

IMF Working Paper

Oil Windfalls in Ghana: A DSGE Approach

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Abstract

We use a calibrated multi-sector DSGE model to analyze the likely impact of oil windfalls on the Ghanaian economy, under alternative fiscal and monetary policy responses. We distinguish between the short-run impact, associated with demand-related pressures, and the medium run impact on competitiveness and growth. The impact on inflation and the real exchange rate could be moderate, especially if the fiscal authorities smooth oil-related spending or increase public spending's import content. However, a policy mix that results in both a fiscal expansion and the simultaneous accumulation of the foreign currency proceeds from oil as international reserves—to offset the real appreciation—would raise demand pressures and crowd-out the private sector. In the medium term, the negative impact on competitiveness—resulting from "Dutch Disease" effects—could be small, provided public spending increases the stock of productive public capital. These findings highlight the role of different policy responses, and their interaction, for the macroeconomic impact of oil proceeds.

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I. INTRODUCTION

Ghana is on the verge of becoming an oil-producing country. Based on proven reserves, oil production is expected to start at the end of 2010 and to quickly decline over the following decade as field capacity is tapped. Oil revenues are expected to be relatively important at an estimate of 4 to 6 percent of GDP over the next five years. Given its magnitude, the prospective windfall calls for a better understanding of its likely impact on the Ghanaian economy, a gap this paper intends to fill.

There is a vast literature that looks at the impact of oil windfalls and natural resources in general on a small open economy.¹ The oil-price shocks first sparked discussions on the harmful side effects of oil windfalls, due to the observation that oil producing countries under-performed relative to other developing countries despite the unprecedented increase in wealth following the oil-price hikes.² Many studies have looked at the "Dutch Disease" phenomenon, which refers to the negative effects that an export boom may have on traditional export sectors and overall productivity growth, if, for example, strong learning-by-doing effects are present in the tradable sector.³ It may also be the case, however, that higher oil-revenue-financed government spending is channeled toward increasing public infrastructure which would raise the productivity of private capital and have a positive effect on the level of output.⁴

In addition to medium-term considerations, there are short-term implications to an oil revenue windfall. The resulting fiscal expansion could generate demand pressures, an important issue in Ghana given its current levels of inflation. To prevent such scenario, the fiscal expansion could thus be associated with a discretionary monetary policy tightening to permanently reduce inflation. The oil-related fiscal expansion could also be associated with a large accumulation of reserves, if the central bank is concerned with real appreciation pressures, in which case inflationary pressures could increase and private sector investment could be crowded out, with potential medium term implications as well. In this paper we provide a coherent framework for thinking about the macroeconomic impact of the expected oil windfall, taking into account both the short- and medium-term implications of various fiscal and monetary policy responses.

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

²See the case studies presented in Gelb (1989).

³A learning-by-doing externality is a feature of the production function in which productivity increases with the level—or the growth—of activity in that sector. It's considered an externality because its effects are not internalized by the individual firms that make up that sector. See Van Wijnbergen (1984) and Krugman (1987), among others. Other, alternative, explanations have also been proposed for the relative under-performance of oil producing countries; see Hausmann and Rigobon (2003), among others.

⁴See Adam and Bevan (2005) and Chatterjee and Turnovsky (2005).

While oil shocks have been analyzed with several macro dynamic models in the past, the framework that is used in this paper (developed in Berg and others (2010) to analyze the macroeconomics of aid inflows) is particularly suitable for constructing plausible scenarios following an increase in oil revenues in a low-income country. First, the model incorporated both short- and medium-term effects of an increase in oil revenues. The short-term effects stem from the aggregate-demand pressures that may result from the fiscal expansion; we focus mostly on their effects on inflation, the output gap and the real exchange rate. The medium-term effects stem from the impact of higher public spending on the productivity of private capital. Second, the model allows for different monetary, reserve and fiscal policy responses and clarifies how different policy combinations will yield different macro-economic outcomes.

The model includes structural features that are relevant in low-income countries. First, it allows for limited access to international capital markets. It also features limited participation by residents in the domestic financial market, which is a pervasive issue in low-income countries and has implications for the transmission of fiscal and external shocks. Third, the model features varying degrees of labor mobility across sectors, which will also matter for macroeconomic adjustment.

Our results can be summarized as follows:

- In the short term, an oil-driven fiscal expansion—similar in size to the expected oil windfall—is likely to generate a moderate demand-led expansion in output and a moderate increase in non-traded goods inflation. The impact on aggregate inflation would be minimal provided that the real exchange rate is allowed to appreciate.
- The impact on medium term competitiveness could be negative if there are sizeable learning externalities in the traded sector. However, this negative effect could be reverted if the fiscal expansion translates into higher public capital.
- The short-run challenges associated with the windfall can be greatly reduced if the government implements an appropriate fiscal policy. A smoother fiscal response to the oil windfall as well as a higher import component in government spending will greatly reduce the associated demand pressures. As for the central bank, a discretionary tightening of monetary policy—to reduce inflation from current high levels to a new, lower steady state—would also reduce inflationary pressures, but it requires a strong commitment to price stability.
- If the government decides to save part of the oil windfall domestically, reserve policy must be consistent with fiscal policy. If the central bank simultaneously accumulates the foreign currency proceeds from oil—while the government spends the local currency proceeds on domestic goods—the real exchange rate appreciation will be smaller but inflation will be higher. This will be the case, even if the accumulation of reserves is sterilized. This highlights

the role of the supply of foreign currency—associated with the oil proceeds—in stabilizing aggregate demand and containing inflationary pressures.

- The structural features of the Ghanaian economy will also play an important role in the adjustment process. In particular, frictions in the labor market and the financial market, features that are accounted for in the model, amplify the impact on inflation. Hence, any progress in decreasing these frictions in the coming years would have a beneficial effect for the economy overall, and in its response to the large oil shock.

Our emphasis on this paper is not on the dynamics of the oil sector per se. We treat net external revenues from the oil sector as a transfer from the rest of the world that accrues directly to the government, similar to an aid inflow, and do not keep track of the actual production of oil or the factors employed in its production. This provides an incomplete accounting of the economy's GDP, as well as an incomplete accounting of the oil sector itself since it does not distinguish between different types of external flows associated with oil production: oil-related foreign direct investment, dividend flows, oil-related imports. Including these flows into the analysis would require a more detailed model. However, we believe our model provides an adequate framework for thinking about the effects of additional oil revenues on the non-oil economy. We think this is the primary channel through which this sector influences non-oil economic activity, since the oil sector is typically segmented from the rest of the economy.

The paper is organized as follows. Section 2 provides an overview of the Ghanaian economy. Section 3 summarizes the model. Section 4 presents the calibration and the simulations for the benchmark case as well as the some sensitivity analysis. Section 5 focuses on fiscal and monetary policy options for managing the oil windfall. Section 6 concludes.

II. GHANA'S ECONOMY AND OIL

Ghana is one of the best-performing economies in Africa. By improving policies and institutions, and investing in infrastructure and basic services, it has experienced high growth rates during the last decade averaging about 5 percent a year (Figure 1). Poverty levels were brought down from 52 percent in 1992 to 28.5 percent in 2006. It has also become one of the few African economies that attracts significant FDI inflows.

Ghana has formally adopted an inflation targeting framework for its monetary policy in May of 2007, announcing price stability as the central bank's primary objective. It is the second country in Sub-Saharan Africa to adopt such regime (after South Africa). At the beginning of the decade, Ghana was grappling with high inflation (Figure 2), large fiscal and external account deficits, and high external and domestic debt. In 2002, the Ghanaian authorities introduced a new monetary and

Figure 1. Ghana: Real GDP Growth Rate

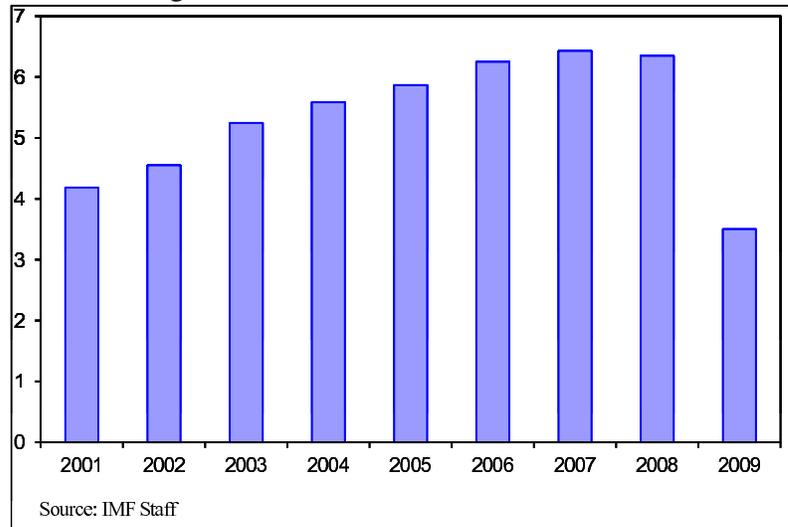
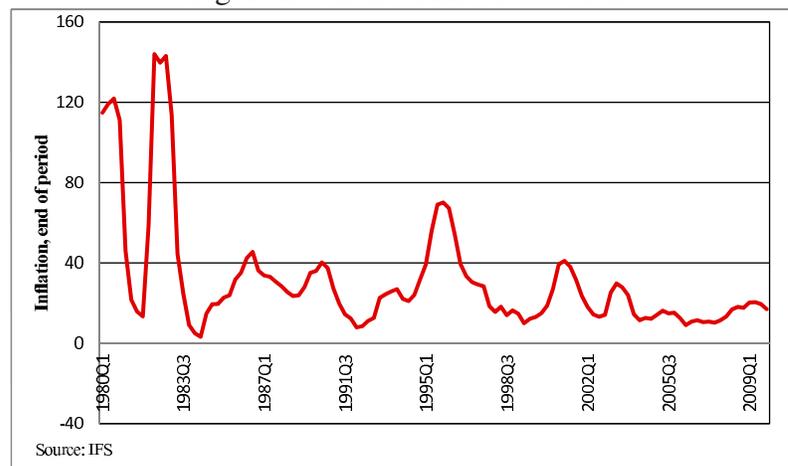


Figure 2. Ghana: Annual Inflation

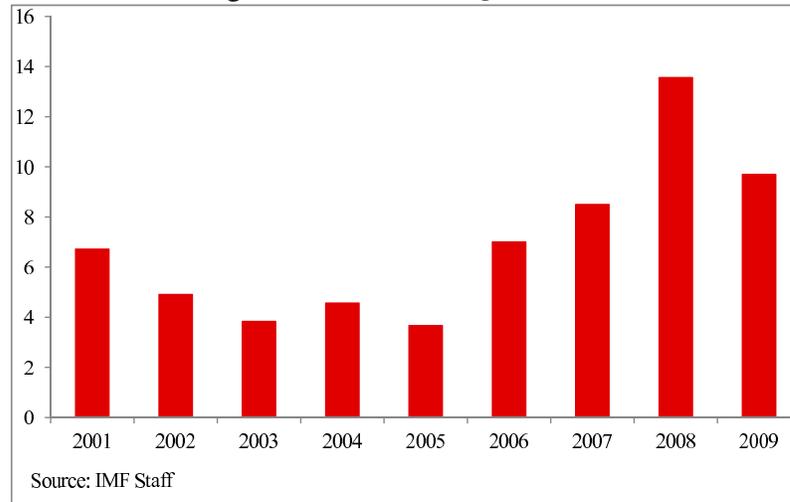


fiscal framework. The Bank of Ghana Act 2002 gave operational independence to the central bank and established an implicit inflation targeting framework. Despite the change in the policy regime, inflation has remained relatively high: the annual inflation rate at end-2008 was around 18%.

