Dynare Working Papers Series
https://www.dynare.org/wp/

Policy Mix in An Oil Exporting Country: Effectiveness of Countercyclical Measures in Mitigating External Shocks

Sami Diaf
Ahmed Zakane

Working Paper no. 83

Initial revision: March 2025
This revision: April 2025

CEPREMAP
CENTRE POUR LA RECHERCHE ECONOMIQUE ET SES APPLICATIONS
48, boulevard Jourdan — 75014 Paris — France
https://www.cepremap.fr

Policy Mix in an Oil Exporting Country: Effectiveness of Countercyclical Measures in Mitigating External Shocks.

Sami Diaf*

Ahmed Zakane†

Abstract

Gauging the impact of oil price variations on small, oil-exporting countries has been heavily investigated under the umbrella of monetary policy interventions, using a standard general equilibrium framework. For some countries, the monetary policy coordinates with fiscal policy to deliver a better response to external oil shocks, in an attempt to make the economic activity resilient to a potential backlash. This paper investigates the policy mix effectiveness in a small open economy, namely Algeria, and its ability to mitigate a negative oil price shock, using a dual monetary/fiscal DSGE framework. The model maps several frictions found in single-commodity economies as for a managed exchange rate regime, the existence of a foreign exchange market accessible to households and a sovereign wealth fund. Simulations show countercyclical fiscal measures (increase in government spending) coupled with monetary interventions have no expansionary effects on output, but still necessary to maintain a resilient economic activity especially for the non-oil sector. Under the sticky prices assumption, households tend to lower their consumption level and use their foreign currency savings as buffer against currency depreciation. This results in alleviating potential pressures on the supply side and preventing possible inflation spikes. Findings confirm the effectiveness of a monetary policy based on targeting export products, which better handles the negative terms of trade shock via a slight exchange rate depreciation. However, the fiscal dominance in the policy-mix leads to the accumulation of public debt, which might require fiscal consolidation during protracted periods of declining oil prices.

Keywords : monetary policy, fiscal policy, exchange rate, oil prices, external shock

JEL Classification : E31, E52, E63, F31, F41, H54, H63, Q35, Q38

1 Introduction

DSGE models are usually linked to developed economies, where their advanced micro-level structure is featured and modeled as a block of equations (Smets and Wouters, 2003). However, applying these models to developing countries could be biased and requires several stylized facts, or frictions, that alter the models' general framework.

*Universität Hamburg, Germany. sami.diaf@uni-hamburg.de

†Research Center for Applied Economics for Developments (CREAD) and High National School of Statistics and Applied Economics (ENSSEA), Algeria. a.zakane@cread.dz

Emerging countries, at the contrary, show different characteristics. For instance, public investment remains an important pillar of the fiscal policy, which must be distinguished from public consumption (Berg et al., 2013). Monetary policy is often conducted as a hybrid mixture of inflation targeting and managed exchange rate regime, thus requiring two distinctive monetary policy instruments: interest rate and foreign exchange interventions (Benes et al., 2015). Households are often heterogeneous in their income distribution and access to financial markets, requiring to define a portion of the population being constrained to just use the earned wages (Mankiw, 2000).

Oil-exporting economies, on the other hand, exhibit different characteristics than emerging ones (Algozhina, 2016), calling for a separate specification of the production sector (oil and non-oil) and defining an accumulation fund that collects oil taxes (example of a sovereign wealth fund). In addition to foreign exchange interventions usually adopted by the central bank, Frankel (2011) suggested monetary authorities the adoption of product price targeting (PPT), as an alternative to consumer price index (CPI), to make the monetary policy automatically countercyclical during periods of volatile terms of trade. Algozhina (2016) tested the effectiveness of these two anchors (PPT and CPI) jointly with fiscal instruments, on the basis of a defined welfare measure equaling the sum of three variances (input, inflation and real exchange rate) (De Paoli, 2009) and concluded that a procyclical fiscal policy coupled with CPI-based monetary targeting deliver the best response for the case of Kazakhstan.

The aforementioned frictions pertain to the case of Algeria, a small open, oil-exporting economy with a heavy reliance on hydrocarbon exports and a less developed financial market. The government plays a pivotal role in the economic landscape, especially during times of lower oil prices, where a prompt response is needed to prevent widespread negative impact on the real sector and a deterioration of its external position. Financial constraints to foreign currencies, because the local currency is not convertible, gave birth to a parallel market. This allows households to exchange, with a high premium, the local currency with main foreign currencies (IMF, 2018). Inflation rate has not reached, during last decade, high levels and was not impacted by an exchange rate pass-through; where price tensions have a domestic origin (fresh food products) (IMF, 2024).

The literature does not demonstrate any attempt to gauge an external oil shock, from a policy mix perspective. The interest of researchers was primarily given to assessing monetary policy practice (Boucekkine et al., 2021), although fiscal instruments have been heavily used to implement economic programs as well as financial planning (Chibi et al., 2019); while public spending remained uncorrelated with fiscal revenues.

This work aims to address this issue by considering both monetary and fiscal policies as tools to face a decline in international oil prices, which accounts for a negative shock affecting the country's terms of trade (Frankel, 2011). It extends the model built by Algozhina (2016) and tailors its framework to match the specification of the Algerian economy, with the purpose to evaluate the outcomes of such actions on key macroeconomic aggregates.

We propose to put forward the interaction of a PPT-anchored, managed exchange rate regime with foreign exchange interventions (monetary instruments), in conjunction with a countercyclical fiscal policy built upon increasing government spending. To this end, we consider a DSGE model with sticky prices, rule-of-thumb consumers (non-ricardian) and optimizer consumers having access to foreign exchange markets (ricardians) because the local currency is non-convertible. It also features a non-oil sector, a single oil-producing company jointly owned by the state and foreign investors; and the rest of the world as one entity.

