of its policymakers (Ostry et al., 2010; Ghosh et al., 2013). To determine a country's debt limit and fiscal space, we begin with a simple fact: a country must issue debt equal to the difference between the interest payments on its existing debt and its primary balance (revenues net of non-debt servicing expenditures). This relationship can be expressed as:

$$\dot{D}_t = D_t r_t - PB_t \dots\dots\dots (1)$$

[5] See Figure 1 in the appendix to distinguish between the three concepts.

[6] The debt limit is defined as the debt level at which a sovereign borrower loses market access and hence cannot serve its debt.

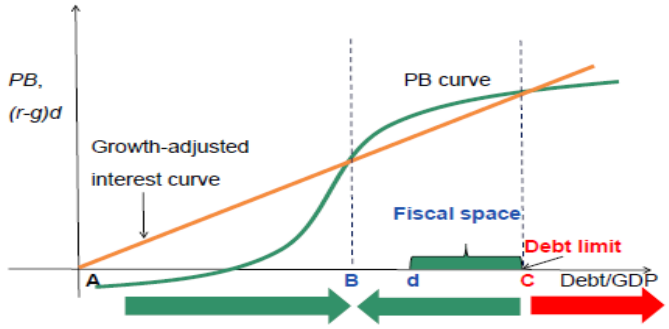
Where D_t is the change in a country's debt level or debt issuance at time t, r_t is the nominal interest rate, and PB_t is the primary balance. This can be rewritten in terms of shares of GDP:

$$\dot{d}_t = (r_t - g_t)d_t - pb_t \dots\dots\dots (2)$$

where d_t is the change in the debt-to-GDP ratio, pb_t is the primary balance-to-GDP ratio, and g_t is the country's nominal GDP growth. $(r_t - g_t)d_t$ is a country's growth-adjusted interest payments.

Governments are generally responsible in managing their fiscal affairs; when their debt-to-GDP ratio is low and manageable, they respond sensibly to rising deficits and tighten their proverbial belts, stabilizing their debt load at a reasonable level. However, there is a point when a country's debt-to-GDP ratio and interest payments on that debt rise so high that policymakers are tempted to give up. This can happen when the share of national income going to paying taxes has become so onerous, or cuts in government spending have grown so severe, that further tax hikes or more cost-cutting are met with stiff resistance. Governments face a Hobson's choice: they can impose fiscal austerity, risking unrest and their own jobs, or they can default and take their chances with the nation's creditors. This dynamic is determined by the relationship between the governments' primary balance reaction function and the growth-adjusted interest payment curve. To see this, suppose that a country's debt-to-GDP ratio lies between B and C in Figure 1; its primary balance is greater than the required interest payment (the BP curve lies above the interest payment curve). This corresponds to the case in which policymakers worry about their country's high debt load and respond by increasing taxes or imposing other austerity measures. The surplus of the primary balance over interest payment is used to pay down debt and the debt-to-GDP ratio falls back to B, the steady state debt-to-GDP ratio. As long as a country's debt-to-GDP ratio stays between A and C, it will remain solvent. However, if a country's debt-to-GDP ratio is so high that it lies to the right of C, it is on a path toward insolvency. From C onward, the primary balance curve is permanently below the interest payment curve and the government is locked in a vicious debt financing cycle; required total interest payments, which are already higher than the primary balance, will rise further if new debt is issued. However, because of public resistance to austerity measures of fiscal fatigue, the primary balance can no longer go up and may even start to decline.

Figure 1. Sovereign debt dynamics



Source: Zandi and all (2011). P:4.

Measurement

On the other hand, several approaches can be used to measure fiscal space. It can be measured in terms of either losing market access or achieving long-term sustainability. In practice, these two aspects of fiscal space are interrelated, as long-term sustainability considerations often affect market access through risk premia. However, it is difficult to comprehensively capture all the factors affecting fiscal space with a single method, and therefore studies usually either focus on market access (Ghosh et al., 2013 and Fournier and Fall, 2015) or long-term sustainability (Blanchard et al., 1990); one method that comes closest to combining these two aspects is Bi (2011) and Bi and Leeper (2013). Figure 2 in the appendix illustrates these two fiscal space dimensions.

To measure fiscal space, the following indicators might be useful:

Interest rate-growth differential: The simplest way to grasp the evolution of fiscal space over time is to look at the interest rate-growth differential. The rationale behind it is that the debt dynamics will be favorable and lead to an increase in fiscal space, when the nominal growth rate is sufficiently high to offset the impact of the nominal interest rates on the debt ratio, for a given primary balance. In addition, the market interest rate includes a risk premium, which should encompass the information that the market can use to assess default probability.[7]

[7] The main limitation of this approach is that it does not explicitly take into account the primary balance. If markets are short-sighted, it may also not take into account the effect of population ageing.

Conventional fiscal space indicators: these compare the current level of public debt or fiscal deficit to a benchmark level that is expected to be associated with debt sustainability. For example, an indicator that is often used is the *debt sustainability gap*, i.e. the difference between a country's current debt level and its estimated sustainable debt level (Zandi et al., 2011; Ostry et al., 2010):

$$debt\ sustainability\ gap = d^* - d_t \ldots\ldots\ldots (3)$$

with d^* denoting the benchmark sustainable debt-to-GDP ratio.[8]

A related indicator is the *primary balance sustainability gap*, which is defined as the difference between the current primary balance and a debt-stabilizing primary balance pb^*.

$$primary\ balance\ sustainability\ gap = pb^* - pb_t \ldots\ldots (4)$$

The debt-stabilizing primary balance can be derived from equation (1) by assuming that stock-flow adjustments and changes in the debt-to-GDP ratio are zero:

$$pb^* = \left(\frac{\tilde{r} - \tilde{g}}{1 + \tilde{g}}\right) \times d^* \ldots\ldots (5)$$

with *r* and *g* denoting the country-specific long-run real interest rate and the long-run growth rate, respectively.

Alternative fiscal space measure (years to repay the public debt): Aizenman and Jinjarak (2010) introduce an alternative fiscal space measure called "*de facto fiscal space.*" The authors argue that the ratio of the public debt level to the "de facto tax base," or the number of tax years a government needs to repay its debt, provides a good indicator of how tight a country's budgetary room is. De facto fiscal space of economy *i*, from the perspective of year *t*:

$$de\ facto\ fiscal\ space = \frac{1}{D_{it}/\sum tr_{iy}} \ldots\ldots\ldots (6)$$

D_{it} denotes the gross general government debt level of economy *i* at year *t*, and tr_{iy} denotes general government tax revenue level of economy *i* at year *y*.

This measure differs categorically from other fiscal measures in that it does not involve an estimation of the maximum debt level. Instead, it requires an estimation of the de facto tax base, which is the realized tax collection average across multiple years. However, since the

[8] For more details about approaches used in estimating the benchmark sustainable debt-to-GDP ratio, see: Cheng and Pitterle (2018).

measure is a function of accumulated debt and realized tax collection, it is backward-looking by design.[9] All previous indicators send clear signals and are easy to communicate. However, their simplicity also means that they fail to capture important factors determining fiscal space.

In addition, the World Bank (2018) broadly grouped multiple aspects (dimensions) of fiscal space into four categories: government debt sustainability, balance sheet composition, external and private sector debt, and market perception of sovereign risk.

3. Empirical literature

There have been numerous empirical studies on debt sustainability in the last decade, and they gained extreme importance after the latest global financial and debt crisis. However, empirical tests on sustainability do not provide a consensus on this issue.

Three empirical frameworks have been used in the empirical literature. The first relies mainly on testing the 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. The third measures the feedback from debt to deficit (fiscal reaction functions).

Under the third framework, empirical studies on this topic are numerous, which were initiated by the leading paper of Ostry et al. (2010). They re-examine the issue of debt sustainability in a large group of advanced economies. They hypothesize that when debt is in a moderate range, its dynamics are sustainable in the sense that increases in debt elicit sufficient increases in primary fiscal balances to stabilize the debt-to-GDP ratio. At high debt levels, however, the dynamics may turn unstable, and the debt ratio may not converge to a finite level. Applying these concepts to a sample of 23 advanced economies, they find a number of countries that have either very little or no additional fiscal space. By the same token, other countries in the sample that have more fiscal space may still need to undertake medium-term adjustment on account of future demographic pressures and the possible realization of contingent liabilities.

In the same context, Gosh et al. (2013) tried to answer the following question: "How high can public debt rise without compromising fiscal solvency?" They answer this question using a stochastic model of sovereign default in which risk-neutral investors lend to a government that displays 'fiscal fatigue,' whereby its ability to increase primary balances cannot keep up with rising debt. Using data for 23 advanced economies over the period 1970-2007, they find robust empirical support for the fiscal fatigue characteristic. Specifically, they find that the marginal response of the primary balance to lagged debt is non-linear, remaining positive at moderate debt levels but starting to decline when debt reaches around 90-100 percent of GDP. The fiscal space estimates indicate limited or no available room for fiscal maneuver for

[9] More importantly, it provides little information about the available room for future fiscal intervention, given the lack of benchmark levels for reference.

Greece, Iceland, Italy, Japan, and Portugal, and ample space for Australia, Korea, and the Nordic countries. In addition, the UK and the US also appear to be constrained in their room for fiscal maneuver.

Furthermore, Fournier et al. (2015) calculate endogenous government debt limits given the market's assessment of the probability to default and the estimated primary balance reaction function to growing debt has the 'fiscal fatigue' property at high debt levels. An application of this framework to OECD countries over the period 1985-2013 shows that current debt limits are high for most of the OECD thanks to particularly low current interest rates. It also shows for some countries that current debt levels are not sustainable without a change in government behavior as compared to the past. Most importantly, the framework illustrates the state-contingent nature of debt limits and therefore the vulnerability of governments to a change in macroeconomic conditions and market reactions.

Similarly, Fournier and Bétin (2018) investigate the effect of structural characteristics on the debt limits of middle-income countries. Two equations relate the probability of default to the interest rate. First, the probability of default is estimated with a logit model. Second, the assumption of non-arbitrage opportunity on the sovereign bond market relates the interest rate, the probability of default, and the recovery rate. The main results emerging from their analysis are the following: i) debt limits vary substantially across countries and are mainly driven by differences in export ratios and the perception of the effectiveness of the government, ii) the model illustrates the risk of a self-fulfilling crisis in the absence of a lender of last resort, iii) the credibility of the government and the expected strength of the legal enforcement of debt contracts are essential, and iv) other institutional features such as the rule of law, regulatory quality, political stability, voice and accountability, and control of corruption are also highly correlated with default episodes and should be considered when assessing sovereign risk.

Hyejin Ko (2019) measures and compares the fiscal sustainability of 17 welfare states. To derive this fiscal space, the debt limit of each country is set, primarily based on estimating the fiscal reaction function and selecting the interest schedule. He uses a pooled-time-series-cross-sectional model to estimate the fiscal reaction function and the vector regression model to set the interest schedule. He finds that Southern European welfare states are unsustainable if they do not immediately change their fiscal policies. Countries outside of Southern Europe are generally financially sustainable. However, the UK, the US, and France have, in their recent actions, exacerbated their financial sustainability. For their part, the social-democratic states remain financially sound despite high levels of welfare spending. This indicates that welfare spending does not necessarily weaken fiscal soundness, which depends on the type of welfare state.

For some Latin American emerging economies, Lozano-Espitia and Julio-Román (2020) provide evidence on the debt limits and fiscal space under the fiscal fatigue approach. They propose the spline technique to estimate each government's reaction function and the

sovereign risk premium endogenous to the country's indebtedness. Estimates were made with an unbalanced panel of 13 economies (six from Latin America) for the period 1980-2018. The results vary importantly across the countries. They suggest, for instance, that the Colombian public debt limit would be close to 68 percent of GDP and that the fiscal space would reach 16 percentage points. Among the other Latin American economies, Peru and Chile have the largest fiscal space (50 and 39 percent, respectively), while Ecuador has the lowest (13 percent). The findings for Mexico look like those of Colombia.

Creel (2020) computes numerical simulations of fiscal space in the euro area, based on 12 different cases, and points to the great uncertainty surrounding the capacity of member states to pay back their public debts. After calculating the primary budget balance sustainability gap indicator, it turns out that unless nominal long-term interest rates remain low and economic growth resumes at its pre-COVID-19 median, most countries will fail to address debt sustainability. In the worst-case scenario of high interest rates and a long recession, even Germany would lack sufficient fiscal space to stabilize its debt-to-GDP ratio. It appears then that debt stability is a shared concern for most EA member states, with the exception of Cyprus, Luxembourg, and Malta. Although the analytics behind this exercise are common knowledge among macroeconomists, it gives an order of the magnitude of fiscal space in the euro area and confirms that interactions between the ECB and EA governments are key to escape the public finances consequences of an exogenous global shock like COVID-19.

