Australian National University

Crawford School of Public Policy

CAMA

Centre for Applied Macroeconomic Analysis

DGE Model for Assessing Macro-Fiscal Vulnerabilities in Algeria

---

CAMA Working Paper 30/2021
March 2021

Emmanuel Pinto Moreira
African Development Bank, Country Economics Department

Baris Alpaslan
Department of Economics, Faculty of Political Science, Social Sciences University of Ankara
Centre for Applied Macroeconomic Analysis, ANU

Abstract

In this paper, we present a Dynamic General Equilibrium (DGE) model to address the macro-fiscal vulnerabilities and the effects of fiscal policy on growth and employment in Algeria. We first discuss a baseline scenario throughout the projection period, 2021-2040 and then conduct several experiments; an increase in the efficiency of public spending on infrastructure investment, a gradual reduction in the share of noninterest government spending in GDP, the same gradual reduction in spending with a permanent increase in the share of investment in infrastructure in total noninterest government expenditure, and a composite fiscal reform program, respectively. The results show that with a well-designed fiscal program, there may be no trade-off between fiscal consolidation and economic growth.

Keywords

DGE model, macro-fiscal vulnerabilities, fiscal policy, Algeria.

JEL Classification

C68,E62,O23

Address for correspondence:

(E) cama.admin@anu.edu.au

ISSN 2206-0332

DGE Model for Assessing Macro-Fiscal Vulnerabilities in Algeria*

Emmanuel Pinto Moreira† and Baris Alpaslan‡

First complete version: November 28, 2020
This version: March 17, 2021

Abstract

In this paper, we present a Dynamic General Equilibrium (DGE) model to address the macro-fiscal vulnerabilities and the effects of fiscal policy on growth and employment in Algeria. We first discuss a baseline scenario throughout the projection period, 2021-2040 and then conduct several experiments; an increase in the efficiency of public spending on infrastructure investment, a gradual reduction in the share of noninterest government spending in GDP, the same gradual reduction in spending with a permanent increase in the share of investment in infrastructure in total noninterest government expenditure, and a composite fiscal reform program, respectively. The results show that with a well-designed fiscal program, there may be no trade-off between fiscal consolidation and economic growth.

JEL Classification Numbers: C68, E62, O23

*The financial support from the African Development Bank is gratefully acknowledged. The conceptual framework of the model presented in this paper was developed by Professor Pierre-Richard Agénor, to whom we are grateful for advice and guidance in its adaptation to a quantitative framework for Algeria. However, we bear sole responsibility for the views expressed here.

†African Development Bank, Director, Country Economics Department. Email: e.pintomoreira@afdb.org

‡Department of Economics, Faculty of Political Science, Social Sciences University of Ankara, Turkey. The author is also a research associate at the Centre for Applied Macroeconomic Analysis (CAMA) in the Crawford School of Public Policy, Australian National University. Email: baris.alpaslan@asbu.edu.tr.

1 Introduction

Algeria's current economic recession, fiscal imbalances, and financial vulnerabilities, the manifestation of the dual shock of the collapse of oil prices and COVID-19 pandemic, underscore the fragility of its development model based on hydrocarbon exports. Real GDP growth has been slow around 1 percent over the past three years. Besides, real GDP per capita growth declined from an average of 1.5 percent between 2014-2016 to an average of 0.6 percent between 2017-2019. As a result, real GDP per capita fell from US$5,466 in 2014 to US$4,630 in 2019. This moderate growth performance has been registered despite a relative high and increasing share of investment reaching an average of more than 50 percent of GDP between 2015-2019. Very few countries of the region have invested more than Algeria. However, high investment rates and slow growth mirrors the inefficiency of investment as reflected by high incremental-capital-output ratio (ICOR). At the same time, government consumption has been high and increasing, reaching a share of about 20 percent of GDP. With high shares of investment and government consumption, Algeria's economic model has left little room for private consumption, which recorded low GDP share of about 40 percent. While prior to 2000, Algeria recorded trade surplus of about 7 percent of GDP, the country switched to a trade deficit of about 10 percent of GDP over the recent period. Increasing private and public consumption as well as investment has led to external imbalances and depletion of the Algeria's sovereign stabilization fund. Algeria's economic structure is dominated by services and industry (in its turn dominated by hydrocarbons) with a smaller share for agriculture. Between 2000 and 2019, the major change was an increase in services at the expense of industry accompanied by a slight increase for agriculture.

Algeria's labor market faces challenges in offering job opportunities for its working-age population, especially for the country's women and youth. Unemployment is high at more than 12 percent in 2019 while the overall labor participation rate is among the lowest in the world, in particular for the youth aged 15-24.

Algeria has performed better in human development and its indicators are much better than its economic and financial indicators. Life expectancy has increased and is more than 76 years old. Primary and secondary school enrollment ratios are high. The completion rate increased at all levels. Women tend to do better than men, underscoring the potential payoffs from enhanced employment opportunities for women. Rate of access to water and sanitation has also increased.

However, recent macroeconomic developments point to a deterioration of the macroeconomic framework. The dual shock of the fall of oil prices and COVID-19 has plunged the Algerian economy into recession. Real GDP is estimated to be -4.7 percent following a slow growth of 0.8 percent in 2019. Government measures of confinement to combat the coronavirus pandemic have affected the services and construction sectors, leading to massive job losses. The fall of hydrocarbon revenues has contributed to deepen the twin deficits of fiscal and current accounts. The fiscal deficit more than doubled from -5.6 percent of GDP in 2019 to -13.6 percent of GDP in 2020. Meanwhile the current account deficit also widened from -10.0 percent of GDP to -14.5 percent of GDP in 2020. As a result, the level of international reserves fell to 12 months of imports compared to 13.6 months at end-2019.

The combination of slow growth, high investment levels, rising ICORs, high unemployment, and low rates of labor force participation together suggest that the economic model of recent years has not succeeded in achieving the country's development potential. More importantly, the recent deterioration of fundamental macroeconomic indicators calls for the need to further investigate the macro-fiscal vulnerabilities in Algeria. In this paper, we therefore present a DGE model to discuss the effects of fiscal policy on growth and employment in Algeria. We first provide a baseline scenario over the 2021-2040 period and then conduct several experiments; an increase in the efficiency of public spending on infrastructure investment, a gradual reduction in the share of noninterest government spending in GDP, the same gradual reduction in spending with a permanent increase in the share of investment in infrastructure in total noninterest government expenditure, and a composite fiscal reform program, respectively.

The remaining part of the paper proceeds as follows: Section 2 presents the model. Section 3 discusses its calibration. A baseline projection for 2021-40 is presented in Section 4. Alternative scenarios are analyzed in Section 5. Finally, Section 6 concludes.

2 The Model

Consider a small open economy with five categories of agents: households, producers of tradables, producers of nontradables, capital good producers, and the government. The economy produces one category of nontradable goods (identified with superscript N) and two categories of tradables: a non-renewable hydrocarbon resource (referred to equivalently as oil for short, and identified with superscript O) and a nonoil tradable good (identified with superscript T). Oil is a flow endowment owned by the government; its extraction requires no use of factor resources. For simplicity, it is also not consumed domestically.[1] Factor inputs are imperfectly mobile across sectors, so their returns are not equalized across sectors. Both tradables and nontradables can be either consumed or invested. Both households and the government spend on tradables and nontradables but only the government can borrow abroad.

2.1 Households

Consumption and labor supply decisions follow a two-step process. Households first determine total consumption, and then allocate that amount between spending on

[1]More generally, assuming that oil production involves a fixed fraction of factor resources, or that a fixed share of it is consumed domestically, would not alter significantly the analysis.

nonresource tradables and nontradables, based on the relative price of these goods. Similarly, they first determine the total amount of labor that they are willing to supply, and then consider its allocation across sectors, based on relative wages.

2.1.1 First-Stage Decisions

In the first stage, the representative household has a period utility function given by

$$U_t = \ln C_t - \frac{\eta_L}{1+\psi} L_t^{1+\psi}, \tag{1}$$

where C_t is consumption, L_t labor supply, ψ the inverse of the Frisch elasticity of labor supply, and $\eta_L > 0$ a preference parameter.

