The Short-run Impact of Oil Windfalls in Low-income Countries: A DSGE Approach†

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Abstract

We use a multi-sector dynamic stochastic general equilibrium (DSGE) model—calibrated to the Ghanaian economy—to analyse the short-term impact of oil windfalls in low-income countries (LICs) and the role of various fiscal and monetary policy responses. The model includes limited access to international capital markets, limited participation by residents in the domestic financial system and limited labour mobility across sectors, features that are pervasive in these countries. Relative to developed countries, oil windfalls are likely to have larger aggregate demand pressures. A policy of fiscal smoothing—associated with a sovereign wealth fund—can help achieve macroeconomic stability and improve welfare. On the other hand, accumulation of reserves in response to the windfall—without fiscal backing—can crowd out the private sector and reduce welfare. These findings highlight the importance of policy coordination for the macroeconomic effects of oil proceeds in LICs.

JEL classification: E20, E62, E63, F41

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1. Introduction

Recently, several low-income countries (LICs) have discovered oil reserves and are in the process of developing their oil industry. A noteworthy example is Ghana, which began extracting oil in 2010 and whose government will receive oil-related revenues of about 4 to 6% of GDP—on average—over the next 5 years. These revenues are then expected to decline over the following decade as field capacity is tapped. Uganda has also discovered oil reserves and may benefit from a similar windfall.

These prospective windfalls call for a better understanding of their likely effects on LICs. There is a vast literature that looks at the impact of natural resource revenues on a small open economy. The emphasis has been mainly on the medium- or long-run effects, based on the observation that oil-producing countries have under-performed relative to other developing countries (See Gelb, 1989). In this context, many studies have looked at the ‘Dutch Disease’ phenomenon, which refers to the negative effects that a commodity boom may have on other export sectors and overall productivity growth.

In this paper, our emphasis is not on medium- or long-term considerations but rather on the short-term effects of oil windfalls. In particular, we focus on the role of fiscal and monetary policy—both interest rate policy and the decision to accumulate reserves. The oil-driven fiscal expansion could generate demand pressures. Are these demand pressures likely to be larger or smaller in LICs, relative to developed countries or emerging markets? Central banks are also likely to accumulate reserves as the oil windfall creates pressures for the real exchange rate to appreciate. In practice, the decision to accumulate reserves may be done independently of the fiscal response. What are the likely effects of such a policy mix?

While the effects of oil shocks have been analysed with dynamic models in the past, the framework that is used in this paper (developed in Berg et al., 2010 to analyse the macroeconomics of aid inflows) is particularly suitable for LICs. The model incorporates both short- and medium-term

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1 See the seminal paper by Corden and Neary (1982). The book by Collier and Gunning (1999) analyses the experience of several developing countries during commodity-based booms.

2 This can be the case if learning-by-doing externalities are present in those sectors. This is a feature of the production function in which productivity increases with the level—or the growth—of activity in that sector. See Van Wijnbergen (1984) and Krugman (1987). The long-term effects from higher oil revenues need not be negative, however, if oil revenues are directed at much-needed public infrastructure. See Adam and Bevan (2006) and Chatterjee and Turnovksy (2005).
effects of an increase in oil revenues. The short-term effects stem from the aggregate demand pressures that may result from the fiscal expansion. The medium-term effects stem from the impact of higher public spending on infrastructure and provide the backdrop against which to assess aggregate demand pressures. The model also allows for different monetary and fiscal policy responses and clarifies how different combinations will yield different macroeconomic outcomes. In addition, because of its microfoundations, we can use the model to assess the impact of the windfall on aggregate welfare in the economy.

The model includes structural features that are relevant in LICs. First, it allows for limited access to international capital markets. It also features limited participation by a large fraction of the population in the domestic financial market, which is a pervasive issue in LICs and has implications for the transmission of fiscal and external shocks. This feature allows us to examine how different types of agents—those that participate and those that do not—will benefit from the windfall and influence its effects. Third, the model features various measures of bottlenecks—which affect the economy’s ability to adjust to the windfalls and will also have macroeconomic implications.

Our findings are as follows. First, oil windfalls can be beneficial—in terms of increasing welfare—but are also likely to create sizable aggregate demand pressures. These stem from the fact that government spending will typically concentrate on sectors of the economy which display nominal rigidities (services, the construction industry, non-traded goods and services more generally). Limited financial development—limited international capital mobility, a large share of agents that do not have access to financial markets—and bottlenecks, all of which are pervasive in LICs, either amplify these demand pressures or reduce the ability of the economy to meet them. The result is greater macroeconomic volatility during the boom. In the absence of fiscal smoothing, this relative instability places greater burden on monetary policy to stabilise the economy by raising interest rates.

Second, and perhaps not surprisingly, we find that fiscal smoothing—and its associated external savings deposited in a sovereign wealth fund—can greatly contribute to stabilising the economy and increasing welfare. In our model, however, fiscal smoothing has different effects on different types of consumers: agents that participate in the financial system benefit from greater macroeconomic stability, whereas those that do not participate benefit first-hand from a short-term boom instead.

Our third result is that the accumulation of reserves in response to the windfall—without fiscal backing—can be counterproductive. An important element of the transmission mechanism of the windfall is the
appreciation of the real exchange rate. This appreciation helps re-allocate resources within the economy (from the traded to the non-traded sector) as well as demand (the expenditure switching effect) and it is associated with a contraction in the production of traded goods. Central banks in LICs are often concerned about the long-run growth implications of these developments, and typically respond by accumulating reserves. Our simulations show that such accumulation—if combined with full spending of the oil revenue by the government—will result in a crowding-out of the private sector—because the aid is being used twice by the public sector: once as external savings and once as government spending. Such a policy mix will reduce welfare relative to the case of no reserve accumulation. This state of affairs does not arise with a sovereign wealth fund, because in that case there is complete consistency between external and fiscal savings.

We view the above scenario as more than just a theoretical possibility. The recent experience of various Sub-Saharan African countries with large increases in aid resulted in a similar policy mix—simultaneous spending of the aid combined with large accumulation reserves—which follows from central banks making reserve decisions independently of fiscal considerations. It also underscores the importance of fiscal/monetary policy coordination in response to large external revenue windfalls.

The paper is organised as follows. Section 2 summarises the model. Section 3 presents the calibration and the simulations for the baseline case as well as the some sensitivity analysis. Section 4 focuses on fiscal and monetary policy options for managing the oil windfall. Section 5 concludes.

2. The model

In this section, we present the dynamic stochastic general equilibrium (DSGE) model developed in Berg et al. (2010). We display the problem solved by firms and households, and the public sector’s budget constraints, balance sheets and policy rules.

