Asymmetric Terms-of-Trade Shocks in a Monetary Union: An Application to West Africa

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Abstract

We propose a two-country dynamic stochastic general equilibrium model of a monetary union facing asymmetric terms-of-trade shocks, calibrated on Nigeria and West African Economic and Monetary Union (WAEMU). Three monetary regimes are successively studied at the union level: a flexible exchange rate with constant money supply, a flexible exchange rate with an accommodating monetary policy and a fixed exchange-rate regime. We find that, in the face of oil-price shocks, the most stabilising regime for Nigeria is a fixed money supply, whereas it is a fixed exchange rate for WAEMU. However, the introduction of an oil-stabilisation fund can reduce the disagreement on the common policy rule. Furthermore, the two zones may agree on a fixed money-supply rule in the face of both oil- and agricultural-price shocks.

JEL classification: E52, F41, Q33

1. Introduction

Monetary regimes in West Africa are divided in two groups of countries that almost match a linguistic divide. On the one hand, a group of
French-speaking countries (the WAEMU: West African Economic and Monetary Union) share a common currency (the CFA Franc) which is pegged to the euro. On the other hand, English-speaking countries have independent currencies with mostly managed floating exchange-rate regimes. Still, both groups of countries are part of the Economic Community of West African States (ECOWAS) grouping, a free trade area (see Figure 1). Since 1993, a monetary union has been an objective of ECOWAS. In 2000, an impetus was given to this project through the creation of the West African Monetary Zone (WAMZ), which groups together five of the non-WAEMU members of ECOWAS (The Gambia, Ghana, Guinea, Nigeria and Sierra Leone). The intention was to proceed to a monetary union within this sub-group by 2003, and then organise a monetary union with WAEMU. However, the first step of this plan was several times rescheduled due to insufficient progress in terms of convergence. In June 2007, a ‘single-track’ approach was adopted to proceed to a monetary union directly at the ECOWAS level in 2012.

The pros and cons of monetary integration in West Africa have been extensively discussed in the literature. The inclusion of a very large, oil-exporting country (Nigeria) in the project has especially been shown as a serious handicap. Thus far, still, the literature has focused on measuring the extent of asymmetric shocks through VAR techniques (Fielding and Shields, 2001) or dynamic factor models (Houssa, 2008), in the same spirit as what was done in the case of the European Economic and Monetary Union (EMU) in the late 1990s. The potential for asymmetric shocks

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1 WAEMU includes Benin, Burkina Faso, Ivory Coast, Guinea Bissau, Mali, Niger, Senegal, Togo.
2 Sierra Leone is pegged to the dollar and Cape Verde to the euro.
3 See, for example, Masson and Pattillo (2001).
has also been investigated using cluster analysis (Bénassy-Quéré and Coupet 2005; Tsangarides and Qureshi, 2008), in the spirit of Artis and Zhang (1997) in the case of the euro.

However, West Africa differs from the EMU in that there is a strong case for pegging the common currency to an external currency due to (i) the importance of extra-regional trade compared with intra-regional trade, (ii) the weight of dollar-denominated commodities in exports, (iii) the foreign currency-denominated debt burden and (iv) the possible lack of credibility of an internal a monetary anchor. For a given country, the pros and cons of a monetary union may differ depending on whether the common currency is pegged to the euro (or the dollar), or whether it is allowed to float freely. Additionally, the weight of the largest country of the zone is much higher in the West African case than it is in the Euro area: Nigeria represented 63% of West African GDP in 2007, while the same year, Germany only represented 27% of the Euro area’s GDP (and 31% in 1999). Contrasting with most countries in the region, the Nigerian economy is dominated by the oil sector (which represents 90% of its exports, almost four-fifths of its fiscal revenues and around 40% of GDP). Hence, given the weight of Nigeria in the zone, the common monetary policy will be tilted towards the interests of Nigeria. The consequences for smaller countries (and the sharing of oil shocks) will be very different whether the common currency is allowed to float or whether it is fixed to the euro or the dollar. This is what we want to investigate in this paper.