On the other hand, fiscal discipline has deteriorated between 2006 and 2008. The fiscal deficit, which stood at around 4 percent of GDP in 2005, rose above 10 percent in 2008 (Figure 3). The Ghanaian authorities have recently taken corrective measures to rein in government spending and avoid such slippage in the future. A fiscal responsibility law (FRL) is under consideration to ensure that the government's medium-term fiscal framework (MTFF) is open to public scrutiny and that comprehensive fiscal information on central and local governments, decentralized agencies and state-owned enterprises are made available. Ghana is also a member of the EITI, and there are plans to extend this to the oil and gas sectors.⁵

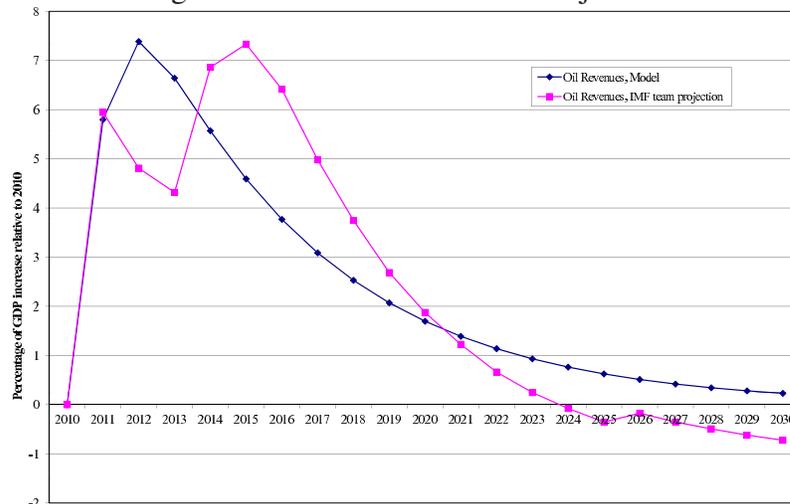
⁵EITI stands for Extractive Industries Transparency Initiative, which sets the global standards for transparency in oil, gas

Figure 3. Ghana: Budget Deficit



Ghana will start producing oil by the end of 2010, as extraction from the Jubilee field is expected to begin, with peak production over an initial 5-6 years, followed by a progressive decline (Figure 4). Initial production is projected at about 13 percent of GDP, with about one half accruing to government revenues (about 6 percent of GDP in 2011 and 2012).⁶

Figure 4. Ghana: Oil Revenue Projection



III. THE MODEL

In this section we briefly present the DSGE model developed in Berg and others (2010). We display the problem solved by firms and households, as well as the public sector budget constraints and the policy rules. The only source of uncertainty in the model is a shock to oil revenues received by the government.

and mining, particularly over payments by companies to governments.

⁶There is some uncertainty regarding these projections.

A. Consumers

1. Dynamic Optimizers

We assume a fraction $\hat{\gamma}$ of all consumers are dynamic optimizers, denoted with a (d) superscript. These consumers own the firms and the financial assets in the economy. The representative agent in this group maximizes life-time utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^d, \frac{M_t^d}{P_t}, l_t^d) = E_0 \sum_{t=0}^{\infty} \beta^t \left(\log([\vartheta^d C_t^d]^{\frac{\eta-1}{\eta}} + (1 - \vartheta^d) \frac{M_t^d}{P_t}]^{\frac{\eta}{1-\eta}} - \frac{\zeta^l}{1+\psi} (l_t^d)^{1+\psi} \right), \quad (1)$$

where C_t^d refers to a consumption basket (to be defined below), $\frac{M_t^d}{P_t}$ is the agent's holding of real money balances and l_t^d is a measure of the agent's labor effort in the exportable and non-traded sectors:

$$l_t^d = [\alpha_N^{-\frac{1}{\rho_L}} l_t^{dN \frac{1+\rho_L}{\rho_L}} + (1 - \alpha_N)^{-\frac{1}{\rho_L}} l_t^{dT \frac{1+\rho_L}{\rho_L}}]^{\frac{\rho_L}{1+\rho_L}} \quad (2)$$

The parameter ψ is the inverse of the labor supply elasticity, α_N is the share of non-traded employment (value added) in total employment (GDP), and ρ_L is the elasticity of substitution between labor services provided in the traded and non-traded sector. The dynamic consumer's budget constraint is given by:

$$P_t C_t^d + B_t^{dc} + M_t^d + S_t B_t^{d*} = (1 - \tau) W_t^N l_t^{dN} + (1 - \tau) W_t^T l_t^{dT} + (1 + i_{t-1}) B_{t-1}^{dc} + M_{t-1}^d + S_t (1 + i_{t-1}^*) B_{t-1}^{d*} - S_t \Psi_t^* (B_t^{d*}) + \frac{1}{\hat{\gamma}} Pr_t^N + S_t Rem_t^* + P_t \varpi^d$$

P_t is the consumer price index, B_t^{dc} is the consumer's holding of domestic nominal bonds, B_t^{d*} denotes his holdings of foreign assets (subject to portfolio adjustment costs $\Psi_t^* (B_t^{d*})$) and S_t is the local currency price of foreign currency. W_t^N and W_t^T are the nominal wages in the non-traded and traded sector, respectively, while τ is the income tax rate and Pr_t^N denotes the dynamic optimizer's share of nominal profits of domestic firms in the non-traded sector. Finally ϖ^d refers to a transfer between dynamic and static consumers.⁷

Most variables in the budget constraint (both real and nominal) are not stationary. Two operations are required to ensure stationarity. First, all domestic nominal variables are deflated by the domestic consumer price index, and foreign nominal variables are deflated by the foreign CPI. Second, since the model features economy-wide productivity growth, all trend stationary variables are divided by

⁷These transfers ensure steady state consumption and labor supply are the same for both dynamic and static consumers. See Galí and others (2007).

their deterministic trend.⁸ The budget constraint with normalized variables, denoted by lower case letters, is the following:⁹

$$c_t^d + b_t^{dc} + m_t^d + s_t b_t^{d*} = (1 - \tau)w_t^N l_t^{dN} + (1 - \tau)w_t^T l_t^{dT} + (1 + i_{t-1}) \frac{b_{t-1}^{dc}}{\pi_t} + \frac{m_{t-1}^d}{\pi_t g_T} + s_t (1 + i_{t-1}^*) \frac{b_{t-1}^{d*}}{\pi^* g_T} - s_t \psi^*(b_t^{d*}) + s_t rem^* + \frac{1}{\hat{\gamma}} pr_t^N + \varpi_t^s, \quad (3)$$

where π_t denotes domestic inflation, π^* denotes foreign inflation (assumed to be constant), g_T denotes productivity growth and s_t is the CPI-based real exchange rate

$$s_t = \frac{S_t P_t^*}{P_t}$$

Portfolio adjustment costs are given by:

$$\psi^*(b_t^*) = \frac{v^*}{2} (b_t^* - \bar{b}^*)^2$$

Depending on the choice of v , it is possible to model a closed capital account (given by $v^* = +\infty$) as well as a partially open one ($0 << v^* < +\infty$). In both of these cases, sterilized exchange rate 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—net of portfolio adjustment costs—and cause a temporary nominal depreciation.

2. Static Optimizers

We assume that the remaining fraction $(1 - \hat{\gamma})$ of consumers are static-optimizers, denoted with a $(^s)$ superscript. These agents do not own firms and their only source of income comes from their labor. The representative agent from this group derives utility from present values of consumption and labor effort:

$$u(C_t^s, \frac{M_t^s}{P_t}, l_t^s) = \left(\log([\vartheta^s C_t^s]^{\frac{\eta-1}{\eta}} + (1 - \vartheta^s) \frac{M_t^s}{P_t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{1-\eta}}) - \frac{\kappa^s}{\psi} (l_t^s)^\psi \right), \quad (4)$$

where l_t^s is of the same form as in the case of dynamic optimizers. Utility maximization is subject to the following constraint (in normalized terms):

$$c_t^s + m_t^s = (1 - \tau)w_t^N l_t^{sN} + (1 - \tau)w_t^T l_t^{sT} + \frac{m_{t-1}^s}{\pi_t g_T} + s_t rem^* - \varpi_t^d \quad (5)$$

⁸The portfolio adjustment costs $\Psi_t^*(B_t^*)$ grow at the same rate than the rest of the economy, otherwise capital mobility would improve over time and would eventually converge to perfect capital mobility.

⁹With very few exceptions by 'real' we shall denote variable expressed in units of households' consumption baskets.