2.1 Consumers

2.1.1 Dynamic optimisers

We assume a fraction ($\gamma$) of all consumers are dynamic optimisers, denoted with a superscript $d$. These consumers own the firms and the financial

3 See Berg et al. (2007).
assets in the economy. The representative agent in this group maximises life-time utility:

\[
E_0 \sum_{t=0}^{\infty} (\beta^d)^t u(C^d_t, \frac{M^d_t}{P_t}, \ell^d_t) = E_0 \sum_{t=0}^{\infty} (\beta^d)^t \\
\left( \log \left( \frac{\vartheta^d C^d_t(\eta - 1)/\eta}{1 - \vartheta^d} \frac{M^d_t(\eta - 1)/\eta}{\eta/(1 - \eta)} \right) - i^d_t \right) \\
\left( \frac{\ell^d_t}{1 + \psi_t (P^d_t)^{1+\psi}} \right).
\]

(1)

where \( C^d_t \) is the consumption basket (to be defined below), \( M^d_t/P_t \) are real money balances and \( \ell^d_t \) is an index of labour effort. The parameter \( \vartheta^d \) helps replicate the ratio of real money balances to consumption, and \( \eta \) is related to the interest semi-elasticity of money demand. The index \( \ell^d_t \) is a constant-elasticity-of-substitution (CES) function of labour supplied to the traded and non-traded sectors:

\[
\ell^d_t = \left[ \frac{\alpha^N_{L} - 1}{\rho_L} \frac{\beta^N(1 + \rho_L)/\rho_L + (1 - \alpha^N)}{\rho_L} \frac{\beta^T(1 + \rho_L)/\rho_L}{\rho_L} \right] / (1 + \rho_L).
\]

(2)

The parameter \( \psi \) is the inverse of the labour supply elasticity, \( \alpha^N \) is the share of non-traded employment (value added) in total employment (GDP) and \( \rho_L \) is the elasticity of substitution between labour services provided to the two sectors.

Before presenting the budget constraint, we discuss the trend properties of the model. Most variables are not stationary, for two reasons. First, economy-wide productivity follows a deterministic trend, which all real variables share—with the notable exception of employment and the real exchange rate. Second, nominal variables also grow at the rate implied by inflation. To ensure stationarity, we deflate all domestic nominal variables by the domestic consumer price index (CPI), and foreign nominal variables—which will be denoted with a superscript*—by the foreign CPI. We also divide all trending real variables by the trend. The budget constraint with normalised variables, represented with lower case letters,

\[\text{In the case of employment, income and substitution effects from higher real wages exactly offset each other along the trend growth path. The real exchange rate is stationary because both sectors feature the same trend in productivity and the same production shares. On the latter, see Cerra et al. (2008).} \]
is the following:

\[
c_t^d + b_t^{dc} + m_t^d + s_t b_t^{d*} = (1 - \tau) w_t^N p_{t-1}^N + (1 - \tau) w_t^T p_{t-1}^T + (1 + i_t\gamma) \frac{b_t^{dc}}{\pi_t} \\
+ \frac{m_t^{d*}}{\pi_t g_T} + s_t (1 + i_t\gamma) \frac{b_t^{d*}}{\pi_t g_T} - s_t \psi^*(b_t^{d*}) + s_t \text{rem}^* + \frac{1}{\gamma} \text{pr}_t^N + \text{σ}_t^d.
\]

(3)

Normalised consumption and real money balances are now given by \(c_t^d\) and \(m_t^d\) and \(b_t^{dc}\) and \(b_t^{d*}\) are the dynamic consumer's holdings of domestic bonds and foreign bonds, with the latter subject to portfolio adjustment costs \(\psi^*(b_t^*)\), while \(s_t\) is the CPI-based real exchange rate. \(w_t^N\) and \(w_t^T\) are real wages in the non-traded and traded sectors, respectively, \(\tau\) is the wage tax rate, \(\frac{1}{\gamma} \text{pr}_t^N\) is the agent’s share of profits in the non-traded sectors and \(\text{rem}^*\) are remittances—which we assume are constant in normalised terms. As a byproduct of the two operations discussed above, holdings of domestic and foreign assets from last period are divided by the growth rate of productivity \(g_T\), and by either domestic or foreign inflation \((\pi_t, \pi^*)\). Finally, \(\text{σ}_t^d\) refers to a transfer between dynamic and static consumers.

Portfolio adjustment costs are given by:

\[
\psi^*(b_t^*) = \frac{\nu^*}{2} (b_t^* - \bar{b}^*)^2.
\]

Depending on the choice of \(\nu\), it is possible to model a closed capital account (given by \(\nu^* = +\infty\)) and a partially open one \((0 < \nu^* < +\infty)\).

In either case, sterilised interventions will influence the exchange rate: by reducing the private sector’s holding of (net) foreign assets, reserve accumulation will increase expected returns on foreign assets and cause—ceteris paribus—a temporary nominal depreciation.

### 2.1.2 Static optimisers

We assume that the remaining fraction \((1 - \gamma)\) of consumers are static optimisers, denoted with a superscript \(s\). These agents are introduced in the model to reproduce the likely behaviour of credit-constrained agents, i.e., agents that would like to borrow to finance higher current

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5 These transfers ensure that steady-state consumption and labour supply are the same for both dynamic and static consumers. See Gali et al. (2007).
consumption levels but cannot access financial markets. As with credit-constrained agents, the consumption of static optimisers will change one for one with changes in current income.

The lifetime utility of static optimisers is given by:

$$E_0 \sum_{t=0}^\infty (\beta^t)^t u \left( \frac{C_t}{P_t}, b^t \right) = E_0 \sum_{t=0}^\infty (\beta^t)^t$$

$$= \left[ \log \left( \frac{\partial C_t}{\partial C_t} \frac{\eta - 1}{\eta} + (1 - \partial^t) \frac{M_t}{P_t} \frac{\eta - 1}{\eta} \right) \right] \eta/(1 - \eta) - \frac{\epsilon}{1 + \psi (\tau_t)^{1+\psi}} ,$$

where $b^t$ is of the same form as in the case of dynamic optimisers. We assume inter-temporal preferences are such that the representative agent from this group derives utility from present values of consumption and leisure only, i.e., $\beta^s$ is set to zero. Their only source of income comes from their labour, which implies the following budget constraint:

$$c^s_t + m^s_t = (1 - \tau) w^N_t l^N_t + (1 - \tau) w^T_t l^T_t + m^s_t - s_t \text{ rem}^* + \sigma^r .$$