Households own both types of firms and receive the return to their capital, in addition to wages.[2] Disposable income, Y_t^D, is thus defined as

$$Y_t^D = (1-\tau_I)(w_t L_t + r_t^{K,N} K_t^{P,N} + r_t^{K,T} K_t^{P,T}) - \mu_G K_t^G, \tag{2}$$

where w_t is the economy-wide wage rate (measured in terms of the price of nonresource tradables), $w_t L_t$ is labor income, $r_t^{K,N} K_t^{P,N}$ ($r_t^{K,T} K_t^{P,T}$) capital income from firms in the nontradable (tradable) sector, $\tau_I \in (0,1)$ the tax rate on income, and $\mu_G \geq 0$ the user fee (if any) charged for access to public capital services, which are proportional to their stock, K_t^G.

Due to liquidity constraints or short planning horizons, desired consumption, C_t^d, is set as a fixed fraction $\kappa_C \in (0,1)$ of disposable income:

$$(1+\tau_C)(C_t^d - C_m) = \kappa_C Y_t^D, \tag{3}$$

where $\tau_C \in (0,1)$ is the tax rate on consumption and C_m an incompressible level of (subsistence) consumption.[3] Household savings are thus

$$S_t = Y_t^D - C_t.$$

[2] As discussed later, public sector domestic borrowing consists mainly of loans from the central bank; we therefore do not account for interest on government bonds in defining household income.

[3] The assumption of liquidity constraints is consistent with the evidence of a number of middle-income countries (see Agénor and Montiel (2015, Chapter 2)).

Consumption being determined by condition (3), maximization of the utility function (1) with respect to L_t subject to (2) gives desired labor supply as:

$$L_t^d = \left\{ \eta_L \frac{\kappa_C(1-\tau_I)}{1+\tau_C} C_t^{-1} w_t \right\}^{1/\psi}. \tag{4}$$

2.1.2 Second-Stage Decisions

In the second stage, total consumption is allocated between consumption of nonoil tradables and nontradables, C_t^T and C_t^N, which are imperfect substitutes:

$$C_t = (C_t^N)^\theta (C_t^T)^{1-\theta}, \tag{5}$$

where $\theta \in (0, 1)$.

Nominal consumption spending is $P_t^T C_t^T + P_t^N C_t^N$. The representative household therefore maximizes (5) subject to the static budget constraint

$$C_t = C_t^T + z_t^{-1} C_t^N, \tag{6}$$

where real consumption is measured (consistent with (3)) in terms of the world price of nonresource tradables, and $z_t = P_t^T / P_t^N$ is the real exchange rate (so that an increase in a depreciation). The solution is given by

$$C_t^N = \theta z_t C_t, \tag{7}$$

$$C_t^T = (1-\theta) C_t. \tag{8}$$

Similarly, to determine the allocation of labor between the two sectors, L_t^N and L_t^T, these two components are taken to be imperfect substitutes, so that

$$L_t = [\Lambda_L^{-\frac{1}{\varsigma_L}} (L_t^N)^{\frac{1+\varsigma_L}{\varsigma_L}} + (1-\Lambda_L)^{-\frac{1}{\varsigma_L}} (L_t^T)^{\frac{1+\varsigma_L}{\varsigma_L}}]^{\frac{\varsigma_L}{1+\varsigma_L}}, \tag{9}$$

where $\Lambda_L \in (0, 1)$ is the benchmark share of labor in the nontradable good sector and $\varsigma_L > 0$ is the elasticity of substitution between the two labor components.

Let w_t^T and w_t^N denote the real wage rates earned in each sector. The household's total labor income is thus

$$w_t L_t = w_t^N L_t^N + w_t^T L_t^T. \tag{10}$$

Maximizing (9) subject to (10) yields the sectoral labor supply equations as:

$$L_t^N = \Lambda_L (\frac{w_t^N}{w_t})^{\varsigma_L} L_t, \tag{11}$$

$$L_t^T = (1 - \Lambda_L)(\frac{w_t^T}{w_t})^{\varsigma_L} L_t, \tag{12}$$

with the aggregate real wage given by

$$w_t = [\Lambda_L (w_t^N)^{1+\varsigma_L} + (1 - \Lambda_L)(w_t^T)^{1+\varsigma_L}]^{\frac{1}{1+\varsigma_L}}. \tag{13}$$

2.2 Oil Production and Prices

Oil production, Y_t^O, follows a predetermined path, $\bar{Y}_t^O$, related to the rate of depletion of these resources:

$$Y_t^O = \bar{Y}_t^O. \tag{14}$$

The country's oil production is assumed to be relatively small compared to world supply. The real price of oil on world markets (relative to the foreign-currency price of nonoil tradables) is exogenously determined outside the home country and denominated in foreign currency. The real price, p_t^O, follows therefore also a predetermined path:

$$p_t^O = \bar{p}_t^O. \tag{15}$$

2.3 Production of Nonoil Tradables

Nonoil tradable output, Y_t^T, is produced competitively using labor, in quantity L_t^T, private capital, $K_t^{P,T}$, and public infrastructure, K_t^G. The production function of these goods is given by

$$Y_t^T = Q_{t-1}^T (L_t^T)^{\beta_T} (K_t^{P,T})^{1-\beta_T} (\frac{K_t^G}{K_t^P})^{\omega_T}, \tag{16}$$

where $\beta_T \in (0,1)$, $\omega_T > 0$, K_t^P is the aggregate private capital stock (defined later), and Q_t^T a productivity factor, which operates with a lag to capture gradual diffusion effects. Although infrastructure is nonexcludable, it is partially rival and subject to congestion (see Agénor (2012)). For simplicity, congestion is measured in terms of the aggregate stock of private capital.

Given equation (16), firms maximize profits, defined as[4]

$$\Pi_t^T = Y_t^T - w_t^T L_t^T - r_t^{K,T} K_t^{P,T},$$

where $r_t^{K,T}$ denotes the (gross) rental rate of capital in the tradable sector. Factor prices and the aggregate private capital stock are taken as given in solving this optimization problem. First-order conditions take the standard form

$$w_t^T = \beta_T (\frac{Y_t^T}{L_t^T}), \tag{17}$$

$$r_t^{K,T} = (1-\beta_T)(\frac{Y_t^T}{K_t^{P,T}}). \tag{18}$$

Productivity in the tradable sector is endogenous and is assumed to increase with the share of the population employed in the nonoil tradable sector:

$$Q_t^T = Q^{T,0} (\frac{L_t^T}{L_t})^{\nu_T}, \tag{19}$$

where $Q^{T,0} > 0$ and $\nu_T \in (0,1)$.

2.4 Production of Nontradables

Nontradable output, Y_t^N, is also produced competitively using labor, L_t^N, private capital, $K_t^{P,N}$, and infrastructure. The production function is given by

$$Y_t^N = Q_t^N (L_t^N)^{\beta_N} (K_t^{P,N})^{1-\beta_N} (\frac{K_t^G}{K_t^P})^{\omega_N}, \tag{20}$$

[4]To simplify matters, we abstract from user fees paid by firms in nonoil production.

where $\beta_N \in (0,1)$, $\omega_N > 0$, and Q_t^N is a productivity parameter. Thus, relative employment in the nontradable sector does not generate positive externalities and there are no learning spillovers between production sectors.

We also assume that oil activity creates an externality for production of nontradables. Thus,

$$Q_t^N = Q_0^N (Y_{t-1}^O)^{\nu_N}, \tag{21}$$

where $\nu_N \in (0,1)$.

Real profits are defined as

$$\Pi_t^N = z_t^{-1} Y_t^N - w_t^N L_t^N - r_t^{K,N} K_t^{P,N},$$

where $r_t^{K,N}$ is the (gross) rental rate of capital in the nontradable sector. Again, firms maximize profits subject to (20), taking w_t^N, $r_t^{K,N}$ and K_{t-1}^P as given. The first-order conditions are now

$$w_t^N = \beta_N (\frac{z_t^{-1} Y_t^N}{L_t^N}), \tag{22}$$

$$r_t^{K,N} = (1-\beta_N)(\frac{z_t^{-1} Y_t^N}{K_t^{P,N}}). \tag{23}$$

2.5 Private Capital Producers

Private capital producers own the private capital in the economy and also take decisions in two steps. First, they determine how much to invest and transform the investment good into capital. Second, they rent the resulting stock to producers of nonoil tradables and nontradables, in proportions that depend on the relative rental rates.