Results confirm the effectiveness of the aforementioned policy-mix in making the economic activity resilient to negative oil shocks and supporting the real sector activity; but highlights a fiscal dominance with looming risks over the sustainability of public debt. Notably, no expansionary effects on the output are noticed, however households' consumption drops due to non-oil labor market fluctuations, despite subdued inflation and a mild exchange rate depreciation. Ricardian households use their foreign exchange savings to face uncertainties in terms of price spikes and currency depreciation, by constantly building up their assets. The efficiency of such policy may be hindered by prolonged lower oil prices and the viability of the external position. In parallel, public debt carries the burden of the countercyclical policies and may require fiscal consolidation over the medium run.

The paper outlines the related literature (Section 2). The theoretical, per-agent build-up of the model is expanded upon in Section 3, before conducting estimation and calibration (Section 4) and finally discuss the simulation results (Section 5).

2 Related Literature

An abundant literature deals with the study of exogenous adverse shocks and their impact through DSGE models, although the scope and the aims are different, depending on the economic structure and the modeling assumptions.

Algozhina (2016) simulated three fiscal policies and two monetary regimes for the case of Kazakhstan and founded a certain effectiveness of a procyclical fiscal stance coupled with inflation targeting without foreign exchange interventions. Results found the PPT rule as the main cause of high variations in output and exchange rate. Bańkowski et al. (2021) built a pre-pandemic and post-pandemic assessments of various policy-mix instruments for the Euro area and concluded that fiscal and monetary policies reinforce each other.

For the case of Algeria, we noticed several contributions, using DSGE frameworks, aimed at assessing a negative oil shock and its potential impact on the domestic economy, with a particular interest given to monetary policy actions and its instruments.

Dib (2010) cited three main transmission mechanisms during the 2008 global crisis that affected the Algerian economy. Increasing costs of firms' borrowing to finance their investments, decline in oil prices, and the lower world interest rates were all found to pose significant risks to Algeria, requiring expansionary monetary and government spending policies to mitigate such impact (Dib, 2010).

Allegret and Benkhodja (2012) studied the monetary policy as a macroeconomic stabilization policy after an oil shock and investigated the dynamic effects of four different shocks (oil price, real exchange rate, international interest rate and foreign inflation) along the appropriate monetary policy rule. A multi-sector DSGE model with nominal and real rigidities was built and showed core inflation targeting was the best monetary rule to stabilize both output and inflation.

Chibi et al. (2019) found, through a VAR model, an evidence of non-ricardian fiscal policy, that dominates monetary policy. It confirms a negative correlation between fiscal balances and government liability, that was prevailing during last two decades.

Boucekkine et al. (2021) used cointegration estimation to study the long-term stability of money supply (1979-2019) and found monetary aggregates M1 and M2 to have a stable demand, at the contrary of fiat currency which was unstable.

3 Description of the model

The proposed model (Algozhina, 2016) comprises several frictions as for an incomplete asset market, adjustment costs, collateral constraint and Calvo price setting. In the presence of a foreign entity (rest of the world), the domestic economy is not considered as a borrower, thus, the domestic and foreign discount factors are equal.

Two producers are considered in the model: an oil firm, owned by the government and foreigners, and non-oil firms owned by nationals. Non-oil firms are monopolistically competitive and have their prices fixed à la Calvo (Calvo, 1983), and their profits given to households. Governement's oil share and revenues are given to the sovereign wealth fund (SWF), whose returns are assumed to be transferred to the government budget. Foreign Direct Investments (FDI) mainly affect the oil production and responds to international oil prices.

Households are two types: ricardian and non-ricardian. Only ricardians can borrow from abroad and have restictions on their non-oil collateral. They also hold local government bond, own non-oil firms, rent capital to these firms and decide about investments. Non-ricardian households use all their revenues during each period. Labor market is assumed competitive without workers' unions and wage bargaining.

The CPI-Taylor rule includes lagged interest rate, the CPI inflation and the GDP (Sarno and Taylor, 2001). The PPT-Taylor rule incorporates oil price inflation and domestic inflation, weighted by the oil sector and non-oil GDP respectively (Sarno and Taylor, 2001). Rules for public consumption and public investment include fiscal debt, oil revenues and oil sector output to capture the fiscal policy position (countercyclical). Public investment is productive in the accumulation of public capital and also considered as an additional input in the Cobb-Douglas function for non-oil production, besides labor and physical capital.

3.1 Households

The domestic economy has a continuum of households on an interval [0,1] where a fraction μ represents non-ricardians unable to access financial markets and consume all their available revenues during each period (non-optimizers). Ricardian households $(1-\mu)$ are prospective optimizers holding government bonds, borrowing from abroad, investing in non-oil capital, renting capital to non-oil firms and receiving profits from them. Labor market is assumed to be competitive and revenues are equal for all households (both household types have the same working hours).

The index S indicates a variable associated to ricardian households and N refers to non-ricardian ones. Ricardians optimize the utility function (Schmitt-Grohe and Uribe, 2002):

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{[C_t^S - \phi^{-1} N_t]^{1-\sigma} - 1}{1-\sigma}, \phi > 1, \sigma > 1 \tag{1}$$

under the budget constraint:

$$C_t^S + I_t + b_t + R_{t-1}^* \frac{RER_t}{RER_{t-1}} \frac{b_{t-1}^*}{\pi_t^{*r}} + T_t^S = W_t N_t + R_t^{kno} K_{t-1}^{kno} + R_{t-1} \frac{b_{t-1}}{\pi_t} + b_t^* + \Pi_t \tag{2}$$

where: $b_t = \frac{B_t}{P_t}$ is the real purchases of government bonds, RER_t is the real exchange rate (price of a basket of foreign goods in terms of a basket of domestic goods), $b_t^* = RER_t \frac{B_t^*}{P_t^*}$ is the real borrowing from abroad expressed in terms of domestic goods, R_{t-1} and R_{t-1}^* are respectively the domestic and foreign interest rates in nominal terms, T_t^S are real taxes collected, W_t real wages, R_t^{kno} is the cost of non-oil physical capital rental, $\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation and Π_t is the real profit of monopolistic non-oil firms.

