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The Impact of High Oil Prices on African Economies

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This Working Paper is developed from a Bank study prepared by Désiré Vencatachellum, Principal Research Economist in the Development Research Department (Task Manager), under the supervision of Abdul B. Kamara (Manager, Research Division, Development Research Department). The report is based on a consultancy report prepared for the African Development Bank by H. Bouakez (a Consultant and Assistant Professor of Economics, Institut d'Economie Appliquée, HEC Montreal, Université de Montréal).

African Development Bank
Angle des trois rues: Avenue du Ghana, Rue Pierre de Coubertin, Rue Hédi Nouira
BP. 323
1002 Tunis Belvedere
Tunisia
TEL: (+216) 71 10 34 87
FAX: (+216) 7110 37 79
E-MAIL: afdb@afdb.org

Abstract

On the one hand the high price of oil is a unique opportunity for African oil producers to use the windfall gains to speed up their development. On the other hand, it is having adverse effects on net-oil importing countries, in particular those which cannot access international capital markets to smooth out the shock. We construct a dynamic stochastic general equilibrium model, which is tailored to reflect the characteristics of African economies, to quantify the effect of the increase in the price of oil on the main macro economic aggregates. The model is general enough that it imbeds both oil producing and oil importing countries. Our results indicate that a doubling of the price of oil on world markets with complete pass through to oil consumers would lead to a 6 per cent contraction of the median net-oil importing African country in the first year. If that country were to adopt a no-pass through strategy, output would not be significantly affected but its budget deficit would increase by 6 per cent. As for the median net oil exporting country, a doubling in the price of oil would mean that its gross domestic product would increase by 4 percent under managed-float and by 9 percent under a fixed exchange rate regime. However, inflation would increase by a much greater magnitude under managed than a fixed exchange rate regime in a median net oil exporting country.

Key words: Oil Shock, Africa, Pass Through
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1. Introduction

While a barrel of crude oil was trading between $18 and $23 in the 1990s it crossed the $40 mark in 2004 and traded at around $60 from 2005. During the summer and fall of 2007, the price of one barrel of crude oil jumped above the $70 mark and even reached $80. Although, in real terms, the price of oil is still lower than in the late 1970s and early 1980s, the recent upsurge can have dramatic consequences on oil-importing countries. The impact of high oil prices is likely to be even more severe in countries that are overly dependent on oil and/or have limited access to international capital markets. This description characterizes many African economies.

Net-oil importing countries have explored a number of policy options to cushion their economies from the adverse impact of the high price of oil. In 2006 the African Development Bank (AfDB) implemented a survey to investigate the extent to which governments of its Regional Member Countries (RMCs) have intervened on the retail market for fuel to limit the pass-through of international oil prices. Out of the 24 RMCs on which we have data, 20 had legislation in place to control the retail price of gasoline and only 4 had full pass-through. As a result, while the price of oil had nearly doubled between 2000 and 2005, domestic prices have increased at a much slower pace. For example, the price of regular gas increased by 65 percent in Benin, 76 percent in Mali and 77 per cent in Mauritius. Interestingly, the retail price of price was even inversely correlated with the world price of crude oil for some period (e.g. Mauritius). Moreover, the survey indicates that governments subsidize, or limit the pass through of, kerosene more than other types of fuel on the grounds that it is consumed by the poor.

Further evidence of government intervention in the fuel market is provided by a 2006 World Bank survey conducted in 36 developing countries. 14 were found to have suspended market-based pricing to avoid full pass through of the world price of oil to domestic customers (ESMAP, 2006). In addition, 12 others were already controlling fuel prices which meant that they were pricing fuel below the true international market equivalent. More recently, Baig et. al. (2007) find that only half of 44 developing and emerging market countries have fully passed-through the increase in international fuel prices to consumers between 2003 and 2006.

As for oil-exporting countries, they stand to benefit from the significant influx of foreign revenue which they could harness for their development. They are challenged to manage the oil windfalls for the benefit of the whole population, as well as future generations, and cushion their economies against any Dutch disease. However, the benefits of the high price of oil are not evenly spread across Africa. The 5 top oil-producing countries (Nigeria, Algeria, Libya, Angola and Egypt) account for more than 80 per cent of the continent's production. At approximately $60 dollars per barrel of oil, the average present value of oil reserves is $33,000 for each resident of an oil-producing African country. Oil-producing countries with small population, which in addition are currently quite poor, stand to benefit substantially on a per capita basis. While oil-exporting countries obviously benefit from high oil prices, economies that are heavily reliant on oil exports can become vulnerable to the Dutch disease. Again, this is the case of most African oil-exporting countries.

While there is a large literature on the macroeconomic effects of oil-price shocks, most are based on vector autoregression (VAR) models (see for example Hamilton (1996) and Bernanke, Gertler and Watson (1997)). Although these models are useful to characterize the statistical relationships between economic variables and to establish relevant stylized facts, they lack economic content and do not reveal mechanisms through which shocks propagate. In addition, the reduced-form nature of VAR models renders them subject to the *Lucas critique*. To the best of our knowledge, only a handful of studies analyze the effects of oil-price shocks within a dynamic stochastic general equilibrium (DSGE) framework. Notable examples are Rotemberg and Woodford (1996), Backus and Crucini (2000), Leduc and Sill (2004), and Medina and Soto (2005). Moreover, none of these earlier papers is concerned with effects of oil prices or is specific to the context of African economies.

This paper departs from the existing literature by using a DSGE model to study the quantitative effects of oil-price shocks on oil-importing and oil-exporting African economies. Our model belongs to the class of new open-economy macroeconomic models, which have become the main tool used in modern international macroeconomics. The model developed in this paper is more general than these earlier ones and is better suited for the African economies. Our model is one of a small open economy that shares some features with the models developed by Kollmann (2001), Bergin (2003), and Bouakez and Rebei (2005).

Our results indicate that a doubling in the world price of oil can lead to an important loss in output and consumption and to higher inflation in oil-importing countries, especially if these countries operate under a fixed exchange rate regime. The adverse effect on output, however, can be mitigated through government intervention or through foreign aid. More specifically, our results indicate that a doubling of the price of oil with complete pass through would lead to a 6 per cent contraction of the median net-oil importing African country in the first year. If that country were to adopt a no-pass through strategy, output would not be significantly affected but its budget deficit would increase by 6 per cent. As for the median net oil exporting country, a doubling in the price of oil would mean that its gross domestic product would increase by 4 percent under managed-float and by 9 percent under a fixed exchange rate regime. However, under inflation would increase by a much greater magnitude under managed than a fixed exchange rate regime in a median net oil exporting country.