To our knowledge, the question of how to tackle commodity-price variations in a monetary union has not yet been studied in the literature. Existing models of the Dutch disease concentrate on the single-country case. This is not surprising since large, specialised oil and gas producers (Saudi Arabia, Russia, Norway, Venezuela, etc.) have so far retained independent currencies. Only countries of the Central African Economic and Monetary Community have experienced the difficulty in mixing together heavy oil-exporting countries (Gabon, Equatorial Guinea, Congo) with non-oil exporting ones (Central African Republic). We construct a stylised, two-country model that extends the single-country, Dutch disease models proposed in the literature (Collier and Gunning, 2005; Adam et al., 2006; Sosunov and Zamulin, 2007; Adam and Goderis, 2008). Specifically, we propose a dynamic stochastic general equilibrium (DSGE) model, whereby monetary policy is introduced through a money-supply

4 Source: World Bank, World Development Indicators.
behaviour that is related to the exchange-rate regime, together with some nominal rigidities à la Calvo and a proportion of financially constrained households. Though some authors have analysed the effects of oil-price shocks within a DSGE model (see, for instance, Backus and Crucini, 2000; Leduc and Sill, 2004), very few have focused on the African countries. One notable exception is a joint paper by the African Development Bank & African Union (2006), but the authors do not address the issue of monetary regime to be chosen by a currency union in a context of asymmetric oil-price shocks.

Our model is calibrated using the key structural characteristics of Nigeria and WAEMU countries. We then simulate the impact of oil-price and other commodity-price shocks under three monetary regimes, successively: (i) a flexible exchange-rate regime with fixed money supply, (ii) a flexible exchange rate with accommodating money supply (where export receipts are monetised) and (iii) a fixed exchange-rate regime with unsterilised official interventions. For each monetary regime, we study the implications of having an oil-stabilisation fund in Nigeria.

We find that, depending on the common monetary regime, WAEMU may react very differently to an oil-price increase: it would benefit from the shock under a flexible exchange rate with accommodating monetary policy, suffer from it under a fixed money-supply regime and be almost isolated from it in the case of a fixed exchange rate. In contrast, Nigeria would of course benefit from the shock, although it would suffer from a Dutch disease, whatever the monetary regime. In the face of oil shocks, the two zones would thus disagree on the common monetary regime, because a fixed money-supply regime is more stabilising in Nigeria, whereas a fixed exchange rate is more stabilising in WAEMU. We show that introducing an oil-stabilisation

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5 We implicitly make the assumption than WAEMU leaves the CFA franc in regimes (i) and (ii). In the fixed exchange-rate regime (iii), the new common currency is pegged to the import invoice currency.

6 Such type of analysis has been performed by Driver and Wren-Lewis (1999) in the case of the European monetary union. However, Driver and Wren-Lewis concentrate on demand and wage shocks, whereas we are interested in commodity-price shocks, which are the main source of disturbance in West Africa. Furthermore, Driver and Wren-Lewis consider optimal, time-consistent policy rules (both monetary and fiscal), whereas we are interested in simple rules that are closer to what can be implemented in practice.

7 Here we disregard the negative effect of the oil-price shock in WAEMU through domestic oil consumption in order to focus on the monetary policy externalities. However, the same results are obtained when introducing oil consumption in WAEMU. They are available from the authors upon request.
fund would help to solve this disagreement since the fund would tax and save when the oil price is high, and pay transfers when the oil price is low. In doing so, the stabilisation fund would provide consumption smoothing for those consumers that lack access to financial markets. This would be stabilising for the union’s economy. Finally, we find that both economies would behave similarly, although to different extents, in the face of non-oil commodity-price shocks, and that they would be best stabilised by a fixed money-supply regime. We conclude that, in the presence of both oil- and agricultural-price shocks, the fixed money-supply regime (with a flexible exchange rate) seems to be the best for both economies, and that a well-functioning stabilisation fund would greatly reduce the monetary challenge faced by the common central bank.

The rest of the paper is organised as follows. Section 2 provides some basic stylised facts on the behaviour of both economies during the past oil-price surges. Section 3 presents the model. Section 4 and 5 analyse the impact of an increase in the oil price and in the non-oil commodity price, successively. Section 6 presents welfare analysis and Section 7 concludes.

2. Asymmetric effects of oil-price increases in WAEMU countries and Nigeria

The recent episodes of oil-price increase, during the 2000s, affected the West African economies in an asymmetric manner.