Non-oil capital movement incorporates adjustment costs fo inflation (Berg et al., 2013)

$$K_t^{no} = (1-\delta) K_t^{no} + \left[1 - \frac{\kappa}{2} (\frac{I_t}{I_{t-1}} - 1)^2 \right] I_t, \kappa > 0 \tag{3}$$

The collateral constraint related to foreign liabilities to a future value of capital (Faia and Iliopulos, 2011) is expressed as:

$$R_t^* b_t^* = E_t \left\{ \Omega \frac{Q_{t+1} \pi_{t+1}^*}{RER_{t+1}/RER_t} K_t^{no} \right\} \tag{4}$$

where Q_t is a real shadow value of capital (Tobin's Q) and Ω is the upper bound of the leverage ratio. While this specification fits the case of a heavily-indebted country (Algozhina, 2016), the application will assign a lower upper bound value, given the relative funding capacity of Algeria.

Hence, households' optimization is stated as a maximization of the utility (1) with respect to consumption C_t^S, investment I_t^S, capital K_t^{no}, government bonds holdings b_t, foreign borrowing b_t^* and hours worked N_t, subjected to the budget constraint (2), capital accumulation equation (3) and collateral constraint (4).

The non-optimizing household has the same preferences as the optimizer but chooses only consumption and labor under the budget constraint:

$$C_t^N + T_t^N = W_t N_t \tag{5}$$

Each type of household ($i \in S, N$) has a composite CES consumption preference over domestic and foreign goods with $\eta > 0$ as an elasticity of substitution between goods:

$$C_t(i) = \left[\gamma^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}}(i) + (1-\gamma)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}(i)\right]^{\frac{\eta}{\eta-1}}$$

where γ is a home-bias parameter and (1-γ) indicated degree of openness. Minimizing a household's consumption expenditures gives the following CPI index:

$$P_t^{1-\eta} = \gamma P_{h,t}^{1-\eta} + (1-\gamma) P_{f,t}^{1-\eta} \text{ ou bien } 1 = \gamma p_{h,t}^{1-\eta} + (1-\gamma) RER_t^{1-\eta} \tag{6}$$

where $p_{h,t}$ is the price of domestic goods to composite consumption and RER_t is the relative price of foreign goods to composite consumption.

$C_t = \mu C_t^N + (1-\mu) C_t^S$ is the equation of the aggregate consumption. As for private consumption, investment is the CES basket with the same home-bias parameter γ and CPI price index for simplicity.

3.2 Firms

As for Galí et al. (2007), we assume the existence of monopolistically competitive non-oil firms producing differentiated intermediate goods, and a perfectly competitive non-oil firm producing a final domestic good, whose producer has a constant returns technology:

$$Y_t^{no} = \left(\int_0^1 X_t(j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}$$

where $X_t(j)$ is the input amount of intermediate good j and $\epsilon > 1$ is the elasticity of substitution between differentiated intermediate goods. It maximizes profit taking as given the domestic final goods price P_t^h and intermediate goods prices $P_t^h(j)$, so the optimal demand allocation could be written as:

$$X_t(j) = \left(\frac{P_t^h(j)}{P_t^h}\right)^{-\epsilon} Y_t^{no} \tag{7}$$

Each company producing intermediary goods has the identical Cobb-Douglas production function that incorporates private non-oil capital, labor and public capital:

$$Y_t^{no}(j) = u^{no} K_{t-1}^{no}(j)^{\alpha} N_t(j)^{1-\alpha} K_{G,t-1}^{\psi} \tag{8}$$

where the level of technology u^{no} remains constant and the usage of public capital are common to all firms.

Intermediate good producers solve their problem in two stages. First minimizing costs according to the production function (8) gives the real marginal costs common to all non-oil firms (real wage and rental cost of capital are assumed given) as:

$$MC_t = \frac{W_t^{1-\alpha} (R_t^{kno})^{\alpha}}{u^{no} K_{G,t-1}^{\psi} (1-\alpha)^{1-\alpha} \alpha^{\alpha}} \tag{9}$$

Second, intermediate non-oil producers choose the price P_t^{hop} to maximize their discounted real profits:

$$\sum_{m=0}^{\infty} \theta^m E_t \left\{ D_{t,t+m} Y_{t+m}^{no}(j) \left(\frac{P_t^{hop}}{P_{t+m}^h} - MC_{t+m}\right)\right\} \tag{10}$$

where $D_{t,t+m} = \beta^m E_t \left(\frac{U_{C^S_{t+m}}}{U_{C^S_t}} \right)$ is a stochastic discount factor stemming from the optimizing household's problem, subject to the demand constraint according to (7):

$$Y^{no}_{t+m}(j) = \left(\frac{P^{hop}_t}{P^h_{t+m}} \right)^{-\epsilon} Y^{no}_{t+m}$$

One can explain the price stickiness (Calvo, 1983) as a fraction $(1-\theta)$ of non-oil firms makes price adjustment at each period, at the contrary of a fraction θ that keeps their prices unchanged. The evolution of the domestic price index is given by:

$$(P^h_t)^{1-\epsilon} = \theta (P^h_{t-1})^{1-\epsilon} + (1-\theta)(P^{hop}_t)^{1-\epsilon}$$

The first order condition of this price setting decision (10) is:

$$\sum_{m=0}^{\infty} \theta^m E_t \left\{ D_{t,t+m} Y^{no}_{t+m}(j) \left(\frac{P^{hop}_t}{P^h_{t+m}} - \frac{\epsilon}{\epsilon - 1} MC_{t+m} \right) \right\} = 0 \tag{11}$$

where $\frac{\epsilon}{\epsilon-1}$ is a frictionless price markup.