Hürtgen (2021) provides novel estimates of non-linear state-dependent fiscal limits for the five largest euro area countries. Within the DSGE model, he builds a COVID-19 scenario calibrated to match the decline in real GDP growth forecasts between February and April 2020 and the fiscal stimulus packages announced until the end of March 2020. On average, fiscal space contracts by 58.4 percent of national GDP.

So, it is noticeable that the aforementioned studies reached different results, according to the concept of fiscal sustainability adopted in the measurement, the econometric methodology used, the size of the sample, and the specificity of the studied economies. Therefore, it is difficult to extract definitive results, but it is possible to make some observations that can help explain the main pattern of the phenomenon.

4. Fiscal space indicators in Algeria

The Algerian economy began the year 2021 with a historical deficit in its overall budget of more than USD 22 billion, amid question marks about the ways and alternatives by which the government will face this unprecedented situation, as all major productive sectors were affected due to the impact of the pandemic on global demand. The size of the losses in 2020 was estimated at 949 billion Algerian dinars (DA) (USD 8.4 billion) in several sectors, most notably oil, health, banking, aviation, irrigation, tourism, and hotels. The oil sector recorded the largest losses for the Algerian economy, as the losses of the 'Sonatrach' Oil Company

amounted to DA 247 billion (USD 1.9 billion).[10] The next most prominent loser was the fuel sector, where the losses of the state-owned 'Naftal' company amounted to DA 20 billion (USD 155.83 million). The electricity and gas sector came next on the list of losses, after the state-owned 'Sonelgaz' company incurred losses of DA 6.5 billion (USD 50.64 million). Also, DA 16 billion (USD 124.66 million) was the value of the losses of Algerian airlines as a result of canceling foreign and domestic flights.

Under these conditions, Algeria's economic growth rate has slowed for the fifth year in a row amid prolonged social mobilization and political transformation, weakening consumer confidence, businesses, and spending (see Figure 3 in the appendix). In 2020, the Algerian economy recorded a negative growth rate that it has never seen before, reaching negative five percent (negative six percent in the non-hydrocarbon sector). Data on industrial production in the public sector in the second quarter of 2020 show a decrease of -14.1 percent compared to the same period of the previous year.

In order to mitigate the effects of the pandemic on the affected economic sectors and social groups, decision-makers have adopted unprecedented measures. Fiscal policy bore the heaviest burden, as it was decided to eliminate the tax on incomes less than or equal to DA 30,000, starting from the beginning of June 2020, and raise the guaranteed minimum national wage with an increase of DA 2,000 (USD 15.64) to become DA 20,000 (USD 220). It also raised the pensions of retirees by seven percent and provided financial compensation to a number of liberal professions, in addition to corporate taxes payment moratoriums in order to mitigate the effects of targeted lockdowns related to COVID-19 on public and private companies. The value of the subsidies allocated to poor families affected by the pandemic increased significantly by DA 24 billion (USD 187 million)[11] and the health sector was allocated DA 12 billion (USD 93.5 million), a number that was repeated as exceptional compensation for workers. Further, the Algerian government has allocated DA three billion (USD 23.37 million) to evacuate nearly 20,000 nationals stranded abroad due to the pandemic. As for the year 2021, the Ministry of Finance confirmed that the state granted financial allocations estimated at DA 530 billion in the context of limiting the effects of the pandemic.

Monetary policy interventions also helped boost confidence, avert credit crises, and provide the liquidity needed to support recovery. During the period from 15 March 2020 to 15 February 2021, the Bank of Algeria cut the reserve requirements ratio from ten percent to eight percent, then to six percent, then to three percent, and, finally, to two percent. It also cut its main policy rate by 25 basis points to 3.25 percent and then to three percent. In addition, he announced the easing of solvency, liquidity, and non-performing loan ratios for banks,

[10] The total volume of hydrocarbons exports in 2020 reached 82 million tons of oil equivalent, with a value of USD 20 billion, which means a decrease of 11 percent and 40 percent, respectively, compared to 2019.

[11] As part of measures to provide immediate relief to families and businesses, 322,000 people benefited from the solidarity grant of an allowance of DA 30,000 per month for low-income employers over a period of three months. In-kind support, consisting of food and water, was distributed to 600,000 families. Moreover, the Ramadan Solidarity Grant was provided to 2.2 million families, with amounts raised from DA 6,000 to 10,000.

encouraged loan repayment moratoriums, provided liquidity, and permitted banks to use their capital conservation buffers.

The pandemic has raided the Algerian economy, which is suffering from a defect in its structure (the dominance of the hydrocarbon sector) and exacerbated the financing weaknesses after the global financial crisis and the oil price shock in mid-2014. This is evident in Figure 4 in the appendix, which reflects the evolution of the budget balance in its various forms.

Despite the efforts made to rearrange spending priorities, Algerian fiscal accounts deteriorated sharply in 2020, reflecting lower revenue because of contracting domestic demand and the slump in oil prices, as well as policy support measures to mitigate the pandemic's impact.[12] The deficit levels increased from -6.2 percent in 2019 to -11.5 percent in 2020, and it is expected to worsen to -13.6 percent in 2021. It is expected that the public finances will gradually adjust starting 2022 because the fragile recovery and the possibly prolonged period for the distribution of vaccines will lower revenues more than expected, with the extension of support policies in 2021. Under these conditions, in 2021 Algeria needs a breakeven fiscal oil price of USD 196.57 and USD 87.69 for external breakeven fiscal oil price (see Figure 5 in the appendix), knowing that the average price of Algerian oil in 2020 was only USD 41.83 per barrel.

The combination of a deteriorating budget deficit and contracting economic growth led to an increase in financing needs to more than 15 percent (See Figure 6 in the appendix) and the public debt ratio from 38.2 percent of GDP in 2018 to 60.9 percent in 2020 (166.74 percent of tax revenues), and it is expected that this ratio will exceed 84 percent by 2023 (see Figure 7 in the appendix). It is true that the external debt ratio remains slight (3.63 percent of GDP, and 8.83 percent of exchange reserves in 2020, of which 37.22 percent is short-term debt),[13] but the internal debt ratio has been on the rise since 2014.

After the collapse of oil prices in mid-2014, the depletion of the stabilization fund resources and the erosion of exchange reserves (see Figure 9 in the appendix), and the authorities' rejection of the external borrowing idea, Algeria launched a domestic debt issue in April 2016 in an attempt to diversify financing needs sources and attract the parallel market fund's outside official channels. In addition, the public treasury resorted to monetary financing of the fiscal deficit (quantitative easing) after the amendment of the Monetary Law in October 2017, which allowed the Bank of Algeria to directly finance the budget deficit, the buy-back of public sector debt, and the National Investment Fund for more than five years (up to 2022). In this regard, the value of loans allocated by the Bank of Algeria to the public treasury amounted to about DA 6556.2 billion until the end of January 2019 (more than USD 60 billion, equivalent

[12] Decrease in general government revenues from 32.6 percent of GDP in 2019 to 28.2 percent in 2020. It is expected to decrease to 25.6 percent in 2021.
[13] For more details on external debt indicators, see Figure 8 in the appendix.

to 23 percent of GDP). A total of DA 2.470 billion was used to finance the treasury deficit during the fiscal years 2017 and 2018, and partly for the fiscal year 2019. On the other hand, a total of DA 1.813 billion contributed to the repayment of the public debts of the national companies Sonatrach and Sonelgaz, as well as the financing of the repayment of the bond loan for growth. It also allocated DA 500 billion to the National Pension Fund in order to refinance its debt to the National Fund for Social Insurance. The National Investment Fund was also financed with an a total of DA 1.773.2 billion, allocated to financing housing programs, the deficit of the National Retirement Fund, and structuring projects.

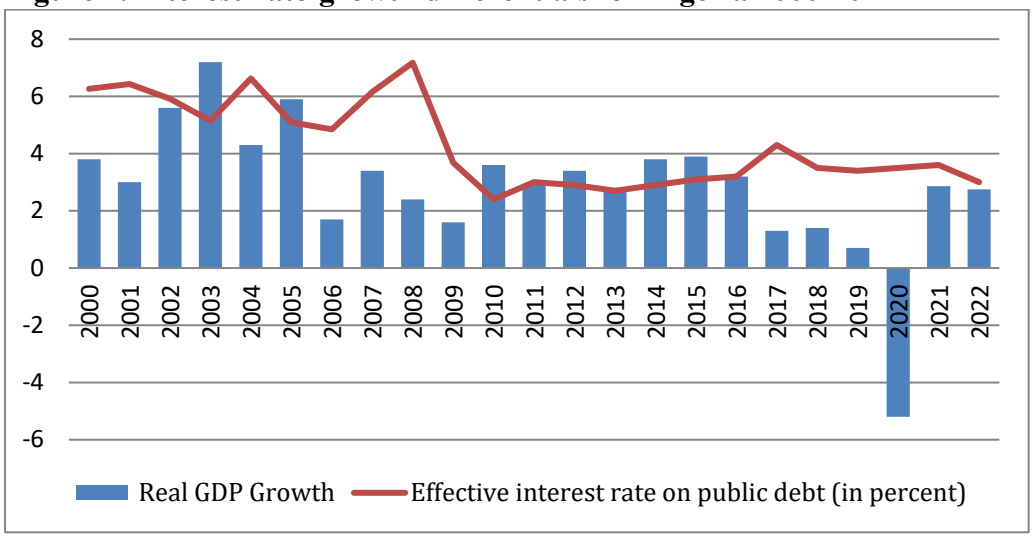
The structure of holding debt securities in Algeria (see Figure 10 in the appendix) reflects their concentration in the central bank and the banking sector as a result of the excess liquidity that created incentives for holding government bonds until their maturity and easing monetary policy in 2020. However, in light of the increasing weaknesses and the rise in the total public financing needs, and in the face of the authorities' continued refusal to benefit from the resources of the international financial markets, the Algerian banking system will need to continue covering a large share of Algerians' high public financing needs in the years ahead. This could lead to more crowding out of private sector credit as was evident after the 2014-15 oil shock, at a time of heightened private financing needs, with implications for the recovery ahead. In turn, a prolonged recovery and possible scarring of small and medium enterprises and, more broadly, the corporate sector, in the aftermath of the pandemic could increase nonperforming loans; thereby further reducing banks' ability to provide the needed financing to the economy. This could give rise to another round of monetary financing, intensifying fiscal dominance concerns.

Now, we move on to calculating some of the traditional fiscal space indicators, whether backward-looking or forward-looking. The simplest way to grasp the evolution of fiscal space over time is to look at the interest rate-growth differential. The rationale behind this is that the debt dynamics will be favorable and lead to an increase in fiscal space, when the nominal growth rate is sufficiently high to offset the impact of the nominal interest rates on the debt ratio, for a given primary balance. In addition, the market interest rate includes a risk premium, which should encompass the information the market can use to assess default probability.

By comparing the interest rate on public debt[14] and economic growth in Algeria (see figures 2 and 3), it is clear that the latter is not sufficient to compensate the nominal interest rates on the debt, especially at the beginning of 2014, which made the growth adjusted interest payments smaller than the growth rate of public debt; suggesting that the fiscal space in Algeria decreased since that time. This situation will raise the sovereign risk premium for the Algerian debt and give information in the international market about the possibility of default.

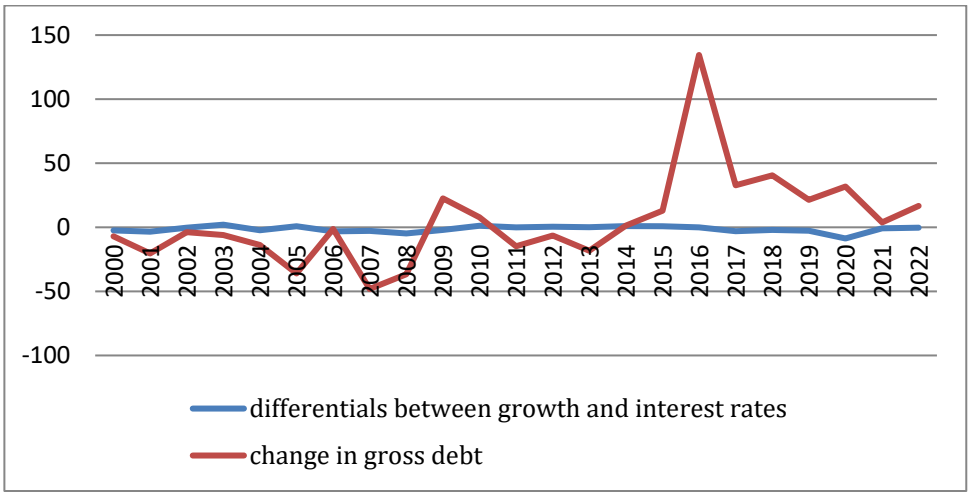
[14] Defined as interest payments divided by debt stock (excluding guarantees) at the end of previous year.