2.5.1 Private Investment and Total Capital Stock

The desired level of private investment by capital good producers is given by

$$(\frac{I_t^P}{Y_t})^d = a_0 + a_1(\frac{\Delta Y_t}{Y_{t-1}}) + a_2(\frac{K_t^G}{K_t^P}) + a_3(\frac{I_{t-1}^P}{Y_{t-1}}), \tag{24}$$

where I_t^P is private investment, Y_t is GDP, K_t^G is public infrastructure, K_t^P is the private capital stock, and $a_i > 0$, for $i = 1, 2, 3$. Thus, private investment, as a share of GDP, depends positively on the growth rate of GDP (in line with the standard *accelerator effect*), the public-private capital ratio, and the lagged ratio of the private investment to GDP. Public capital raises private investment (in line with the standard *complementarity effect*) but there is a *congestion effect* as well, associated again with the private capital stock.[5]

The private capital stock available during period t is equal to the stock available at the end of period $t-1$ net of depreciation, plus the amount invested at the beginning of period t:

$$K_t^P = I_t^P + (1 - \delta^P)K_{t-1}^P, \tag{25}$$

where $\delta^P \in (0, 1)$ is a constant rate of depreciation.

2.5.2 Sectoral Allocation of Private Investment and Capital

Total private investment is spent in fixed proportions on nontradables and nonoil tradables:

$$I_t^{P,N} = \Lambda_P z_t I_t^P, \tag{26}$$

$$I_t^{P,T} = (1 - \Lambda_P)I_t^P, \tag{27}$$

where $\Lambda_P \in (0, 1)$. By implication, therefore,

$$I_t^P = I_t^{P,T} + z_t^{-1} I_t^{P,N}, \tag{28}$$

To determine the allocation of capital to final good firms in the nontradable and nonoil tradable sectors, $K_t^{P,N}$ and $K_t^{P,T}$, it is assumed that the capital stocks supplied to each of these sectors are imperfect substitutes, so that

$$K_t^P = [\Lambda_K^{-\frac{1}{\varsigma_K}}(K_t^{P,N})^{\frac{1+\varsigma_K}{\varsigma_K}} + (1 - \Lambda_K)^{-\frac{1}{\varsigma_K}}(K_t^{P,T})^{\frac{1+\varsigma_K}{\varsigma_K}}]^{\frac{\varsigma_K}{1+\varsigma_K}}, \tag{29}$$

[5] See Agénor (2004, 2012) for a discussion of these various effects.

where $\Lambda_K \in (0,1)$ is the benchmark share of private capital in the nontradable good sector and $\varsigma_K > 0$ is the (intratemporal) elasticity of substitution between the two capital stocks. Given the definitions provided earlier for the real rental rates in each sector, the capital producer's total income at t is thus

$$r_t^K K_t^P = r_t^{K,N} K_t^{P,N} + r_t^{K,T} K_t^{P,T}. \tag{30}$$

Maximizing (30) subject to (29) yields the sectoral capital supply equations as:

$$K_t^{P,N} = \Lambda_K (\frac{r_t^{K,N}}{r_t^K})^{\varsigma_K} K_t^P, \tag{31}$$

$$K_t^{P,T} = (1-\Lambda_K)(\frac{r_t^{K,T}}{r_t^K})^{\varsigma_K} K_t^P, \tag{32}$$

with the aggregate rental rate given by

$$r_t^K = [\Lambda_K (r_t^{K,N})^{1+\varsigma_K} + (1-\Lambda_K)(r_t^{K,T})^{1+\varsigma_K}]^{\frac{1}{1+\varsigma_K}}. \tag{33}$$

2.6 Government

The government receives revenues from oil production, T_t^O, taxes on nonresource income, T_t^{NO}, which include income taxes on households. Total revenue, measured in foreign-currency terms, is thus given by

$$T_t = T_t^O + T_t^{NO}, \tag{34}$$

Oil revenues allocated to the budget are set as a fixed fraction of oil production:

$$T_t^O = \tau_O p_t^O Y_t^O, \tag{35}$$

where $\tau_O \in (0,1)$ is the oil tax rate.

Nonoil tax revenues are given by the sum of indirect taxes (with consumption as the tax base), income taxes (using nonoil output as the tax base), user fees, and other revenues (determined residually), T_t^R:

$$T_t^{NO} = \tau_C C_t + \tau_I (Y_t - p_t^O Y_t^O) + \mu_G K_t^G + T_t^R, \tag{36}$$

Other revenues are kept fixed as a fraction of GDP:

$$T_t^R = \tau_R Y_t, \tag{37}$$

where $\tau_R \in (0,1)$.

Real noninterest government spending, G_t, is set as a fixed fraction of total output:

$$G_t = \upsilon_G Y_t, \tag{38}$$

where $\upsilon_G \in (0,1)$. This expenditure is allocated in fixed fractions to investment in infrastructure, I_t^G, and consumption, $z_t^{-1}C_t^G$:

$$I_t^G = \upsilon_I G_t, \tag{39}$$

$$z_t^{-1}C_t^G = (1-\upsilon_I)G_t, \tag{40}$$

where $\upsilon_I \in (0,1)$. Thus, by definition, we also have

$$G_t = I_t^G + z_t^{-1}C_t^G. \tag{41}$$

Public consumption consists of spending on nontradable goods only. By contrast, public investment is spent in fixed proportions on nontradables, $I_t^{G,N}$, and nonoil tradables, $I_t^{G,T}$:

$$I_t^{G,N} = \upsilon_{I,N} z_t I_t^G, \tag{42}$$

$$I_t^{G,T} = (1-\upsilon_{I,N})I_t^G, \tag{43}$$

where $\upsilon_{I,N} \in (0,1)$. By implication, therefore,

$$I_t^G = I_t^{G,T} + z_t^{-1}I_t^{G,N}. \tag{44}$$

The government borrows domestically, in the amount D_t^D, at the constant real interest rate r_t^D, and contracts foreign-currency denominated debt, D_t^W, at the constant world real interest rate r_t^W, to finance its deficit. The government's flow budget constraint is thus given by

$$D_t = (1+r_{t-1}^D)D_{t-1}^D + (1+r_{t-1}^W)D_{t-1}^W + G_t - T_t, \tag{45}$$

where $D_t = D_t^D + D_t^W$.

The external debt is assumed to be kept as a constant share $\upsilon_W \in (0,1)$ of GDP, to reflect limited incentives to borrow abroad:

$$D_t^W = \upsilon_W Y_t. \tag{46}$$

Substituting (46) in (45) yields the dynamics of domestic debt.

Given its importance as a fiscal sustainability indicator in the literature on natural resource management (see Lundgren et al. (2013)), it is important to keep track of the nonresource, noninterest primary balance, B_t^{NO}, which is defined as

$$B_t^{NO} = T_t^{NO} - G_t. \tag{47}$$

The stock of public capital evolves according to

$$K_t^G = (1-\delta^G)K_{t-1}^G + \varphi_t I_t^G, \tag{48}$$

where $\varphi_t \in (0,1)$ is an indicator of efficiency of spending on infrastructure and $\delta^G \in (0,1)$ is the depreciation rate.[6] To capture absorption capacity constraints, and in line with Agénor (2016), the efficiency parameter is assumed to be negatively related to the lagged ratio of public investment to public capital:

$$\varphi_t = \varphi_0 (\frac{I_{t-1}^G}{K_{t-1}^G})^{-\varphi_1}, \tag{49}$$

where $\varphi_0, \varphi_1 > 0$. Thus, as investment (in proportion of the capital stock) increases, absorptive constraints tend to develop, possibly at an increasing rate ($\varphi_1 > 1$); this, in turn, tends to slow the rate of public capital accumulation and mitigate the benefits of higher public investment.[7]

[6] This specification of capital stock accumulation was first proposed by Pritchett (2000), in a discussion of growth accounting, and was first used by Agénor (2010) in a theoretical model of growth and development. Note also that we do not account for adjustment costs to public capital, only lack of efficiency.