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

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

B. Consumption Baskets, Demand Functions, Price Indices

There are two types of goods: traded and no-traded. Non-traded goods, of which there are infinite varieties along the $[0,1]$ continuum, are indexed by superscript (N) . Consumption of different varieties of non-traded goods are aggregated into a sub-basket using a standard Dixit-Stiglitz function:

$$c_t^N = \left(\int_0^1 c_{it}^N \frac{\theta-1}{\theta} di \right)^{\frac{\theta}{\theta-1}},$$

where θ is the elasticity of substitution between different varieties. The demand for variety i is given by:

$$c_t^N = \left(\frac{p_{it}^N}{p_t^N} \right)^{-\theta} c_t^N$$

The price index for the non-traded sub-basket is given by:

$$P_t^N = \left(\int_0^1 P_{it}^{N1-\theta} di \right)^{\frac{1}{1-\theta}}$$

Regarding traded goods, denoted with a superscript (T) , their price is given by the law of one price (LOP):

$$P_t^T = S_t P_t^*$$

1. The Aggregate Basket

The total consumption basket is a standard CES basket:

$$c_t = \left(n_1^{\frac{1}{\chi}} (c_t^N)^{\frac{\chi-1}{\chi}} + (1 - n_1)^{\frac{1}{\chi}} (c_t^T)^{\frac{\chi-1}{\chi}} \right)^{\frac{\chi}{\chi-1}} \quad (6)$$

The parameter χ is the elasticity of substitution between non-traded goods and traded goods and n_1 measures the degree of home bias in consumption. The government spends on a different basket of goods:

$$G_t = \left(v_1^{\frac{1}{\chi}} (G_t^N)^{\frac{\chi-1}{\chi}} + (1 - v_1)^{\frac{1}{\chi}} (G_t^T)^{\frac{\chi-1}{\chi}} \right)^{\frac{\chi}{\chi-1}} \quad (7)$$

Normalized price indices associated with the two baskets are the following:

$$1 = \left(n_1 (p_t^N)^{1-\chi} + (1 - n_1)(s_t)^{1-\chi} \right)^{\frac{1}{1-\chi}}, \quad (8)$$

$$p_t^G = \left(v_1 (p_t^N)^{1-\chi} + (1 - v_1)(s_t)^{1-\chi} \right)^{\frac{1}{1-\chi}} \quad (9)$$

Finally, demand for traded and non-traded goods is given by:

$$c_t^N = n_1 (p_t^N)^{-\chi} c_t; \quad c_t^T = (1 - n_1) s_t^{-\chi} c_t; \quad (10)$$

$$g_t^N = v_1 \left(\frac{p_t^N}{p_t^G} \right)^{-\chi} g_t; \quad c_t^T = (1 - v_1) \left(\frac{s_t}{p_t^G} \right)^{-\chi} g_t \quad (11)$$

C. Non-Traded Goods Sector

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

$$Y_{it}^N = Z^N \left(K_{it-1}^N \phi^N Q_{t-1}^N \right)^{1-\alpha^N} (T_t L_{it}^N)^{\alpha^N} \quad (12)$$

L_{it}^N is the volume of labor employed by firm i , K_{it-1}^N is private capital, and Q_{t-1}^N stands for public capital in the non-traded sector (which is assumed common to all firms in that sector). The coefficients α^N and ϕ^N indicate the production shares of labor and public and private capital. Z^N is the aggregate efficiency level in the non-traded sector and T_t is the level of Hicks-neutral productivity. Private capital K_{it}^N is accumulated via investments (X_{it}^N) and subject to a depreciation rate of δ^N and investment adjustment costs $S^N \left(\frac{X_{it}^N}{X_{it-1}^N} \right) = \frac{\kappa^N}{2} \left(\frac{X_{it}^N}{X_{it-1}^N g_T} - 1 \right)^2$ as in Christiano and others (2005):

$$K_{it}^N = (1 - \delta_n) K_{it-1}^N + \left(1 - S^N \left(\frac{X_{it}^N}{X_{it-1}^N} \right) \right) X_{it}^N$$

1. Firms' Optimization Problem

Every individual firm i faces the following demand:

$$y_{it}^{dN} = \left(\frac{p_{it}^N}{p_t^N} \right)^{-\theta} y_t^N \quad (13)$$

Combining equations (12) and (13), and after normalizing, the firm's labor demand can be expressed as follows:

$$L_{it}^N = \left(\frac{p_{it}^N}{p_t^N} \right)^{-\frac{\theta}{\alpha^N}} y_t^N \frac{1}{\alpha^N} Z^{N-\frac{1}{\alpha^N}} k_{it-1}^N \frac{\phi^N (\alpha^N - 1)}{\alpha^N} q_t^N \frac{1 - \phi_{n1} (\alpha^N - 1)}{\alpha^N}$$

Firms choose a price level p_{it}^N , investment x_{it}^N and capital k_{it}^N to maximize profits. The firm's profit maximization program is the following:

$$\begin{aligned} \max_{p_{it}^N, k_{it}^N, x_{it}^N} E_0 \sum_{t=0}^{\infty} J_t \left\{ p_{it}^N \left(\frac{p_{it}^N}{p_t^N} \right)^{-\theta} y_{nt} (1 - \varpi) - w_t^N \left(\frac{p_{it}^N}{p_t^N} \right)^{-\frac{\theta}{\alpha^N}} y_t^N \frac{1}{\alpha^N} Z^{N-\frac{1}{\alpha^N}} k_{it-1}^N \frac{\phi^N (\alpha^N - 1)}{\alpha^N} q_t^N \frac{\phi_{n2} (\alpha^N - 1)}{\alpha^N} \right. \\ \left. - \Gamma^N (p_t^N, y_t^N, \pi_{it}^N, \pi_{t-1}^N) - x_{it}^N + \lambda_{nt} \left[-k_{it}^N g_T + (1 - \delta_n) k_{it-1}^N + \left(1 - S^N \left(\frac{x_{it}^N}{x_{it-1}^N} \right) \right) x_{it}^N + \varpi p_t^N y_t^N \right] \right\}, \end{aligned}$$

where $J_{t+j} = \beta^j u_{ct+j}^d$. Two features are worth discussing. First, we assume there is a distortion (given by ϖ) that reduces the value of firms' sales for any given level of production. While this distortion is offset in the aggregate (the amount $\varpi p_t^N y_t^N$ is restituted to each firm), it affects firms' incentive to hire labor and invest in new capital. This feature is useful to match the observed low investment shares in many low-income countries. Second, each firm i faces price adjustment costs, given by $\Gamma^N (p_t^N, y_t^N, \pi_{it}^N, \pi_{t-1}^N) = p_t^N y_t^N (1 - \varpi) \frac{S_p^N}{2} \left(\frac{\pi_{it}^N}{\pi_{t-1}^N} - 1 \right)^2$, where $\pi_{it}^N = \pi_t \frac{p_{it}^N}{p_{it-1}^N}$ and $\pi_{t-1}^N = \pi_{t-1} \frac{p_{t-1}^N}{p_{t-2}^N}$. These price adjustment costs are a variant of the costs in Rotemberg (1982), adjusted to allow for indexation to past values of inflation.¹⁰

D. 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:

$$y_{jt}^T = Z^T \left(K_{jt-1}^T \phi^T Q_{t-1}^T \right)^{1-\phi^T} (T_t L_{jt}^T)^{\alpha^T} \quad (14)$$

Profit maximization (in normalized terms) for the representative firm j is given by:

$$\begin{aligned} \max_{L_{jt}^T, k_{jt}^T, x_{jt}^T} E_t \sum_{t=0}^{\infty} J_t \left\{ s_t \text{tot}_t Z^T \left(k_{jt-1}^T \phi^T q_t^{T1-\phi^T} \right)^{1-\alpha^T} L_{jt}^T \alpha^T (1 - \varpi) - w_t^T L_{jt}^T - \right. \\ \left. - x_{jt}^T + \lambda_{jt}^T \left[-k_{jt}^T g_T + (1 - \delta^T) k_{jt-1}^T + \left(1 - S^T \left(\frac{x_{jt}^T}{x_{jt-1}^T} \right) \right) x_{jt}^T + \varpi s_t \text{tot}_t y_t^T \right] \right\} \end{aligned}$$

where $S^T(\cdot)$ is of the same form as $S^N(\cdot)$.

¹⁰We assume that price adjustment costs have a structure similar to consumption, i.e. that they combines non-traded and traded components in a CES function with the same shares and elasticities as the consumption function

E. The Government

1. The Inter-Temporal Budget Constraint

The government's inter-temporal budget constraint (in normalized terms) is the following:

$$p_t^G g_t = \tau w_t (L_t^d + L_t^s) + b_t - \frac{b_{t-1}}{\pi_t g_T} - \frac{i_{t-1} b_{t-1}^c}{\pi_t g_T} + s_t (\bar{A}^* + O_t^*) - (d_t^G - \frac{d_{t-1}^G}{\pi_t g_T}) \quad (15)$$

The government can finance its spending $p_{gt} g_t$ through a variety of sources: taxes on labor income $\tau w_t (L_t^d + L_t^s)$, using the domestic currency value of foreign aid and oil proceeds $s_t (\bar{A}^* + O_t^*)$, drawing down on deposits held at the central bank $-(d_t^G - \frac{d_{t-1}^G}{\pi_t g_T})$, or issuing domestic debt $b_t - \frac{b_{t-1}}{\pi_t g_T}$. The government pays interest on lagged 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} :

$$b_t = b_t^{cb} + b_t^c \quad (16)$$

We assume government spending g_t can be used for public consumption or investment purposes. We distinguish between the share of public investment out of steady state spending (\bar{g}) and the share when government spending increases, e.g., in response to an increase in oil revenues:

$$x_t^G = \gamma^{\bar{G}} \bar{g} + \gamma^G (g_t - \bar{g})$$

The accumulation of public capital is the following:

$$q_t^G g_T = (1 - \delta^G) q_{t-1}^G + \varepsilon_s x_t^G,$$

where ε_s measures the efficiency of public investment. Public capital is assumed to be a non-rival good, but is (potentially) unequally accessible by the two productive sectors:

$$q_t^N = \varrho_n q_t^G$$

$$q_t^T = \varrho_e q_t^G$$

2. Government Debt and Deposits with the Central Bank

Fiscal policy is determined by the policy rules for government deposit accumulation and gross debt. The rule for government deposits depends on the amount of additional oil revenues that is received

on any given period:

$$d_t^g = \rho^d d_{t-1}^g + (1 - \rho^d) \bar{d}^g + (1 - \gamma) s_t O_t^*, \quad (17)$$

In this setup, the decision to spend the new oil revenues in the short run is represented by the parameter γ . If it is not spent initially ($\gamma < 1$), oil revenues will accumulate as deposits at the central bank and will be gradually spent over time. The speed at which initially saved revenues is spent is given by ρ^d . Regarding government debt accumulation, we assume a simple rule:

$$b_t = b_{t-1} - \varsigma (b_{t-1}^c - \bar{b}^c), \quad (18)$$

where ς is small but positive. This rule 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 steady state interest payments.