Government intervention limits the degree of pass-through from the world price of oil, which shields the economy from higher input costs. To the extent that the government relies mostly on public debt to finance its expenditures, this policy will translate into a higher budget deficit and a larger consumption loss. As for foreign aid, the model predicts that the amounts needed to offset the output loss associated with higher oil prices are fairly small. In oil-exporting countries, a doubling in the world price of oil generates a sizable increase in output and consumption. The effect on inflation depends on which exchange rate regime is in effect. The expansionary effects of oil-price shocks are accompanied by a sharp appreciation of the real exchange rate, which can be harmful if the economy is heavily concentrated in a few industries.

The remainder of the paper is structured as follows. Section 2 describes the model. Section 3 describes the main results regarding the effects of an oil-price shock. Section 4 discusses the policy implications of these results. Section 5 concludes and discusses possible future extensions of the model.

2. Literature Review

There are few studies that analyze the effects of oil-price shocks for African countries. Ayadi, Chatterjee and Obi (2000) study the effects of oil production shocks in Nigeria. A standard Vector Auto-Regression (VAR) process including oil production, oil exports, the real exchange rate, money supply, net foreign assets, interest rate, inflation, and output is estimated over the 1975-1992 period. Empirically, the response of output is positive after a positive oil production shock. Moreover, the impact response of output is less than one fifth of that of oil production, but the response of output after a year is slightly larger than that of oil production. The response of inflation is negative after a positive oil production shock. The impact response of inflation is negligible relative to that of oil production, but the response of inflation after a year is more than two times larger than that of oil production. The response of the real exchange rate is generally positive after a positive oil production shock, indicating a real depreciation of the Naira. The impact response of the real exchange rate is negligible relative to that of oil production, but the response of the real exchange rate after a year is around two times larger than that of oil production. To the extent that an oil price increase leads to an oil production increase, the responses suggest that output increases, inflation decreases, and the national currency depreciates following a positive oil-price shock.

Ayadi (2005) uses a standard VAR process to analyze directly the effects of oil-price shocks for Nigeria over the 1980-2004 period. This VAR process includes the same set of variables as in Ayadi, Chatterjee and Obi (2000), except that the oil production variable is replaced by oil prices. Unfortunately, the responses of the macroeconomic variables to an oil-price shock are not reported. Nevertheless, it is likely that the responses of output, inflation, and the real exchange rate are small following an oil price shock. This can be deduced from the small contributions of the oil price shock to the variance decompositions of output, inflation, and the real exchange rate. More precisely, the contributions of the oil price shock to the variance of output are 1 percent at impact and about 7 percent after a year. The contributions of the oil price shock to the variance of inflation are less than 1 percent at impact and after a year. The contributions of the oil price shock to the variance of the real exchange rate are 0 percent at impact and 5 percent after a year. In comparison, the contributions of the oil-price shock to the variance of oil prices are 100 percent at impact and about 97 percent after a year.

Finally, Semboja (1994) studies the effects of oil price changes for Kenya, which is a net importer of oil. For this purpose, he calibrates a static computable general equilibrium model to obtain the impact responses, rather than estimating a VAR process to generate the dynamic responses. The impact responses suggest that an increase in oil prices lead to an increase of the trade balance, a decrease of output and of the price index, and a deterioration of the terms of trade.

More recently, international financial institutions and development banks have produced estimates of the impact of high oil prices on the world and regional economies. IMF estimates indicate that highly-indebted oil-intensive and fragile sub-Saharan African countries would suffer the most from higher oil prices. According to its estimates, they would lose more than 3 percent of their GDP following a $5 increase in the price of crude oil (International Energy Agency, 2004).[*] The World Bank, using the MULTIMOD model, estimates that a $10 increase in the price of oil, from a baseline of $23/bbl, would mean that net-oil importing countries with per capita income below US$ 300 for 1999-2001 would lose 1.47 percent of their GDP. Some of the lowest income countries would be even worse off losing 4 percent of their GDP (ESMAP, 2005 and UNDP/ESMAP, 2005). Were oil prices to increase by US$20 then the effect on GDP would be doubled.

These estimates are however subject to a number of limitations. The World Bank estimate is based on the ratio of the net oil and oil products imports to GDP assuming there is a zero price elasticity of demand for oil and oil products. Under this assumption, following a rise in the oil price, GDP changes by as much as the change in the value of net imports. This linear relation is simple but, as recognized by the authors themselves, is limited (UNDP/ESMAP, 2005). First, it assumes no microeconomic adjustments to the oil shocks, and that the response is entirely by a reduction in oil absorption. Second, economies gradually adjust to large changes and this can offset some of the severity of the initial oil shock.

A few papers have explored the distributional impact of an increase in the price of oil. Nicholson et al. (2003) find that a 100 percent increase of oil prices lead to 2 percent increase of the average household's expenditure in Mozambique. Coady and Newhouse (2005) using data from Ghana

[*] The countries which fall into this group is not given.

report that a 20 percent increase in average oil prices leads to 3.4 percent fall in average real income. In Mali, Kpodar (2006) calculates that a 34 percent rise in the prices of all oil products lead reduces real income of the poorest by to 0.9 percent and the income of richest households by 1 percent.

3. The Model

3.1. Overview of the Model

The economy consists of households, firms, a government, and a monetary authority. There are four types of goods: a final good, a composite non-oil good, oil, and intermediate goods. The production sector of the economy is summarized in Figure 1.

The final good, which serves consumption and investment purposes, is produced by perfectly competitive firms using oil and a non-oil composite good as inputs. The non-oil composite good is produced by mixing domestically produced and imported intermediate goods. Domestic intermediate goods are produced by monopolistically competitive firms that use domestic labor and capital as inputs. Domestically produced intermediate goods are also exported to the rest of the world. Export prices are denominated in foreign currency (dollars). Foreign intermediate goods are imported by monopolistically competitive importers at the world price. These goods are then sold to local firms at domestic-currency prices. Prices set by monopolistic firms are costly to change, and are thus sticky. Price stickiness in import and export prices causes the law of one price to fail, and leads to movements in the real exchange rate.

Oil used to produce the final good is either imported or locally produced, depending on wether the country is a net importer or a net exporter of oil. In oil-importing countries, the government practices local currency pricing (LCP), buying oil at the world price, P_t^{o*}, and reselling it to domestic firms at the domestic price P_t^o, In oil-exporting countries, it is assumed that the oil industry is owned by the government, which sells oil to the rest of the world at the world price, P_t^{o*}, and to domestic firms at the domestic price, P_t^o. These two prices need not be identical even after converting the world price to domestic currency. Depending on how the government sets P_t^0, pass-through from the world price to the local price of oil will be complete or incomplete. In the model, the government follows a rule that can yield any degree of pass-through from zero to 100%.

The government finances its expenditures mostly by issuing public debt. On the other hand, access to international financial markets can be limited, depending on the severity of credit constraints that a given country faces. Countries that have only limited access to international financial markets cannot buffer shocks and smooth consumption by resorting to international borrowing. This feature is captured in the model by assuming portfolio-adjustment costs that are quadratic in the stock of foreign debt.