[7] By contrast, in Berg et al. (2013) and related contributions, the efficiency parameter is subject to a threshold effect related to the *level* of public investment. An alternative approach, as in van der Ploeg (2012) and van den Bremer and van der Ploeg (2013), would be to assume that public investment is subject to adjustment costs, which fall with the amount invested.

The user fee charged on public capital is computed as a fraction of recurrent costs:

$$\mu_G = \mu_G^0 \delta^G, \tag{50}$$

where $\mu_G \in (0,1)$. If public services are provided free of charge, then $\mu_G^0 = 0$.

2.7 Market-Clearing Conditions

Total output, Y_t, measured in terms of the price of nonresource tradables, can be defined as

$$Y_t = Y_t^T + z_t^{-1} Y_t^N + p_t^O Y_t^O, \tag{51}$$

so that total factor income, which appears in (2), is also given by

$$w_t L_t + r_t^{K,N} K_t^{P,N} + r_t^{K,T} K_t^{P,T} = Y_t - p_t^O Y_t^O. \tag{52}$$

The market-clearing condition of the nontradable sector equates supply of nontradables to demand, consisting of consumption spending by households and the government, and investment by capital good producers and the government:

$$Y_t^N = C_t^N + C_t^G + I_t^{P,N} + I_t^{G,N}. \tag{53}$$

Combining equations (2), (3), (6) and (52) for households, (28) for private capital producers, (34), (35), (36), (41), (44) and (45) for the government, together with the equilibrium condition (53), yields the current account balance as

$$CA_t = Y_t^T + p_t^O Y_t^O - C_t^T - I_t^{P,T} - I_t^{G,T} - r_{t-1}^W D_{t-1}^W. \tag{54}$$

2.8 Link with Unemployment

The model assumes that wages are fully flexible, and that labor is perfectly mobile across sectors; consequently, there is no open unemployment. However, in line with the evidence for North Africa, what prevails more is *disguised* unemployment—mostly in the nontradable sector (which includes the informal economy). In that sense, official statistics, which show positive open unemployment, can be viewed as a conversion of disguised unemployment into open unemployment. Nevertheless, to assess in a simple manner the impact of the policy experiments on open unemployment, an Okun's law specification is adopted, relating the relative change in the unemployment rate, U_t/U_{t-1}, and the growth rate of GDP, $1+\gamma_t^Y$:

$$U_t/U_{t-1} = u_0(1+\gamma_t^Y)^{-0.116}, \tag{55}$$

where u_0 is a constant term which is calibrated for the base year, and -0.116 is a constant elasticity, whose value is consistent with the linear parameter estimated by Hamia (2016, Table 4) for Algeria.

3 Calibration

The model is calibrated for Algeria. Data sources include the World Bank's *World Development Indicators* database, the IMF's *World Economic Outlook* (WEO) database, national sources (compiled by the Country Economic Department of the African Development Bank), as well as parameter estimates from various published papers. We use 2019 as a benchmark. In addition, we impose partial adjustment on some of the variables, to ensure stability of the model, given the long time horizon (23 years) for the projections.

Regarding *households*, the Frisch elasticity of labor supply is set at 0.125 (so that $\psi = 8$) to capture a relatively inelastic supply of labor.[8] The preference parameter η_L is set at 10, a common value to ensure that in equilibrium households devote about one third of their time endowment to market activity.

To account for exogenous growth of the active population, we assume that actual labor supply is subject to partial adjustment with trend. Specifically, let n denote

[8] Berg et al. (2013) and Richmond et al. (2013) for instance used a slightly higher value of $\psi = 10$.

the long-term growth rate of the population in Algeria, and let $\hat{L}_t = L_t - (1+n)L_{t-1}$; the partial adjustment equation is thus

$$\Delta \hat{L}_t = (1 - \lambda_Q)(L_t^d - \hat{L}_{t-1}),$$

where $\lambda_Q \in (0, 1)$ and L_t^d is given in (4). By implication,

$$\hat{L}_t = (1 - \lambda_Q)L_t^d + \lambda_Q \hat{L}_{t-1},$$

or equivalently, substituting out for $\hat{L}_t$ and $\hat{L}_{t-1}$,

$$L_t = (1 + n)L_{t-1} + (1 - \lambda_Q)L_t^d + \lambda_Q[L_{t-1} - (1 + n)L_{t-2}]. \tag{56}$$

The growth rate of the labor force is set at $n = 0.019$, the growth rate of the population; this implies that the participation rate is assumed constant. The adjustment parameter λ_Q is set at 0.95.

The marginal propensity to consume out of disposable income, κ_C, is set at 0.85, to reflect the relatively low level of income. We also assume that actual consumption adjusts gradually to desired consumption, defined in (3):

$$\Delta C_t = C_t - C_{t-1} = (1 - \lambda_C)(C_t^d - C_{t-1}), \tag{57}$$

where $\lambda_C \in (0, 1)$. In the benchmark calibration, we set $\lambda_C = 0.6$ to capture habit formation.

The share of labor in the nontradable good sector, Λ_L, is set equal to 0.62, in line with the available data for Algeria for 2018. Thus, the share of employment in the nonoil tradable sector is 38 percent.[9] The intratemporal elasticity of substitution between labor in the two sectors, ς_L, is set at 0.2, to capture a low degree of intersectoral mobility. There are no available values for Algeria regarding the share

[9] Data for 2017 indicate that employment in mining is only 4 percent. Given that mining production is treated exogenously, for simplicity we calculated the distribution of employment between the nonmining tradable sector and the nontradable sector only.

of nontradables in total consumption, θ; we set it to 0.62, to match the share of nontradables in production.

Regarding the *production side*, as noted earlier, oil production and world resource prices follow an exogenous path in the projections. The size of the hydrocarbon sector in the country's GDP is kept at the observed value in 2019, that is, 19 percent. In addition, the share of nontradable output in GDP is set at 0.62, consistent with the employment data referred to earlier. The share of the nonoil tradable sector is thus $1-0.62-0.19=19$ percent. The elasticities of production with respect to labor, β_T and β_N, in the nonoil sectors are set equal to 0.6 and 0.7, respectively, to capture the fact that production in the nontradable sector is relatively more labor intensive ($\beta_N > \beta_T$). These values are fairly standard. The evidence on the strength of learning-by-doing effects in tradable activities is somewhat ambiguous (see Syverson (2011)). In the benchmark scenario, the elasticity of the productivity factor in the tradable sector with respect to the share of the labor force engaged in that sector, ν_T, is set to 0.6. The externality parameter associated with oil in the production function of nontradables, ν_N, is set at a relatively low value of 0.2 based on an assessment of the impact of extraction industries on the country's transportation sector. The elasticities with respect to the composite infrastructure input, ω_N and ω_T, are set initially at the same value in both sectors, 0.17, which corresponds to the long-run value estimated through meta-regression analysis by Bom and Ligthart (2014, Table 4) for core public capital. This value may underestimate the true elasticity of output with respect to infrastructure, because it does not account for other externalities associated with infrastructure (Agénor (2012) and Agénor and Neanidis (2015)). Sensitivity analysis is thus reported later on. The active population is calibrated at 15.9 million, the value for 2019.

Regarding *private capital good producers*, the rate of depreciation of private capital, δ^P, is set at 0.04, in line with the value used by Agénor (2016).[10] For the investment function, based on its estimation, we set $a_1 = 0.098$, $a_2 = 0.041$, and $a_3 = 0.938$. However, with a lower value of a_3, the congestion effect on the growth rate is reduced. Therefore, we set a_3 equal to a low value, 0.1. The coefficient a_0 in (24) is then determined residually, so that $a_0 = 0.227$. In addition, we assume that actual private investment adjusts gradually to its desired value, given in (24), so that

$$\frac{I_t^P}{Y_t} - \frac{I_{t-1}^P}{Y_{t-1}} = (1-\lambda_I)[(\frac{I_t^P}{Y_t})^d - \frac{I_{t-1}^P}{Y_{t-1}}], \tag{58}$$

where $\lambda_I \in (0,1)$. In the benchmark calibration we set $\lambda_I = 0.6$.

The share of nontradable goods in private investment, Λ_P, is set at 0.5, which corresponds to the aggregate estimate reported by Bems (2008, Table 8). The benchmark share of the private capital stock in the nontradable good sector, Λ_K, is set at 0.62, in line with the composition of employment and production reported earlier. The (intratemporal) elasticity of substitution between the two capital stocks, ς_K, is set at 0.2, to capture a low degree of capital mobility across sectors.