F. The Central Bank

1. Reserve Accumulation

We assume the following rule for the (normalized) foreign currency value of reserves:

$$R_t^* = \frac{\rho^{R^*}}{R_{t-1}} + (1 - \rho^{R^*}) \bar{R}^* + (1 - \omega) O_t^* - \omega_e (\pi_t^S - \pi^S), \quad (19)$$

where π_t^S is the nominal depreciation of the currency:

$$\pi_t^S = \frac{\pi_t}{\pi^*} \frac{s_t}{s_{t-1}} \quad (20)$$

The accumulation of reserves is driven by three separate factors. First, the central bank may accumulate reserves as oil revenues accrues to the government. The coefficient ω measures the fraction of additional oil revenues (in dollars) sold on the market by the central bank; a value of $\omega < 1$ implies some of the oil revenues is kept by the central bank. Second, the central bank may also target a nominal exchange rate level or rate of change; ω_e pins down the commitment to that target.¹¹ Depending on the steady state level of inflation in the country, the authorities may target an exchange rate level (if $\pi_t = \pi^*$) or a rate of crawl (if $\pi_t > \pi^*$). Finally, while the amount of reserves may deviate persistently from its long run value, we assume that the central bank targets a particular long run value of reserves (provided that ω_e is not infinite).

¹¹Depending on the degree of capital mobility, the commitment to an exchange rate target may be limited by the monetary policy rule

2. The Central Bank Balance Sheet

In nominal terms, the central bank balance sheet is the following:

$$M_t = B_t^{cb} - D_t^g + NFA_t, \quad (21)$$

where B_t^{cb} is the nominal value of government bonds, D_t^g are government deposits at the central bank and NFA_t are net foreign assets of the central bank measured in local currency. Taking first differences and normalizing, this equation becomes:

$$m_t - \frac{m_{t-1}}{\pi_t g_T} = b_t^{cb} - \frac{b_t^{cb}}{\pi_t g_T} - \left(d_t^g - \frac{d_{t-1}^g}{\pi_t g_T} \right) + nfa_t - \frac{nfa_{t-1}}{\pi_t g_T}, \quad (22)$$

where changes in nfa_t are related to reserves in the following way:

$$nfa_t - \frac{nfa_{t-1}}{\pi_t g_T} = s_t \left(R_t^* - \frac{R_{t-1}^*}{\pi^* g_T} \right) \quad (23)$$

3. The Monetary Policy Rule

We assume the central bank follows a simple Taylor rule and targets non-traded inflation:

$$r_t = \frac{1}{\beta} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi}, \quad (24)$$

where $\bar{\pi}$ is the inflation objective.

G. Non-Traded Goods Market Equilibrium and the Balance of Payments

Equilibrium in the non-traded goods sector is given by:

$$y_{nt} = p_{nt}^{-X} D_{nt} \quad (25)$$

where

$$D_{nt} = \left\{ n_1 \left(c_t + x_t^N + x_{et}^T + \Gamma^N \left(\frac{\pi_{nt}}{\pi_{nt-1}} \right) \right) + v_1 (p_{gt})^X G_t \right\} \quad (26)$$

The balance of payments constraint, which is derived by adding consumers and firms' budget constraint, the government's and the central bank's, is the following:

$$c_t + p_t^G g_t + x_t^N + x_t^T + \Gamma^N (p_t^N, y_t^N, \pi_t^N, \pi_{t-1}^N) - \{ p_t^N y_t^N + s_t y_t^T \} = s_t \left\{ rem^* + \omega O_t^* + \bar{A}^* - \frac{(\pi^* g_T - \rho^R)}{\pi^* g_T} (\bar{R}^* - R_{t-1}^*) + \omega_e (\pi_t^S - \pi^S) + (1 + i_{t-1}^*) \frac{b_{t-1}^*}{\pi^* g_T} - b_t^* - \psi_*(b_t^*) \right\} \quad (27)$$

Labor market clearing requires demand for labor by firms in both sectors to equal the sector specific supply of labor.

H. Stochastic Processes for O_t^*

The description of the model is complete once we specify the processes for oil revenues:

$$O_t^* = \rho_1 O_{t-1}^* + \rho_2 O_{t-2}^* + \rho_3 O_{t-3}^* + \epsilon_t^O \quad (28)$$

I. Aggregate GDP

Finally, it is helpful to define aggregate measures of economic activity. We define real gdp as the sum of value added in the two sectors, measured by their steady state prices:

$$y_t = p^N y_t^N + s y_t^T \quad (29)$$

We also define nominal GDP (deflated by the CPI) as follows:

$$Y_t = p_t^N y_t^N + s_t y_t^T \quad (30)$$

IV. MODEL SIMULATIONS

A. Baseline Calibration

Calibration is presented in Tables 1-3. When possible, the calibration of the deep structural parameters of the model, i.e. the parameters that determine the preferences of households, the production technology and the market structure, are chosen to match the structure of the Ghanaian

Table 1. Baseline Calibration, Preference Parameters

Parameters	Value	Source/Method
α_N	0.40	Broadly consistent with National Income Accounts
χ	1.5	Standard value in literature
θ	12	Standard value in literature
\varkappa	0.24	Normalizes aggregate employment to 1 at steady state
ψ	3	Standard value in literature
ϑ^d, ϑ^s	0.9993, 0.9888	Matches Ghana's real money balances in % of GDP
η	1.5	
α_N	0.61	Matches the share of non-traded production in value added (60 %)
ρ_L	1	In line with Horvath (2000).
rem^*	0.4281	Ensures trade deficit equals 31 percent of GDP
β	0.9951	Implies real interest rates equal 8 percent
$\hat{\gamma}$	0.60	

economy. Otherwise, their values are chosen in line with the literature ¹². Of particular interest for our simulation is ρ_L , the elasticity of substitution between labor supplied to different sectors and ϵ , which captures the learning-by-doing effects, since we will experiment with both as part of our sensitivity analysis. For the baseline scenario we assume a low substitutability of labor and no learning-by-doing effects.

¹²See Berg et al. (2010).

Table 2. Baseline Calibration, Technology Parameters

Parameters	Values	Source/Method
<i>Production and Price Rigidities</i>		
α^T, α^N	0.7	Standard value in literature
ϕ^T, ϕ^N	0.33	In line with Arslanalp and others. (2010)
ϵ	0.00001	No learning by doing in the baseline
κ_T, κ_N	25	Ensures smooth impulse responses for investment
g_T	1.0171	Ensures steady state annual growth is (6%)
Z^T	1	Normalization
Z^N	1.044	Ensures the real exchange rate equals one at steady state
δ_N, δ_T	0.015	In line with Bu (2004)
ζ_p^N	30	Implies prices are sticky for 6 moths on average
<i>Distortions and Subsidies</i>		
ϖ	0.3609	Helps match Ghana's investment share (19%)
ι	0.091	Eliminates monopolistic distortion at steady state
<i>Capital Mobility</i>		
ν	10^5	Implies the capital account is closed
$\bar{\theta}^{a*}$	0.2684	

Other parameters are calibrated to match key ratios for the year 2008, which is assumed to represent the steady-state, and are shown in Table 4. Government spending is particularly large in Ghana standing at around 37% of GDP in 2008. Around two thirds of this spending is on government consumption. The steady state inflation rate is set to 18% which is the average inflation rate for 2008. The parameters of the models are set so to meet these and other key variables of the Ghanaian economy shown in Table 4.

For fiscal and monetary policy, the benchmark scenario assumes the following:

- Based on current proven reserves, oil production is expected to be relatively front-loaded with peak production over broadly the first 5 years. IMF staff calculation predicted that government revenues from oil and gas could reach a cumulative amount of US 12 billion during the production period 2012–2030. In our model, the path for oil revenue is similar to the projection, including in present value terms, except that it peaks a couple of years earlier (Figure 4). A key question for the government is whether to spend the oil revenues as they accrue—resulting in front-loaded peak in spending—or whether to smooth out spending to a more sustainable level over the lifetime of the field.
- Regarding the central bank’s foreign exchange operations, the benchmark assumes that (i) it does not pursue an exchange rate target and (ii) all foreign-exchange inflows related to oil production are sold. This implies that the foreign currency proceeds from oil that are not directly spent by the government on imports are made available to the private sector for increasing import production, reducing export production or accumulating foreign assets.
- With respect to monetary policy operations, we assume that the central bank raises the interest rate if inflation exceeds its target but that the tightening is relatively modest. We assume the target is identical to the inflation rate in the base year, i.e., it is set to 18 percent.

Table 3. Baseline Calibration, Policy Parameters, and Aid Process

Parameters	Value	Source/Method
<i>Aid process</i>		
ρ_1, ρ_2, ρ_3	1.33,-0.15,-0.2	Helps match the path of oil revenue
\bar{A}^*	0.1764	Matches current share of aid in GDP (5%)
$var(\epsilon^O)$	0.0780	Oil revenue equals 6 percentage points of GDP in the first year
<i>The Government</i>		
v_1	0.62	
τ	0.59	Matches the current share of government spending (37%)
$\gamma^{\bar{G}}$	0.3514	Matches the current share of public investment (12%)
γ^G	0.3514	Policy parameter
\bar{b}^c	0.03068	Matches the stock of outstanding domestic government debt (16%)
\bar{b}^{cb}	0.0828	Helps match real money balances
δ_g	0.035	Broadly in line with Arslanalp et al. (2010)
ε_s	0.7	In line with Arestoff and Hurlin (2006)
ρ_d	0.95	Policy parameter
\bar{d}^g	0.224	
γ	1	Policy parameter for the experiments
<i>The Central Bank</i>		
ρ_R	0.97	Policy parameter
\bar{R}^*	0.21	Matches Ghana's stock of reserves in % of GDP (11%)
ω	1	Policy parameter for the experiments
ω_e	0	Policy parameter for the experiments
π^*	1.04	Consistent with Ghana's current inflation (18%)
ϕ_π	1.5	Standard value in literature

Table 4. Ghana: Steady State Values

Variables	Value
<i>National Income Accounts in Percent of GDP</i>	
Private Consumption	75
Traded	45
Non-traded	30
Private Investment	19
Traded	7
Non-traded	13
Government Spending	37
Consumption	24
Investment	13
Traded	14
Non-traded	23
Trade Balance	-31
Value added, Traded sector	27
Value added, Non-traded sector	73
<i>Government Accounts in Percent of GDP</i>	
Government Spending	37
Taxes	26
Seigniorage	2
Aid	9
Interest Payments	1
Government Debt	14
<i>Central Bank Balance Sheet in Percent of GDP</i>	
Government debt held by CB	10
Government deposits at CB	2
Reserves	11
Real money balances	20
<i>Private Sector Assets in Percent of GDP</i>	
Net foreign assets	4
Government debt	4
<i>Other Variables</i>	
Annual inflation, nominal depreciation	18
Real GDP growth	6