Finally, for all consumer-related variables, we aggregate across the two types of consumers:

$$f = \gamma f^d + (1 - \gamma) f^s \text{ for } f = (c, m, l^N, l^T, b^*, b^c, \sigma^r) .$$

### 2.2 Consumption baskets, demand functions, price indices

There are two types of goods: traded and non-traded. Non-traded goods, of which there are infinite varieties along the $[0, 1]$ continuum, are indexed with a superscript $N$. Consumption of different varieties is aggregated with a Dixit–Stiglitz function:

$$c^N_t = \left( \int_0^1 c^N_t \frac{u^{(\theta-1)/\theta}}{u^{(\theta-1)}} \right)^{\theta/(\theta-1)} ,$$

where $\theta$ is the elasticity of substitution between varieties. Demand for variety $i$ is given by:

$$c^N_{it} = \left( \frac{P^N_{it}}{P_t} \right)^{-\theta} c^N_t .$$
where $p_{it}^N$ and $p_t^N$ are normalised prices, i.e., deflated by the CPI. $p_t^N$ is the price index for the non-traded basket:

$$
\tilde{p}_t^N = \left( \int_0^1 p_{it}^{N(1-u)} \, du \right)^{1/(1-u)}.
$$

Traded goods are denoted with a superscript $T$. Their domestic price is given by the law of one price, which implies that the normalised price of traded goods is equal to the real exchange rate ($p_t^T = s_t$).

### 2.2.1 The aggregate basket

Total consumption is given by a standard CES basket:

$$
c_t = \left( n^{1/\chi} (\tilde{c}_t^N)^{(\chi-1)/\chi} + (1-n)^{1/\chi} (\tilde{c}_t^T)^{(\chi-1)/\chi} \right)^{\chi/(\chi-1)}.
$$

The parameter $\chi$ is the elasticity of substitution between traded and non-traded goods, and $n$ measures the degree of home bias in consumption. Note that the government spends on a different basket of goods, with the same elasticities but different weights ($v$ instead of $n$). Normalised price indices associated with the two baskets are the following:

$$
1 = \left( n (\tilde{p}_t^N)^{1-\chi} + (1-n)(s_t)^{1-\chi} \right)^{1/(1-\chi)},
$$

$$
p_t^G = \left( v (\tilde{p}_t^N)^{1-\chi} + (1-v)(s_t)^{1-\chi} \right)^{1/(1-\chi)}.
$$

### 2.3 The non-traded goods sector

The production function of the representative non-traded goods producer $i$ is the following:

$$
Y_{it}^N = Z^N \left( K_{it-1}^N e^{-\phi Q_{t-1}} \right)^{1-\alpha} \left( T_i l_{it}^N \right)^{\alpha}.
$$

$l_{it}^N$ is the volume of labour employed by firm $i$, $K_{it-1}^N$ is the firm’s private capital and $Q_{t-1}$ is the stock of public capital (which is equally available to all firms). The coefficients $\alpha$ and $\phi$ indicate the production shares of labour and public and private capital. $Z^N$ is the aggregate efficiency level in the non-traded sector and $T_i$ is the level of Hicks-neutral productivity.
(the source of trend growth in the model). The accumulation equation for private capital is the following:

$$K^N_{it} = (1 - \delta)K^N_{it-1} + \left(1 - S\left(\frac{X^N_{it}}{X^N_{it-1}}\right)\right)X^N_{it},$$

(8)

where $X^N_{it}$ is gross investment, $\delta$ is the depreciation rate and $S(\cdot)$ are investment adjustment costs as in Christiano et al. (2005):

$$S\left(\frac{X^N_{it}}{X^N_{it-1}}\right) = \frac{\kappa}{2} \left(\frac{X^N_{it}}{X^N_{it-1}S_T} - 1\right)^2.$$

2.3.1 Firms’ optimisation problem

Consistent with consumer demand, every individual firm $i$ faces the following normalised demand:

$$y^N_{it} = \left(\frac{p^N_{it}}{p^N_t}\right)^{-\theta} y^N_t.$$

(9)

Firms choose a price level $p^N_{it}$, employment $l^N_{it}$, investment $x^N_{it}$ and capital $k^N_{it}$ to maximise lifetime profits (in normalised terms):

$$\max_{p^N_{it}, k^N_{it}, x^N_{it}, l^N_{it}} E_0 \sum_{t=0}^{\infty} J_t \{p^N_{it} y^N_{it}(1 - ds) - w^N_{it} l^N - \Gamma^N(p^N_{it}, p^N_{it-1}) - x^N_{it}$$

$$+ ds p^N_{it} x^N_{it}\},$$

where $J_{t+j} = \beta^j u_{ct+j}^d$, subject to equations (7 to 9). Two features are worth discussing. First, we assume there is a distortion (given by $ds$) that reduces the value of firms’ sales for any given level of production. While this distortion is offset in the aggregate (the amount $ds p^N_{it} x^N_{it}$ is given back to each firm), it affects firms’ incentive to hire and invest. This feature is useful to match the observed low investment shares in many LICs.

Second, each firm $i$ faces price adjustment costs $\Gamma^N(\pi^N_{it}, \pi^N_{t-1})$:

$$\Gamma^N(\pi^N_{it}, \pi^N_{t-1}) = \frac{\xi_p^N}{2} \left(\frac{\pi^N_{it}}{\pi^N_{t-1}} - 1\right)^2,$$

where $\pi^N_{it} = \pi_t(p^N_{it} / p^N_{it-1})$ and $\pi^N_{t-1} = \pi_{t-1}(p^N_{t-1} / p^N_{t-2})$. These adjustment costs are a variant of those in Rotemberg (1982), adjusted for indexation to past values of inflation.
2.4 Exportable goods sector

There is also a continuum \([0, 1]\) of firms in the exportable goods sector, each taking the foreign currency price of exports as given. Production is the following:

\[
Y_{jt}^T = Z^T \left( K_{jt-1}^T (1 - \phi) Q_{t-1}^T \right)^{1-\alpha} (T_l^T)^\alpha. \tag{10}
\]

Profit maximisation (in normalised terms) for the representative firm \(j\) is given by:

\[
\max_{l_{jt}^T, k_{jt}^T, x_{jt}^T} E_t \sum_{t=0}^{\infty} J_t \{ s_t Y_{jt}^T - w_t^T I_{jt}^T - x_{jt}^T \},
\]

subject to equation (10) and the equivalent of equation (8) for firms in the traded sector.

2.5 The central bank

We start by presenting the central bank balance sheet before describing operational targets and their respective rules.