The monetary authority sets the nominal interest rate according to a Taylor-type rule, which is general enough to encompass practically all possible monetary-policy/exchange rate regimes. In particular, the rule nests fixed exchange rate regimes and managed floats, which characterize the vast majority of African economies.

The rest of this section provides a detailed description of the model, derives the first-order conditions, and describes the equilibrium. Throughout the paper, variables that originate in the rest of the world are denoted by an asterisk, and variables that do not have a time subscript refer to steady-state values.

3.2 Households

The representative household maximizes its lifetime utility given by

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, m_t, h_t), \tag{1}$$

where β is the subjective discount factor (0<β<1), u is the instantaneous utility function, c_t is consumption, m_t denotes real money balances held at the end of period t, and h_t denotes hours worked by the household.[†] The instantaneous utility function is assumed to be

$$u(.) = \frac{\gamma}{\gamma - 1} c_t^{\frac{\gamma-1}{\gamma}} + \frac{\eta}{\eta - 1} m_t^{\frac{\eta-1}{\eta}} + \varpi \log(1 - h_t), \tag{2}$$

[†]In each period, the household's total endowment of time is normalized to unity.

where $m_t = M_t/P_t$, with M_t being the nominal money stock and P_t the price of the final good; and γ, η and ϖ are positive parameters.

The representative household enters period t with M_{t-1} units of domestic money, B_{t-1} government bonds, B^{*}_{t-1} foreign-currency non-state-contingent bonds, and a stock of capital, k_t. In period t, the household pays a lump-sum tax, T_t, to the government and receives dividends, D_t, from monopolistic firms. It also receives total factor payments of $W_t h_t + Q_t k_t$ from selling labor and renting capital to domestic intermediate-good producers, where W_t and Q_t denote the nominal wage and rental rates, respectively. The household's income in period t is allocated to consumption, investment, money holdings, and the purchase of nominal bonds. Acquiring foreign bonds entails paying (nominal) portfolio-adjustment costs:[‡]

$$\frac{\psi_b}{2} e_t P_t^{*} \left(\frac{B_t^{*} - B^{*}}{P_t^{*}} \right)^2$$

where ψ_b is a positive parameter and e_t is the nominal exchange rate defined as the number of units of domestic currency needed to purchase one unit of foreign currency. Investment, i_t, increases the household's stock of capital according to

$$k_{t+1} = (1-\delta) k_t + i_t, \tag{3}$$

where $\delta \in (0,1)$ is the depreciation rate of capital. Investment is subject to quadratic adjustment costs:

$$\frac{\psi_k}{2} \left(\frac{i_t}{k_t} - \delta \right)^2 k_t ,$$

where $\psi_k \geq 0$. The household's budget constraint is given by:

$$P_t(c_t + i_t) + B_t + e_t B_t^* \leq W_t h_t + Q_t k_t + R_{t-1} B_{t-1} + e_t R_{t-1}^* B_{t-1}^* + D_t + T_t - \frac{\psi_k}{2} P_t \left(\frac{i_t}{k_t} - \delta \right)^2 k_t - \frac{\psi_b}{2} e_t P_t^* \left(\frac{B_t^* - B^*}{P_t^*} \right)^2, \tag{4}$$

where $D_t = D_t^d + D_t^m$, with D_t^d being dividends received from domestic intermediate-good producers and D_t^m those received from importers of foreign intermediate goods, R_t denotes the gross domestic nominal interest rate, and R_t^* denotes the gross world nominal interest rate.

The representative household chooses $c_t, h_t, M_t, B_t, B_t^*$, and k_{t+1} to maximize its lifetime utility subject to its budget constraint (4), the capital accumulation equation (3), and a no-ponzi-game condition on its holdings of assets. The household's first-order conditions are

$$\lambda_t = c_t^{-\frac{1}{\gamma}} \tag{5}$$

$$\omega_t = \frac{\varpi (1 - h_t)^{-1}}{\lambda_t} \tag{6}$$

$$\lambda_t = \beta E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \right) + m_t^{-\frac{1}{\eta}} \tag{7}$$

$$\lambda_t = \beta R_t E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \right) \tag{8}$$

$$\lambda_t = \beta R_t^* \left(1 + \psi_b \frac{B_t^* - B}{P_t^*} \right)^{-1} E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \frac{e_{t+1}}{e_t} \right) \tag{9}$$

$$\lambda_t = \frac{\beta E_t \left\{ \lambda_{t+1} \left[1 + q_{t+1} - \delta + \psi \left(\frac{i_{t+1}}{k_{t+1}} - \delta \right) + \frac{\psi}{2} \left(\frac{i_{t+1}}{k_{t+1}} - \delta \right)^2 \right] \right\}}{1 + \psi \left(\frac{i_t}{k_t} - \delta \right)} \tag{10}$$

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‡Without portoflio-adjustment costs, the model would have a unit root because the bond holdings process would follow a random walk.

where λ_t is the Lagrange multiplier associated with the budget constraint expressed in real terms; $w_t \equiv W_t/P_t$ is the real wage; $q_t \equiv Q_t/P_t$ is the real rental rate; and $\pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate between t-1 and t.

3.3 Production

3.3.1 Final good

Firms in the final-good sector are perfectly competitive. They combine oil and a non-oil composite good to produce a single homogenous good using the following constant elasticity of substitution (CES) technology:

$$y_t = \left[\phi^{\frac{1}{\nu}} \left(y_t^o \right)^{\frac{\nu-1}{\nu}} + (1-\phi)^{\frac{1}{\nu}} \left(y_t^{no} \right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{11}$$

Where $\phi>0$ is the weight of oil in the production of the final good and $\nu>0$ is the elasticity of substitution between oil and non-oil inputs. Oil is either imported or produced locally, depending on whether the country is a net importer or a net exporter of oil. In both cases, it is assumed that the oil sector is managed by the government. In oil-importing countries, the government practices LCP, buying oil at the world price, P_t^{o*}, and reselling it to domestic firms at the domestic price P_t^o. In oil-exporting countries, it is assumed that the oil industry is owned by the government, which sells oil to the rest of the world at the world price, P_t^{o*}, and to domestic firms at the domestic price, P_t^o. The dollar-price of oil, P_t^{o*}, is exogenous to the small open economy and follows the stochastic process

$$\log P_t^{o*} = (1-\rho_0)\log\left(P^{o*}\right) + \rho_o \log\left(P_{t-1}^{o*}\right) + \varepsilon_{ot} \tag{12}$$

The representative final-good producer solves .

$$\max_{\{y_t^d, y_t^m\}} P_t y_t - P_t^o y_t^o - P_t^{no} y_t^{no} \tag{13}$$

Where y_t is given by (11). Profit maximization implies

$$y_t^o = \phi \left(\frac{P_t^o}{P_t} \right)^{-\nu} y_t \tag{14}$$

and

$$y_t^{n_0} = (1-\phi) \left(\frac{P_t^{no}}{P_t} \right)^{-\nu} Y_t \tag{15}$$

The zero-profit condition implies that the price of the final good, P_t, is given by

$$P_t = \left[\phi (P_t^0)^{1-\nu} + (1-\phi)(P_t^{no})^{1-\nu} \right]^{\frac{1}{1-\nu}} \tag{16}$$