Figure 2. Interest-rate-growth differentials for Algeria 2000-2022



Source: Authors' calculations, based on data from: Fiscal Monitor Database (April 2021) and IMF Country Report No. 18/168.

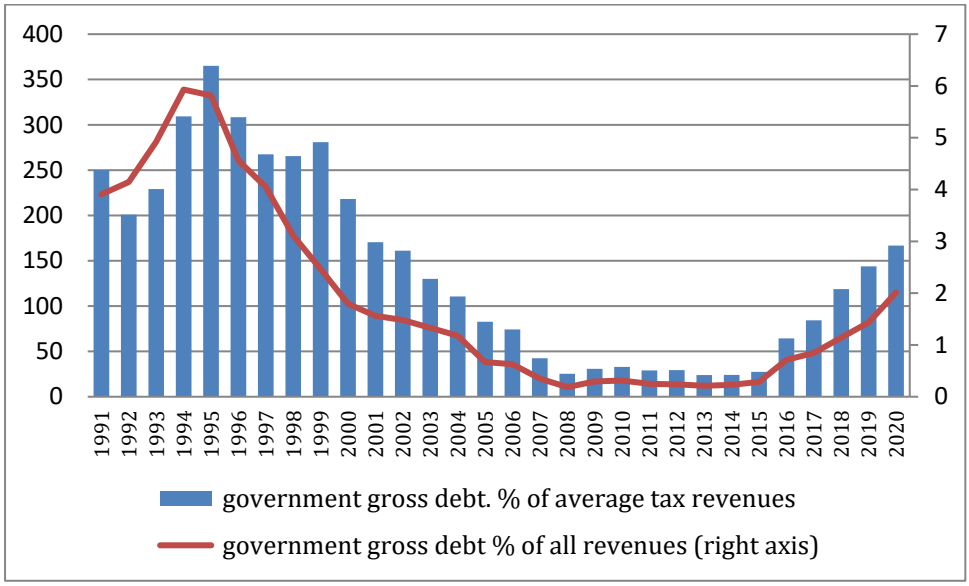
Figure 3. Comparison between change in gross debt and differentials between growth and interest rates 2000-2022



Source: Authors' calculations.

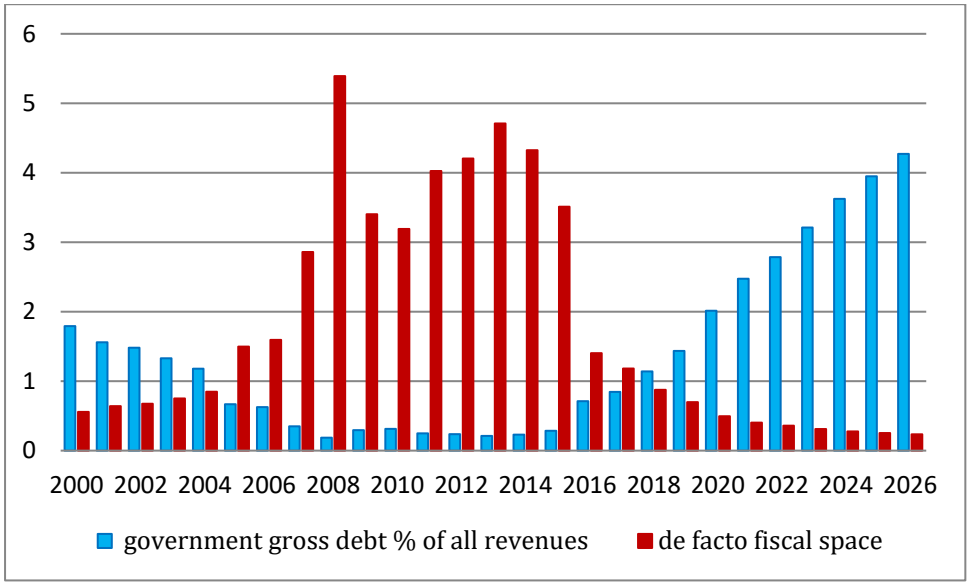
De facto fiscal space, computed as the inverse of the tax years it would take to repay public debt (equation 6), is shown in figures 4 and 5. The rise in public debt relative to the tax base since 2014 shown in Figure 4 can be taken as evidence of a limited financial ability to finance incentives using the current tax capacity. Empirically, it would have taken two years to fully repay the public debt in 2020 (relative to the overall state income: taxes revenues plus oil revenues) and 166 years (taxes revenues). The number of years would be much higher (exceed three years) after 2022 in light of the fragile recovery, and a prolonged rollout of vaccines may lead to lower-than-expected revenues and reduce the available fiscal space as shown in Figure 5.

Figure 4. Years to repay the public debt in Algeria 1991-2020



Source: World Bank: A Cross-Country Database of Fiscal Space (April 2021).

Figure 5. De facto fiscal space in Algeria 2000-2026

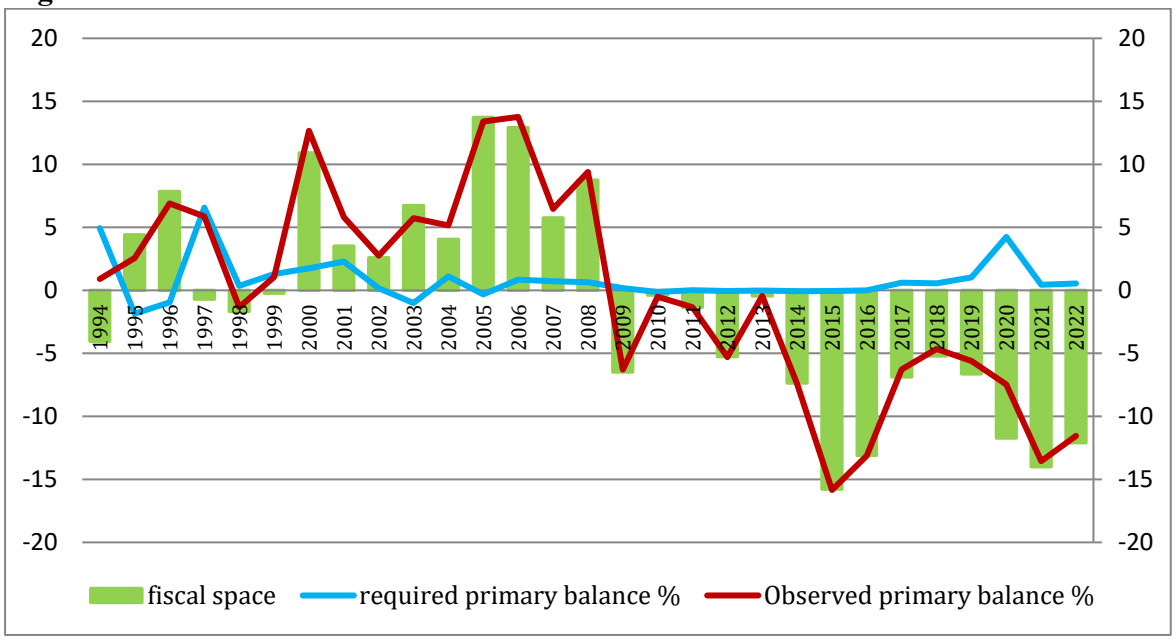


Source: Authors' calculations based on data from: IMF: Fiscal Monitor Database (April 2021).

Moreover, using equations (4) and (5), the primary balance sustainability gap index, which is defined as the difference between the current primary balance and a debt-stabilizing primary balance (forward-looking), was calculated in Figure 6. It appears that the observed primary fiscal balance since 2009 is still less than the debt-stabilizing primary fiscal balances each year, with its sharp exacerbation after the oil shocks of 2015 and 2020. This was clearly reflected on the public debt dynamic, which has known an upward curve since 2014. For example, the government should have achieved a budget surplus of 4.24 percent of GDP in 2020 in order to maintain the same level of debt for 2019, but the primary balance achieved

was -7.47 percent of GDP (negative fiscal space, i.e. the deficit must be reduced by 11. 72 percent), which led to an increase in the public debt by 31.8 percent.

Figure 6. Primary fiscal balances versus debt-stabilizing primary fiscal balances in Algeria 1994-2022



Source: Authors' calculations.

The combined results of these indicators are clear evidence of the fiscal fatigue state in which the Algerian economy is still floundering despite the efforts made to rearrange spending and income priorities.

5. Model specification

In this study, we follow the approach of Ostry et al. (2010) and Gosh et al. (2013) to investigate the fiscal fatigue phenomenon in Algeria. To determine a country's debt limit and fiscal space, we follow these steps: (i) estimate the Fiscal Reaction Function FRF (how the primary fiscal balance reacts to debt in the previous period); (ii) determine the appropriate interest rate-growth rate differential; and (iii) calculate each country's debt limit and associated fiscal space (defined as the difference between current debt ratios and the computed debt limit).

The starting point of our model specification process is the simplest case of the linear Fiscal Reaction Function proposed by Bohn (1998):

$$pb_t = \beta_0 + \beta_1 d_{t-1} + \varepsilon_t \text{.....(7)}$$

where pb_t is the primary fiscal balance as a share of GDP[15] and d_{t-1} is a one period lag of debt to GDP.

Bohn (2008) shows that for an economy to satisfy its intertemporal budget constraint and the so-called no-Ponzi condition, the coefficient $\beta_1 > 0$ is sufficient because primary balance improves when debt increases. However, as shown in some studies of Ghosh et al. (2013) or Daniel and Shiamptanis (2012), a positive coefficient β_1 cannot be viewed as sufficient to achieve fiscal sustainability if there is a limit for positive values of primary balances, for instance, at very high debt levels or if the reaction of financial markets is accounted for (e.g., the increase in the primary balance is not large enough to account for the exploding interest rate-growth differential). In this respect, Ghosh et al. (2013) call Bohn's condition a "weak sustainability condition" (Checherita-Westphal and Žďárek 2017).

Ghosh et al. (2013) made a significant contribution to the literature by proposing the non-linear specification of the FRF function, which accounts for the fiscal fatigue in the context of the cubic polynomial specification. Fiscal fatigue can be described as "the existence of mean reversion properties in the primary balance for high levels of public debt." The baseline cubic specification of the non-linear FRF function is as follows:

$$pb_t = \beta_0 + \beta_1 d_{t-1} + \beta_2 {d_{t-1}}^2 + \beta_3 {d_{t-1}}^3 + \varepsilon_t \text{.....(8)}$$

The fiscal fatigue proposition of a positive but eventually slowing response of the primary balance to rising debt should show up as a $\beta_3 < 0$ (in a cubic specification) or $\beta_2 < 0$ and $\beta_3 = 0$ (in a quadratic specification).

Through previous theoretical and empirical considerations with the specificity of the Algerian economy, we developed equation (8) to take the following form:

$$pb_t = \beta_0 + \beta_1 d_{t-1} + \beta_2 {d_{t-1}}^2 + \beta_3 {d_{t-1}}^3 + \sum_i \phi_i Z_i + \varepsilon_t \text{.....(9)}$$

In line with the existing literature, Z is a set of following macroeconomic, institutional, and political determinants of the primary balance that includes:

[15] Two main policy variables – the primary balance (PB) or the cyclically-adjusted primary balance (CAPB) – have been employed in the FRF literature as the *dependent variable*. Such a choice obviously highlights the primary focus of a study: models with CAPB estimate the "fiscal effort" directly, while models with PB are connected with the output gap and show the total "fiscal impulse." Given that the primary balance is the "observable" fiscal policy variable, less prone to expost revisions (due to output gap and elasticities' uncertainty), and following most studies, we prefer using it as our dependent variable and leave the CAPB for robustness checks. As pointed out in Golinelli and Momigliano (2008), there is basically no difference whether one chooses the dependent variable (CAPB/PB) in first differences or in levels, only the coefficient on the lagged term is different (Checherita-Westphal, and Žďárek, 2017. P:6).

Output gap: The temporary fluctuations in GDP (cyclical deviation of GDP from potential GDP). We estimate the output gap using the Hodrick-Prescott filter (HP-filtered cyclical components of real output).

Expenditure gap: The temporary fluctuations in government expenditure resulting from: natural disasters, political events such as elections,[16] the COVID-19 pandemic that increased spending on health and services…etc. we estimate the expenditure gap using the Hodrick-Prescott filter (HP-filtered cyclical components of real government expenditure). In addition, we included a dummy variable that expresses political events (presidential and parliamentary elections),[17] but it was not statistically significant in all the estimated models.

Oil price: The Algerian crude Sahara Bland price. Since Algeria has also gained revenue from natural resources, especially oil, an oil price indicator is considered to be incorporated in the fiscal reaction function model (oil revenue represents more than 60 percent of revenues).

Annual data for model variables during the period 1990-2020 were obtained from the following sources:
IMF: World Economic Outlook Database, April 2021.
IMF: Fiscal Monitor Database, April 2021.
World Bank: World Development Indicators, April 2021.
World Bank: A Cross-Country Database of Fiscal Space, April 2021.
The U.S. Energy Information Administration (EIA): Crude Oil in Dollars per Barrel.