Regarding the *government*, the tax rate on income, τ_I, is set equal to 8.9 percent for Algeria. The oil tax rate, τ_O, is set equal to the ratio of oil revenues divided by the value of oil production, or 91 percent. Similarly, the tax rate on household consumption, τ_C, for Algeria for 2019, 11.4 percent. The tax rate associated with other revenues, τ_R, is calibrated at 7.3 percent in 2019. The initial ratio of noninterest spending in GDP, υ_G, is set equal to 38.2 percent, which corresponds to the value for 2019. The initial share of infrastructure investment in primary government spending, υ_I, is set at 25.4 percent, or equivalently $0.254 \times 0.382 = 9.7$ percent of GDP, which is again based on the data for 2019. The share of public investment in infrastructure allocated to nontradable goods, $\upsilon_{I,N}$, is set at 0.5, again, the aggregate estimate

[10] The value estimated by Bu (2006, Table 8) for Kenya is 0.066, based on the ratio of the depreciation expenses recorded in company accounts to the value of total fixed assets. However, our estimate refers to the private capital stock as a whole.

reported by Bems (2008, Table 8). For the efficiency parameter for public investment, φ, there is no available estimate for Algeria. Accordingly, φ is set equal to the median value estimated by Dabla-Norris et al. (2012) for a sample of 71 developing countries, that is, 0.4. Thus, we assume that initially 60 percent of investment does not turn into public capital. The parameter φ_1 is set initially at a low value, 0.05. Given the value of I^G/K^G reported later, this implies that φ_0, which is solved for residually from (49), is equal to 0.352. The rate of depreciation of public capital, δ^G, is set at 0.025, a standard value in the literature. We also set $\mu_0^G = 0.0$. Thus, public services are provided at no fees, independently of recurrent costs.

In the presentation of the model, it was assumed that the real exchange rate adjusts freely and instantaneously so as to ensure that the market for nontradables is in continuous equilibrium. To ensure stability of the calibrated version, we assume that the actual real exchange rate adjusts only partially to its equilibrium value (that is, the value that equates supply and demand, as implied by equation (53)), with an adjustment coefficient $\lambda_z = 0.998$. This assumption provides a simple way of introducing price stickiness in the nontradable sector.

Table 1 summarizes the benchmark parameter values.

As noted earlier, the share of oil production is 0.19 initially, whereas the shares of nontradable and nonoil tradable output are 0.62 and 0.19 initially. To estimate the initial private and public capital stocks in the base period, we use the IMF's capital stock database.[11] From this database, there are, however, only 3-year data available for Algeria: 2015, 2016, and 2017. Therefore, we estimated private and public capital stocks for 2018 and 2019 using the data available. As a result, in 2019 the private capital-GDP ratio, K^P/Y, was $946.76/618.88 = 1.53$ and the public capital-GDP ratio, K^G/Y, was $789.43/618.88 = 1.28$. This gives an initial public-private capital ratio, or K^G/K^P, of 0.84, which shows that private capital is a slightly

[11] See http://www.imf.org/external/np/fad/publicinvestment/#5.

more abundant input than public capital. However, both stocks are low relative to GDP, which implies that both types of capital are relatively scarce.

In 2019, private consumption as a share of GDP, C/Y, is set equal to 44 percent, whereas private investment as a share of GDP, I^P/Y, is 29 percent. As noted earlier for υ_G and υ_I, noninterest government spending accounts for 38.2 percent of GDP and public investment for 25.4 percent of noninterest government spending. Using the value of total tax revenues T and the estimate of debt service (itself calculated from values of D^D and r^D, and D^W and r^W, reported next), the value of other tax revenues, T^R, can be calculated backward from the government budget constraint (45). The nonoil primary balance is in deficit initially, at -18.7 percent of GDP. Based on actual data for 2019, domestic government debt as a share of GDP, D^D/Y, is equal to 31 percent, whereas external government debt as a share of GDP, D^W/Y, is equal to 2.6 percent. Thus, total government debt as a share of GDP, $D/Y = (D^D + D^W)/Y$, is equal to 33.6 percent. The change in debt, adjusted for foreign direct investment, is set so as to match the current account balance (defined in (54)), which is equal to -9.6 percent of GDP in the base period.

The interest rate on the domestic debt is calculated in effective terms, by dividing interest payment on domestic debt by domestic debt for 2019; this gives a nominal domestic interest rate of 1.9 percent. With inflation (in terms of the consumer price index) equal at 2 percent in 2019 according to the data by Office National de la Statistiques (ONS) for Algeria, we therefore have $r^D = (1 + 0.019)/(1 + 0.02) - 1 = -0.1$ percent. The effective interest rate on the country's external debt is calculated in the same way. Therefore, dividing interest payments on foreign debt by foreign-currency denominated debt gives a nominal interest rate of 3.8 percent. With world inflation rate of 1.5 percent (in terms of the consumer price index) in 2019 based on the IMF World Economic Outlook report (2019, Table A5), we then obtain $r^W = (1 + 0.038)/(1 + 0.015) - 1 = 2.3$ percent.

Based on these parameter and initial values, the model is solved numerically in its nonlinear form.

4 Baseline Projection, 2021-2040

We begin by building a baseline projection. This projection, which is not meant to be a forecast, reflects a mix of policies throughout the projection period. We also assume that annual inflation remains at its baseline value in 2019, 2 percent, and that world inflation in terms of prices of manufacturing goods remains at its initial value, in both cases through the entire projection period.[12] On the fiscal side, we assume that all tax rates (τ_I, τ_C, τ_O, and τ_R) remain constant throughout at their 2019 value. The same assumption is made for noninterest government spending as a share of GDP, υ_G, and the share of public investment in infrastructure as a share of noninterest government spending, υ_I.[13] These assumptions reflect a *status quo scenario*, in which both tax rates and spending are kept constant. In addition, we assume that foreign debt as a share of GDP is kept constant throughout the projection period at the value observed in the base year, 2.6 percent. This is aimed to capture the government's declared objective of not borrowing abroad. The share of the hydrocarbon sector in GDP is kept constant at its 2019 value, 19 percent. Finally, in calculating the real world price of oil, the composite nominal price of hydrocarbons (calculated as a weighted average, based on 2018 export shares) is kept at its 2021 value, whereas projections for the nominal price of export prices of manufacturing goods of advanced economies is based on IMF data. As a result, the

[12] Changing either one of these assumptions can be implemented fairly easily, by adjusting nominal interest rates on domestic and external public debt to calculate interest payments and match the output of the model with actual data on these payments.

[13] However, to capture the impact of the COVID-19 outbreak, we assume that noninterest government spending as a share of GDP, υ_G increases from 38.2 percent in 2019 to 41 percent in 2020 and then falls back gradually to its original value in 2019, and remains constant at its 2019 value throughout the projection period.

real price of hydrocarbon products is constant from 2022 to the end of the projection period.

The results of the baseline projection are shown in Table 2. In the long run, and given the assumptions above, the annual growth rate of real GDP stabilizes at about 3.5 percent per annum at the end of the period. As a result of sustained growth, the unemployment rate drops from 11.1 percent in 2020 to an average of 4.9 percent in 2036-40. However, because under the status quo scenario the primary fiscal deficit remains high (averaging $8.1-8.2$ percent of GDP a year over the period 2031-40), domestic and total public debt increase quite dramatically—from values of 47.9 and 50.5 percent of GDP in 2020, to 130.6 and 133.2 percent of GDP over the period 2036-40, respectively.[14] Put differently, without fiscal consolidation (entailing a significant reduction in the primary deficit), even relatively high growth will not be sufficient to put public debt on a sustainable path. We therefore turn to several experiments to assess how various policies can be implemented to bring public debt under control.