The production function of the oil firm is only dependent of capital input, so to match the hypothesis of a capital-intensive sector and canceling any complication coming from labor mobility between the oil and non-oil sector:

$$Y^o_t = (K^o_{t-1})^{\alpha_0} \tag{12}$$

Oil capital accumulated by FDI which responds to world oil prices [1]:

$$K^o_t = (1-\delta) K^o_t + FDI^*_t \tag{13}$$

$$\widehat{FDI^*_t} = \rho_{FDI} \widehat{FDI^*_{t-1}} + (1-\rho_{FDI}) \widehat{P^{o*}_t} \tag{14}$$

World oil price are assumed to follow an AR(1) process and has an exogenous shock referred as terms of trade shock:

$$\widehat{P^{o*}_t} = \rho_o \widehat{P^{o*}_{t-1}} + \epsilon^o_t \tag{15}$$

The oil firms receives its profits Π^{o*}_t net of royalties levied on production quantity at a rate τ_o:

$$\Pi^{o*}_t = (1-\rho^o) P^{o*}_t Y^o_t \tag{16}$$

The oil sector is owned by the foreigners and the government, the latter receives ι^{div} which denotes dividend share of oil profits

3.3 Fiscal Policy

Government collects lump-sum taxes T_t and oil revenues OR_t to transfer them to the sovereign wealth fund (SWF). It issues treasury bonds to fund government purchases which include

[1] Hereafter, hat sign $\hat{}$ denotes the deviation of the variables from their steady states.

public consumption G_t^C and public investment G_t^I. The government's budget constraint is written as:

$$(1-\mu)b_t + T_t + \underbrace{(R^*_{t-1}\frac{1}{\pi^*_t} - \rho_{swf})SWF^*_{t-1}RER_t}_{OR_t} = p_t^g(G_t^C + G_t^I) + (1-\mu)R_{t-1}\frac{b_{t-1}}{\pi_t} \tag{17}$$

where $T_t = (1-\mu)T_t^S + \mu T_t^N$ and p_t^g is the price of government purchases related to the composite consumption with its own bias parameter γ_2:

$$p_t^g = \left[\gamma_2 p_{h,t}^{1-\eta} + (1-\gamma_2)RER_t^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{18}$$

Public investment is productive, so that the law of public capital motion is given by:

$$K_t^G = (1-\delta_g)K_{t-1}^G + G_t^I \tag{19}$$

Oil revenues, collected in foreign currency, consist of dividends and the share of government in the oil sector's profit.

$$T_t^{o*} = \tau^o P_t^{o*} Y_t^o + \iota^{div}\Pi_t^{o*} \tag{20}$$

which build up the accumulation of the SWF, following:

$$SWF_t^* = \rho_{swf}SWF_{t-1}^* + T_t^{o*} \tag{21}$$

Two fiscal instruments, public investment and public consumption, have the following laws with their responses regarding oil production (ϑ_{GI} and ϑ_{GC}), associated to the fiscal cycle:

$$\widehat{G_t^I} = \rho_{GI}\widehat{G_{t-1}^I} + (1-\rho_{GI})[\vartheta_{GI}\widehat{Y_t^o} - \gamma_{GI}\widehat{b}_{t-1} + \gamma_{OR}^{GI}\widehat{OR}_t] \tag{22}$$

$$\widehat{G_t^C} = \rho_{GC}\widehat{G_{t-1}^C} + (1-\rho_{GC})[\vartheta_{GC}\widehat{Y_t^o} - \gamma_{GC}\widehat{b}_{t-1} + \gamma_{OR}^{GC}\widehat{OR}_t] \tag{23}$$

Because fiscal debt is part of the government's budget constraint, taxes require a separate equation that includes fiscal debt, public spending (similar to Galí et al. (2007)) and taxes from oil revenues.

$$\widehat{T}_t = \phi_b\widehat{b}_{t-1} + \phi_I\widehat{G_t^I} + \phi_C\widehat{G_t^C} - \phi_{OR}\widehat{OR}_t \tag{24}$$

3.4 Monetary Policy

Nominal interest rate is a function of its lagged value, CPI inflation and the aggregate production, following a Taylor rule for inflation targeting:

$$\widehat{R}_t = \rho\widehat{R}_{t-1} + (1-\rho)[\phi_\pi\pi_t + \phi_y\widehat{Y}_t] \tag{25}$$

For the PPT Taylor rule, PPT inflation is a weighted mean of oil prices' inflation (in real terms) $\pi_t^o = \Delta\widehat{P}_t^{o*} + \Delta\widehat{RER}_t$ and domestic inflation $\pi_t^h = \pi_t - \frac{1-\gamma}{\gamma}\Delta\widehat{RER}_t$, where the weights are simply the GDP shares of oil sector s_o and non-oil sector $(1-s_o)$ respectively.

$$\widehat{R}_t = \rho \widehat{R}_{t-1} + (1-\rho)\left[\phi_\pi [s_o \pi_t^o + (1-s_o)\pi_t^h] + \phi_y \widehat{Y}_t\right] \tag{26}$$

Interventions in the foreign exchange market are buying/selling foreign currencies by the central bank, which accumulates reserves (Benes et al., 2015), following the exchange rate and its depreciation rate.

$$\widehat{fxr}_t^* = \rho_{fxr}\widehat{fxr}_{t-1}^* + (1-\rho_{fxr})\left[\alpha_1 \widehat{RER}_t + \alpha_2 \Delta \widehat{RER}_t\right], \alpha_1 < 0, \alpha_2 < 0 \tag{27}$$

where $fxr_t^* = RER_t \dfrac{FXR_t^*}{P_t^*}$ are the real exchange reserve expressed in domestic products. Three clearing conditions were introduced in the model:

The domestic non-oil goods market:

$$p_t^h Y_t^{no} = \gamma \left[C_t + (1-\mu)I_t\right] + \gamma_2 p_t^g (G_t^C + G_t^I) \tag{28}$$

Real GDP from supply and demand sides:

$$p_t^h Y_t^{no} + Y_t^o P_t^{o*} RER_t = C_t + (1-\mu)I_t + p_t^g (G_t^C + G_t^I) + NX_t \tag{29}$$

Balance of payments condition equalizing its current and financial accounts.

$$NX_t + (R_{t-1}^* \frac{1}{\pi} - \rho_{swf}) SWF_{t-1}^* RER_t - (1 - iota^{div}) RER_t \Pi_t^{o*} =$$

$$(1-\mu)\left(R_{t-1}^* \frac{RER_t}{RER_{t-1}} \frac{b_{t-1}^*}{\pi_t^*} - b_t^*\right) - RER_t FDI_t^*$$

3.5 The rest of the world

Three exogenous equations define the rest of the world, as a large economy:

$$\widehat{Y}_t^* = \rho_{Y^*} \widehat{Y}_{t-1}^* + \epsilon_t^{Y^*} \tag{30}$$

$$\widehat{R}_t^* = \phi_\pi^* \pi_t^* + \phi_y^* \widehat{Y}_t^* \tag{31}$$

$$\pi_t^* = \beta^* E_t \pi_{t+1}^* + \lambda^* \left(\sigma + \frac{\phi^* + \alpha^*}{1-\alpha^*}\right) \widehat{Y}_t^* \tag{32}$$

Overall, 27 variables, represented as log-deviations from the steady state, constitute a system of 27 equations: inflation π_t, aggregated households consumption $\widehat{C}_t$, hours worked $\widehat{N}_t$, domestic interest rate $\widehat{R}_t$, net exports $\widehat{NX}_t$, foreign reserve $\widehat{fxr}_t^*$, foreign interest rate $\widehat{R}_t^*$, l'inflation de l'étranger π_t^*, la production $\widehat{Y}_t^*$, external debt $\widehat{b}_t^*$, oil sector capital $\widehat{K}_t^o$, non-oil sector capital $\widehat{K}_t^{no}$, public sector capital $\widehat{KG}_t$, real exchange rate $\widehat{RER}_t$, la fiscal debt $\widehat{b}_t$, collected taxes $\widehat{T}_t$, public consumption $\widehat{GC}_t$, public investment $\widehat{GI}_t$, private investment $\widehat{I}_t$, oil production $\widehat{Y}_t^o$, non-oil production $\widehat{Y}_t^{no}$, aggregated production $\widehat{Y}_t$, domestic prices $\widehat{p}_t^h$, government purchasing prices $\widehat{p}_t^g$, sovereign wealth fund assets $\widehat{SWF}_t$, foreign direct investments $\widehat{FDI}_t$ and international oil prices $\widehat{P}_t^{o*}$

4 Estimation et Calibration

The model was calibrated according to original methodology (Algozhina, 2016), while some parameters where tuned to match the case of Algeria as for the oil royalty rate (τ^o), the persistence parameter in world oil price (ρ_o) and the ratios (nx_y, $bstar_y$, swf_y, fdi_y, s_o, gI_y, gC_y) (Bank of Algeria, 2024).

We simulate, using Dynare (Adjemian et al., 2024), a policy-mix intervention to alleviate the effect of a persistent 10% drop in international oil prices (po), by considering a countercyclical fiscal policy coupled with a PPT-anchored managed exchange rate regime, under the sticky price hypothesis. This negative external shock could be seen as a negative terms of trade shock (Frankel, 2011), that needs to be addressed via exchange rate depreciation.

The parameters ϕ_π and ϕ_y, respectively inflation and output response in the PPT Taylor rule (Equation 26), are first learned using grid search strategy to minimize the loss measure expressed as the sum of three variances: inflation, output and real exchange rate (De Paoli, 2009). Values ranging from 0 to 2, with 0.1 increments, were used to run the grid search and yielded ϕ_π=1 and $\phi_y = 0.6$. Table 2 reports the loss function when considering sticky prices (θ=0.9) and flexible prices (θ=0.001) using the estimated Taylor parameters and demonstrates a higher loss when flexible prices prevail. The output response (ϕ_y) appears not far from the standard value (0.125) found by many researchers (Algozhina, 2016; Galí, 2015).

5 Results

A simulation of a 10% drop in international oil prices, coupled with a countercyclical fiscal policy at a managed exchange rate regime with sticky prices yields the impulse responses displayed in Figure 1.

Receding oil prices instantly impacts, at lower levels, many key aggregates in the model. However, most deviations from the steady states are mean-reverting with noticeable exceptions for the foreign currency held by households. The oil sector seems to be resilient to such impact, by maintaining its output (yo) and investments (ko) almost unchanged. Noticeable IRFs (yno, gi, gc, b and n) get stabilized after five periods, corresponding to the half life of the oil shock (infl), while fiscal-related variables show important variations then monetary ones.

Increasing government spending, consumption (gc) and investment (gi), has relatively no expansionary effects on the total output (y) but helps alleviating the oil price shock on the non-oil activity (yno) and keeps oil production (yo) practically unchanged (partly due its capital-intensive production function) by supporting investments in capital (slight long-run diminution of kg at 0.1% below its steady state).

From a household perspective, a negative oil shock shifts consumption instantly to an estimated 6% level lower than its steady-state before stabilizing at 1%, mainly driven by the constrained consumption of non-ricardian households. The investment behavior (kno) grows at a steady but lower rate before peaking at +0.2% in the long run. This could be explained

Table 1: Calibration of the model's parameters.