It is more natural to study the reaction of fiscal policy using annual data, since the budget is adopted annually, and the government often reacts to economic changes in the subsequent year. However, annual data reduce the number of observations, since the calculations span the years 1990-2020. Moreover, quarterly data are more appropriate for identifying specific fiscal policy regimes. Using the practice of Burger and Marinkov (2012) and Vdovychenko (2017), we use quarterly data with a fourth lag as a substitute for annual data with one lag. We converted the annual data to the corresponding quarterly data using cubic spline interpolation method (1990 Q1-2020 Q4).

On the other hand, following the recommendations in Di Iorio and Fachin (2019) and Sevda (2019) if $t\ pb_t$ and d_t have the same order of integration and deterministic structure, the linear model will be the appropriate specification. If they have the same order of integration, but a different deterministic structure, a non-linear specification will be more suitable.

We estimate the FRF parameters using Fully Modified Least Squares (FM-OLS) regression. FM-OLS regression was created by Phillips and Hansen (1990) to ensure optimal estimates of

[16] It is necessary to take into account the timing of the elections because politicians may increase public spending to promote their re-election, which may affect the financial situation of the country. Moreover, debt accumulation may increase sharply in relation to a lower probability of re-election or significant differences in political ideology between the ruling party and others, so elections should always be judged in the context of the uncertainty of re-election. For further clarifications, see: Mawejje and Odhiambo (2020).

[17] Data were obtained from the International Institute for Democracy and Electoral Assistance website: https://www.idea.int/data-tools/country-view/97/40

cointegration regressions. The method changes the least-squares that take into account the effects of serial correlation and endogeneity in the regressors resulting from the presence of the cointegration relationship. FM-OLS is used in models with cointegrated I(1) regressor. The limit theory for FM estimates of the stationary regressors is equal to that of OLS, while the FM estimates of non-stationary regressors keep their optimality. This feature is shared by the FM-OLS estimator when OLS estimates of fixed components are optimal. FM-OLS can be applied even in models with stationary regressors and in this case, has the same limit theory as OLS (Sevda, 2019).

6. Empirical results

To check the balanced equation conditions for the linear FRF, we conduct unit root tests to determine the integration order of pb_t and d_t as well as the structure of their time series. Table 1 presents the Augmented Dickey-Fuller (ADF) test results, which indicate that both variables are I(1). We also performed the Zivot Andrews unit root tests with a structural break in both the intercept and trend. The results show that both variables are I(1).

Table 1. Unit root and stationarity tests

	Zivot Andrews			ADF	
	Break date	**level**	**1 st difference**	**level**	**1 st difference**
d	1996Q3	-3.80	-5.98	-1.54	-2.44
pb	2009Q3	-3.90	-5.26	-2.50	-4.66

ADF and Zivot Critical values are: -1.94 and -4.93 at five percent, respectively.

The deterministic structure of the variables is analyzed to determine whether it is compatible or not. For this purpose, ARMA models in differences are estimated with a constant and a trend. The estimation results are presented in Table 2. The results reveal that the public debt series took the form AR(2) MA(4), while the series of the initial budget balance took the form AR(4) MA(4). This implies that the variables do not have the same deterministic structure. Thus, a fiscal reaction function model with non-linear specification would be more suitable.

Table 2. Variables' structure

ARMA Maximum Likelihood (BFGS) Specification					
	pb			**d**	
	Coefficient	**Prob**		**Coefficient**	**Prob**
C	-0.160042	0.3480	C	-0.706031	0.5095
AR(1)	1.637089	0.0000	AR(1)	1.826202	0.0000
AR(2)	-0.463029	0.2689	AR(2)	-0.833209	0.0000
AR(3)	-0.540717	0.1487	SAR(4)	-0.546331	0.0000
AR(4)	0.337716	0.0295	MA(1)	1.571437	0.8661
SAR(4)	-0.513869	0.0000	MA(2)	1.583696	0.9342
MA(1)	1.852587	0.8923	MA(3)	1.558074	0.9571
MA(2)	1.709669	0.8881	MA(4)	0.547314	0.9565
MA(3)	1.850885	0.9016	SMA(4)	-0.997426	0.9351
MA(4)	0.998730	0.9441	SIGMASQ	0.015812	0.9397
SMA(4)	-0.999895	0.9960			
SIGMASQ	0.003429	0.9950			
R-squared	0.998654		R-squared	0.998958	

Table 3. Estimation results for the fiscal reaction function

	Fully Modified Least Squares (FMOLS)		
	Linear	Quadratic	Cubic
$(\boldsymbol{\beta_1})$	-0.012332**	0.280619*	-0.334405**
	(0.0241)	(0.0009)	(0.0146)
$(\boldsymbol{\beta_2})$		-0.001163*	0.005500*
		(0.0038)	(0.0026)
$(\boldsymbol{\beta_3})$			-7.14E-06*
			(0.0051)
$(\boldsymbol{\phi_1})$	5.13E-10	5.58E-10***	3.96E-10*
	(0.2330)	(0.0525)	(0.0007)
$(\boldsymbol{\phi_2})$	-9.18E-10*	-8.67E-06*	-6.69E-10*
	(0.0000)	(0.0000)	(0.0003)
$(\boldsymbol{\phi_3})$	0.074903***	0.095376**	0.178236**
	(0.0686)	(0.0383)	(0.0104)
$(\boldsymbol{\beta_0})$	2.553180*	3.256703*	3.314708***
	(0.0000)	(0.0063)	(0.0955)
R-squared	0.378611	0.347060	0.433600

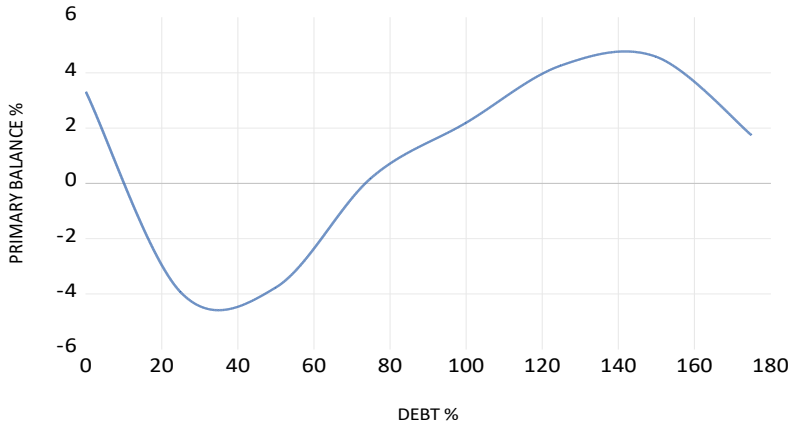
* is significance at the one percent level, ** at the five percent level and *** at the ten percent level.

The FM-OLS estimation results of the long-run non-linear FRF are presented in Table 3. The results show that the primary balance has a negative ($\beta_1 < 0$) and statistically significant relationship with lagged debt on average; this suggests that when lagged debt increases, the primary balance deteriorates in most of the study period. This implies that the primary budget balance was not sufficient to stabilize the public debt, which is not a sign of fiscal sustainability.

Within the model with nonlinear characteristics, the results showed that the coefficient $\beta_2 < 0$ is negative and significant within the quadratic model, while the coefficient $\beta_3 < 0$ is also negative and significant within the cubic model, which is exhibits signs of "fiscal fatigue" behavior and fiscal unsustainability in Algeria. This means that at very high public debt, the fiscal effort must be so high that they may become untenable.

The X-Y plot of the FRF, based on the estimation results, is displayed in Figure 7 (drawn as the sample average primary balance for a given range of debt, 0-25 percent of GDP, 25-50 percent of GDP, 50-75 percent of GDP…etc.). As can be seen from Figure 7, the FRF plot has a sinusoidal shape. This plot also provides evidence of the fiscal fatigue phenomenon.

Figure 7. Estimated non-linear fiscal reaction function



Source: Authors' estimates.

The estimated coefficients of other determinants included in the fiscal reaction function are also plausible and broadly in line with previous studies. For example, the output gap and oil positive coefficients show the pro-cyclical nature of fiscal policy in Algeria (output above potential means great balance); temporary increases in government outlays – as captured by the government expenditure gap variable – affect the primary balance negatively. This is an important result that reveals the behavior of successive governments with regard to their fiscal policy, in which government spending was increasing at growth rates that exceeded revenue growth rates. It is clear that the ease of financing public spending with the oil resource, due to its political and social satisfactions, has left an institutional weakness and difficulty in diversifying the economy outside of oil. Also, as the number of pressure groups on the financial decision increases, public spending increases in a pattern called the 'Voracity Effect,' and its efficiency decreases. In this poor political and institutional environment, the rise in the oil price stimulates more spending, while the government faces many difficulties that do not allow it to be reduced to appropriate levels when the price of oil falls.

Establishing the empirical validity of the cubic format of the fiscal reaction function enables the calculation of the debt limits as proposed by Ostry et al. (2010). To derive the debt limits, the estimated coefficients from equation (7) (where d_t term is assumed to be a cubic function) are plugged into this equation:

$$(r_t - g_t)\overline{d_t} = \beta_0 + \beta_1 d_t + \varepsilon_t \Rightarrow \overline{d_t} = \frac{\beta_0 + \beta_1 d_t + \varepsilon_t}{(r_t - g_t)} \quad \text{.....(10)}$$

To perform our calculations of fiscal space, we also need to calculate the real interest rate growth (r−g) differential. We consider the historical average[18] of the implied nominal interest rate on government debt (interest payments divided by end-period debt) relative to the growth rate of nominal GDP (In the Algerian case, it is equal to 1.16 percent). The results indicate that the debt-to-GDP limit is to 67.5 percent depending on the historical average of the r−g

[18] Ostry et al. (2010) argue that projected interest rate-growth rate differentials (IMF projections of long-term government bond yields and for GDP growth) are considerably less favorable than historical differentials, reflecting the expectation of both higher interest rates and lower real GDP growth rates.

differential. The actual debt ratio projected for 2021 is 63.3 percent, so fiscal space for further borrowing is 4.2 percent (67.5-63.3 percent).[19]

Robustness check

To increase the robustness of the estimation of the 'fiscal fatigue' hypothesis, the primary balance reaction function is estimated with debt thresholds as in Fournier et al. (2015). We used the following threshold model (Caner and Hansen (2001) Threshold autoregression model), instead of the cubic specification of the FRF, for this purpose:

$$pb_t = \beta_0 + \beta_1 d_{t-1} + (\alpha_0 + \alpha_1 d_{t-1}) I(d_{t-1} \rangle \tau) + \sum_i \phi_i Z_i + \varepsilon_t \text{.....(11)}$$

Where I(.) is a regime indicator defined by d_{t-1} . If d_{t-1} is above the estimated threshold level of τ, the $(\alpha_0 + \alpha_1 d_{t-1})$ Part of Equation (10) will be active. Otherwise, the equation will turn into a simple linear model. It is obvious that the τ value is unknown at the beginning of the analysis. It is also estimated with other parameters during the estimation process. To confirm the presence of a fiscal fatigue phenomenon, the debt should have a positive effect on the primary balance until certain threshold value in the low debt regime. This relationship should become negative in a high debt regime.

Table 4. Threshold model estimates

Transition variable	Debt $_{t-4}$		oil $_{t-4}$	
	Debt t-4 ≤ 61.1%	Debt t-4 ≥ 61.1 %	oil t-4 ≤ 59.6	oil t-4 ≥ 59.6
$(\boldsymbol{\beta_1})$	0.609502*	-0.015085**	-0.001857**	0.266166**
	(0.0000)	(0.0419)	(0.0475)	(0.0110)
$(\boldsymbol{\phi_1})$	1.14E-09*	-1.49E-09*	9.30E-10*	-1.01E-10 (0.5720)
	(0.0019)	(0.0000)	(0.0000)	
$(\boldsymbol{\phi_2})$	-6.76E-06*	-8.28E-06*	-3.28E-09*	-3.54E-10**
	(0.0003)	(0.0000)	(0.0000)	(0.0502)
$(\boldsymbol{\phi_3})$	0.04729***	0.193379*	0.440952*	0.350631**
	(0.0649)	(0.0002)	(0.0000)	(0.0115)
$(\boldsymbol{\beta_0})$	-13.15569*	10.95191*	12.77007*	34.17881*
	(0.0006)	(0.0001)	(0.0101)	(0.0037)
R-squared	0.718900		0.604886	

* is significance at the one percent level, ** at the five percent level and *** at the ten percent level.