3.3.2 Non-oil composite good

The non-oil composite good is produced by perfectly competitive firms using the following Cobb-Douglas technology:

$$y_t^{n_0} = \Gamma (y_t^d)^{\sigma} (y_t^m)^{1-\sigma} \tag{17}$$

Where $\Gamma \equiv \sigma^{-\sigma} (1-\sigma)^{\sigma-1}$ is a positive parameter; $y_t^d \equiv \left(\int_0^1 y_t^d (i)^{(\theta-1)/\theta} di \right)^{\theta/(\theta-1)}$ and $y_t^m \equiv \left(\int_0^1 y_t^m (i)^{(\vartheta-1)/\vartheta} di \right)^{\vartheta/(\vartheta-1)}$ are aggregates of domestic and imported intermediate goods, respectively; and θ (ϑ)>1 is the elasticity of substitution between domestic (foreign) intermediate goods. Define $P_t^d \equiv \left(\int_0^1 P_t^d(i)^{1-\theta} di \right)^{1/(1-\theta)}$ and $P_t^m \equiv \left(\int_0^1 P_t^m(i)^{1-\vartheta} di \right)^{1/(1-\vartheta)}$ as the price indexes associated with the aggregators y_t^d and y_t^m. Then, demands for individual domestic and imported intermediate goods are, respectively, given by

$$y_t^d(i) = \left(\frac{P_t^d(i)}{P_t^d} \right) y_t^d \qquad i \in (0,1) \tag{18}$$

and

$$y_t^m(i) = \left(\frac{P_t^m(i)}{P_t^m} \right)^{-\vartheta} y_t^m \qquad i \in (0,1) \tag{19}$$

where y_t^d, y_t^m, and $P_t^{n_0}$ are given by, respectively

$$y_t^d = \sigma \left(\frac{P_t^d}{P_t^{no}} \right)^{-1} y_t^{no} \tag{20}$$

$$y_t^m = (1-\sigma) \left(\frac{P_t^m}{P_t^{no}} \right)^{-1} y_t^{n_0} \tag{21}$$

and

$$P_t^{no} = \left(P_t^d\right)^{\sigma} \left(P_t^m\right)^{1-\sigma} \tag{22}$$

3.3.3 Domestic intermediate goods

Domestic intermediate-good producers have identical Cobb-Douglas production functions given by

$$z_t(i) \equiv y_t^d(i) + y_t^x(i) = A_t k_t(i)^{\alpha} h_t(i)^{1-\alpha} \tag{23}$$

Where $\alpha \in (0,1); k_t(i)$ and $h_t(i)$ are capital and labour inputs used by firm *i*; and A_t is an aggregate technology shock.

Domestic intermediate-good producers are monopolistically competitive, and are thus price setters. They segment markets by setting different prices for different destinations. That is, firm *i* chooses a domestic-currency price $P_t^d(i)$ for its sales in the domestic market and a foreign-currency price $P_t^x(i)$ for its exports. Changing prices entails quadratic adjustment costs à la Rotemberg (1982):

$$\frac{\psi_j}{2}\left(\frac{P_t^j(i)}{\pi^j P_{t-1}^j(i)} - 1\right)^2$$

where $j=d, x$; $\psi_j \geq 0$; and π^j is the steady-state value of $\pi_t^j \equiv P_t^j / P_{t-1}^j$. Firm *i* solves the following dynamic problem:

$$\max_{\{h_t(i), k_t(i), P_t^d(i), P_t^x(i)\}} E_t \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t}\right) \frac{D_{t+s}^d(i)}{P_{t+s}} \tag{24}$$

where

$$D_t^d(i) \equiv P_t^d(i)y_t^d(i) + e_t P_t^x(i)y_t^x(i) - W_t h_t(i) - Qk_t(i) - \frac{\psi_d}{2}\left(\frac{P_t^d(i)}{\pi^d P_{t-1}^d(i)} - 1\right)^2 P_t^d(i)y_t^d(i) - \frac{\psi_x}{2}\left(\frac{P_t^x(i)}{\pi^x P_{t-1}^x(i)} - 1\right)^2 e_t P_t^x(i)y_t^x(i)$$

It is assumed that the world demand for the domestic intermediate good *i* is analogous to the domestic demand for that good. That is,

$$y_t^x(i) = \left(\frac{P_t^x(i)}{P_t^x}\right)^{-\theta} y_t^x, \qquad i \in (0,1) \tag{25}$$

Where $P_t^x \equiv \left(\int_0^1 P_t^x(i)^{1-\theta} di\right)^{1/(1-\theta)}$, and y_t^x is an aggregate of exported intermediate goods that represents a fraction Y of world demand

$$y_t^x = \Psi\left(\frac{P_t^x}{P_t^*}\right)^{-\varsigma} y_t^* \tag{26}$$

In this equation, the parameter ς is the price-elasticity of world demand for domestic output; P_t^* is the world price; and y_t^* is the overall world output, which is assumed to be exogenous.

Given the demand functions (18) and (25), the first-order conditions for firm *i* are

$$\omega_t = (1-\alpha)\xi_t(i)\frac{z_t(i)}{h_t(i)} \tag{27}$$

$$q_t = \alpha\xi_t(i)\frac{z_t(i)}{k_t(i)} \tag{28}$$

$$-\theta\frac{\xi(i)}{P_t^d(i)} = (1-\theta)\left[1 - \frac{\psi_d}{2}\left(\frac{\pi_t^d(i)}{\pi^d} - 1\right)^2\right] - \psi_d\left[\frac{\pi_t^d(i)}{\pi^d}\left(\frac{\pi_t^d(i)}{\pi^d} - 1\right) - \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\frac{(\pi_{t+1}^d(i))^2}{\pi_{t+1}\pi^d}\left(\frac{\pi_t^d(i)}{\pi^d} - 1\right)\frac{y_{t+1}^d(i)}{y_t^d(i)}\right] \tag{29}$$

$$-\theta\frac{\xi(i)}{P_t^x(i)}\frac{1}{s_t} = (1-\theta)\left[1 - \frac{\psi_x}{2}\left(\frac{\pi_t^x(i)}{\pi^x} - 1\right)^2\right] - \psi_d\left[\frac{\pi_t^x(i)}{\pi^x}\left(\frac{\pi_t^x(i)}{\pi^x} - 1\right) - \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\frac{s_{t+1}}{s_t}\frac{(\pi_{t+1}^x(i))^2}{\pi_{t+1}^*\pi^x}\left(\frac{\pi_t^x(i)}{\pi^x} - 1\right)\frac{y_{t+1}^x(i)}{y_t^x(i)}\right] \tag{30}$$

where $\xi_t(i)$ is the Lagrange multiplier associated with equation (23) and is equal to the real marginal cost of firm i; $P_t^d(i) \equiv P_t^d(i)/P_t$; $P_t^x(i) \equiv P_t^x(i)/P_t^*$; $\pi_t^d(i) \equiv P_t^d(i)/P_{t-1}^d(i)$; $\pi_t^x(i) \equiv P_t^x(i)/P_{t-1}^x(i)$; and $\pi^* \equiv P_t^*/P_{t-1}^*$ is the gross inflation rate in the rest of the world, which is normalized to 1.