B. Benchmark Simulation

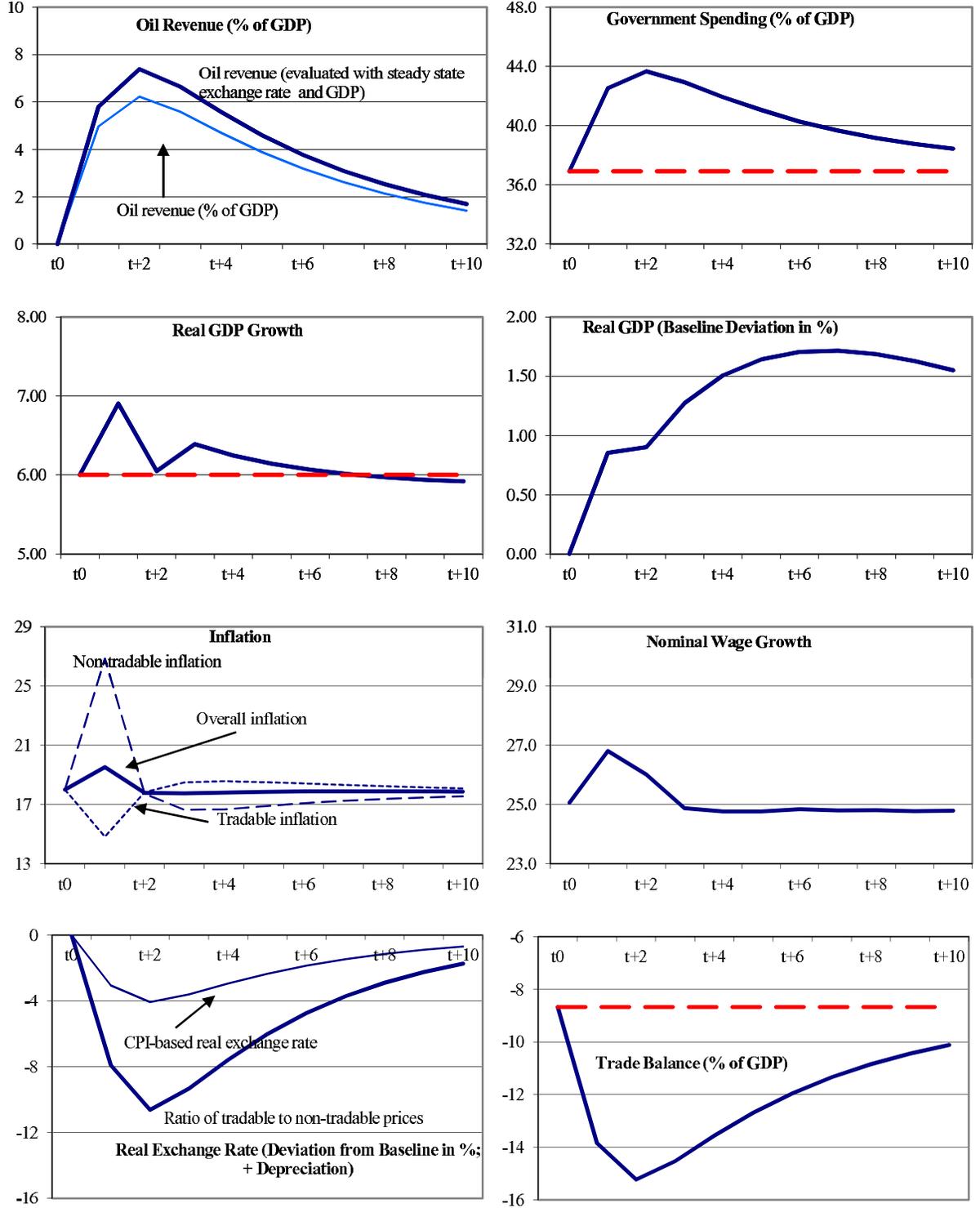
Figure 5 displays the response of key macroeconomic variables to the oil windfall under the benchmark:

- The government spends the oil revenue as it accrues (panel 2).
- The resulting increase in aggregate demand leads to a sharp (but short-lived) spike in real GDP growth (panel 3). There is a persistent effect on real GDP (panel 4).
- Inflation increases moderately, which is accounted for by the increase in non-tradable inflation combined with a decrease in inflation in the tradable sector (panel 5). Nominal wage growth increases in the short run (panel 6).
- The real exchange rate - both measured as the ratio of tradable to non-tradable prices or as the nominal exchange rate deflated by the CPI - appreciates (panel 7). The trade deficits net of oil revenues widens (panel 8), broadly in line with the oil windfall.

To understand the simulation results, it is helpful to distinguish three channels: the inter-sectoral reallocation channel, the nominal rigidities channel, and the medium-term supply-side effects from higher government investment. Regarding the first channel, higher government spending increases the relative demand for non-traded goods, as most of the additional government spending falls on those types of goods (62 percent). Labor demand in that sector increases, which generates pressures the real exchange rate to appreciate to reallocate labor between sector. The real appreciation also contributes to macroeconomic adjustment by shifting private sector demand away from non-traded toward imports and ensure that the trade deficit net of oil revenues increases. Depending on how difficult it is to reallocate labor across sectors, the required real appreciation will be larger. Note that, when prices are flexible, the short term effects from the reallocation of labor has little effect on aggregate variables, such as gdp, employment or real wages, but sizeable effects on sectoral output (as indicated in Figure 6).

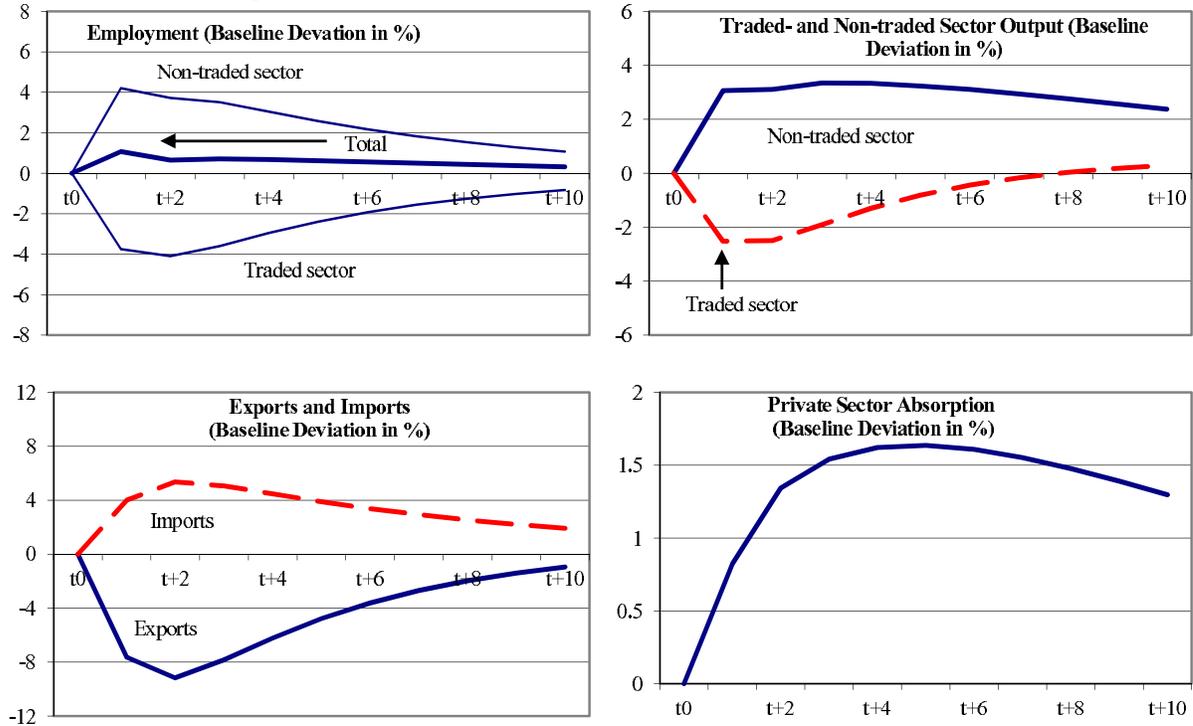
With nominal rigidities in the non-traded sector however, higher government demand for non-traded goods generate an increase in the aggregate demand for labor, as firms in that sector will respond to the increase in demand by hiring more labor regardless of the level of the real exchange rate (in the short run). Aggregate employment and GDP increase, and inflationary pressures in the non-traded sector increase as well. Nominal wages increase, reflecting the increase in real wages and the inflationary pressures. The magnitude of these effects depend on how easy it is to reallocate factors of production across sectors. When labor is not very mobile, firms in the non-traded sector face a steeper sectoral labor supply curve, which generates additional pressures on real wages to increase

Figure 5. Baseline Scenario: Macroeconomic Impact of the Oil Windfall



and create stronger aggregate-demand pressures. The magnitude of these aggregate-demand effects also depends critically on the monetary policy reaction function.

Figure 6. Baseline Scenario: The Transmission Mechanism



Finally, the medium term effects on GDP depend on the impact of public investment on the productive capacity of the country. Given our calibration, both sector benefit from these effects.