The estimation results of the threshold model are reported in Table 4. If we choose lagged debt as threshold variable, the estimated threshold value is 61.17 percent.[20] In the low debt regime

[19] Algeria's public debt in 2020 amounted to 60.96 percent and is likely to rise to 63.3 percent in 2021. Therefore, the estimated limit although there are those who reserve its accuracy, but it is considered as an alarm that may push the country into a state of financial insolvency and resurface of sovereign debt risks.

[20] We used the same method as in Fournier et al. (2015) to determine two thresholds d1 and d2 beyond which the fiscal reaction to debt changes (see Figure 11 in the appendix). Estimates confirm that governments react weakly by increasing their primary balance when debt increases but remains below d1. However, from d2 governments react strongly to rising debt. Beyond this threshold, governments may abandon fiscal discipline and reduce the primary balance. But, as discussed in Bai (1997), the second threshold is asymptotically efficient, but the first one is not, and this is what Fournier et al. (2015) adopted in their study. They also believe (in pages: 19-20) that the fiscal reaction function with one threshold ignores that the fiscal reaction to debt can increase when debt is getting

(78 obs), the lagged debt positively affects the primary balance with a significant coefficient value of 0.6. On the other hand, the primary balance is negatively affected by the lagged debt in the high debt regime (39 obs) with a significant coefficient of -0.015. The findings from the threshold model estimation confirm the fiscal fatigue phenomenon. The continued accumulation of fiscal deficits resulting from public spending voracity, and the decline of financial resources in oil revenues weaken fiscal policies' sustainability and push the risks of sovereign debts to the surface yet again. Moreover, if we choose lagged oil price as a threshold variable (according to the characteristics of the Algerian economy), the estimated threshold value is USD 59.69 per barrel. In the low oil price regime (72 obs), the lagged debt negatively affects the primary balance with a significant coefficient value of -0.0018. On the other hand, the primary balance is positively affected by the lagged debt in the high oil price regime (45 obs) with a significant coefficient of 0.26.

7. Conclusion

The overall aim of this research work is to analyze the technical basis of financial soundness and state solvency and provide some evidence on the sustainability of public debt in Algeria, especially when fiscal policy is conducted as a nonlinear process, which has been hardly treated in the literature. For this purpose, this paper uses a "fiscal space and public debt limits" approach to analyze the fiscal sustainability in Algeria during the period 1990-2020 by estimating the fiscal reaction function using Fully Modified Least Squares method and threshold models. In spite of the efforts made to rearrange the priorities of spending and incomes in Algeria, the results of the descriptive and econometric study were clear evidence of the fiscal fatigue state and the decrease in the fiscal space available in Algeria. The results also demonstrated the existence of a threshold level in the debt ratio (debt ceiling or fiscal cliff), approximately equal to 61.1 percent (or USD 59.6 per barrel), above which Algerian fiscal policymakers are concerned with corrective actions to avoid insolvency. On the other hand, the estimation results of the long-run non-linear fiscal reaction function show that the output gap and oil affect the primary balance positively, which shows the pro-cyclical nature of fiscal policy in Algeria. Also, temporary increases in government outlays, as captured by the government expenditure gap variable, affect the primary balance negatively. This is an important result that reveals the behavior of public spending which increases in a pattern called the 'Voracity Effect,' and its efficiency decreases.

Based on these results, and given the vulnerabilities generated by the COVID-19 pandemic, the Algerian fiscal framework should implement policies and reforms to help reduce elevated public gross financing needs and, over time, mitigate the concentration of bank exposure to the sovereign, underpinned by a strong medium-term debt management strategy and the development of a clear and transparent communication plan with market participants. Coordination among debt management, monetary, fiscal, and financial sector regulatory authorities – both with respect to policies and specific measures – is also essential to form a

closer to dangerous levels; and hence embeds a bit less fiscal tightening at a high debt level. In our study, the thresholds were estimated at 27.09 percent and 61.176 percent respectively.

common view on the overall absorption capacity of domestic financial markets and analyze the impact of measures that might affect the ability of the sovereign to borrow.

Furthermore, in the context of limited or no fiscal space, the Algerian fiscal framework will need to start implementing growth-friendly consolidation plans, anchored on a credible medium-term fiscal framework.

Also, to reduce risks stemming from a concentrated government debt holding structure, the Algerian fiscal framework should move along several levers. Domestic capital markets should be developed and supported by: addressing the structural excess bank liquidity that inhibits the development of money markets and promotes a buy-and-hold investment strategy; increasing domestic savings, particularly in long-term instruments; and establishing deep and liquid secondary markets, including developing larger benchmark government securities at all points of the yield curve.

On the other hand, the tax policy must be reviewed in order to achieve more efficiency (the ratio of tax revenues to GDP in Algeria is estimated at 14 percent, which is slightly less than the global average of 15 percent) by reconsidering tax exemptions, reviewing tax legislation, and improving collection efficiency levels by simplifying procedures.

In addition, public spending must be rationalized (the ratio of public spending to GDP in Algeria is estimated at 38 percent, which is 27 percent greater than the global average), and raise its efficiency levels, especially current spending. This is done through many measures that include: encouraging ministries and government agencies to reduce their expenditures; stopping all unnecessary parties and events and other measures aimed at strengthening the budget situation; and implementing a large number of projects through public-private partnership frameworks. Also, public spending must be re-orientated to the areas that encourage productivity growth.

Finally, we point out the need to move forward with policies of economic diversification and structural and institutional reforms to remove some distortions.[21] In this context, the institutional environment must be improved and its role in stimulating market mechanisms must be activated, including intellectual property protection policies, competition and monopoly prevention, improving the administrative components of the general government, reducing transaction costs, and increasing levels of transparency, integrity, and governance.

[21] Administrative corruption has cost the state treasury in Algeria around USD 70 billion in recent years.

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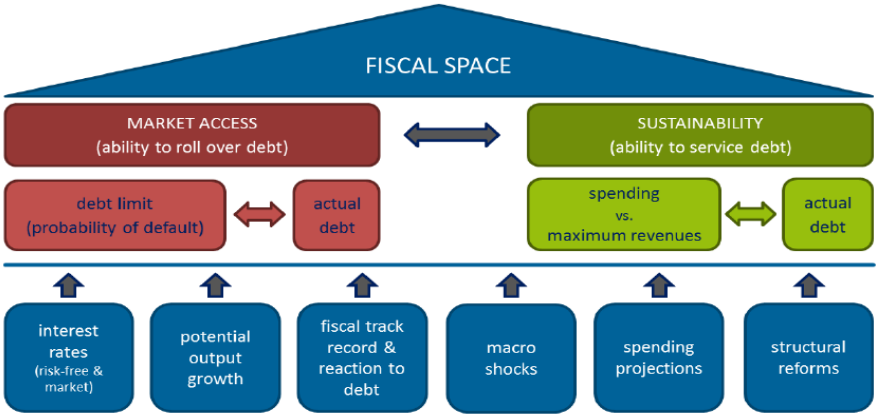
Appendix

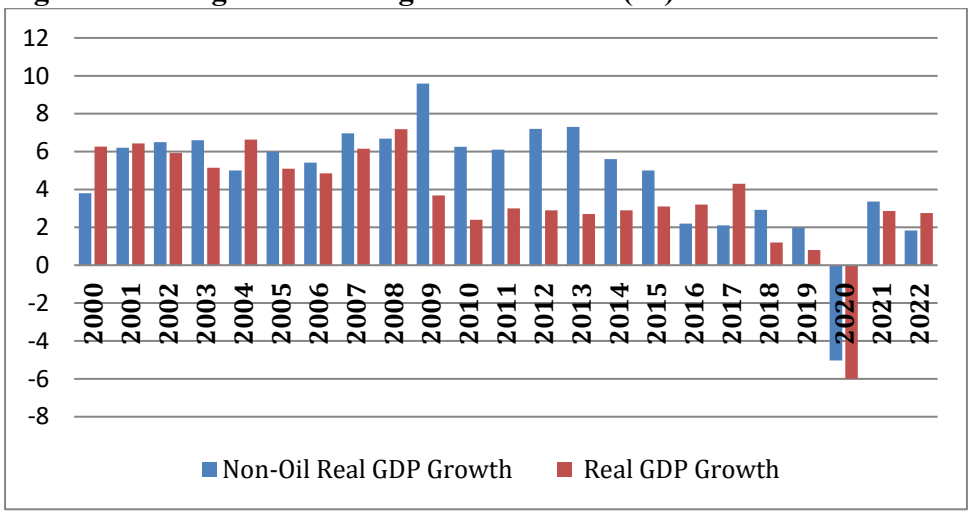
Figure 1. Prudent debt targets design

Figure 2. Different approaches to measuring fiscal space



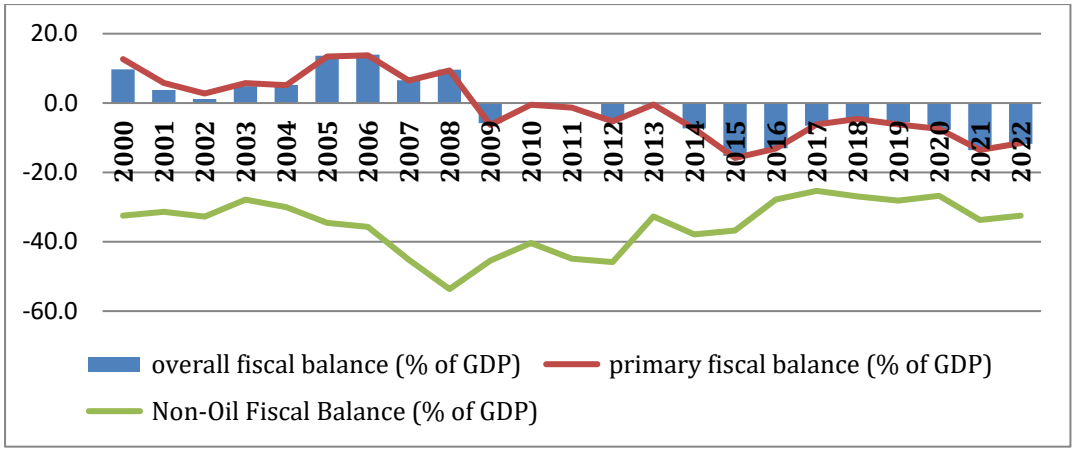
Source: Botev and all (2017). P: 9.

Figure 3. GDP growth for Algeria 2000-2022 (%)



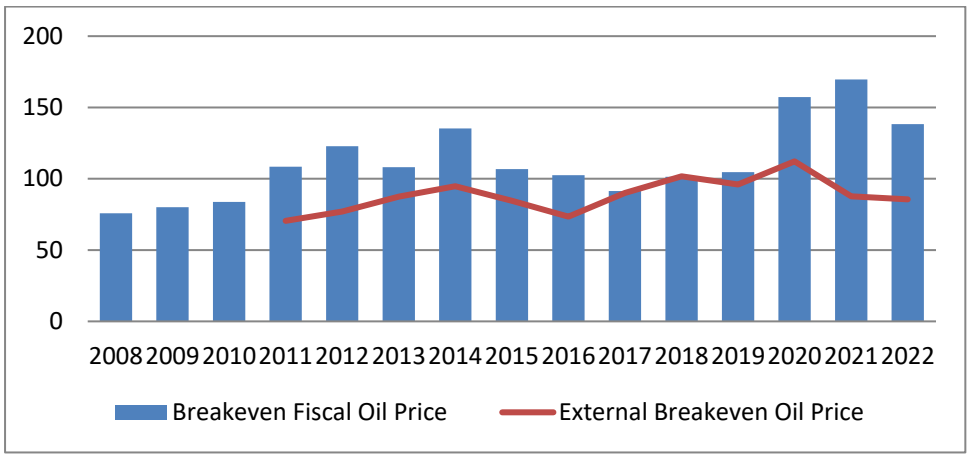
Source: World Bank: A Cross-Country Database of Fiscal Space (April 2021).

Figure 4. Overall and primary fiscal balance for Algeria 2000-2022 (% of GDP)



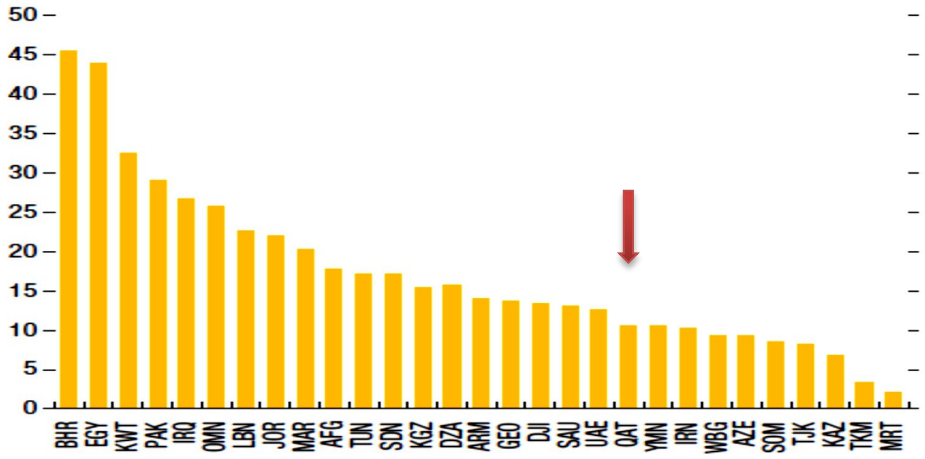
Source: IMF: Regional Economic Outlook Database. April 2021. Fiscal Monitor Database. April 2021.