3.3.4 Imported intermediate goods

Foreign intermediate goods are imported by monopolistically competitive firms at the world price, P_t^*. Importing firms then sell those goods in domestic currency to final-good producers. Resale prices, $P_t^m(i)$ are also subject to quadratic adjustment costs:

$$\frac{\psi_m}{2}\left(\frac{P_t^m(i)}{\pi^m P_{t-1}^m(i)}-1\right)^2$$

where π^m is the steady-state value of $\pi_t^m \equiv P_t^m/P_{t-1}^m$. The importing firm i solves the following problem:

$$\max_{\{P_t^m(i)\}} E_t \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t}\right)\frac{D_{t+s}^m(i)}{P_{t+s}} \tag{31}$$

Where

$$D_t^m(i) = \left(P_t^m(i) - e_t P_t^*\right) y_t^m(i) - \frac{\psi_m}{2}\left(\frac{P_t^m(i)}{\pi^m P_{t-1}^m(i)}-1\right)^2 P_t^m(i) y_t^m(i) \tag{32}$$

The first-order condition for this problem is

$$\vartheta\frac{s_t}{P_t^m(i)} = 1+(1-\vartheta)\frac{\psi_m}{2}\left(\frac{\pi_t^m(i)}{\pi^m}-1\right)^2 - \psi_m\left[\frac{\pi_t^m(i)}{\pi^m}\left(\frac{\pi_t^m(i)}{\pi^m}-1\right) - \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{\left(\pi_{t+1}^m(i)\right)^2}{\pi_{t+1}\pi^m}\left(\frac{\pi_t^m(i)}{\pi^m}-1\right)\frac{y_{t+1}^m(i)}{y_t^m(i)}\right] \tag{33}$$

Where $P_t^m(i) \equiv P_t^m(i)/P_t$; and $\pi_t^m(i) \equiv P_t^m(i)/P_{t-1}^m(i)$

3.4 The government

It is assumed that the government sets the domestic price of oil according to the following rule:

$$P_t^o = (1-\chi)P_{t-1}^o + \chi e_t P_t^{o*}.$$

Thus, if χ=1, there is complete pass-through from the world price of oil to the domestic price. If χ=0, there is zero pass-through.

The government's revenues include receipts from selling oil to domestic firms and to the rest of the world (if the country is a net oil exporter), overseas development assistance (ODA) funds, taxes and seigniorage revenues.[§] The government's expenditures include the cost of acquiring oil (if the country is a net oil importer) and interest payments on outstanding public debt. Hence, the government's budget constraint is given by

$$B_t = R_{t-1}B_{t-1} + G_t - T_t - (M_t - M_{t-1}) - e_t ODA_t, \qquad (34)$$

where

$$G_t = \left(e_t P_t^{o*} - P_t^o\right) y_t^o$$

if the country is a net oil importer, and

$$G_t = -(e_t P_t^{o*} y_t^{ox} + P_t^o y_t^o)$$

if the country is a net oil exporter. In the above equation, the world demand for domestic oil, y_t^{ox}, is assumed to be given by

$$y_t^{ox} = \Omega \left(\frac{P_t^{o*}}{P_t^*} \right)^{-\tau} y_t^*,$$

where τ is the elasticity of world demand for oil.

Equation (3) implies that public expenditures can be financed by (*i*) taxes, (*ii*) seignoriage revenues, (*iii*) ODA, and (*iv*) issuing new public debt. Note that this equation can be rewritten in the following form:

$$FD \equiv B_t - B_{t-1} = (R_{t-1} - 1)B_{t-1} + G_t - T_t - (M_t - M_{t-1}) - e_t ODA_t, \tag{35}$$

where *FD* denotes the fiscal deficit. This equation implies that the fiscal deficit can be reduced by (*i*) lowering public expenditures, (*ii*) raising taxes, (*iii*) increasing seignoriage revenues, and (*iv*) higher ODA. The remaining financial needs are met by issuing new public debt.

In what follows, it is assumed, as in Galí, López-Salido, and Vallés (2006), that the government follows a fiscal rule given by

$$(T_t - T) = \varphi_b (B_{t-1} - B) + \varphi_g (G_t - G),$$

where φ_b and φ_g are positive parameters. Depending on the values of φ_b and φ_g, this rule accomodates any mixture of means (taxes, debt, ODA) of financing public expenditures or reducing or the budget deficit. For values of φ_b and φ_g that are sufficiently close to zero, an increase in outstanding public debt or in current government expenditures does lead to a significant change in taxes. In such a case, an ODA necessarily reduces the fiscal deficit. On the other hand, choosing a high value of φ_g implies that the bulk of a given increase in public spending is largely financed by raising taxes.

[§]ODA is assumed to follow an exogenous first-order autoregressive process with an autocorrelation coefficient ρ_{oda}.

3.5 Monetary authority

It is assumed that the central bank manages the short-term nominal interest rate according to the following Taylor-type policy rule:

$$\log(R_t / R) = \rho_R \log(R_{t-1} / R) + (1-\rho_R)(\rho_\pi \log(\pi_t / \pi) + \rho_y \log(y_t / y) + \rho_\mu \log(\mu_t / \mu) + \rho_e \log(e_t / e))$$
(36)

where μ_t is the gross rate of money growth and $\rho_R \geq 0$ is the interest-rate-smoothing coefficient. This rule encompasses several monetary-policy/exchange-rate regimes. In particular:

- if $\rho_\pi = \rho_y = \rho_e = 0$, a pure monetary-aggregate targeting regime is obtained
- if $\rho_y = \rho_\mu = \rho_e = 0$, a pure inflation targeting regime is obtained (South Africa)
- if $\rho_\pi = \rho_y = \rho_\mu = 0$, a pegged exchange rate regime is obtained (Benin, Mali, ...)
- if $\rho_\pi = \rho_y = 0$, a managed-floating regime is obtained (Ghana, Mauritius, Tunisia, ..)