2.5.1 The central bank balance sheet

In nominal terms, the central bank balance sheet is as follows:

\[
M_t = B_{cb}^t + S_t \text{RES}_{t}^* - NW_t, \tag{11}
\]

where \(B_{cb}^t\) denotes the central bank’s holding of government bonds, \(\text{RES}_{t}^*\) is the level of international reserves, measured in foreign currency, \(S_t\) is the nominal exchange rate and \(NW_t\) is the central bank’s net worth.

The central bank derives profits from interest payments on reserves \(S_t^* \text{RES}_{t-1}^*\)—which, we assume, have the same return as foreign bond holdings by private agents—but does not earn interest on its stock of government debt. These earnings are transferred to the government, which implies that changes in the nominal value of the central bank’s net worth are given by capital gains from exchange rate depreciation only:

\[
NW_t = NW_{t-1} + (S_t - S_{t-1}) \text{RES}_{t-1}^*.
\]

Normalising and taking first differences of equation (11) and replacing
changes in net worth with the above equation, yield the following identity:

\[ m_t - \frac{m_{t-1}}{\pi_t g_T} = b^{ch}_t - b^{ch}_{t-1} + s_t(\text{res}^*_t - \text{res}^*_t) \]

(12)

where \( \text{res}^*_t \) is the real, normalised, value of international reserves (relative to the foreign CPI).

2.5.2 Two operational targets and two rules

We believe monetary policy in many LICs and emerging markets is best characterised as having two operational targets, each with its own rule, rather than the single rule framework typically found in the macro-literature.6 As will be discussed later, this plurality of instruments can have important consequences for the macroeconomic effect of oil windfalls. In this section, we briefly describe this framework.

The first rule is standard. Central banks in LICs set an operational, time-varying target for monetary aggregates or the short-term interest rate; the primary objective of this target is to stabilise some combination of inflation and output. In the case of Ghana, which we will use to illustrate the effects of a windfall, the country formally adopted an inflation targeting regime in 2007, with an inflation target that is currently between 7 and 11%, and with the (prime) short-term rate as the operational target.7 For this reason, we assume that the central bank follows a simple Taylor rule:

\[ 1 + i_t = (1 + \bar{i})(\frac{\pi_t}{\bar{\pi}})^{\phi_p}, \]

(13)

where \( \bar{i} \) is the steady-state value of nominal interest rates and \( \bar{\pi} \) is the inflation objective.

In addition to the interest rate rule, we assume that the central bank also sets an operational target on reserve accumulation. Central banks in LICs are constantly intervening in the foreign exchange market, for a variety of reasons.8 We believe that the macroeconomic effects of these interventions are not well understood—especially when they interact with changes in fiscal policy as we will explore here. In this model, the central banks

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6 See Woodford (2003) for a thorough description of modern monetary models.
7 See Bank of Ghana (2010).
8 See Benes et al. (2011) for a discussion.
follows the rule below:

\[ \text{res}_t^* = \rho^R \text{res}_{t-1}^* + (1 - \rho^R) \text{res}^* + (1 - \omega) o_t^* . \]  \hspace{1cm} (14)

The accumulation of reserves is driven by two separate factors. First, the central bank may accumulate part of the foreign currency inflow from the oil windfall (\(o_t^*\)) as reserves. The coefficient \(\omega\) measures how much of the foreign currency proceeds are made available to the rest of the economy; a value of \(\omega < 1\) implies some of the oil revenues is kept by the central bank. The reason why the central bank may decide to accumulate reserves when the oil windfall occurs is because policy-makers may be concerned with the effects of these inflows on the exchange rate.9 As will become clear later, this decision to accumulate reserves is independent of the government’s response to the windfall, allowing for potential conflicts between fiscal and reserve policy. Second, we assume the central bank targets a particular long-run value of reserves, given by \(\text{res}^*\). While reserve accumulation may deviate persistently from this target—with the persistence captured by \(\rho^R\)—it eventually returns to that level.10

2.6 The government

We extend the model in Berg et al. (2010) to introduce a sovereign wealth fund \(\text{swf}^*\), in which the government can save part of the oil windfall. These funds have become the norm when discussing oil-related savings and they will be useful when describing alternative policy responses.11

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9 We can also model this concern of policy-makers by allowing reserve accumulation to respond directly to movements in the nominal exchange rate. Results are similar to our current specification.

10 Note that, given the rules for the interest rate and for reserve accumulation, accommodating money demand will require open-market operations by the central bank, i.e., changes in its holdings of government debt.

11 See Collier et al. (2010) for a critical view of the standard prescription regarding sovereign wealth funds.
2.6.1 The inter-temporal budget constraint

The government’s inter–temporal budget constraint (in normalised terms) is the following:

\[
p^G_t G_t = \tau w_t (l^d_t + l^s_t) + b_t - \frac{b_{t-1} b^c_t}{\pi_t G_T} - \frac{i_{t-1} b^c_{t-1}}{\pi_{t-1} G_T} + s_i (\bar{a}^* + o^*_t) + s_t \frac{j^*}{\pi^* G_T} (\text{swf}^*_t \bar{t} + \text{res}^*_t - 1) - s_t (\text{swf}^*_t - \frac{\text{swf}^*_t}{\pi^* G_T}).
\]

(15)

The government can finance its spending through a variety of sources: taxes on wage income \((\tau w_t (l^d_t + l^s_t))\), using the domestic currency value of foreign aid and oil proceeds \((s_i (\bar{a}^* + o^*_t))\), interest earned by the sovereign wealth fund and on reserves \((s_t \frac{\pi^*}{\pi^* G_T} (\text{swf}^*_t \bar{t} + \text{res}^*_t - 1))\) drawing on the sovereign wealth fund \((-s_t \frac{\pi^*}{\pi^* G_T} (\text{swf}^*_t \bar{t} + \text{res}^*_t - 1))\), or issuing domestic debt \((b_t - b_{t-1} / \pi_t G_T)\). The government pays interest on past government debt held by the private sector \(b^c\), the stock of which can vary depending on the open-market operations of the central bank \(b^{cb}\):

\[
b_t = b^c_t + b^f_t.
\]

Government spending \(g_t\) can be used for public consumption or public investment. We assume that the share of public investment out of spending \((\gamma^G)\) is constant. The accumulation of public capital is the following:

\[
q^G_t G_t = (1 - \delta^G) q^G_{t-1} + x^G_t.
\]

2.6.2 Simple fiscal rules

As the wage tax rate is constant, fiscal policy is determined by the response of government spending to the windfall. We consider two simple, alternative, rules. Under the first rule:

\[
\text{swf}^*_t = \text{swf}^*_t \bar{t} = 0.
\]

(16)

In this case, spending is a residual in the government’s budget constraint, so that an oil windfall would result in an automatic (and almost equivalent) increase in spending, with no increase in public savings.