Figure 5. Breakeven fiscal oil price for Algeria 2008-2022



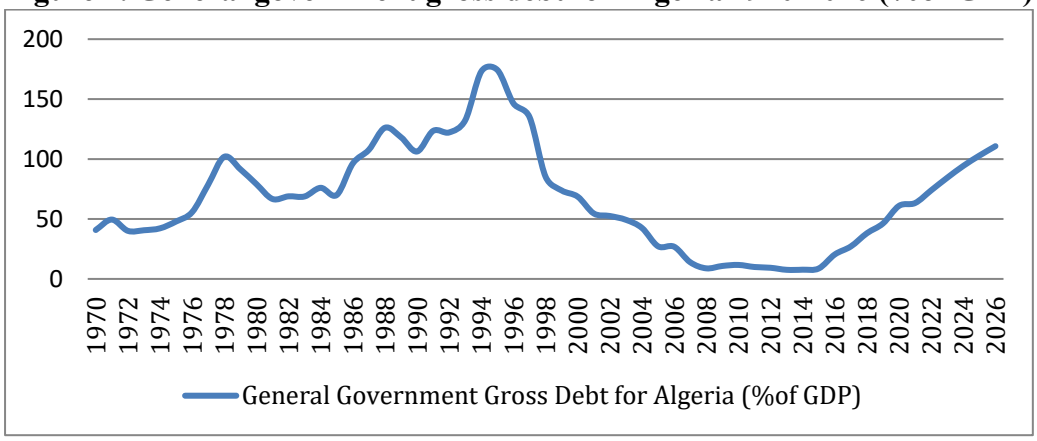
Source: IMF: Fiscal Monitor Database. April 2021.

Figure 6: Public gross financing needs in MENA countries 2020 (Percent of GDP)



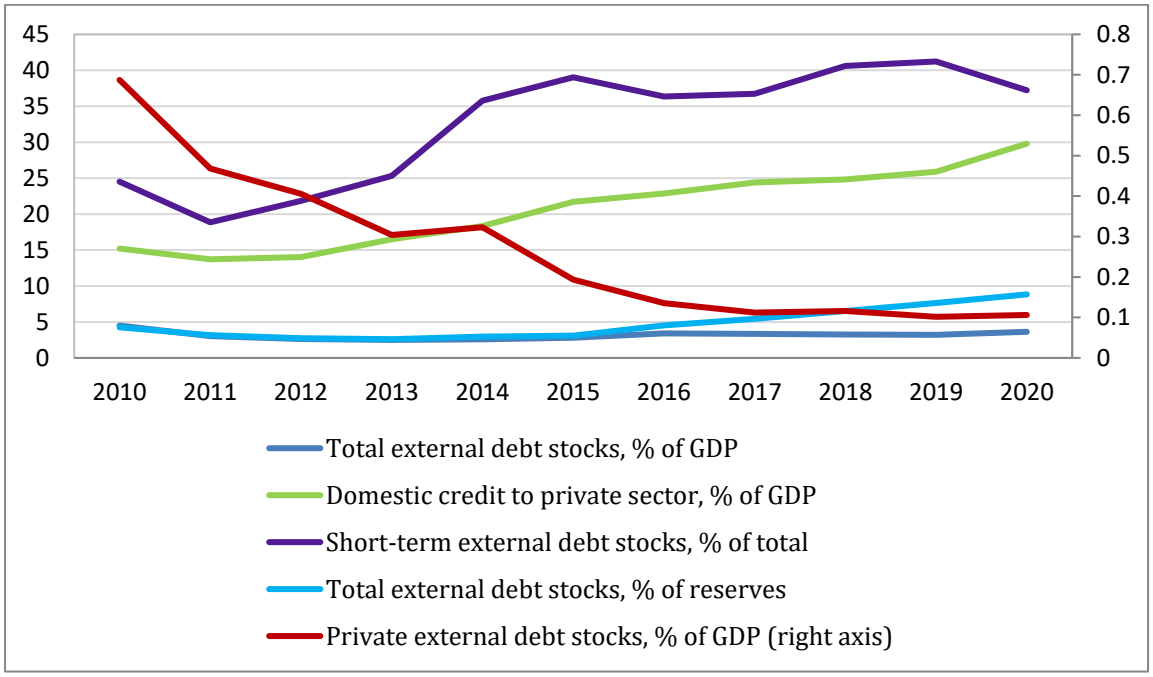
Source: IMF: Regional Economic Outlook (MENA). April 2021. P:15.

Figure 7. General government gross debt for Algeria 1970-2026 (%of GDP)



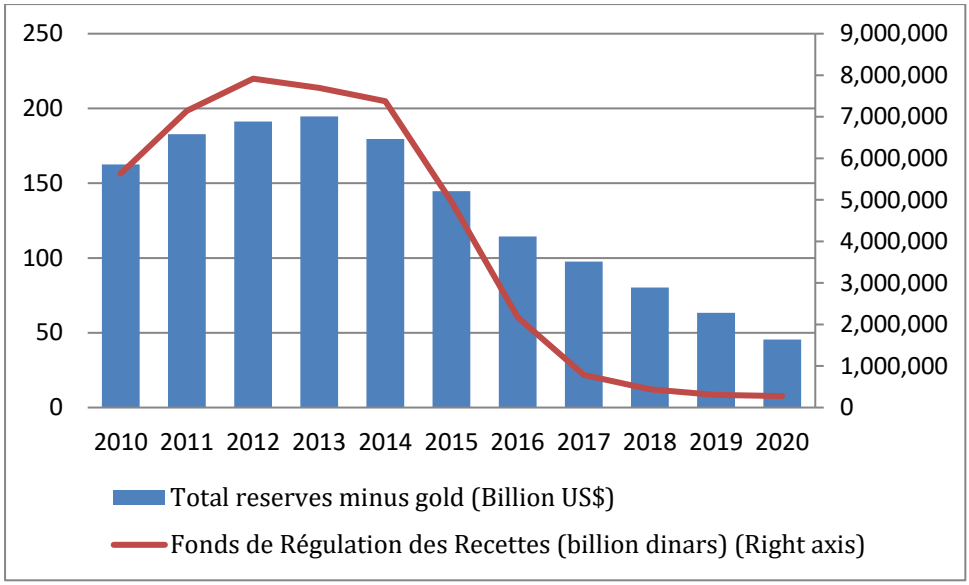
Source: IMF: Fiscal Monitor Database (April 2021).
World Bank: WDI.

Figure 8. Algeria: External debt indicators (2010-2020)



Source: World Bank: A Cross-Country Database of Fiscal Space. April 2021.

Figure 9. Algeria's foreign exchange reserves and oil stabilization fund 2010-2020



Source: Algerian Ministry of Finance and the World Bank.

Figure 10. Government debt structure by creditor (percent of GDP)

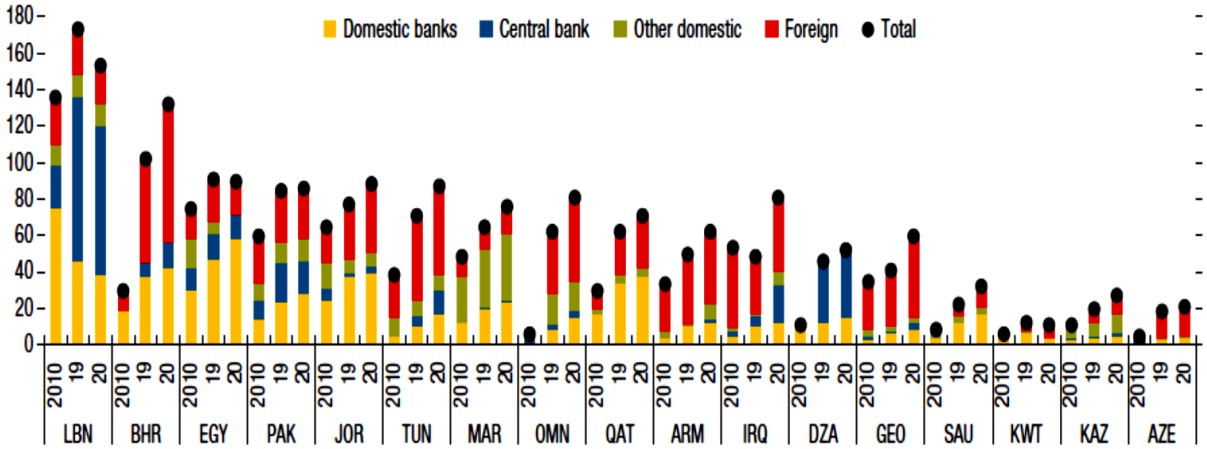
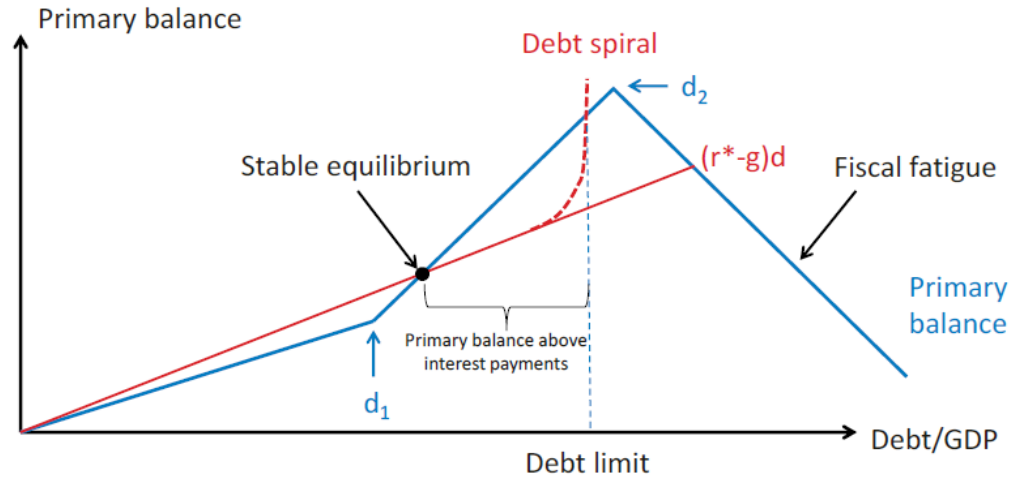


Figure 11. Determination of the debt limit



Source: Fournier and Fall (2015). P:14.

Essay 2: Public Debt and Economic Growth in Algeria: Threshold Analysis

1. Introduction

The impact of public debt on economic growth has been a controversial issue among economists and policymakers, particularly since the debt crisis of the 1980s. After the recent global financial crisis, Reinhart and Rogoff (2010) successfully revived academic and policy debates on the economic impact of public debt. Their contribution sparked a new debate on the growth-debt nexus. The central question in this debate is whether there is a threshold for public debt ratios above which medium-term economic growth is compromised. A plethora of literature since then has investigated the threshold effect in the link between public debt and GDP growth rate, but there is not yet a general consensus on this issue (Panizza and Presbitero, 2013; Pattillo et al., 2011; Cecchetti et al., 2011; Baum, Checherita and Rother, 2013; Afonso and Jalles, 2013; Herndon, Ash, and Pollin, 2013; Pescatori, Sandri, and Simon, 2014). This study contributes to the existing empirical evidence on the relationship between debt and growth in developing countries, using Algeria as a case study.

Algeria makes an interesting case for analyzing the effect of debt on growth. Algeria depends heavily on hydrocarbon income for government revenues, therefore, a sustained decline in oil prices contributes to the widening of budget deficits and the accumulation of public debt. The country witnessed sustained expansions in debt over the 1980s and 1990s. This situation forced Algeria to undertake a structural adjustment program (SAPs) backed by the IMF to promote economic growth, balance the budget, and reduce public debt. More recently, the collapse of oil prices that began in mid-2014 has pushed Algeria's debt to GDP ratio from 8.7 percent of GDP at the end of 2015 to 57.2 percent of GDP at the end of 2020. These stylized facts about a recent upward trend in public debt raise serious concerns regarding the debt to GDP ratio's threshold at which economic growth can be sustained in Algeria. The main aim of this study is, therefore, to examine whether there is a debt to GDP threshold in the relationship between public debt and economic growth for Algeria.

Reinhart and Rogoff (2010) suggested a debt to GDP threshold equal to 60 percent for developing countries. however, Algeria may have a different debt threshold value due to its different economic structure.