3.6 Symmetric equilibrium

In a symmetric equilibrium, all intermediate-good producers make identical decisions. That is, $z_t(i) = z_t$, $k_t(i) = k_t$, $h_t(i) = h_t$, $P_t^d(i) = P_t^d$, $P_t^m(i) = P_t^m$, and $P_t^x(i) = P_t^x$, for all $i \in (0,1)$. Hence, a symmetric equilibrium for this economy is a collection of 34 sequences

$$\left(c_t, m_t, h_t, i_t, k_{t+1}, y_t, y_t^d, y^0, y_t^{n0}, y_t^m, y_t^x, y_t^{0x}, z_t, \omega_t, q_t, \xi_t, \lambda_t, \pi_t, \pi_t^d, \pi_t^{n0}, \pi_t^m, \pi_t^x, R_t, \mu_t, s_t, e_t, b_t^*, P_t, p_t^d, p_t^0, p_t^{n0}, p_t^m, p_t^x, g_t \right)_{t=0}^{\infty}$$

satisfying the private agent's first-order conditions, the government fiscal rule, the monetary policy rule, market-clearing conditions, and a balance of payments equation (the full set of equations are available upon request). The variables g_t and b_t^* denote G_t/P_t and B_t^* / P_t^*, respectively. The model is solved up to a first-order approximation. To do so, the model equations are log-linearized around a deterministic steady state in which all variables are constant. This yields a system of stochastic linear difference equations that can be solved using the method described in Blanchard and Kahn (1980). Due to the complexity of the model, the Blanchard-Kahn solution cannot be found analytically. Instead, it is computed numerically, which requires assigning values to the model parameters before starting to compute the solution.

4 Results

This section discusses the impact of a doubling in the world price of oil on main macroeconomic variables both in the case of a median oil-importing economy and a median oil-exporting economy. The variables of interest are output, consumption, inflation, the real exchange rate, the government budget deficit, and foreign debt. The simulations are performed both under a fixed exchange rate regime and a managed float. For each case, two different scenarios are considered: complete and zero pass-through. In all simulations, the oil-price shock is assumed to be persistent, with a first-order autocorrelation coefficient of 0.85, as estimated from the data. This assumption is consistent with the view that the expected durability of the high oil demand from East Asia (especially China) is sustaining the market expectations that oil prices will remain high (see for example 'High Oil Prices and the African Economy' presented at the AfDB 2006 Annual Meetings).

4.1 Median Oil-Importing Economy

This economy is calibrated such that oil imports represent roughly 13% of total imports and 5% of total GDP in the steady state. Simulation results for this case are shown in Tables 1 and 2. The main conclusions are the following:

- Under fixed exchange rates and complete pass-through, a doubling in the world price of oil leads to a decline in output and consumption, a slight increase in inflation, a small appreciation of the real exchange rate, and moderate changes in public and foreign borrowing. The output loss is about 6 percent during the first year, while the cumulative loss is around 23.5 percent during the five years following the shock. For consumption, the corresponding numbers are 4.5 and 19 percent, approximately.

- The drop in output and consumption is attributed to a combination of two effects of high oil prices: a direct income effect, through the resource constraint, and a direct effect on production, through higher costs of inputs. The former decreases consumption and increases labor supply. The latter decreases demand for non-oil inputs and, by extension, demand for labor and capital. The net effect on hours worked is ambiguous, but labor income and investment unambiguously fall (due to lower marginal productivity of labor and capital). The resulting reduction in households' disposable income further decreases consumption and output.

Table 1. Effects of a 100% increase in the price of oil
(Net-Oil Importing Country, Fixed Exchange Rate Regime)

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-6%	-24%
Zero pass-through	-1%	-5%
Consumption		
Complete pass-through	-5%	-19%
Zero pass-through	-6%	-25%
Investment		
Complete pass-through	-11%	-39%
Zero pass-through	-7%	-25%
Inflation		
Complete pass-through	2%	1%
Zero pass-through	-4%	-4%
Real exchange rate		
Complete pass-through	-2%	-7%
Zero pass-through	4%	22%
Budget deficit		
Complete pass-through	4%	7%
Zero pass-through	31%	45%
Foreign debt		
Complete pass-through	-1%	2%
Zero pass-through	9%	11%

Note: Budget deficit in percentage of steady-state output.

- The increase in inflation is due to the fact that the domestic price of oil enters the aggregate price index, and since there is complete pass-through, oil-price inflation contributes to *core* inflation. The higher inflation explains the appreciation of the real exchange rate (since the nominal exchange rate is fixed).

- Under zero pass-through, the increase in the price of oil still leads to a decline in output and consumption, but the magnitude of the effects differs significantly compared with the complete pass-through case. The decline in output during the first year is less than 1 percent and the cumulative loss during the five years following the shock is roughly 5 percent. Hence, by practicing LCP, the government shields the production sector of the economy, which minimizes the output loss. The cost of this intervention, however, is a dramatic deterioration of the budget deficit (31 percent during the first year and 45 percent after five years), and most importantly, a large decline in consumption, which drops by more than 6 percent during the first year and 25 percent after five years.

- Under zero pass-through, there is a decrease in inflation, which translates into a real exchange rate depreciation of roughly 4.3 percent in the first year and 22 percent after five years.

Table 2. Effects of a 100% increase in the price of oil (Net-Oil Importing Country, Managed Floating)

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-6%	-23%
Zero pass-through	2%	-1%
Consumption		
Complete pass-through	-4%	-18%
Zero pass-through	-5%	-25%
Investment		
Complete pass-through	-10%	-38%
Zero pass-through	-1%	-21%
Inflation		
Complete pass-through	5%	4%
Zero pass-through	4%	5%
Real exchange rate		
Complete pass-through	-1%	-5%
Zero pass-through	9%	30%
Budget deficit		
Complete pass-through	0%	-1%
Zero pass-through	6%	20%
Foreign debt		
Complete pass-through	1%	2%
Zero pass-through	16%	12%

Note: Budget deficit in percentage of steady-state output.

- Under managed floating, the nominal exchange rate is, to a certain extent, free to adjust, thereby acting as a shock absorber. In principle, therefore, the adverse effects of high oil prices should be less severe compared to the case with fixed exchange rates. A comparison of Tables 1 and 2 confirms this intuition. Under complete pass-through, however, there are only minor differences in the response of output, consumption, inflation, and, to a lesser extent, foreign debt across the two regimes.[**] The gain from letting the nominal exchange rate float is much more apparent under zero pass-through. For example, output initially increases by almost 2 percent (as opposed to a decline of 1 percent) following the rise in the price of oil, and the cumulative loss after five years is barely over 1 percent (as opposed to a loss of 5 percent). This smaller output loss is due to the larger depreciation of the real exchange rate relative to the case with pegged nominal exchange rates.

4.2 Median Oil-Exporting Economy

This economy is calibrated such that oil exports represent roughly 88% of total exports and 35% of total GDP in the steady state. Simulation results for this case are shown in Tables 3 and 4. The main conclusions are the following:

Table 3: Effects of a 100% increase in the price of oil
(Net-Oil Exporting Country, Fixed Exchange Rate Regime)

[**] The only notable difference across the two regimes is the response of the budget deficit, which deteriorates under the peg one, but slightly improves under managed floating.