5 Policy Experiments

We conduct four experiments and assess their impact on fiscal accounts, growth, and unemployment. The first involves an increase in the efficiency of public spending on infrastructure investment, achieved through governance reforms. The second involves a gradual reduction in the share of noninterest government spending in GDP, as a first step toward reducing the country's primary deficit. The third combines the same gradual reduction in spending with a permanent increase in the share of investment in infrastructure in total noninterest government expenditure. The fourth considers

[14] Note that we have assumed that the premium on the domestic debt, PR^D, is constant. This reflects the fact that most of that debt is borrowed from the central bank, rather than markets. Had we assumed instead that this premium depends positively on the ratio of domestic public debt to GDP, it would lead to even higher increases in the ratio of domestic debt to GDP over time.

a composite fiscal reform program.

5.1 Higher Efficiency of Investment Spending

The results associated with a permanent increase in the autonomous component of efficiency of public investment in infrastructure, φ_0 in (49), from an initial value of 0.352 to 0.6 starting in 2021 are displayed in Table 3, in terms of deviations from the baseline projections shown in Table 2. The increase in efficiency raises the public capital stock, which in turns exerts two effects, alluded to earlier: a *productivity effect*, which raises output in both the tradable and the nontradable sectors, and a *complementarity effect*, which raises private investment. In the long term, the increase in real GDP is of the order of 1.3 percentage points annually, whereas the increase in private investment is of the order of 0.4 percentage points annually. However, the increase in the private capital stock also creates a congestion effect, which mitigates the benefits of the increase in the public capital stock. In the absence of this congestion effect, the increase in the longer-term growth rate would be higher. At the sectoral level, because the real exchange rate appreciates (due to the demand-side effect of the policy, which dominates the supply-side effect), output of the nonoil tradable sector expands contracts slightly as a share of GDP, whereas the opposite occurs for the nontradable sector. However, by itself the policy has limited impact on fiscal accounts, except for the fact that the public debt ratio is lower due to higher GDP.

5.2 Reduction in Share of Noninterest Government Spending

Consider a now a gradual reduction in the ratio of noninterest government spending to GDP, υ_G, as follows: *a*) 1 percentage point in 2023; *b*) 2 percentage points in 2024; *c*) 3 percentage points in 2025; and *d*) 4 percentage points from 2026 to 2040. The motivation for this experiment is that the ratio of noninterest government spending to GDP is quite in Algeria (close to figures observed in some advanced economies) and that some of this spending is not highly efficient. Thus reducing this spending is an important step in fiscal consolidation. We consider two cases: first, the reduction in υ_G only, as described, and then the reduction in υ_G combined with an increase in υ_I, the share of noninterest government spending allocated to public investment in infrastructure.

5.2.1 Across-the-Board Reduction

Table 4 shows the results associated with a reduction in υ_G only. Clearly, by reducing the primary fiscal deficit, the policy has a dramatic effect on the total debt-to-GDP ratio, which falls by 39.6 percentage points over the period 2036-40 (compared to the baseline value of 133.2 percent reported in Table 2, or equivalently a drop to 93.6 percent). However, because the cut in spending occurs across the board, investment in infrastructure suffers as well; with a lower public capital, the productivity and complementarity effects alluded to above operate in reverse. As a result, the reduction in the ratio of noninterest government spending to GDP, has a negative effect on growth. Put differently, fiscal consolidation through an across-the-board reduction in government expenditure only, to the extent that it also lowers productive spending, creates a trade-off with growth.

5.2.2 Combined with Higher Share of Infrastructure Investment

Consider now the case where the reduction in υ_G, as defined above, is combined with an increase in the share of noninterest government spending allocated to public investment in infrastructure, υ_I, by 8 percentage points, from 2021 onward. Thus, the goal here is to preserve productive spending, while pursuing at the same time fiscal consolidation.

Table 5 shows the results. Again, the benefits of the policy in terms of debt sustainability are sizable. In addition, the simultaneous increase in the share of productive spending helps to sustain growth, which increases by 0.9 percentage points by 2036-40.

5.3 Fiscal Reform Program

Consider now the case where a *fiscal reform program*, involving tax, spending, and governance reforms, is implemented to the sustainability of public debt and promote growth and employment.

Specifically, we consider a composite program consisting of the following policies:

a) A gradual increase in the autonomous component of investment efficiency, φ_0, from 0.352 to to 0.4 in 2021-23, 0.5 in 2024-27, 0.6 in 2028-31, and 0.8 in 2032-40;

b) A permanent increase, starting in 2021, in the user fees charged by the government, from 0 to $\mu_0^G = 0.8$;

c) A gradual reduction in the ratio of noninterest government spending to GDP, υ_G, as defined earlier (1 percentage point in 2023, 2 percentage points in 2024, 3 percentage points in 2025, and 4 percentage points from 2026 to 2040);

d) A gradual increase in the share of primary government spending on infrastructure investment, υ_I, by 2 percentage points over 2021-23, 3 percentage points over 2024-27, and by 4 percentage points over 2028-40;

e) A gradual increase in the income tax rate, τ_I, by 1 percentage point between 2023-27, 2 percentage points between 2028-32, and 4 percentage points between 2033-40.

The results of this program are illustrated in Table 6. They show that the program helps not only to stabilize the public debt, by increasing both non-hydrocarbon revenues and reducing total noninterest government spending. Indeed, at the horizon 2036-40, non-hydrocarbon revenues increase by 3.3 percentage points of GDP, the primary deficit turns into a surplus (from -8.1 percent of GDP reported in Table 2 to a change of 7.3 percent in Table 6), and the public debt to GDP ratio drops by 75.5 percentage points (compared to the baseline value of 133.2 percent reported in Table 2, or equivalently a drop to 57.7 percent of GDP). At the same, because of the composition of noninterest government spending toward infrastructure investment, and the governance reforms aimed at improving the efficiency of such spending, the program also helps to promote growth: the annual growth rate of real GDP rises on average by 1.7 percentage points between 2036-40. For its part, the share of private investment in GDP rises by 0.6 percentage points during the same period.[15] Thus, this experiment has important practical implications for Algeria: with a well-designed fiscal reform program, there may be no trade-off between fiscal consolidation, aimed at ensuring public debt sustainability, and economic growth.

6 Concluding Remarks

In this paper, we presented a macro-fiscal model that allows us to discuss the effects of fiscal policy on growth and employment in Algeria. We first discussed the baseline scenario throughout the projection period, 2021-2040. According to our baseline results, without fiscal consolidation, even relatively high growth will not be sufficient to put public debt on a sustainable path. We then conducted four experiments and assessed their impact on fiscal accounts, growth, and unemployment: an increase in the efficiency of public spending on infrastructure investment, a gradual reduction in the share of noninterest government spending in GDP, the same gradual reduction in spending with a permanent increase in the share of investment in infrastructure in total noninterest government expenditure, and a composite fiscal reform program, respectively. The results suggest that public debt sustainability can be achieved, and growth and employment can be promoted, as long as a fiscal reform program,

[15] Despite the congestion effect associated with a higher private capital stock, the growth effect is stronger relative to the increase in private investment.

involving tax, spending, and governance reforms is implemented. Importantly, our quantitative analysis shows that with a well-designed fiscal program, there may be no trade-off between fiscal consolidation and economic growth.

References

Agénor, Pierre-Richard, *The Economics of Adjustment and Growth.* 2nd ed., Harvard University Press (Boston, MA: 2004).

——, "A Theory of Infrastructure-led Development," *Journal of Economic Dynamics and Control*, 34 (May 2010), 932-50.

——, *Public Capital, Growth and Welfare*, Princeton University Press (Princeton, New Jersey: 2012).

——, "Optimal Fiscal Management of Commodity Price Shocks," *Journal of Development Economics*, 122 (September 2016), 183-96.

Agénor, Pierre-Richard, and Peter J. Montiel, *Development Macroeconomics*, 4th ed., Princeton University Press (Princeton, New Jersey: 2015).

Agénor, Pierre-Richard, and Kyriakos Neanidis, "Innovation, Public Capital, and Growth," *Journal of Macroeconomics*, 44 (June 2015), 252-75.

Bems, Rudolfs, "Aggregate Investment Expenditures on Tradable and Nontradable Goods," *Review of Economic Dynamics*, 11 (October 2008), 852-83.

Berg, Andrew, Rafael Portillo, Shu-Chun S. Yang, and Luis-Felope Zanna, "Public Investment in Resource-Abundant Developing Countries," *IMF Economic Review*, 61 (March 2013), 92-129.