This study is structured as follows. The second section summarizes the literature review. Section three presents the estimation methodology. Section four discusses the empirical results. Finally, section five provides the general conclusion.

2. Theoretical background and literature review

Conceptually, the impact of public debt on economic growth depends on assumptions about expectations. Ricardian Equivalence suggests public debt is neutral to long-run economic growth. The neutrality stems from individuals adjusting their consumption in anticipation of higher future taxes to repay the public debt in the future (Ahiakpor, 2013). Therefore, public debt will generally be ineffective at boosting economic growth.

In the aftermath of the great depression of the 1930s, a fundamental change of perspective was produced regarding the impact of public debt on the economy. According to Keynes, government expenditure is an important component of aggregate demand in the economy. Government spending, which increases aggregate demand and employment, is the best way to boost national output. The main message of the Keynesian paradigm is that public debt does not reduce economic growth, and expansionary fiscal policy is the best tool to be used in times of recession for building strong economic growth (Alshammary et al. 2020).

Contrary to the Keynesian view, the neo-classical theory asserts the harmful impact of public debt on economic growth via the crowding out channel. According to this view, government borrowing reduces the funds available for private investment and thus causes increases in interest rates. Higher domestic interest rates crowd out private investment, which results in decreased future capital stock. Under this assumption, the new-classical theory predicts that an increase in budget deficits could potentially lead to slower economic growth.

Furthermore, the debt overhang theory of Krugman (1988) and Sachs (1989) posits that higher foreign debt levels tend to reduce the government's ability to repay external debt; this will reduce foreign and local investment, thereby adversely affecting capital stock and undermining economic growth.

Apart from these theories, there is the conventional view on public debt (Elmendorf and Mankiw, 1999). The conventional view distinguishes between the short- and long-run effects of public debt on economic growth. According to Elmendorf and Mankiw (1999), by injecting new financial resources into the economy, government debt will stimulate aggregate demand and encourage economic growth in the short run, but will crowd out capital and reduce national savings and investment in the long run. Elmendorf and Mankiw (1999) argue that a large increase in debt could adversely affect the economy in various ways. High public debt can negatively affect economic growth via heightened interest rates and inflation (De Rogy and Salmon, 2020). An extensive public debt can also reduce the fiscal flexibility of the government and make the economy more vulnerable to a great risk of fiscal crises (CBO, 2014). More recent studies suggest that larger debts could lead to serious intergenerational inequity and lower future incomes (Boskin, 2020).

On the empirical side, several studies have examined the relationship between public debt and economic growth in developed and developing countries. The empirical findings from the literature on the debt-growth nexus are inconclusive and even inconsistent (Panizza and Presbitero, 2013). Certain studies support the negative effect of public debt on economic growth, while others demonstrate a positive relation between the two variables. However, other empirical studies find no evidence of a significant association between public debt and growth (Saungweme and Odhiambo, 2019).

More recently, other strands of literature provide empirical evidence indicating an inverted U-shaped relationship between public debt and economic growth (Reinhart and Rogoff, 2010, 2012; Pattillo et al., 2011). Starting from the seminal article "Growth in a Time of Debt" of

Reinhart and Rogoff (2010), a large number of studies have investigated the presence of a threshold in the debt and growth relationship over the past decade. Reinhart and Rogoff (2010) compile data on 44 countries over the period 1946-2009 and find that the link between debt and growth is relatively weak when the debt ratio is less than 90 percent, whereas a debt to GDP levels above 90 percent is associated with notably lower growth outcomes. This threshold effect for the debt ratio is similar in both advanced and emerging countries. Kumar and Woo (2010) find an inverted U-shaped relationship between public debt and economic growth. Their results also support the proposed 90 percent debt threshold. Similarly, Cecchetti et al. (2011) find a debt to GDP threshold of 85-90 percent beyond which public debt becomes a drag on growth. Checherita and Rother (2012) also find a non-linear effect of debt on growth with a turning point between 90 to 100 percent, beyond which public debt leads to slower growth. Focusing on 12 Euro area countries, Baum, Checherita, and Rother (2013) confirm evidence of a threshold debt ratio of 95 percent, above which additional debt has a negative impact on economic activity. In the same vein, Canner et al. (2010) and Afonso and Jalles (2013) argue that the effect of public debt on economic growth depends on a threshold of debt between 60 and 80 percent of GDP, above which public debt decreases growth. On a sample of 99 developing countries, Elbadawi et al. (1997) find a debt threshold at around 97 percent of GDP beyond which the effect of debt on growth becomes negative. More recently, Hansen (2017) proposes a regression kink model with an unknown threshold to model the non-linear debt-growth relationship. Using Reinhart and Rogoff (2010) times series for the US, Hansen (2017) reports a kink (threshold) of about 44 percent for debt to GDP in the US. As the debt levels increase above this point, aggregate economic growth tends to slow.

In a major break with the findings of Reinhart and Rogoff, other studies dispute the notion that there is a clear debt threshold effect above which government debt substantially lowers growth (Panizza and Presbitero, 2012; Herndon, Ash, and Pollin, 2013; Pescatori, Sandri, and Simon, 2014). Herndon, Ash, and Pollin (2013) contradict Reinhart and Rogoff's claim of debt threshold. The authors replicate the Reinhart and Rogoff study and find no evidence for a debt threshold of around 90 percent of GDP, and they suggest that the relationship between public debt and GDP growth differs significantly by time period and country. In a survey of the literature on the link between public debt and economic growth in developed economies Panizza and Presbitero (2012) show that the evidence of a common debt threshold above which debt hampers growth is far from being robust. In its 2012 World Economic Outlook, the International Monetary Fund emphasizes that debt-to-GDP thresholds are not robust: "There is no simple relationship between debt and growth. In fact, our … analysis emphasizes that there are many factors that matter for a country's growth and debt performance. Moreover, there is no single threshold for debt ratios that can delineate the 'bad' from the 'good'." Focusing on 34 advanced economies over 1875 to 2011, Pescatori, Sandri, and Simon (2014) find no evidence of any debt thresholds above which debt-to-GDP ratios severely undermine medium-term growth prospects. Focusing on 105 developing, emerging, and developed economies from 1972 to 2009, Eberhardt and Presbitero (2013) find no evidence of a common debt threshold within countries. Their results indicate some support for a negative relationship between public debt and long-run growth across countries. The authors also observe that long-run debt coefficients appear to be lower in countries with higher average debt burdens. Using data on a

sample of 40 advanced and developing countries over the period 1965-2010, Chudik and al. (2015) do not find a common debt threshold effect in the relationship between public debt and economic growth, however, the authors find significant negative long-run effects of public debt build up on growth. It is clear from the above empirical literature on the relationship between public debt and economic growth for both developing and developed countries that the consensus of a common debt threshold does not hold.

Despite being subject to frequent debt crises since the 1980s, studies on the debt-growth threshold effects for Algeria remain scarce. To our knowledge, few studies exist in the empirical literature. For instance, a study by Ndoricimpa (2020) for African countries over the period 1980-2017 that also included Algeria finds no evidence of a single debt threshold applicable to all African countries. The results show a debt threshold in the range of 58-66 percent for African middle-income and resource-intensive countries. Alshammary et al. (2020) use data for 20 Middle East and North African (MENA) countries for the period 1990-2016 and find a debt threshold at around 58 percent of GDP. Khanfir (2019) finds a debt threshold effect on growth in four North African countries (Tunisia, Algeria, Morocco, and Egypt) at 42.8 percent of GDP, beyond which the relationship between debt and growth becomes negative. Omrane Belghith et al. (2017) show a public debt threshold equal to 39.5 percent of GDP for four MENA countries (Tunisia, Turkey, Morocco, and Egypt).

In the current study, we examine the debt threshold effects on growth in Algeria for the following reasons. A decade past, sustained high oil prices have allowed the country to accumulate large currency reserves, repay the official external debt earlier than had been scheduled, and keep a low debt to GDP ratio, while the persistent low of oil prices since 2014 has resulted in a widening budget deficit and dwindling foreign exchange reserves. If this situation continues, the country will be forced to look for alternative sources of financing – rather than unconventional financing – including external borrowing. Thus, it seems important to suggest to policymakers a debt threshold level beyond which economic growth can be jeopardized. This study applies a different estimation technique: a regression kink model with an unknown threshold proposed by Hansen (2017).

3. Econometric methodology and data

3.1. Regression kink model

The regression kink model (Card et al., 2012 and Hansen, 2017) is a threshold regression constrained to be continuous with a kink at an unknown threshold (Hansen, 2017). In the regression kink model, the regression function is continuous, but the slope has a discontinuity at a threshold point. This method is appropriate in the case that the threshold is not set by the policy, which corresponds with our objective of examining endogenous thresholds from a relationship between economic growth and public debt.

According to Hansen (2017), the functional form of the regression kink model is as follows:

$$Y_t = \beta_1(x_t - \gamma)_- + \beta_2(x_t - \gamma)_+ + \beta_3 z_t + e_t \dots\dots\dots\dots\dots (1)$$

Where: y_t , x_t are the relevant time series variables for $t = 1,2, \dots, n$, and z_t is a k vector of other explanatory variables which includes an intercept. e_t is an error term. The parameters to be estimated are the regression slops β_1, β_2, and β_3 , and the parameter γ called the threshold or the kink point. It is assumed that $\gamma \in \Gamma$ where Γ is compact and strictly interior of the support of the threshold variable x_t.

As in Hansen (2017), we set y_t to be GDP growth rate in year t , and x_t to be the debt to GDP ratio, so that the regression contains a lagged dependent variable to account for dynamic effects and minimize autocorrelations.

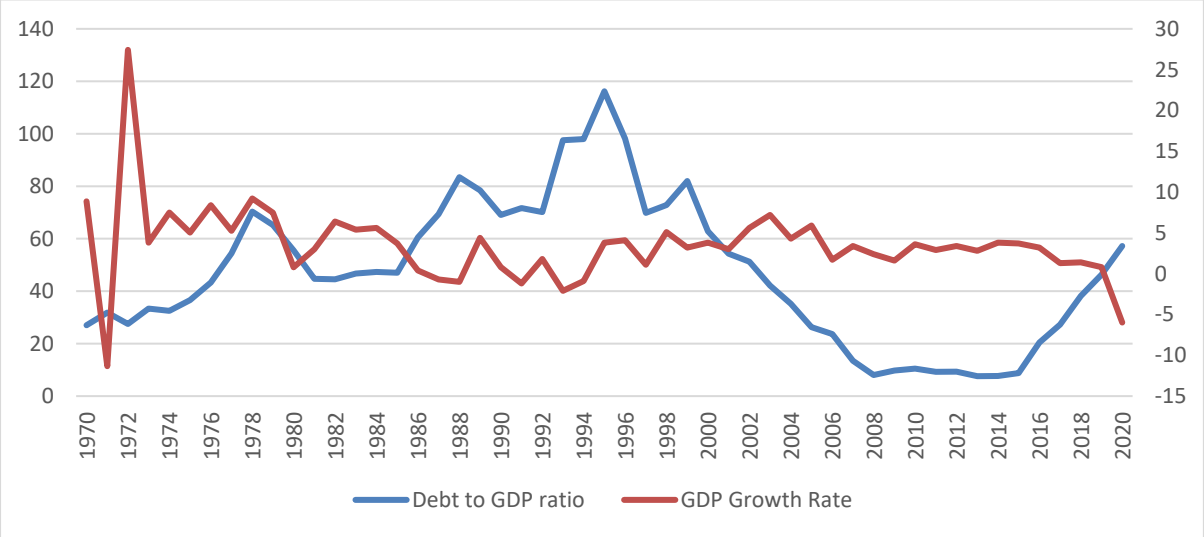
3.2. Data description

To examine the debt threshold effects on economic growth in Algeria, this study uses GDP growth rate as a dependent variable and public debt to GDP ratio as the threshold independent variable. We use annual data over the period 1970-2020. The data for the growth rate of GDP and public debt to GDP ratio are taken from the Historical Public Debt Database (HPDD) and the World Development Indicators (WDI) of the World Bank. Table 1 provides definition, sources, and descriptive statistics of the selected variables. As Table 1 shows, average GDP growth during 1970-2020 has been 3.43 percent, while the average debt to GDP ratio is 47.2. Algeria experienced the highest public debt to GDP ratio of 116.2 in 1994. In fact, high levels of debt to GDP were witnessed during the 1990s (Figure 1); a period characterized by political instability and a significant decline in oil export revenues.