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12 Equation(15) implies \(\omega = 0\), i.e., there are no aggregate transfers to households.

13 We also allow for \(\gamma^G\) to vary in response to the windfall, as part of the sensitivity analysis. We do not present these results here but we will briefly discuss them in the next section.
Alternatively, spending follows a simple forward-looking rule:

$$\frac{p^G \varepsilon_t}{gdp_t} = \frac{p^G_{t+1} \varepsilon_{t+1}}{gdp_{t+1}},$$  \hspace{1cm} (17)$$

where gdp is the normalised level of nominal GDP (to be defined below). This rule ensures a smooth path for government spending (in percent of GDP) in response to the windfall. We can think of these two rules as two reasonable bounds on the likely response, with the actual response somewhere in between.

For technical reasons, we also need a simple feedback rule for total government debt accumulation:

$$b_t = b_{t-1} - 6 \frac{b_{t-1} - \bar{b}}{\overline{b}} ,$$  \hspace{1cm} (18)$$

where 6 is very small but positive. This rule has no noticeable impact on the fiscal response, but it ensures that open-market operations—which shift government bonds from the central bank balance sheet to the private sector—do not have a permanent effect on the latter variable and thus on interest payments by the government.

2.7 Stochastic processes for $o^*_t$

We specify the following processes for oil revenues:

$$o^*_t = \rho^o o^*_{t-1} + \varepsilon^o_t ,$$  \hspace{1cm} (19)$$

which implies that oil revenue has a steady-state value of zero, and any oil windfall ($\varepsilon^o > 0$) will be temporary.

2.8 Equilibrium conditions and aggregate GDP

The model is completed by equilibrium conditions in the non-traded goods sector, the labour market and the balance of payments (not shown). Finally, it is helpful to define aggregate measures of non-oil economic activity:

$$y_t = p^N y^N_t + sy^T_t ; \hspace{1cm} gdp_t = p^N y^N_t + s t y^T_t ,$$

where $y_t$ is real output—the sum of value added in the two sectors, measured at steady-state prices—while gdp is nominal output deflated by the CPI. We will use the latter when looking at variables in percent of GDP.
3. Model simulations

In this section, we discuss the calibration of the model and present the baseline results. We then discuss how certain features of LICs amplify the macroeconomic effects of oil windfalls.

3.1 Calibration

Calibration is presented in Tables 1–3, with parameters divided into three categories. For each parameter, the tables provide a brief description, the value chosen and the source or the method used for calibration. Note that calibrating DSGE models to an LIC is a difficult exercise, given the data limitations.

Our approach is the following. While the purpose of the paper is to help understand the likely impact of an oil windfall on LICs in general, we specifically calibrate the model to Ghana, as its recent oil discovery provides a perfect example of the windfalls we are interested in. As can be seen from the tables, many of the parameters of the model can be related to the steady-state values of aggregate variables in percent of GDP, which we adjust to fit Ghana’s data for 2008–09 (Table 4).

A few features of Ghana’s economy are worth mentioning. Government spending is particularly large, standing at 37% of GDP in 2008–09. Around two-thirds of this spending is on government consumption. The steady-state inflation rate is set to 10%, which is below the actual inflation for 2008–09 but is in line with the central bank’s target. We also adjust the stochastic process for \( o^* \) to broadly match Ghana’s (Table 3). According to IMF (2009), government revenue from oil was expected to go from near zero in 2010 to about 6% in 2011, and to gradually return to zero over the next 10–15 years.

There are also a number of parameters for which we do not have Ghana-specific data. In the case of the share for public capital in production \( \phi \), we use estimates from other LICs from Arslanalp et al. (2010). In other cases, we use parameters that are standard in the DSGE literature, i.e., not specific to LICs. Among other parameters, this is the case for the degree of nominal rigidities \( \zeta_N^p \) and the elasticity of substitution between varieties in the non-traded sector \( \theta \)—which is directly related to the size of markups in this sector.

The data for Ghana are collected from publicly available IMF Staff reports (e.g., IMF, 2009) and from discussions with the IMF team working on Ghana.
Table 1: Baseline Calibration, Preference Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source/Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta^d$</td>
<td>Discount factor of optimising agents</td>
<td>0.995</td>
<td>To match 18% $i$</td>
</tr>
<tr>
<td>$\delta^d$, $\delta^s$</td>
<td>Weight of $c$ in utility</td>
<td>0.9999, 0.9983</td>
<td>To match $m$/gdp</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Elasticity of substitution between $c$ and $m$</td>
<td>0.11</td>
<td>To match the interest elasticity of money</td>
</tr>
<tr>
<td>$\lambda^s$, $\lambda^D$</td>
<td>Weight of $l$ in utility</td>
<td>0.671, 0458</td>
<td>To normalise $l$ to 1</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Inverse of labour supply elasticity</td>
<td>3</td>
<td>Standard value</td>
</tr>
<tr>
<td>$\alpha_N$</td>
<td>Share of $y^N$ in $y$</td>
<td>0.61</td>
<td>National Income Accounts</td>
</tr>
<tr>
<td>$\rho_L$</td>
<td>Elasticity of substitution between $l^T$ and $l^N$</td>
<td>0.75</td>
<td>Assumption</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Elasticity of substitution between $c^T$ and $c^N$</td>
<td>0.89</td>
<td>Assumption</td>
</tr>
<tr>
<td>$n$</td>
<td>Share of $c^N$ in $c$</td>
<td>0.4</td>
<td>National Income Accounts</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Elasticity of substitution between $c^N$ varieties</td>
<td>12</td>
<td>Standard value</td>
</tr>
<tr>
<td>rem*</td>
<td>Remittances</td>
<td>0.43</td>
<td>To match non–oil trade deficit (% of gdp)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Share of dynamic optimisers</td>
<td>0.60</td>
<td>Lowest possible value</td>
</tr>
<tr>
<td>$\omega^d$, $\omega^s$</td>
<td>Transfers between agents</td>
<td>0.07, −0.05</td>
<td>Ensures $c^d = c^s$</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Value</td>
<td>Source/Method</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------</td>
<td>--------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Production and price rigidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Labour share</td>
<td>0.7</td>
<td>Standard value</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Public capital share</td>
<td>0.33</td>
<td>Arslanalp et al. (2010)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>$x$ adjusted cost</td>
<td>25</td>
<td>Smooth impulse responses for $x$</td>
</tr>
<tr>
<td>$g_T$</td>
<td>Trend growth</td>
<td>1.0171</td>
<td>6% annual growth</td>
</tr>
<tr>
<td>$Z^T$</td>
<td>Efficiency in $T$ sector</td>
<td>1</td>
<td>Normalisation</td>
</tr>
<tr>
<td>$Z^N$</td>
<td>Efficiency in $N$ sector</td>
<td>1.044</td>
<td>To normalise $s$ to 1</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Capital depreciation</td>
<td>0.015</td>
<td>Bu (2004)</td>
</tr>
<tr>
<td>$\zeta^N_p$</td>
<td>Nominal rigidities in $N$ sector</td>
<td>49</td>
<td>Prices are sticky for 6 months on average</td>
</tr>
<tr>
<td>Distortions</td>
<td>Production distortion</td>
<td>0.112</td>
<td>To match $x / gdp$</td>
</tr>
<tr>
<td>Capital mobility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\nu$</td>
<td>Portfolio adjusted costs</td>
<td>$10^5$</td>
<td>Closed capital account</td>
</tr>
<tr>
<td>$b^*$</td>
<td>Steady-state private NFA</td>
<td>0.2825</td>
<td>To match $s mf^* / gdp$</td>
</tr>
</tbody>
</table>
### Table 3: Baseline Calibration, Policy Parameters and Oil Process