Parameter	Value	Definition
β	0.99	discount factor
γ	0.68	home-bias in consumption and investment
γ_2	0.90	home-bias in government purchases
Ω	0.54	the upper bound of leverage ratio
μ	0.50	the fraction of rule-of-thumb (non-ricardian) households
α	0.30	non-oil output elasticity to private capital
ψ	0.16	non-oil output elasticity to public capital
α^o	0.70	oil output elasticity to private capital
ϕ	1.45	wage elasticity to hours worked
σ	2	the inverse of intertemporal elasticity of substitution (C_t)
σ	0.025	the depreciation rate of private capital (oil and non-oil)
σ^g	0.020	the depreciation rate of public capital
θ	0.9	price stickiness index
ϵ	9	elasticity of substitution for intermediate goods
κ	20	investment adjustment costs parameter
ϕ_y	2	output response in the Taylor rule
ϕ_π	1.8	inflation response in the Taylor rule
α_1	-0.18	exchange rate response in the intervention rule
α_2	-0.57	exchange rate change response in the intervention rule
τ^o	0.27	oil royalty rate
ι^{div}	0.05	the dividend share of oil profit accrued to the government
γ_{GC}=γ_{GI}	0.3	the response of public consumption/investment to fiscal debt
ϑ_{GI}	0.54	the response of public investment to output
ϑ_{GC}	0.3	the response of public consumption to output
γ_{OR}^{GC}	0.2	the response of public consumption to oil revenues
γ_{OR}^{GI}	0.1	the response of public investment to oil revenues
φ_b	0.4	the response of lump-sum taxes to fiscal debt
φ_{OR}	-0.3	the response of lump-sum taxes to oil revenues
φ_C	1	the response of lump-sum taxes to public consumption
φ_I	0.2	the response of lump-sum taxes to public investment
ρ_{GC}	0.53	persistence in public consumption
ρ_{GI}	0	persistence in public investment
$1-\rho_{FDI}$	0.8	FDI response to the world oil prices
ρ_{swf}	0.775	persistence in SWF process
ρ	0.65	interest rate smoothing in the Taylor rule
ρ_{fxr}	0.7	persistence in the foreign exchange reserves of a central bank
ρ_o	0.80	persistence in the world oil prices
σ_0	0.15	standard deviation of the world oil prices
nx_y	0.2	ratio of net export to output
$bstar_y$	0.05	ratio of foreign bond to output
swf_y	0.30	ratio of SWF to output
fdi_y	0.05	ratio of FDI to output
s_o	0.4	share of oil in total output
gI_y	0.35	ratio of public investment to output
gC_y	0.18	ratio of public consumption to output

Table 2: Loss function (as the sum of estimated variances) at sticky and flexible prices.

	Sticky prices	Flexible prices
Loss	0.0150	2.1494
$Var(\widehat{\pi}_t)$	0.0002	1.5267
$Var(\widehat{Y}_t)$	0.0087	0.3534
$Var(\widehat{RER}_t)$	0.0061	0.2693

by the relative importance of non-ricardian households in the simulation (μ=0.5), which take some time in adjusting their behavior in context of raising prices and currency depreciation; while ricardian households build their foreign assets (bf) to offset the impact during the first three periods, before stabilizing them by taking the opportunity of lower inflation rates (infl) and a minor depreciation of the exchange rate (appreciation of the real exchange rate rer, peaking at 3% after 4 periods) due to monetary policy interventions in a managed exchange rate regime.

Monetary policy interventions anchored on PPT, coupled with sticky prices, prevent soaring the domestic inflation via the exchange rate pass-through, assuming that public investments and consumptions are met by a substantial supply capacity, to not create persistent inflationary tensions in the domestic market. Achieving price stability, in correlation with a stable overall output, bolsters the real sector by maintaining an investment/consumption dynamic that may not hinder intra-sectoral changes. A drop in the number of hours worked (n) during the first 5 periods may be interpreted as difficulties, local businesses face when government limits its action. Such negative effect on unemployment provides another explanation of the drop in the household consumption (c) and non-oil output (yno). Government subsidies[2], as part of government consumption (gc), could be seen as a catalyst in maintaining the purchasing power of non-ricardian households unchanged, by limiting a potential deterioration over the long run.

This favorable domestic policy generates a sizable amount of public debt (b), which accumulates to a 3% deviation units over the medium run, in correlation to government investments (gi) whose steady deviation reaches 0.8% after ten periods. The accumulation of public debt is explained by measures adopted toward non-oil sector, namely the small and medium sized entreprises (SMEs), as well as subsidies to households (IMF, 2024). Hence, supporting the economic activity during prolonged negative oil outlooks can exacerbate the fiscal debt and may hinder further implementation of countercyclical policies if the negative oil shock is expected to prevail over the long term. For instance, a 10% drop in oil prices shift instantly net exports to a negative deviation level of 15% and returns to equilibrium after ten periods.

Monetary policy interventions in PPT regime, particularly the use of foreign reserves, impacts the sovereign wealth fund (fxr) which is slightly affected by the adopted policy-mix (3% deviation lower than the steady state), in-line with a delayed deterioration of the public debt. This development indicates a policy preference toward keeping a robust external position to face potential sudden stops affecting the balance of payments (euro-dollar fluctuations or a prolonged drop in oil prices), at the expenses of domestic equilibria. The exchange rate depreciation (rer) is delayed and have a narrow fluctuation range, due to the PPT anchor

[2]Subventions could be either direct (social transfers) or indirect (price caps or staple food subsidies).