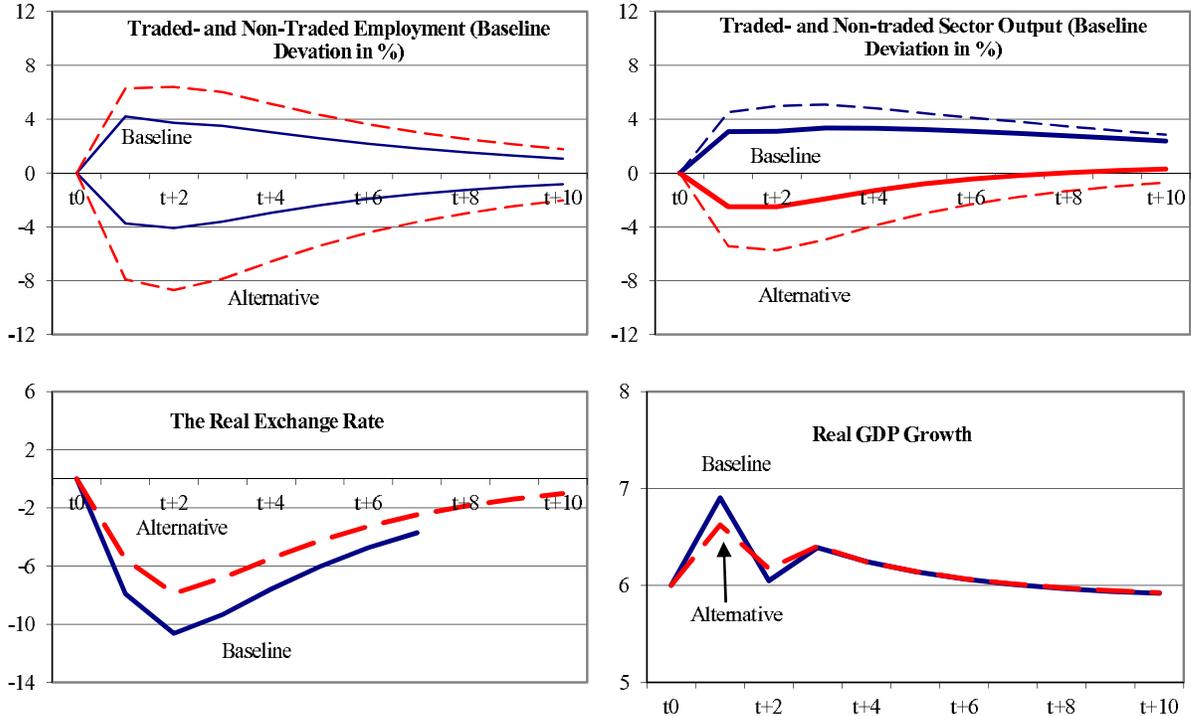
Holding the monetary policy rule constant, higher inflation and the real appreciation are thus important parts of the required macroeconomic adjustment. Unlike the real appreciation however, an increase in inflation is not an inevitable part of the transmission mechanism but is a result of the aggregate-demand pressures that can arise from a rapid increase in spending and the monetary policy stance. We will later see how different fiscal and monetary policy responses affect the resulting inflation and real exchange rate appreciation.

C. Sensitivity Analysis

One of the key parameters governing the macroeconomic response to spending of the oil windfall is the elasticity determining the substitutability of labor between the tradable and non-tradable sectors. The lower this elasticity is, the more difficult it is to shift labor from one sector to the other, i.e., doing so requires larger price movements. For the benchmark, this elasticity has been set to 1; Figure 7 illustrates the effect of raising the elasticity to 5. With a larger elasticity, labor migrates more easily from the tradable to the non-tradable sector (panel 1 of figure 7). The impact on the production in the tradable and non-tradable sector is more significant than in the benchmark scenario. As it easier to

reallocate production across sectors, demand pressures are smaller, which results in a smaller spike in output growth in the first year. The increased flexibility on the labor market reduces the magnitude of the real appreciation required for this reallocation.

Figure 7. Higher Substitutability of Labor Between Sectors



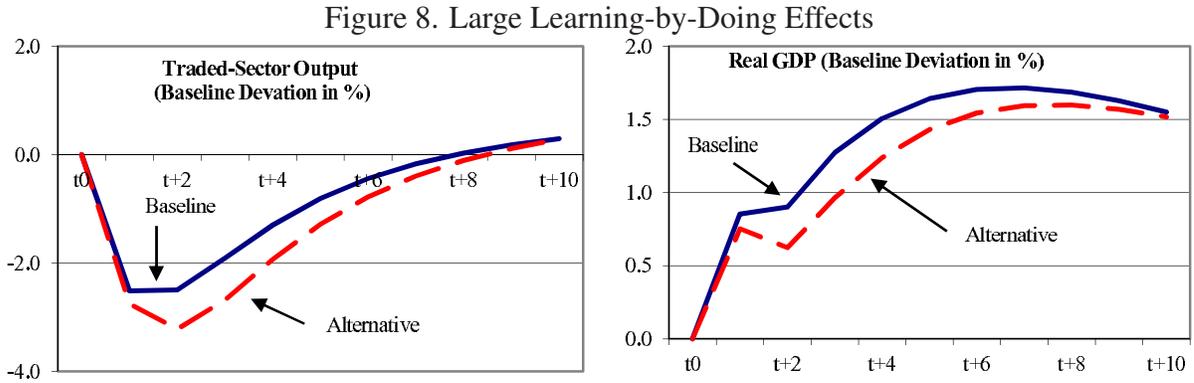
D. Dutch Disease Effects

The earlier simulations showed a temporary shrinkage in the tradable sector (relative to its trend path), which resulted from the reallocation of labor from the tradable to the non-tradable sector. As such, this contraction is an equilibrium outcome. However, if the tradable sector is a special source of productivity growth, as it is sometimes argued in the literature on dutch disease for reasons related to productivity advances being more likely in the manufacturing sector, then the shrinkage of the tradable sector could lead to a permanent or persistent loss in productivity. The last outcome is indeed undesirable. We will refer to the latter effect as representing 'Dutch disease' effects. So far this factor was not taken into account, as the learning-by-doing factor was not incorporated in the benchmark simulation. However this factor could be studied in the context of this model. To give a special, productivity enhancing role to the tradeable sector we assume that increases in the size of the tradable sector have an impact on overall productivity. This is done by endogeneizing the level of

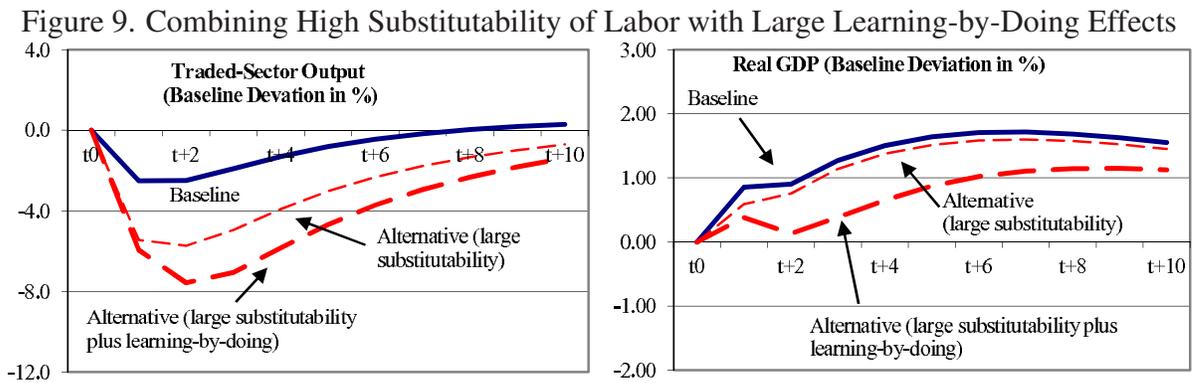
productivity in the traded sector as follows:

$$Z_t^T = \bar{Z}^T (y_{t-1}^T)^\epsilon \tag{31}$$

The larger this sector is, the larger is multifactor productivity in the sector. When the tradable sector shrinks however, the overall productivity decreases too, thus leading to a potentially long-term negative impact on the growth rate of the economy.



In the benchmark specification, the parameter ϵ was set to zero. Figure 8 shows the effect of switching these effects 'on', i.e., by choosing a positive epsilon (0.2). In the presence of such externalities, the impact on output from higher public investment is smaller, and the contraction in the traded sector more pronounced (panels 1 and 2). While the effect on GDP is smaller, it would be larger if less of the oil windfall were used for public investment. Alternatively, the simulation above assuming a large substitutability of labor between sectors yielded a large and sustained decline in the tradable sector. Figure 9 adds large learning-by-doing effects to this specification. Combining these two assumptions now leads to a more substantial Dutch disease effect, with output considerably below its trend. These output losses do not outweigh the benefits of the oil windfall, since overall GDP is still above its baseline levels.



These simulations yield three lessons:

- Dutch disease effects do not necessarily need to be large. They depend on the extent to which

the tradable sector shrinks, which in turn is a function of a number of parameters. For example, a limited substitutability of production factors between the tradable and non-tradable sectors curbs the extent to which the first declines when an oil windfall occurs and therefore also contains the Dutch disease effects; the downside is that limited substitutability also implies large wage pressures, higher inflation, and a more pronounced real appreciation.

- Policy measures that bolster the tradable sector limit the overall Dutch disease effects as well. In the benchmark simulation, public investment spending leads eventually to an increase in the size of the tradable sector relative to baseline, at which point Dutch disease effects disappear. In fact, the same mechanism that yields Dutch disease effects when the sector shrinks generates positive productivity effects when the sector expands due to public investment.
- Even if large Dutch disease effects occur, these do not necessarily outweigh the benefits from the oil windfall. Of course, the analysis here applies only one specific mechanism for simulating Dutch disease effects. Alternative mechanisms, e.g., linking the size of the tradable sector to the productivity growth rate instead of the level, could yield much larger effects, in which case it would be more likely that Dutch disease effects outweigh oil windfall benefits.