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source/Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil process</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho^o )</td>
<td>Windfall persistence</td>
<td>0.95</td>
<td>To match windfall path</td>
</tr>
<tr>
<td>( \epsilon^o )</td>
<td>Size of windfall</td>
<td>0.0780</td>
<td>To match windfall size</td>
</tr>
<tr>
<td><strong>The government</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \nu )</td>
<td>Share of ( g^N ) in ( g )</td>
<td>0.62</td>
<td>Follows from rest of calibration</td>
</tr>
<tr>
<td>( a^* )</td>
<td>Aid revenues</td>
<td>0.1856</td>
<td>To match ( sa^* / gdp )</td>
</tr>
<tr>
<td>( \tau )</td>
<td>Wage tax rate</td>
<td>0.3398</td>
<td>To match ( p^G g / gdp )</td>
</tr>
<tr>
<td>( \gamma^G )</td>
<td>Share of ( x^G ) in ( g )</td>
<td>0.35</td>
<td>To match ( p^G x^G / gdp )</td>
</tr>
<tr>
<td>( b^c )</td>
<td>Steady-state value of ( b^c )</td>
<td>0.3068</td>
<td>To match ( b^c / gdp )</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Depreciation rate for ( Q )</td>
<td>0.035</td>
<td>Arslanap et al. (2010)</td>
</tr>
<tr>
<td><strong>The central bank</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho^R )</td>
<td>Persistence of reserve accumulation</td>
<td>0.95</td>
<td>Policy parameter</td>
</tr>
<tr>
<td>( r^R )</td>
<td>Reserve target</td>
<td>0.22</td>
<td>To match ( srr^* / gdp )</td>
</tr>
<tr>
<td>( nw )</td>
<td>CB net worth</td>
<td>0</td>
<td>Simplifying assumption</td>
</tr>
<tr>
<td>( \omega )</td>
<td>Reserve response to the windfall</td>
<td>0.9</td>
<td>Policy parameter</td>
</tr>
<tr>
<td>( \pi^* )</td>
<td>Inflation target</td>
<td>1.025</td>
<td>To match Ghana's inflation target</td>
</tr>
<tr>
<td>( \phi_\pi )</td>
<td>Taylor rule coefficient</td>
<td>2</td>
<td>Standard value</td>
</tr>
</tbody>
</table>
Finally, there are several parameters we choose deliberately to emphasise LIC-specific aspects. These include the elasticity of substitution for labour supplied to different sectors $\rho_L$, the elasticity of substitution between traded and non-traded goods $\chi$ (both of which we will interpret as capturing bottle necks in these countries), the share of dynamic optimisers $\gamma$ and the degree of capital mobility $v^*$. We also assume a small reserve accumulation, i.e., $\omega = 0.9 < 1$. We believe that central banks are likely to start from low reserves, so that they would use—at least—a small fraction of the additional foreign exchange to rebuild reserves. We will revise these parameters when we perform sensitivity analysis.

3.2 Baseline simulation

In the baseline calibration, presented in Figure 1, we assume that the government follows rule (16), so that government spending follows almost one for one the oil windfall (see panels 1 and 2). The resulting increase in demand leads to a sharp but short-lived spike in real GDP growth.

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**Table 4: Ghana: Steady-state Values**

<table>
<thead>
<tr>
<th>National income accounts (% of GDP)</th>
<th>Government accounts (% of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Value</td>
</tr>
<tr>
<td>Private consumption</td>
<td>75</td>
</tr>
<tr>
<td>Traded</td>
<td>45</td>
</tr>
<tr>
<td>Non–traded</td>
<td>30</td>
</tr>
<tr>
<td>Private investment</td>
<td>19</td>
</tr>
<tr>
<td>Traded</td>
<td>7</td>
</tr>
<tr>
<td>Non–traded</td>
<td>13</td>
</tr>
<tr>
<td>Government spending</td>
<td>37</td>
</tr>
<tr>
<td>Consumption</td>
<td>24</td>
</tr>
<tr>
<td>Investment</td>
<td>13</td>
</tr>
<tr>
<td>Traded</td>
<td>14</td>
</tr>
<tr>
<td>Non-traded</td>
<td>23</td>
</tr>
<tr>
<td>Trade balance</td>
<td>−31</td>
</tr>
<tr>
<td>Value added, traded sector</td>
<td>27</td>
</tr>
<tr>
<td>Value added, non–traded sector</td>
<td>73</td>
</tr>
<tr>
<td>Other variables</td>
<td></td>
</tr>
<tr>
<td>Annual inflation, nominal depreciation</td>
<td>10</td>
</tr>
<tr>
<td>Real GDP growth</td>
<td>6</td>
</tr>
</tbody>
</table>

---

15 There are small differences between the government spending response and the oil windfall, reflecting the endogeneity of tax revenue.
(panel 3), leading to a persistent increase in the level of GDP (panel 4). The real exchange rate—both the CPI–based measure and the ratio of traded to non-traded prices \( (p^N/s) \)—appreciates, while the non-oil trade deficit widens slightly less than the windfall (panel 8), consistent with the small accumulation of reserves.