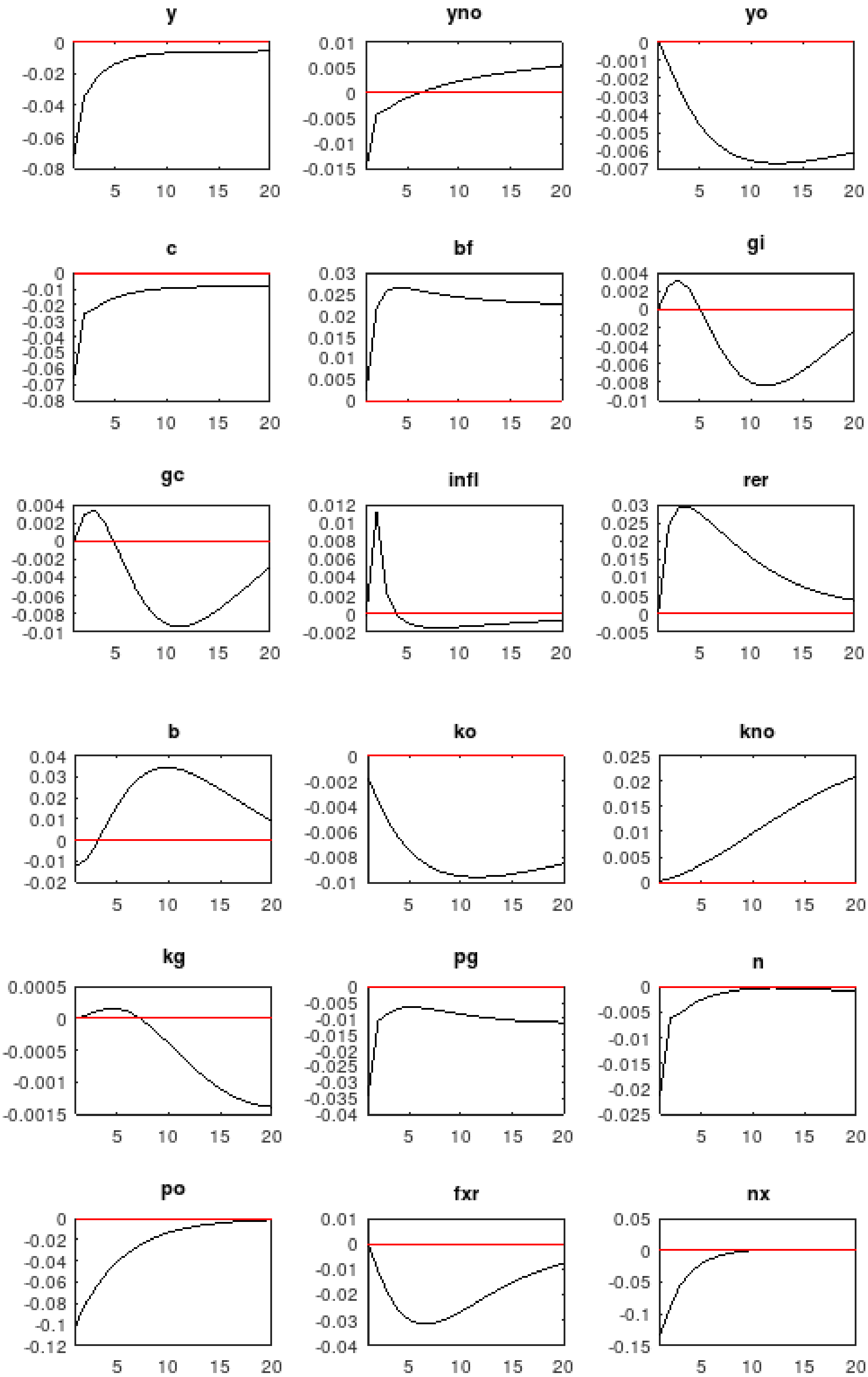
targeting export commodities (here oil prices), at the contrast of CPI anchor which responds to import prices, not to export prices (Frankel, 2011).

The existence of a foreign currency market accessible to households helps ricardian households to face a sudden drop in oil prices by using their savings regarding the amount by which the exchange rate is expected to depreciate in the future. Impulse response function of households foreign holdings (bf) seems to be slightly delayed, but correlated with the real exhchange rate (rer) and domestic prices (infl). This hedging strategy could be seen as a buffer against any shock that may affect the real sector, in addition of being a proxy of domestic savings. By slightly reducing their consumption and under a managed exchange rate regime, non-ricardian households (rule-of-thumb consumers) deliver a consumption smoothing (Galí et al., 2007) that eases potential pressures on the supply side (bottlenecks and inflation spikes over the short run), while benefiting from the government's subsidy policy (social safety nets), aiming at protecting the purchasing power of lower income classes.

6 Conclusion

The study of governments' responses to adverse oil shocks has been extensively examined under a single perspective separating fiscal and monetary policy. The lessons learned from the 2008 financial crisis highlighted the necessity to adopt a policy-mix that provides a comprehensive response to support the real sector. Despite huge revenues earned from favorable international prices, oil producers have been facing macroeconomic imbalances following drops in oil prices. Algeria, as a single-commodity exporter, experienced several challenges during episodes of lower oil prices, necessitating a robust and effective response in terms of monetary and fiscal policies to support the economic activity. This paper simulated a negative oil price shock and studied its impact on main macroeconomic aggregates using a DSGE framework. It incorporated a countercyclical fiscal policy associated to a PPT (product price targeting) managed exchange regime with foreign exchange interventions and a substantial share of households having access to a foreign exchange market, due to the non-convertibility of the local currency. Findings confirm the positive impact of this policy-mix in ensuring the sustainability of the economic activity by supporting the non-oil sector, canceling inflation spikes over the medium run and alleviating losses in the labor market. Under a managed exchange rate regime, the central bank can limit and delay the depreciation of the exchange rate without deteriorating its external position. Hence, canceling a potential inflation pass-through that may lead to a surge in domestic inflation. However, fostering government spending triggers a growing fiscal deficit that cannot be sustainable if oil prices are expected to remain at lower levels over the long run. The presence of ricardian households, endowed with access to foreign exchange market, emulates the existence of a forex market usually linked to the underground economy and responding to fluctuations of the nominal exchange rate. Foreign reserves detained by households are a proxy of private savings, which could be used to support consumption in uncertain times of high inflation. Finally, simulations underscore closer coordination between fiscal and monetary measures when facing a negative oil shock, to be implemented over the short run. In prolonged episodes of lower oil prices, government may be required to set up fiscal consolidation schemes to reduce the accumulated public debt, whose effectiveness hinges on the preservation of external and internal equilibria.