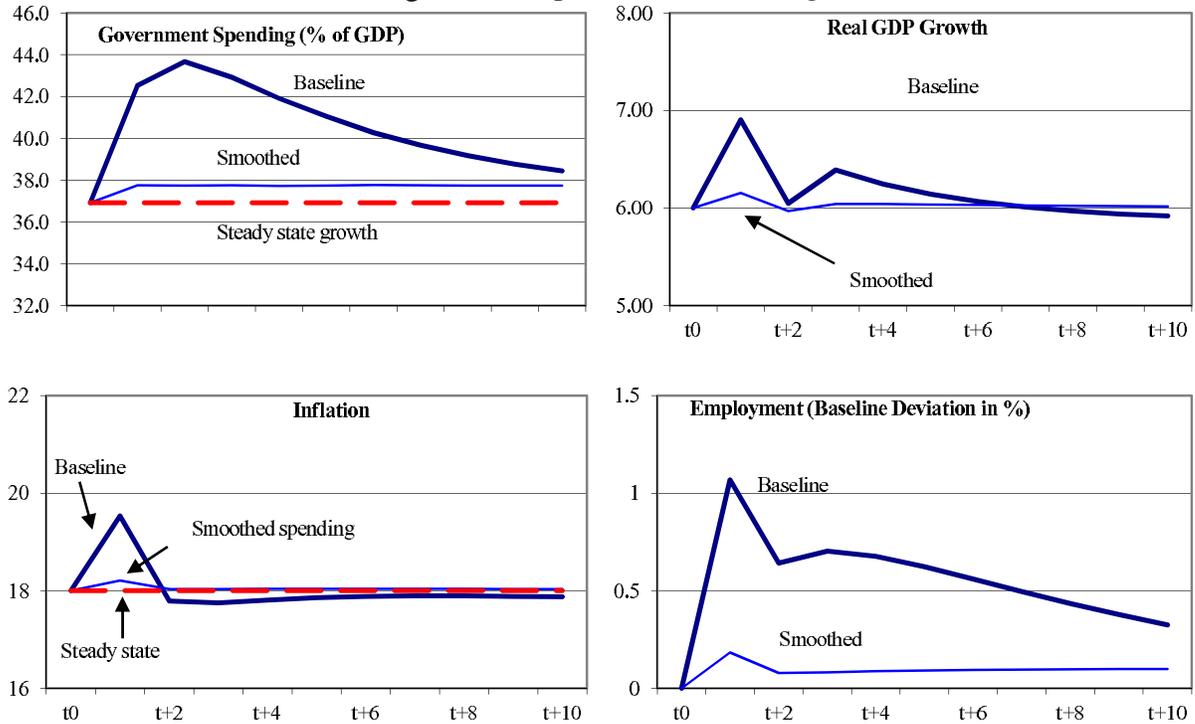
V. FISCAL AND MONETARY POLICY OPTIONS FOR MANAGING THE OIL WINDFALL

A. Fiscal Policy Options

1. Expenditure Smoothing

The benchmark assumes full spending of all oil windfall revenue as soon as it accrues, but it is not obvious that this would be the optimal, or even natural, policy choice. The permanent income hypothesis, for example, would suggest to spend only the permanent component of the oil windfall revenue, i.e. to limit spending increases to an amount that can be sustained over time. More generally, if consumers dislike consumption volatility, and the government shares their preferences, expenditure smoothing would be the optimal choice. Figure 10 implements a spending scenario that roughly corresponds to the permanent income hypothesis: instead of increasing spending to 6 percent of GDP and then gradually decreasing it, spending is increased by only 1 of GDP but is permanently sustained at this level. Not surprisingly, the macroeconomic impact of this scenario is small and avoids the large demand-driven boom that occurs in the first two years in the benchmark scenario. In sum, this scenario has two benefits: (i) it spreads the benefits of the oil windfall over time, which is consistent with the consumption decision of optimizing, forward-looking consumers, and (ii) it avoids the macroeconomic volatility that characterizes the first years of the benchmark scenario.

Figure 10. Expenditure Smoothing



2. Expenditure Composition

We return to the case without spending smoothing. We now explore the implications of two variations to the specification:

- Lower government spending on non-tradables; or
- Higher spending in investment.

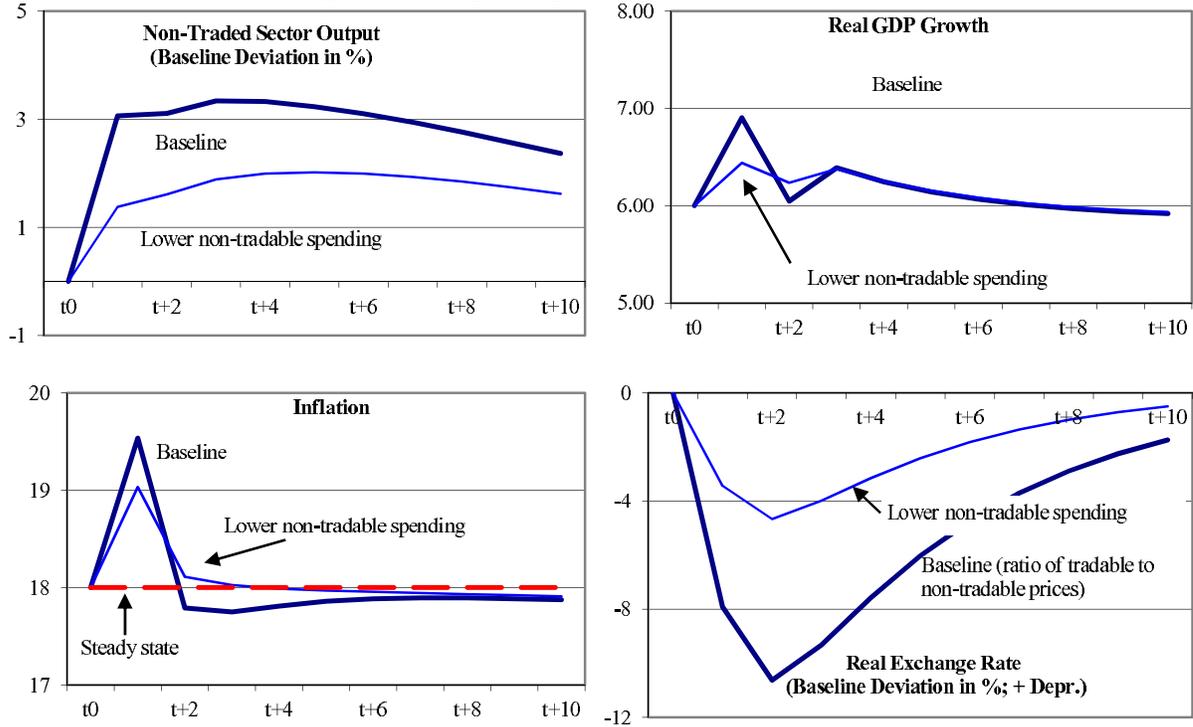
Lower Non-Tradables Government Spending Share

In this scenario, the share of government spending out of oil revenue on non-tradables is reduced from 62 percent in the baseline to 40 percent. The results are shown in Figure 11. Reducing the share of government spending on non-tradables is equivalent to increasing the import share of spending. As a result, higher government demand can be met more easily through imports, requiring less of a real appreciation (panel 4) for shifting resources from the tradable to the non-tradable sector and for redirecting private sector demand from non-tradables to imports. In fact, if all government spending were directed towards tradables, there would be practically no pressure for the exchange rate to appreciate.

Less government spending on non-tradables reduces demand pressures in this sector, which dampens the short-term non-tradables output boom (panel 1), as well as wage pressures and the increase in

non-tradables inflation (panel 3). Lower demand implies also less need for private sector capital accumulation in the non-tradable sector, yielding a smaller increase in private sector investment. Taken together, the smaller boom and capital accumulation reduce the overall real GDP growth response compared to the baseline simulation (panel 2).

Figure 11. Higher Spending on Non-Tradeables



Overall, reducing the spending share on non-tradables has the effect of smoothing the path for key macroeconomic variables. This is not surprising, given that higher government demand for non-tradables is at the center of the transmission mechanism in the baseline simulation. From a policy perspective, focusing spending on projects that are likely to have a high import content can be useful if the real appreciation of the currency or bottlenecks in the non-tradable sector are a concern.

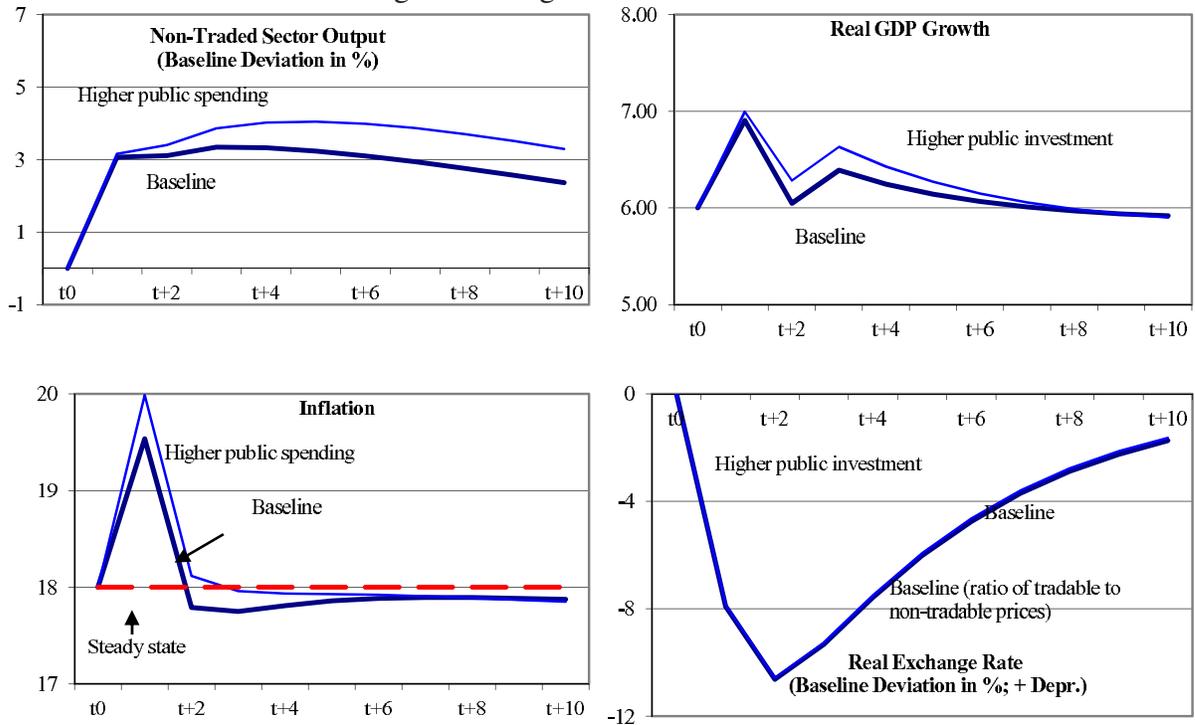
Increasing the Public Investment Share

We assume that the share of oil-financed government spending on productive investment goes from 35 percent to 60 percent. Higher public capital accumulation boosts the overall growth response (Figure 12, panel 2), benefiting both the tradable and non-tradable sectors (panel 1). This is mostly the result of the direct effect of higher capital accumulation raising the production potential. In addition, the increase in the public capital stock lifts the productivity of private capital and triggers higher private investment, leading to a crowding in effect on private capital.

The real exchange rate appreciation is similar (panel 4), as the relative performance of the traded sector and non-traded sector does not change. On the other hand, wealth effects associated with

higher output result in an increase in aggregate demand in the first year, resulting in an increase in inflation relative to the baseline.

Figure 12. Higher Public Investment



In sum, using oil revenue for public investment is a powerful tool for boosting the medium-term output gains stemming from Ghana's oil wealth. Moreover, if Dutch disease effects are likely to be significant, an increase in public investment can be used to offset the decline in productivity in the tradable sector due to Dutch disease. Together with focusing spending on items with a high import content, these are potentially effective fiscal policy tools to mitigate Dutch disease effects.