The impact of the windfall on the economy is driven by two factors. First, the increase in government spending expands the demand for non-traded goods. The non-traded sector partly expands by drawing labour from the
traded sector. In addition, as firms in the non-traded sector display nominal rigidities, they respond to the windfall by increasing their own demand for labour, for any given real wage. This results in a shift in the aggregate labour demand curve and accounts for the economic expansion that is observed at the onset of the windfall, as well as the increase in non-traded inflation and higher real wages (not shown). These effects can be observed in panel 1 of Figure 2: total employment increases while employment in the traded sector contracts. Over time, the demand-driven boom fades. However, as part of the spending has been used to increase public capital, there is a persistent and positive effect on output.

The other factor, the increase in the volume of FX available to the economy, facilitates adjustment by reducing the economy’s need for its own traded production, which is reflected in the real exchange rate appreciation. The appreciation reduces profitability in the tradable sector and thereby helps with factor re-allocation. It also leads to expenditure-switching effects. Both effects result in the required increase in the non-oil trade deficit. Note that in this situation, the oil-financed higher non-oil trade deficit ensures that the increase in government spending does not crowd out the private sector. This can be observed in panel 4 of Figure 2, which shows private absorption (private consumption plus private investment) broadly constant in the short run and gradually increases as higher public investment increases the productive capacity of the economy.

Figure 2: Baseline Scenario: The Transmission Mechanism.
Finally, the increase in non-traded prices is partly offset by the nominal appreciation. However, overall inflation increases, resulting in a monetary policy tightening during the first year of the windfall (Figure 1). Higher inflation and the real appreciation are thus important parts of the required macroeconomic adjustment. Unlike the real appreciation, however, an increase in inflation is not an inevitable part of the transmission mechanism but rather a result of the aggregate demand pressures that can arise from a rapid increase in spending. We will later see how different fiscal and monetary policy responses affect these two variables (inflation and the real exchange rate).

3.3 Sensitivity analysis

This section focuses on the parameters that distinguish an LIC such as Ghana from a resource-rich high-income country like Norway. We focus on: (i) the share of cash-constrained consumers, (ii) the openness of the capital account and (iii) the role of bottlenecks in the supply-side response of the economy.

Table 5 compares the standard deviation of selected variables under the baseline with an alternative calibration that modifies the above parameters—either one at a time or all together—to mimic a developed country. Relative to a developed country, our choice of parameters results in increased macroeconomic volatility following an oil windfall. In particular, the last column shows that if all of these parameters are changed together then macroeconomic volatility would decline considerably. Hence, macroeconomic management of natural resource inflows is more challenging in LICs.

These three parameters affect macroeconomic volatility in different ways:

- **Share of optimising consumers:** Due to an underdeveloped financial sector, the share of cash-constrained consumers is likely to be much higher in LICs. These consumers spend all of their additional income, such as that generated by an increase in government spending. Demand pressures therefore tend to be larger. This is compensated in part by a tighter monetary policy, which implies that the burden of maintaining macroeconomic stability is heavier for Ghana’s central bank than for an advanced economy’s. A tighter monetary policy stance also crowds out the consumption of the optimising agents, which matters when we assess alternative fiscal and monetary policy choices from a welfare viewpoint (see below).
### Table 5: Standard Deviation of Growth Rates of Key Variables

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>High share of optimising consumers</th>
<th>Open capital account</th>
<th>Few bottlenecks</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Standard deviation</td>
<td>Difference in</td>
<td>Standard</td>
<td>Difference</td>
</tr>
<tr>
<td></td>
<td>deviation</td>
<td></td>
<td>percentage</td>
<td>deviation</td>
<td>in percentage</td>
</tr>
<tr>
<td>Real GDP</td>
<td>0.82</td>
<td>0.70</td>
<td>14</td>
<td>0.74</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.39</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.38</td>
<td>53</td>
</tr>
<tr>
<td>Traded sector</td>
<td>1.08</td>
<td>1.01</td>
<td>6</td>
<td>0.79</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.72</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.31</td>
<td>21%</td>
</tr>
<tr>
<td>Non-traded sector</td>
<td>2.02</td>
<td>1.79</td>
<td>12</td>
<td>1.71</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.73</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.45</td>
<td>28</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>3.44</td>
<td>3.64</td>
<td>6</td>
<td>3.32</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.52</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.55</td>
<td>55</td>
</tr>
<tr>
<td>Nominal wages</td>
<td>3.88</td>
<td>2.47</td>
<td>36</td>
<td>1.29</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.87</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.58</td>
<td>85</td>
</tr>
<tr>
<td>Private sector absorption</td>
<td>0.17</td>
<td>0.18</td>
<td>4</td>
<td>0.34</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.36</td>
<td>106</td>
</tr>
<tr>
<td>Consumption of optimising</td>
<td>1.04</td>
<td>0.21</td>
<td>80</td>
<td>1.26</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.73</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.53</td>
<td>49</td>
</tr>
<tr>
<td>Nominal interest rate (level)</td>
<td>24.16</td>
<td>6.71</td>
<td>72</td>
<td>3.03</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.68</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.36</td>
<td>94</td>
</tr>
<tr>
<td>Inflation rate (level)</td>
<td>1.53</td>
<td>0.40</td>
<td>74</td>
<td>0.24</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.69</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.18</td>
<td>88</td>
</tr>
</tbody>
</table>

**Notes:** Standard deviations are computed over a 5-year horizon. The scenario with a high share of optimising consumers assumes that the last account for 90% of all households, compared with 60% in the benchmark simulation. The scenario with an open capital account lowers portfolio adjustment costs to practically zero. The scenario with few bottlenecks raises the elasticity of substitution between sector-specific labour types from 0.75 to 3% and the elasticity of substitution between traded and non-traded goods from 0.89 to 2%.
Open capital account: Another consequence of an underdeveloped financial market is that financial linkages to the rest of the world are limited, *de facto* closing the capital account. An open capital account makes it easier for (optimising) consumers to smooth their consumption in response to the windfall, as they can easily save the additional income abroad. With a closed capital account, however, their attempt to save domestically results in higher investment and higher demand pressures. Keeping these in check also requires a tighter monetary policy stance.

Bottlenecks: The real appreciation in the baseline results from the need to re-allocate resources, a process that is inevitably characterised by bottlenecks. These are bound to be larger in a low-income economy, because the available pool of skilled labour, know-how, supply networks and so on is much narrower. Hence, the resulting supply-side response will be smaller, it will require larger relative price changes and it will increase the inflationary impact of changes in government spending—simply because it makes labour costs more sensitive to aggregate demand. A similar argument holds for the ease with which tradable and non-tradable goods can be substituted.