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	9%	53%
Zero pass-through	10%	56%
Consumption		
Complete pass-through	42%	152%
Zero pass-through	41%	149%
Investment		
Complete pass-through	16%	62%
Zero pass-through	16%	62%
Inflation		
Complete pass-through	9%	15%
Zero pass-through	6%	14%
Real exchange rate		
Complete pass-through	-9%	-71%
Zero pass-through	-7%	-63%
Budget deficit		
Complete pass-through	-114%	-147%
Zero pass-through	-108%	-139%
Foreign debt		
Complete pass-through	-33%	-47%
Zero pass-through	-30%	-45%

Note: Budget deficit in percentage of steady-state output.

- Under fixed exchange rates and complete pass-through, a doubling in the world price of oil leads to a 9 percent increase in output, a 42 percent increase in consumption, a 9 percent increase in inflation, a 9 percent real appreciation, a 114 percent reduction in the budget deficit, and a 33 percent reduction in foreign debt during the first year. The magnitudes of the cumulative effects after five years indicate that the adjustment of output, the real exchange rate, and foreign debt is non monotonic. For example, the model predicts that the response of output to the 100 percent increase in the price of oil is hump-shaped, attaining its peak of 16 percent during the third year after the shock.

- The increase in the price of oil generates a positive income effect, via the resource constraint, which increases consumption. This rise in consumption translates into higher demand for the final good, which more than offsets the negative effect of the higher price of oil. As a result, the demand for oil and non-oil inputs increases (due to their complementarity), thereby raising the demand for labor and capital. The resulting increase in labor demand and investment further boosts the demand for the final good and, therefore, output.

- Under zero pass-through, there is a slightly larger increase in output, a lower inflation, and a smaller appreciation of the real exchange rate compared to the case with complete pass-through. This “gain”, however, comes at the expense of a (marginally) smaller increase in consumption and a smaller improvement in the budget deficit.

Table 4. Effects of a 100% increase in the price of oil (Exporting country, managed floating)

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	4%	25%
Zero pass-through	4%	27%
Consumption		
Complete pass-through	16%	75%
Zero pass-through	16%	76%
Investment		
Complete pass-through	3%	22%
Zero pass-through	4%	23%
Inflation		
Complete pass-through	-13%	-12%
Zero pass-through	-14%	-13%
Real exchange rate		
Complete pass-through	-38%	-136%
Zero pass-through	-36%	-130%
Budget deficit		
Complete pass-through	-7%	-24%
Zero pass-through	-6%	-23%
Foreign debt		
Complete pass-through	-55%	-39%
Zero pass-through	-53%	-38%

Note: Budget deficit in percentage of steady-state output.

- Under managed floating, the output and consumption gains induced by the increase in the price of oil are smaller than under fixed exchange rates. This result is mainly due to the larger appreciation of the real exchange rate under the former regime. The smaller increase in consumption implies that the budget deficit narrows less than under fixed exchange rates.

- Under managed floating, the effects of an increase in the price of oil under complete and zero pass-through are strikingly similar.

5. Policy Implications

5.1 Government intervention

The above analysis suggests that LCP can cushion the economy from the adverse effects of oil-price shocks in oil-importing countries. This policy, however, amplifies the consumption loss and aggravates the government's budget deficit. Hence, the answer to the question of whether a government should intervene or not depends on its implicit objective function. To the extent that the government is concerned with stabilizing output, choosing LCP proves to be the optimal policy. Alternatively, if the government is a benevolent social planner, then *laisser-faire* is likely to be the welfare-maximizing policy. For oil-exporting countries, government intervention does not seem to affect in a substantive way the outcome of the economy, especially in the case of a managed floating. This observation implies that both intervention and *laisser-faire* could be acceptable policy choices in those countries.

5.2. Foreign aid

Can foreign aid help African oil-importing countries cope with high oil prices? Are the required amounts prohibitive? Table 5 shows the permanent level of overseas development assistance (in percentage of steady-state output) that is required to completely offset the initial output loss associated with a persistent 100 percent increase in the price of oil. The table shows that the largest amount of foreign aid needed is less than 2 percent of steady-state output. This amount is clearly non-prohibitive (foreign aid in a number of African countries represents more than 5 percent of GDP), implying that there is scope for international-community actions to help debt-burdened African economies mitigate the adverse effects of high oil prices.

Table 5. ODA to offset Output Loss in the First Year (% of Steady-State Output)

	Fixed exchange rate regime	Managed Floating
Complete pass-through	1.60%	1.98%
Zero pass-through	0.23%	–

Note: ODA: Overseas Development Assistance.

5 Conclusion

High oil prices can have very harmful effects on African oil-importing countries, especially those with a high debt-burden and those which have limited access to international capital markets. They lead to a decrease in output and consumption, and to a worsening of the net foreign asset position. For the median oil-importing country, the five-year cumulative output loss resulting from a doubling in the price of oil can be as large as 23 percent under a fixed exchange rate regime. This recessionary effect, however, can be substantially mitigated through LCP or through foreign aid. In this regard, the model can be used to determine the optimal degree of intervention by the government given its objective function.

For the median oil-exporting country, the five-year cumulative increase in output associated with a doubling in the price of oil exceeds 70 percent, regardless of the exchange rate regime under which the country operates. This manna, however, is accompanied by a sharp appreciation of the real exchange rate, which may hinder the competitiveness of the country. It is therefore important that oil-export revenues be spent in a way that favors future growth, and not in wasteful or badly planned projects.

It should be emphasized, however, that while the analysis above focuses on “median” countries, there is a great deal of heterogeneity within the groups of oil-importing countries and oil-exporting countries. This means that the effects of oil-price shocks can differ dramatically from one country to the other. As stated above, however, the proposed model can be configured to represent any of these countries.

An important question that the model does not address is the effect of high oil prices on poverty, which is a crucial dimension of the African context. The model could be extended to capture this feature by allowing for heterogeneity across households and by assuming that some of them have liquidity constraints. The model can also be extended to include other types of shocks, such as productivity shocks, monetary-policy shocks, and world-interest-rate shocks. This would allow the model to answer a broader set of questions of relevance to policy makers.