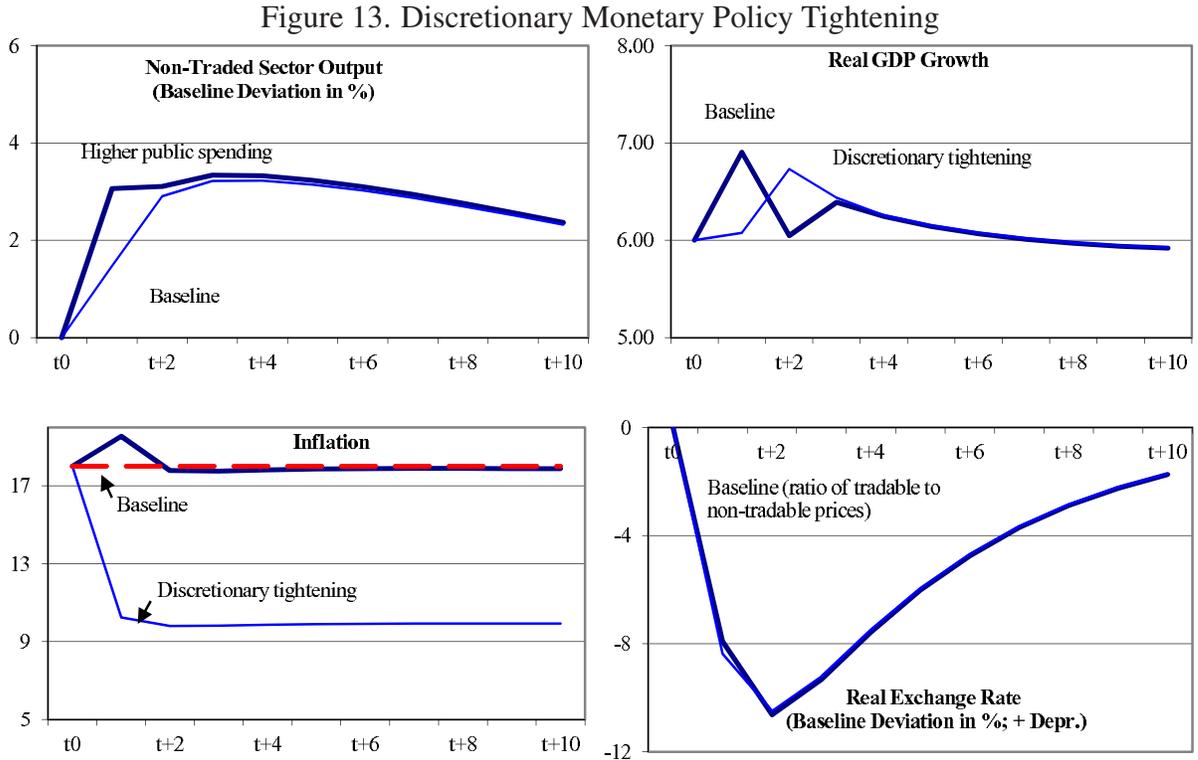
B. Monetary Policy Options

Monetary Policy is confronted to a minor increase in inflation—but starting from an excessively high level—and a moderate real appreciation. We now explore the implications of two alternative monetary policy responses.

1. Discretionary Policy Tightening

The projected increase in oil revenues come at a time where inflation remains high (18 percent). We now explore what happens when the central bank decides to reduce inflation to a new lower target (10 percent). We assume the decrease in the target comes as an initial surprise to economic agents in

the model, so that the decrease in inflation target implies a discretionary policy tightening and leads to a temporary reduction in aggregate-demand. The decrease in the target is perceived as credible once inflation is reduced to its new target. In this scenario, the monetary policy tightening leads to lower GDP growth in the short run, which is then moved forward to the second year (see Figure 13), with a more gradual increase in non-traded production and a similar real exchange rate appreciation.



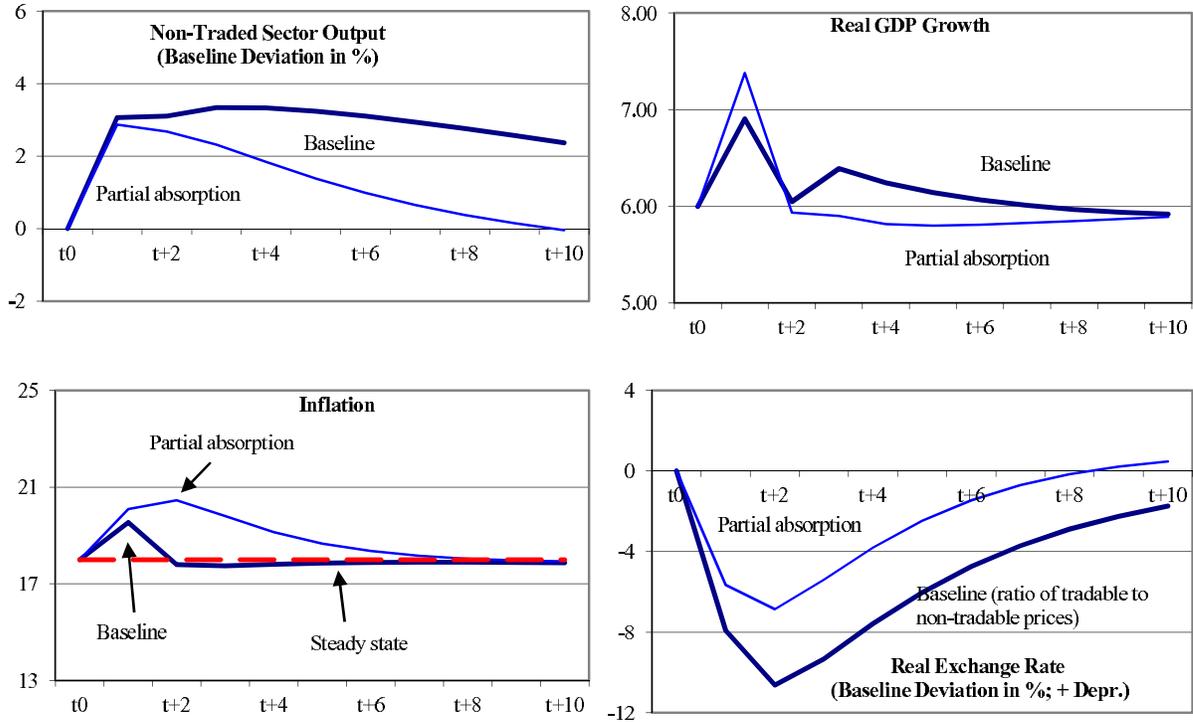
These results imply a reduction in the inflation target is relatively costless. This is due to the fact that nominal rigidities are relatively small in the model, so that discretionary changes in monetary policy have a short-lived effect. Inflation expectations also adjust relatively quickly (after one year), which implies monetary policy credibility is relatively easy to acquire. For these reasons, these projections are optimistic, and should be therefore interpreted with caution.

2. Reducing Foreign Exchange Sales

In the baseline, the small impact on inflation is driven by the real appreciation, which reduces the domestic currency price of traded goods and offsets the increase in non-traded inflation. The real appreciation also amplifies the expenditure switching effects and therefore reduces demand pressures in the non-traded sector. This real appreciation is driven by the increase in the demand for non-traded goods—caused by the increase in government spending—and the sale of the foreign currency in the FX market from the oil proceeds.

If the central bank decides to accumulate part of the foreign currency proceeds from oil as reserves, to reduce the real appreciation, while the government continues to spend the local currency counterpart, the macroeconomic impact changes considerably (Figure 14). Under the assumption that 50 percent of the oil proceeds are now accumulated as reserves, the impact on GDP is higher in the short term but considerably lower in the medium term. While the real exchange rate appreciation is smaller, inflation increases considerably.

Figure 14. Reserve Accumulation



The above results can be explained as follows. First, the smaller real appreciation reduces expenditure switching effects, which aggravates the demand pressures associated with the fiscal expansion. Short run growth is higher and inflation increases considerably. Second, the sterilized accumulation of reserves raises real interest rates, which leads to the crowding out of private investment (and consumption), which reduces the magnitude of the output expansion in the medium term. This scenario is akin to a domestically-financed fiscal expansion, with similar implications for aggregate-demand and private sector crowding out.

This scenario highlights the importance of fiscal/central bank policy coordination: to the extent there is reserve accumulation, it should be supported by fiscal savings. Otherwise, the private sector will have to bear the brunt of the adjustment.

VI. CONCLUSION

Ghana is on the verge of becoming an oil-producing country, with oil production expected by the end of 2010. This paper studied the impact of oil windfalls on the Ghanaian economy using a dynamic general equilibrium model that is suitable for the analysis of low-income countries. As oil revenues accrue directly to the government, the oil shock translates into higher government spending. Given that size of the government is already large in Ghana it is important to evaluate quantitatively the overall impact on the main macroeconomic aggregates and on price levels. The model is calibrated to the Ghanaian economy. One of the main advantages of this model is that it incorporates both short- and medium-term effects.

Our findings highlight the role of different public policies—and their interaction—for the macroeconomic impact of oil proceeds. In the short run, an increase in government spending need not increase short run inflation beyond its current level: the simulations suggest that, under the current composition of government spending between the tradable and non tradable sector, the impact on inflation is likely to be moderate. However, the risks are high if the government were to increase the non-tradable component of its spending.

Simulations highlight the role of the real exchange rate in the adjustment process. In principle, the resulting real appreciation can lead to a persistent decline in productivity if there are learning-by-doing externalities in the traded sector. However, the simulations suggest this effect can be offset by increases in productive public capital.

We have also assessed what would happen if the central bank were to simultaneously tighten monetary policy to bring inflation down to a lower target. We show this would result in lower output growth in the short run and slightly larger real appreciation. Finally, our results indicate that reserve accumulation when government spending increases would amplify aggregate-demand pressures and would result in higher inflation.

We have abstracted from formally analyzing the role of proper fiscal institutions for managing the oil wealth. Implicitly we have assumed that the country would be capable, from an institutional point of view, of absorbing relatively large increases in public investment. In practice, limitations in implementation capacity could result in a smaller accumulation of public capital. We do not treat this issues directly, although the discussion on the importance of public investment, in section 5, is consistent with this view.¹³

¹³See Aydin (2010) for a discussion on how Ghana compares with middle and lower income countries in terms of institutional quality.

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