In sum, this analysis indicates that oil windfalls are likely to have a larger macroeconomic impact in LICs. In the absence of fiscal measures, monetary policy must bear a higher stabilisation burden than in developed countries. Note that we have abstracted from the obvious observation that a given windfall is likely to be larger in LICs (in percent of GDP), simply because these countries are poorer. This would add to the macroeconomic challenge.

4. Fiscal and monetary policy options for managing the windfall

We now consider two policy options, one fiscal and the other monetary.\(^{16}\)

4.1 Fiscal policy option: expenditure smoothing

In the light of the aggregate demand pressures in the baseline, we now explore rule (17), which implies expenditure smoothing and the

\(^{16}\) We ran an additional fiscal scenario where the government spends a larger fraction of its spending on public investment, and because investment is more intensive in traded goods, the share of the additional government spending allocated to traded goods also increases. We find that such a composition of spending would result in a smaller demand boom in the short run and a larger impact on output in the medium run. Results are available upon request.
accumulation of savings in the sovereign wealth fund. Spending would increase permanently by slightly less than 1% of GDP and the short-run macroeconomic effects would be smaller (Figure 3).

We assess the benefits of the two alternative rules by measuring their impact on aggregate welfare, i.e., on the sum of lifetime utility of the two representative consumers weighted by their relative share $\gamma$ (Table 6). Not surprisingly, expenditure smoothing increases aggregate welfare, although there are interesting differences between the two types of agents. Static optimisers prefer a frontloaded expenditure profile because the utility gain from the resulting short-run consumption boom typically dominates the overall welfare effect. The dynamic optimiser, in contrast, dislikes macroeconomic volatility (as this volatility affects their work effort and consumption profile) and therefore prefers expenditure smoothing.17

It must be stressed that the benefits from smoothing go beyond short run considerations and are also related to the ability to finance higher public investment in the long run, which helps achieve permanently higher levels of output. In this case, the sovereign wealth fund helps

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17 We also assess welfare under the assumption that both agents derive utility directly from government spending. Results are broadly similar. Note that we discount future utility of both agents by the dynamic optimiser’s discount factor, otherwise static optimisers would prefer front–loading even more.
finance the recurrent costs of higher public investment. Unlike some of the recent literature—which treats external savings as an inferior substitute to much needed domestic investment in infrastructure—our results suggest a complementary role instead.\textsuperscript{18}

4.2 Monetary policy option: reserve accumulation

As mentioned earlier, central banks may be concerned by the likely contraction of the traded sector following the windfall, which, as we discussed earlier, is an important part of the adjustment process but may have potentially damaging consequences for economic development.\textsuperscript{19} Central banks may thus respond by accumulating more reserves to reduce the extent of real appreciation.

We therefore compare the baseline with a specification where the central bank accumulates 50\% of the windfall as reserves ($\omega = 0.5$). Figure 4 summarises the results. In both cases, the increase in government spending is the same. Compared with the baseline, however, reserve accumulation is effective in limiting the real appreciation and the contraction in the traded sector (panels 3 and 4), and the resulting non-oil trade deficit is smaller. This comes at the cost of crowding out of private investment and consumption (panels 5 and 6). The larger the accumulation of reserves, the larger the crowding out. Results from the simulation (not shown) also indicate that this policy mix is more inflationary, because it amounts to a domestically financed fiscal expansion rather than an oil-financed one.

The crowding out results from the public sector’s attempt to use the windfall twice: once as government spending and once as external

\begin{table}
\centering
\caption{Utility Gains With and Without Expenditure Smoothing}
\begin{tabular}{lcc}
\hline
 & Benchmark & Expenditure smoothing difference in percentage \\
\hline
Total utility gain & 0.29 & 16 \\
Optimising consumers & 0.24 & 41 \\
Cash-constrained consumers & 0.37 & -9 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{18} See Collier et al. (2010)

\textsuperscript{19} This is the so-called Dutch disease. In a previous version of the paper, we experimented with a learning-by-doing externality in the traded sector that captures some of these effects. Results were similar to those we present there.
savings (reserves). From a balance sheet perspective, the double use of the windfall is reflected in the increase of government bonds held by the private sector $b^c$, which are the counterpart to the sterilised accumulation of reserves. Because this double use is not materially possible however, the private sector must decrease its spending, which is made possible by an increase in real interest rates. Table 7 shows the welfare effects from such a policy mix. Holding the fiscal response constant, the higher the reserve
accumulation, the lower the increase in welfare resulting from the oil windfall.

It must be stressed at this point that it is not the accumulation of reserves that is problematic *per se* but rather the lack of coordination with fiscal policy. Because reserve accumulation is decided independently of the fiscal response, scenarios such as this one are possible and, as the experience with episodes of aid scaling up suggest, even likely. Note that this type of coordination problem does not arise with a sovereign wealth fund because in that case, external savings are automatically equivalent to government savings.

Our analysis ignores important benefits from reserve accumulation, such as providing self-insurance against large external shocks. However, it emphasises the importance of the fiscal backing for reserve accumulation.

5. Conclusion

This paper studied the likely impact of oil windfalls in LICs using a dynamic general equilibrium model that is suitable for these countries. We calibrated the model to Ghana and analysed the macroeconomic implications of various fiscal and monetary policy options.

We found that oil windfalls can be beneficial—in terms of increasing welfare—but are also likely to create large aggregate demand pressures. Limited financial development and bottlenecks, both of which are pervasive in LICs, amplify these demand pressures and imply greater macroeconomic volatility as a result of the windfall. In the absence of fiscal smoothing, this places greater burden on monetary policy to stabilise the economy. Not surprisingly, we found that fiscal smoothing—and its associated external savings—can greatly contribute to raising the impact of the oil windfall on welfare, although in our simulations it has different effects on different types of consumers.

More importantly, we found that lack of coordination between the fiscal and the monetary policy response to the windfall can have unintended consequences for the private sector and reduce welfare. Our simulations point to the dangers of accumulating reserves while also spending the local currency proceeds from the windfall. The experience of various countries in managing large increases in aid suggests that this policy mix is more than just a theoretical curiosity.

20 See *Berg et al.* (2010).
We have abstracted from analysing the role of proper fiscal institutions for managing the oil wealth. Implicitly, we have assumed that the government would be capable, from an institutional point of view, of absorbing relatively large increases in oil revenues without affecting the efficiency with which it carries out current and investment spending. Understanding how this may affect the macroeconomic consequences of oil windfalls is left for future research.

References