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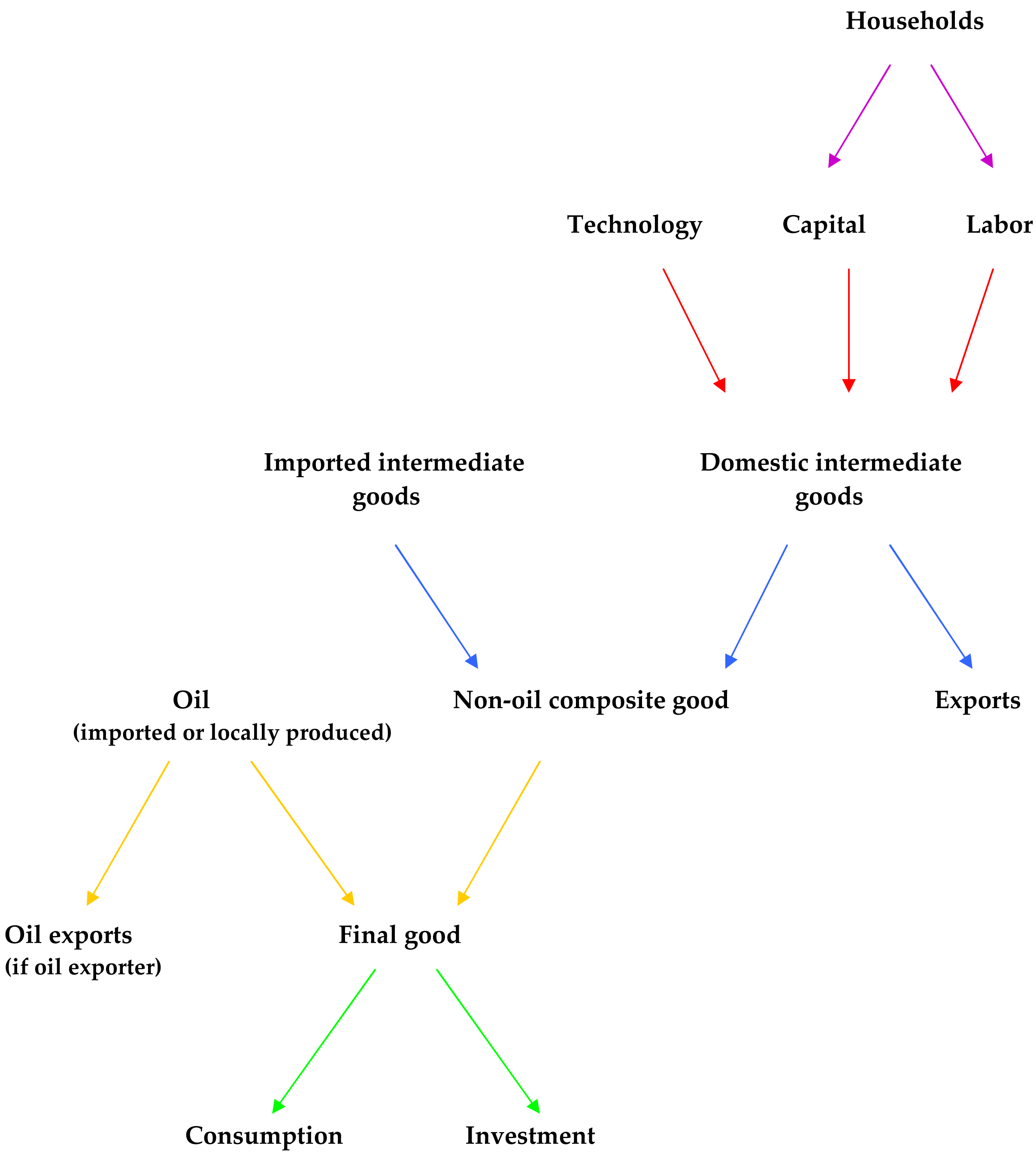
7. Appendix

Figure 1: Structure of the production sector



7.2 Simulation Results

Oil-Importing Countries: Some Country Specific Results

Burkina Faso

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-4%	-15%
Zero pass-through	-1%	-3%
Consumption		
Complete pass-through	-3%	-12%
Zero pass-through	-4%	-15%
Investment		
Complete pass-through	-7%	-25%
Zero pass-through	-4%	-14%
Inflation		
Complete pass-through	-1%	-1%
Zero pass-through	-5%	-4%
Real exchange rate		
Complete pass-through	1%	7%
Zero pass-through	5%	25%
Budget deficit*		
Complete pass-through	9%	11%
Zero pass-through	24%	34%
Foreign debt		
Complete pass-through	2%	4%
Zero pass-through	8%	10%

Ghana

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-7%	-29%
Zero pass-through	2%	-4%
Consumption		
Complete pass-through	-5%	-35%
Zero pass-through	-7%	-25%
Investment		
Complete pass-through	-13%	-49%
Zero pass-through	-7%	-25%
Inflation		
Complete pass-through	7%	5%
Zero pass-through	7%	7%
Real exchange rate		
Complete pass-through	-5%	-18%
Zero pass-through	9%	24%
Budget deficit*		
Complete pass-through	-1%	-3%
Zero pass-through	8%	27%
Foreign debt		
Complete pass-through	-3%	-1%
Zero pass-through	18%	12%

Kenya

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-12%	-49%
Zero pass-through	6%	4%
Consumption		
Complete pass-through	-9%	-39%
Zero pass-through	-11%	-56%
Investment		
Complete pass-through	-21%	-81%
Zero pass-through	-1%	-41%
Inflation		
Complete pass-through	10%	9%
Zero pass-through	9%	10%
Real exchange rate		
Complete pass-through	-2%	-7%
Zero pass-through	23%	76%
Budget deficit*		
Complete pass-through	-1%	-3%
Zero pass-through	14%	51%
Foreign debt		
Complete pass-through	3%	5%
Zero pass-through	38%	30%

Madagascar

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-6%	-25%
Zero pass-through	2%	-2%
Consumption		
Complete pass-through	-5%	-20%
Zero pass-through	-6%	-29%
Investment		
Complete pass-through	-11%	-42%
Zero pass-through	-2%	-25%
Inflation		
Complete pass-through	6%	5%
Zero pass-through	5%	6%
Real exchange rate		
Complete pass-through	-3%	-12%
Zero pass-through	8%	25%
Budget deficit*		
Complete pass-through	-1%	-2%
Zero pass-through	6%	22%
Foreign debt		
Complete pass-through	-1%	0%
Zero pass-through	16%	12%

Malawi

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-4%	-16%
Zero pass-through	1%	-2%
Consumption		
Complete pass-through	-3%	-12%
Zero pass-through	-4%	-17%
Investment		
Complete pass-through	-7%	-26%
Zero pass-through	-1%	-16%
Inflation		
Complete pass-through	4%	3%
Zero pass-through	3%	3%
Real exchange rate		
Complete pass-through	-2%	-7%
Zero pass-through	5%	15%
Budget deficit*		
Complete pass-through	0%	-1%
Zero pass-through	4%	13%
Foreign debt		
Complete pass-through	-1%	0%
Zero pass-through	10%	7%

Senegal

	Impact effect (1 year)	Cumulative effect (5 years)
Output		
Complete pass-through	-5%	-21%
Zero pass-through	-1%	-5%
Consumption		
Complete pass-through	-4%	-16%
Zero pass-through	-6%	-23%
Inflation		
Complete pass-through	3%	1%
Zero pass-through	-3%	-2%
Real exchange rate		
Complete pass-through	-3%	-9%
Zero pass-through	3%	16%
Budget deficit*		
Complete pass-through	2%	4%
Zero pass-through	27%	38%
Foreign debt		
Complete pass-through	-1%	1%
Zero pass-through	7%	9%

Note: *Budget deficit in percentage of steady-state output.