Bom, Pedro R., and Jenny E. Ligthart, "What have we Learned from Three Decades of Research on the Productivity of Public Capital?," *Journal of Economic Surveys*, 28 (December 2014), 889-916.

Bu, Yisheng, "Fixed Capital Stock Depreciation in Developing Countries: Some Evidence from Firm Level Data," *Journal of Development Studies*, 42 (December 2006), 881-901.

Dabla-Norris, Era, Jim Brumby, Annette Kyobe, Zac Mills, and Chris Papageorgiou, "Investing in Public Investment: An Index of Public Investment Efficiency," *Journal of Economic Growth*, 17 (September 2012), 235-66.

Hamia, Mohamad A., "Jobless Growth: Empirical Evidence from the Middle East and North Africa Region," *Journal for Labour Market Research*, 49 (November 2016), 239-51.

IMF, *World Economic Outlook: Growth Slowdown, Precarious Recovery,* IMF Publications (Washington DC: 2019).

Lundgren, Charlotte J., Alun H. Thomas, and Robert C. York, Boom, Bust, or Prosperity? Managing Sub-Saharan Africa's Natural Resource Wealth, International Monetary Fund (Washington DC: 2013).

Pritchett, Lant, "The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital," *Journal of Economic Growth*, 5 (December 2000), 361-84.

Richmond, Christine, Irene Yackovlev, and Susan Yang, "Investing Volatile Oil Revenues in Capital-Scarce Economies: An Application to Angola," Working Paper No. 13/147, International Monetary Fund (June 2013).

Syverson, Chad, "What Determines Productivity?," *Journal of Economic Literature*, 49 (June 2011), 326-65.

van den Bremer, Ton S., and Frederick van der Ploeg, "Managing and Harnessing Volatile Oil Windfalls," *IMF Economic Review*, 61 (April 2013), 130-67.

van der Ploeg, Frederick, "Bottlenecks in Ramping Up Public Investment," *International Tax and Public Finance*, 19 (August 2012), 509-38.

Table 1
Parameterization: Benchmark Case

Parameter	Value	Description
Households		
η_L	10	Preference parameter, labor in utility function
ψ	8	Inverse of Frisch elasticity of labor supply
κ_C	0.85	Propensity to consume
Λ_L	0.62	Distribution parameter, labor in nontradable sector
ς_L	0.2	Elasticity of substitution, sectoral employment levels
θ	0.62	Share of nontradables in private consumption
Final goods		
β_T, β_N	$0.6, 0.7$	Labor shares, tradable and nontradable sectors
ν_T	0.6	Learning-by-doing effect, nonmining tradable sector
ν_N	0.2	Externality parameter, mining sector to nontradable sector
ω_T, ω_N	0.17	Elasticity of output with respect to public capital
Capital producers		
δ^P	0.04	Depreciation rate, private capital
Λ_P	0.5	Share of nontradable goods in private investment
Λ_K	0.62	Share of private capital stock in nontradable goods sector
ς_K	0.2	Elast. of substitution, tradables and nontradables, in capital
a_1	0.098	Investment, coefficient of GDP growth
a_2	0.041	Investment, coefficient of public-private capital stock
a_3	0.1	Investment, coefficient of private investment to GDP ratio
Government		
τ_C	0.114	Effective consumption tax rate
τ_I	0.089	Effective income tax rate
τ_0	0.910	Effective oil tax rate
τ_R	0.073	Effective tax rate, other revenues
υ_G	0.382	Share of noninterest primary government spending in GDP
υ_I	0.254	Share of investment in nonint. primary government spending
$\upsilon_{I,N}$	0.5	Share of government investment allocated to nontradables
φ	0.4	Efficiency parameter, government investment
φ_1	0.05	Absorption constraint parameter, government investment
δ^G	0.025	Depreciation rate, public capital
μ_G^0	0.0	User fee parameter, public capital
World interest rate		
r^W	0.023	Market cost of foreign borrowing

Table 2. Algeria: Baseline Projections, 2021-40

	2021	2022	2023	2024	2025	2026-30	2031-35	2036-40
Real Sector								
Real GDP growth rate (percent)	0,7%	3,1%	3,8%	4,0%	4,1%	4,2%	4,4%	3,5%
Private investment (share of GDP)	28,4%	28,3%	28,3%	28,2%	28,1%	27,8%	27,3%	27,1%
Share of hydrocarbon sector in GDP (percent)	10,1%	10,0%	10,0%	10,0%	10,0%	10,0%	10,0%	10,0%
Share of non-hydrocarbon tradables in GDP (percent)	14,7%	14,6%	14,6%	14,6%	14,5%	14,3%	13,8%	13,2%
Share of nontradables in GDP (percent)	75,2%	75,3%	75,3%	75,4%	75,4%	75,7%	76,2%	76,8%
Public Sector								
Hydrocarbon revenues (percent of GDP)	9,2%	9,1%	9,1%	9,1%	9,1%	9,1%	9,1%	9,1%
Non-hydrocarbon revenues (percent of GDP)	20,8%	20,7%	20,6%	20,6%	20,6%	20,7%	20,8%	21,0%
Share of income tax revenues (percent)	38,4%	38,7%	38,8%	38,9%	38,9%	38,7%	38,4%	38,1%
Share of consumption tax revenues (percent)	26,5%	26,0%	25,8%	25,7%	25,7%	26,0%	26,6%	27,2%
Share of user fees (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Other taxes (percent)	35,1%	35,3%	35,4%	35,5%	35,5%	35,3%	35,0%	34,7%
Total revenues (percent of GDP)	30,0%	29,8%	29,7%	29,7%	29,7%	29,8%	30,0%	30,1%
Noninterest government spending (percent of GDP)	40,0%	38,2%	38,2%	38,2%	38,2%	38,2%	38,2%	38,2%
Share of spending allocated to consumption (percent)	74,6%	74,6%	74,5%	74,5%	74,5%	74,5%	74,5%	74,5%
Share of spending allocated to investment (percent)	25,4%	25,4%	25,4%	25,4%	25,4%	25,4%	25,4%	25,4%
Share of investment spending allocated to non-hydrocarbon tradable goods (percent)	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%
Share of investment spending allocated to nontradable goods (percent)	50,0%	50,0%	50,0%	50,0%	50,0%	49,9%	49,9%	49,9%
Primary budget balance (percent of GDP)	-10,0%	-8,4%	-8,5%	-8,5%	-8,5%	-8,4%	-8,2%	-8,1%
Non-hydrocarbon primary balance (percent of GDP)	-19,2%	-17,5%	-17,6%	-17,6%	-17,6%	-17,5%	-17,4%	-17,2%
Interest payments (percent of GDP)	1,0%	1,2%	1,3%	1,4%	1,5%	1,8%	2,2%	2,5%
Interest payments on domestic debt (percent of GDP)	0,9%	1,1%	1,2%	1,3%	1,4%	1,7%	2,1%	2,4%
Interest payments on foreign debt (percent of GDP)	0,1%	0,1%	0,1%	0,1%	0,1%	0,1%	0,1%	0,1%
Overall fiscal balance (percent of GDP)	-11,0%	-9,6%	-9,8%	-9,9%	-10,0%	-10,2%	-10,4%	-10,5%
Total public debt (percent of GDP)	60,1%	66,7%	72,8%	78,5%	83,9%	98,3%	117,7%	133,2%
Domestic debt (percent of GDP)	57,5%	64,1%	70,2%	75,9%	81,3%	95,7%	115,1%	130,6%
External debt (percent of GDP)	2,6%	2,6%	2,6%	2,6%	2,6%	2,6%	2,6%	2,6%
Current account balance (percent of GDP)	-17,3%	-16,6%	-16,2%	-15,9%	-15,8%	-15,7%	-16,0%	-16,5%
Unemployment rate (percent)	10,7%	10,2%	9,7%	9,3%	8,9%	7,8%	6,2%	4,9%
External environment								
Composite real world price of hydrocarbon (2018 = 1.0)	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53