Figure 1: Impulse response functions following a 10% drop in international oil prices.



References

S. Adjemian, M. Juillard, F. Karamé, W. Mutschler, J. Pfeifer, M. Ratto, N. Rion, and S. Villemot. Dynare: Reference Manual, Version 6. Dynare Working Papers 80, CEPREMAP, Feb. 2024. URL https://ideas.repec.org/p/cpm/dynare/080.html.

A. Algozhina. Monetary Policy Rule, Exchange Rate Regime, and Fiscal Policy Cyclicality in a Developing Oil Economy. Dynare Working Papers 49, CEPREMAP, May 2016. URL https://ideas.repec.org/p/cpm/dynare/049.html.

J.-P. Allegret and M. T. Benkhodja. External shocks and monetary policy in a small open oil exporting economy. Post-Print hal-01411705, HAL, 2012. URL https://ideas.repec.org/p/hal/journl/hal-01411705.html.

B. Bank of Algeria. Rapport Annuel 2023 : Evolution Economique et Monétaire. Technical report, 2024.

K. Bańkowski, K. Christoffel, and T. Faria. Assessing the fiscal-monetary policy mix in the euro area. Working Paper Series 2623, European Central Bank, Dec. 2021. URL https://ideas.repec.org/p/ecb/ecbwps/20212623.html.

J. Benes, A. Berg, R. Portillo, and D. Vavra. Modeling Sterilized Interventions and Balance Sheet Effects of Monetary Policy in a New-Keynesian Framework. Open Economies Review, 26(1):81–108, February 2015. URL https://ideas.repec.org/a/kap/openec/v26y2015i1p81-108.html.

A. Berg, R. Portillo, S.-C. S. Yang, and L.-F. Zanna. Public Investment in Resource-Abundant Developing Countries. IMF Economic Review, 61(1):92–129, April 2013. URL https://ideas.repec.org/a/pal/imfecr/v61y2013i1p92-129.html.

R. Boucekkine, M. Laksaci, and M. Touati-Tliba. Long-run stability of money demand and monetary policy: The case of algeria. The Journal of Economic Asymmetries, 24: e00217, 2021. ISSN 1703-4949. doi: https://doi.org/10.1016/j.jeca.2021.e00217. URL https://www.sciencedirect.com/science/article/pii/S1703494921000220.

G. A. Calvo. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics, 12(3):383–398, September 1983. URL https://ideas.repec.org/a/eee/moneco/v12y1983i3p383-398.html.

A. Chibi, M. Benbouziane, and S. M. Chekouri. Interaction between monetary and fiscal policy : Empirical evidence from algeria. 25th Annual Conference. Kuwait, March 10-12, 2019. Economic Research Forum, 2019. URL https://api.semanticscholar.org/CorpusID:203631167.

B. De Paoli. Monetary policy and welfare in a small open economy. Journal of International Economics, 77(1):11–22, 2009. ISSN 0022-1996. doi: https://doi.org/10.1016/j.jinteco.2008.09.007. URL https://www.sciencedirect.com/science/article/pii/S0022199608001001.

A. Dib. Implications of the global financial crisis on the algerian economy. Revue des économies nord Africaines, 7, 2010. URL https://www.univ-chlef.dz/renaf/Articles_Renaf_N_07/Article_17_en.pdf.

E. Faia and E. Iliopulos. Financial openness, financial frictions and optimal monetary policy. Post-Print hal-00628737, HAL, Nov. 2011. URL https://ideas.repec.org/p/hal/journl/hal-00628737.html.

J. A. Frankel. A Comparison of Product Price Targeting and Other Monetary Anchor Options for Commodity Exporters in Latin America. Technical report, 2011.

J. Galí. Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications Second edition. Number 10495 in Economics Books. Princeton University Press, 2015. URL https://ideas.repec.org/b/pup/pbooks/10495.html.

J. Galí, J. D. López-Salido, and J. Vallés. Understanding the effects of government spending on consumption. Journal of the European Economic Association, 5(1):227–270, 2007. doi: 10.1162/JEEA.2007.5.1.227. URL https://onlinelibrary.wiley.com/doi/abs/10.1162/JEEA.2007.5.1.227.

IMF. 2018 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for Algeria. Technical report, International Monetary Fund. Middle East and Central Asia Department., Washington D.C., 2018.

IMF. 2023 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for Algeria. Technical report, International Monetary Fund. Middle East and Central Asia Department., Washington D.C., 2024.

N. G. Mankiw. The Savers-Spenders Theory of Fiscal Policy. American Economic Review, 90(2):120–125, May 2000. URL https://ideas.repec.org/a/aea/aecrev/v90y2000i2p120-125.html.

L. Sarno and M. P. Taylor. Official Intervention in the Foreign Exchange Market: Is It Effective, and, If So, How Does It Work? CEPR Discussion Papers 2690, C.E.P.R. Discussion Papers, Feb. 2001. URL https://ideas.repec.org/p/cpr/ceprdp/2690.html.

S. Schmitt-Grohe and M. Uribe. Closing Small Open Economy Models. NBER Working Papers 9270, National Bureau of Economic Research, Inc, Oct. 2002. URL https://ideas.repec.org/p/nbr/nberwo/9270.html.

F. Smets and R. Wouters. An estimated dynamic stochastic general equilibrium model of the euro area. Journal of the European Economic Association, 1(5):1123–1175, 09 2003. ISSN 1542-4766. URL https://doi.org/10.1162/154247603770383415.