Table 1. Descriptive statistics

Variables	Obs.	Mean	Std.Dev.	Min	Max	Definition, description, and source
Growth	51	3.434	4.938	-11.331	27.423	Growth rate of GDP. Source: World Development Indicators, WDI (2021)
Public debt	51	47.348	27.436	7.600	116.195	Public debt-to-GDP ratio. Source: Historical Public Debt database created by IMF)

Figure 1. Annual Algeria public debt to GDP ratio and GDP growth rate 1970-2020

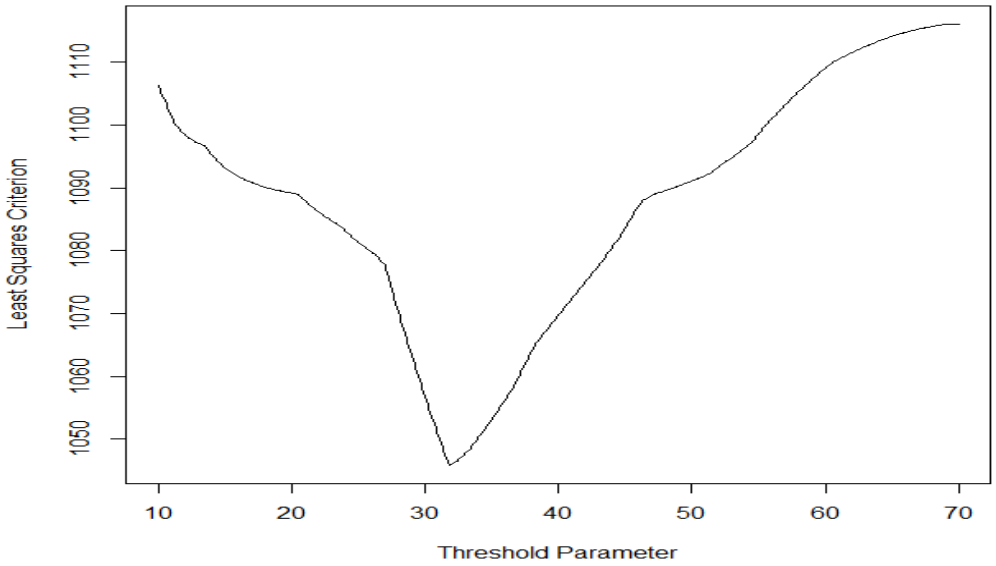


4. Empirical results

In this section, we examine the relationship between public debt and economic growth and investigate whether a unique debt turning point exists for Algeria, by running a new methodology: a regression kink recently developed by Hansen (2017).

The estimate strategy follows Hansen (2017). We set a closed interval [ten percent, 70 percent] for the threshold parameter, with discrete grid increments of one, to guarantee that the majority of observations are inside the bounds of the grid. At each grid point for γ, the regression coefficients are estimated and the least squares criterion Sn∗(γ) are computed and plotted in Figure 3. We see that the function has a global minimum at $\hat{\gamma} = 31.9$, which is the estimated debt threshold for Algeria. This figure reveals that the relationship between public debt and economic growth is non-linear.

Figure 3. Concentrated least-square criterion for threshold parameter



Then, the estimated parameters from this regression kink model are as follows:

$$y_t = \underset{(0.598)}{0.134}(x_{t-1} - 31.9)_- - \underset{(57.18)}{0.069}(x_{t-1} - 31.9)_+ - \underset{(0.032)}{0.287}y_{t-1} + \underset{(57.18)}{6.405} + \underset{(0.351)}{\hat{e}_t} \quad (4.796)$$

In this equation, y_t is the GDP growth rate, x_t is the debt to GDP ratio, and the parentheticals are the standard errors of estimators. The results of the estimates suggest that when the public debt to GDP ratio is below the 31.9 percent threshold, a one percent increase in debt to GDP increases the growth rate of GDP by 0.134 percentage points. However, every one percent increase in the debt to GDP ratio above the threshold reduces the GDP growth rate by 0.069 percentage points. Therefore, the effect of public debt on economic growth in Algeria is positive until a ratio of 31.9 percent, but negative on the margin above that threshold.

Moreover, to determine the significance of the estimated threshold, we use the algorithm proposed by Hansen (2017) to construct the confidence interval by Wild bootstrap Confidence intervals for parameters. For this purpose, the threshold F-statistic is calculated according to the test of hypothesis $H_0: \gamma = \gamma_0$ against $H_1: \gamma \neq \gamma_0$. The criterion test is to reject the null hypothesis if the values of the F-type statistic $F_n(\gamma_0)$ $\left[where, F_n(\gamma) = \frac{n(\hat{\delta}^2(\gamma) - \hat{\delta}^2)}{\hat{\delta}^2}\right]$ are larger than the bootstrap critical value. Figure 4 plots the statistic $F_n(\gamma)$ as a function of the threshold. Because the asymptotic interval (dashed blue line) in Figure 4 is a subset of the bootstrap confidence interval (dashed red line), we reject the null hypothesis. Therefore, the threshold parameter is statistically significant.

In Table 2 the confidence intervals for the estimated coefficients are also computed by the bootstrap method recommended by Hansen (2017) with 10,000 bootstrap replications. The 90 percent confidence interval for the threshold γ is 10 percent to 70 percent. The 90 percent

confidence interval for the coefficient β_2 (the slope effect of debt on growth for debt ratios above the threshold) is $[-0.163\,;0.024]$. Hansen (2017) justifies the wide width of the bootstrap confidence intervals due to the small sample size.

Figure 4. Confidence interval construction for threshold

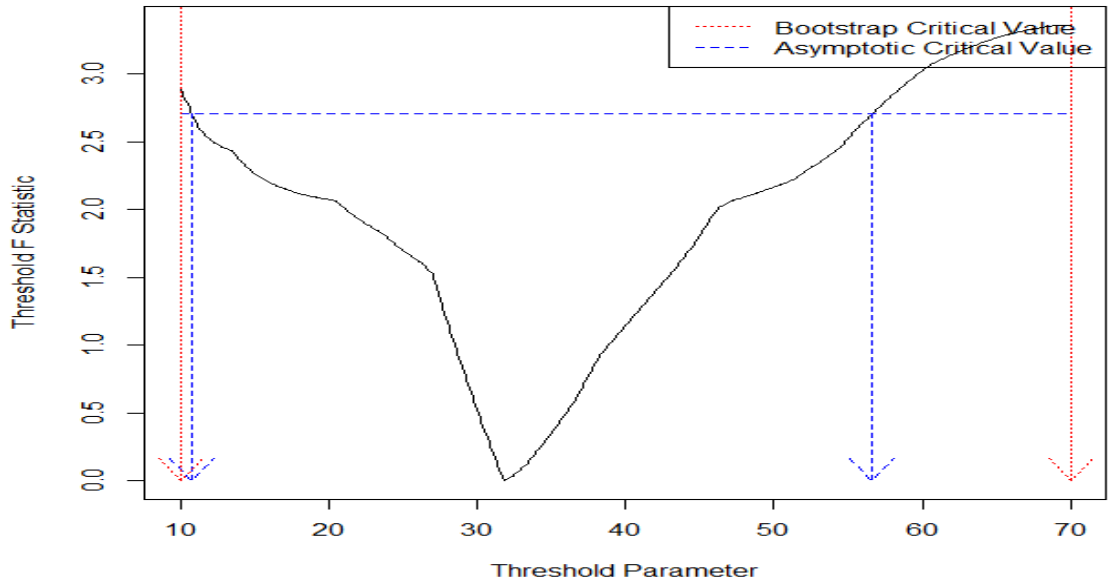


Table 2. Coefficient estimates and bootstrap 90 percent confidence intervals

	Estimate	Bootstrap 90% confidence intervals	
		Lower	Upper
β_1	0.134 (0.598)	-0.086	0.355
β_2	-0.069 (0.032)	-0.163	0.024
Y_{t-1}	-0.287 (0.351)	-0.806	0.232
Intercept	6.405 (4.796)	1.852	10.959
λ	31.900 (57.179)	10.00	70.000

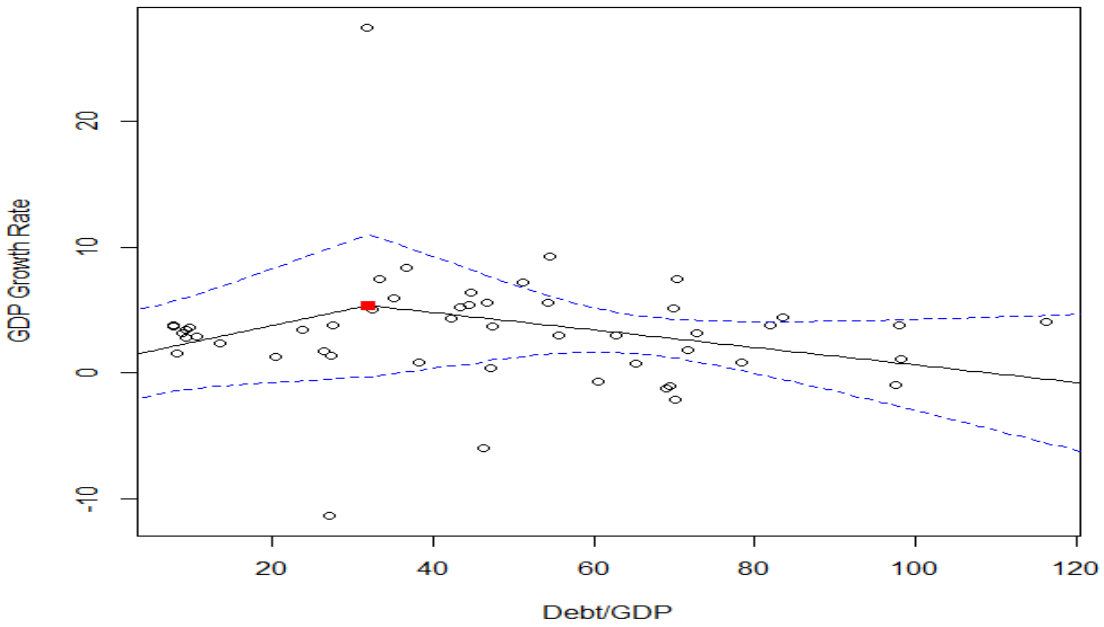
Note: Between parentheses (.) are standard errors

Furthermore, for a better visualization of the results, a scatter plot analysis for the relationship between public debt and economic growth where the red point corresponds to the kink point (threshold) along with the fitted regression line corresponding to equation (1) and pointwise 90 percent confidence intervals are reported in Figure 5.

The scatter plot analysis for the relationship between public debt and economic growth for Algeria reveals a positive slope for low debt ratios, with a threshold around 31.9 percent (displayed as the red square in Figure 5), shifting to a negative slope for debt ratios above that kink point.

Figure 5 shows that the confidence intervals remain quietly constant around the threshold of 31.9 percent and then widen slightly as the debt ratios increase above this threshold. This indicates that all our estimators are consistent, statistically significant, and robust.

Figure 5. Scatterplot of GDP growth and debt to GDP ratio, with estimated regression kink model, and 90 percent confidence intervals



Our kink regression results suggest a debt threshold of around 32 percent for Algeria. This finding is close to the debt to GDP threshold found by Omrane Belghith et al. (2017), which is 39.5 percent for four MENA countries. However, it is lower than the debt threshold value estimated by Alshammary et al. (2020), which is 58.51 percent for 20 MENA countries, and Khanfir (2019), which is 42.8 for North African countries. Our finding is also higher than the debt threshold calculated by Boukhatem and Kaabi (2015), which is 15 percent for the MENA countries.

5. Conclusion

In this study, we examine whether there is a debt to GDP threshold value in the relationship between public debt and economic growth in Algeria over the period 1970-2020. The main contribution of this study is the adoption of the kink regression with an unknown threshold method developed by Hansen (2017). For Algeria, this study estimates a public debt threshold equal to 31.9 percent. Our main results also indicate that public debt ratios have a positive effect on growth below the threshold of 31.9 percent, but they are detrimental to Algeria's economic growth beyond this threshold.

The estimated debt threshold is consistent with the literature. More precisely, it is lower than the debt threshold computed by Alshammary et al. (2020) for the MENA region, and

Ndoricimpa (2020) for African countries. However, it is relatively close to that found by Pattillo et al. (2011) who found a debt threshold between 35-40 percent for developing countries, and Mensah et al. (2019), who found a debt threshold in the range of 20-50 percent for African countries.

The policy implication of the study is that accumulating public debt above the threshold of 32 percent of GDP could have a detrimental effect on Algeria's economic growth. In the late 1980s and early 1990s, Algeria had experienced a large increase in its public debt. The ratio of public debt to GDP rose from 47 percent in 1985 to 116 percent in 1994. The double effect of the debt crisis and the oil price decline severely reduced Algeria's economic growth from an average rate of seven percent in the 1970s to an average rate of 2.7 percent during the 1980s. Therefore, this threshold should be a guide for policymakers when accumulating debt to boost economic growth in Algeria.

The Algerian government may provide incentives to encourage businesses to invest more in non-oil sectors to diversify its economy and export bases, thereby reducing the reliance on oil revenue. The government also should pay more attention to the fiscal deficits due to their impact on debt accumulation.

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