Table 3. Algeria: Higher Efficiency of Public Infrastructure Investment

	2021	2022	2023	2024	2025	2026-30	2031-35	2036-40
Real Sector								
Real GDP growth rate (percent)	0,3%	0,4%	0,4%	0,4%	0,4%	0,4%	0,4%	1,3%
Private investment (share of GDP)	0,0%	0,1%	0,1%	0,2%	0,2%	0,3%	0,4%	0,4%
Share of hydrocarbon sector in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of non-hydrocarbon tradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,1%	-0,2%
Share of nontradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,1%	0,2%
Public Sector								
Hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Non-hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of income tax revenues (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of consumption tax revenues (percent)	0,0%	-0,1%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,1%
Share of user fees (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Other taxes (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Total revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Noninterest government spending (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of spending allocated to consumption (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of spending allocated to investment (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to non-hydrocarbon tradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to nontradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Primary budget balance (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Non-hydrocarbon primary balance (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Interest payments (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,1%
Interest payments on domestic debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,1%
Interest payments on foreign debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Overall fiscal balance (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,1%
Total public debt (percent of GDP)	-0,2%	-0,4%	-0,6%	-0,8%	-1,1%	-2,0%	-3,6%	-6,2%
Domestic debt (percent of GDP)	-0,2%	-0,4%	-0,6%	-0,8%	-1,1%	-2,0%	-3,6%	-6,2%
External debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Current account balance (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,2%	-0,3%
Unemployment rate (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
External environment								
Composite real world price of hydrocarbon (2018 = 1.0)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 4. Algeria: Reduction in Share of Noninterest Government Spending

	2021	2022	2023	2024	2025	2026-30	2031-35	2036-40
Real Sector								
Real GDP growth rate (percent)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,1%	-0,1%	-1,8%
Private investment (share of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of hydrocarbon sector in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of non-hydrocarbon tradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,2%
Share of nontradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,2%
Public Sector								
Hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Non-hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of income tax revenues (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
Share of consumption tax revenues (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%
Share of user fees (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Other taxes (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
Total revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Noninterest government spending (percent of GDP)	0,0%	0,0%	-1,0%	-2,0%	-3,0%	-4,0%	-4,0%	-4,0%
Share of spending allocated to consumption (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,2%	0,3%
Share of spending allocated to investment (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to non-hydrocarbon tradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to nontradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,1%	0,2%
Primary budget balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,0%	4,0%	4,0%	4,0%
Non-hydrocarbon primary balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,0%	4,0%	4,0%	4,0%
Interest payments (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,2%	-0,5%	-0,7%
Interest payments on domestic debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,2%	-0,5%	-0,7%
Interest payments on foreign debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Overall fiscal balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,1%	4,2%	4,5%	4,7%
Total public debt (percent of GDP)	0,0%	0,0%	-1,0%	-2,9%	-5,8%	-16,3%	-31,1%	-39,6%
Domestic debt (percent of GDP)	0,0%	0,0%	-1,0%	-2,9%	-5,8%	-16,3%	-31,1%	-39,6%
External debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Current account balance (percent of GDP)	0,0%	0,0%	0,1%	0,3%	0,4%	0,5%	0,6%	0,7%
Unemployment rate (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
External environment								
Composite real world price of hydrocarbon (2018 = 1.0)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 5. Algeria: Reduction in Share of Noninterest Government Spending, Combined with Higher Share of Infrastructure Investment

	2021	2022	2023	2024	2025	2026-30	2031-35	2036-40
Real Sector								
Real GDP growth rate (percent)	0,1%	0,2%	0,1%	0,1%	0,1%	0,1%	0,1%	0,9%
Private investment (share of GDP)	0,0%	0,0%	0,0%	0,1%	0,1%	0,1%	0,1%	0,1%
Share of hydrocarbon sector in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of non-hydrocarbon tradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of nontradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Public Sector								
Hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Non-hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of income tax revenues (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of consumption tax revenues (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of user fees (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Other taxes (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Total revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Noninterest government spending (percent of GDP)	0,0%	0,0%	-1,0%	-2,0%	-3,0%	-4,0%	-4,0%	-4,0%
Share of spending allocated to consumption (percent)	-8,0%	-8,0%	-8,0%	-8,0%	-7,9%	-7,8%	-7,7%	-7,6%
Share of spending allocated to investment (percent)	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%
Share of investment spending allocated to non-hydrocarbon tradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to nontradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,2%	0,3%
Primary budget balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,0%	4,0%	4,0%	4,0%
Non-hydrocarbon primary balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,0%	4,0%	4,0%	4,0%
Interest payments (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,3%	-0,5%	-0,8%
Interest payments on domestic debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,3%	-0,5%	-0,8%
Interest payments on foreign debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Overall fiscal balance (percent of GDP)	0,0%	0,0%	1,0%	2,0%	3,1%	4,3%	4,6%	4,8%
Total public debt (percent of GDP)	-0,1%	-0,2%	-1,2%	-3,3%	-6,2%	-17,0%	-32,3%	-45,6%
Domestic debt (percent of GDP)	-0,1%	-0,2%	-1,2%	-3,3%	-6,2%	-17,0%	-32,3%	-45,6%
External debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Current account balance (percent of GDP)	-1,6%	-1,5%	-1,4%	-1,2%	-1,0%	-0,9%	-0,8%	-0,8%
Unemployment rate (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
External environment								
Composite real world price of hydrocarbon (2018 = 1.0)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 6. Algeria: Composite Reform Program

	2021	2022	2023	2024	2025	2026-30	2031-35	2036-40
Real Sector								
Real GDP growth rate (percent)	0,1%	0,1%	0,1%	0,3%	0,3%	0,4%	0,8%	1,7%
Private investment (share of GDP)	0,0%	0,0%	0,0%	0,1%	0,1%	0,2%	0,4%	0,6%
Share of hydrocarbon sector in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of non-hydrocarbon tradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%
Share of nontradables in GDP (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
Public Sector								
Hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Non-hydrocarbon revenues (percent of GDP)	0,0%	0,0%	0,9%	0,8%	0,8%	1,3%	2,7%	3,3%
Share of income tax revenues (percent)	0,0%	0,0%	2,6%	2,7%	2,7%	4,2%	7,8%	9,6%
Share of consumption tax revenues (percent)	0,0%	0,0%	-1,2%	-1,3%	-1,3%	-2,0%	-3,9%	-4,8%
Share of user fees (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Other taxes (percent)	0,0%	0,0%	-1,4%	-1,4%	-1,4%	-2,1%	-3,9%	-4,7%
Total revenues (percent of GDP)	0,0%	0,0%	0,9%	0,8%	0,8%	1,3%	2,7%	3,3%
Noninterest government spending (percent of GDP)	0,0%	0,0%	-1,0%	-2,0%	-3,0%	-4,0%	-4,0%	-4,0%
Share of spending allocated to consumption (percent)	-2,0%	-2,0%	-2,0%	-3,0%	-3,0%	-3,5%	-3,7%	-3,6%
Share of spending allocated to investment (percent)	2,0%	2,0%	2,0%	3,0%	3,0%	3,6%	4,0%	4,0%
Share of investment spending allocated to non-hydrocarbon tradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Share of investment spending allocated to nontradable goods (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,2%	0,3%
Primary budget balance (percent of GDP)	0,0%	0,0%	1,9%	2,8%	3,8%	5,3%	6,7%	7,3%
Non-hydrocarbon primary balance (percent of GDP)	0,0%	0,0%	1,9%	2,8%	3,8%	5,3%	6,7%	7,3%
Interest payments (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,3%	-0,8%	-1,3%
Interest payments on domestic debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	-0,1%	-0,3%	-0,8%	-1,3%
Interest payments on foreign debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Overall fiscal balance (percent of GDP)	0,0%	0,0%	1,9%	2,9%	3,9%	5,7%	7,5%	8,6%
Total public debt (percent of GDP)	-0,1%	-0,1%	-2,0%	-5,0%	-8,8%	-23,1%	-48,4%	-75,5%
Domestic debt (percent of GDP)	-0,1%	-0,1%	-2,0%	-5,0%	-8,8%	-23,1%	-48,4%	-75,5%
External debt (percent of GDP)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Current account balance (percent of GDP)	-0,4%	-0,4%	-0,1%	-0,1%	0,1%	0,2%	0,4%	0,5%
Unemployment rate (percent)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,1%
External environment								
Composite real world price of hydrocarbon (2018 = 1.0)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00