On the one hand, oil importers suffered from a decrease in consumption and growth, a worsening of their net foreign asset position, as well as a fall in their terms of trade, a situation that characterised most of the WAEMU countries which are classified in the group of low-income countries. For instance, in Burkina Faso, terms of trade dropped by 30% between 2003 and 2007 and GDP growth fell from 7.3% to 3.6%, while its current account remained negative at an average −10% of GDP during this period.8 Similar evolutions were observed in the other WAEMU economies. The simultaneous rise in most commodity prices did not compensate for the increase in the oil bill. For WAEMU taken as a whole, foreign exchange reserves (in terms of months of imports of goods and services) declined from 5.1 months in 2003 to 4.2 months in 2008.

On the other hand, Nigeria, ranked among the five top oil producers in the African continent, benefited from the oil-price surge. Its current-account balance grew from −5.7% of GDP in 2003 to +5.6% in

8 Source: IMF, World Economic Outlook, April 2009.
During the same period, foreign exchange reserves increased from 3.2 to 12.1 months of imports. However, real GDP growth actually declined from 10.3% to 6.4%. In fact, heavy reliance on oil exports can induce a Dutch disease phenomenon, whereby a rise in the price of oil crowds out the non-oil exporting sectors, translates into an increase in public spending and leads to a real appreciation of the domestic currency (see Corden and Neary, 1982; Corden, 1984; van Wijnbergen, 1984).

As shown in Figure 2, public expenditures in Nigeria have generally absorbed the entire windfalls (if not more) since the first oil-price shock, in 1974. Furthermore, there is some evidence of a positive correlation between the real exchange rate (measured either in terms of official or parallel rate) and the oil price, as predicted by Dutch disease models (see Sala-i-Martin and Subramanian, 2003; Ayadi 2005; Adejumo and Olomola, 2006). In the recent period of oil-price increase (2004–2008), a substantial share of oil revenues were spent, with the (cash) non-oil primary deficit jumping from 30% of GDP in 2002 to 35% in 2004 and 40% in 2005 (van Wijnbergen et al., 2007).

Nigerian authorities have tried to prevent the Dutch disease through both fiscal and monetary policies. In 2004, they set up a hybrid of stabilisation, saving and financing funds, where current spending is based on a medium-term oil price and the windfall in excess of this reference price are saved in an ‘excess crude oil account’. Savings are used for clearing foreign debt in booming times. On the monetary-policy side, the Central Bank of Nigeria (CBN) adopted, in the 2000s, a strategy of inflation...
stabilisation to avoid the inflationary pressures related to oil-price determined demand booms. The CBN managed to avoid fiscal dominance through a higher coordination with fiscal authorities and through the decision to use the extra oil revenues to reimburse the country’s outstanding debt (Baldini and Ribeiro, 2008).

Participating in a monetary union may reduce the ability of Nigerian authorities to stabilise the economy since the common monetary policy would aim at stabilising the union-wide inflation rate or the union’s exchange rate rather than that of Nigeria. Symmetrically, participating in a monetary union with Nigeria may change the reaction of monetary policy to oil-price shocks elsewhere in this region, possibly with a destabilising impact.

3. A DSGE model of the Dutch disease in a monetary union

3.1 Overview

Here we present a stylised, two-country model comprising one oil-exporting country (Nigeria, representing the bulk of the West African Monetary Zone (WAMZ)), and one non-oil exporting country (WAEMU). These two countries are assumed to share the same currency that can either float or be fixed against the foreign currency. Contrasting with the existing literature on sub-Saharan economies, we assume that some households have full access to both domestic and foreign bonds, so that the interest parity applies. This choice is motivated by our focus on monetary policy for a zone where there is already free capital mobility for the WAEMU grouping.9

The model is inspired by (Sosunov and Zamulin 2007) who consider a Dutch disease model for a single country without a stabilisation fund. Here, both Nigeria and WAEMU are considered small open economies: they take the world interest rate and the world price of commodities as given in foreign currency, and their currency is not held by non-residents. In each country, there are two production sectors as follows:

- a cash-crop agricultural sector (henceforth designated with an A subscript) that produces a good that is not consumed locally but only exported out of the region;10

9 In contrast, O’Connell et al. (2007) and Adam et al. (2008) assume imperfect substitution between domestic and foreign money holdings and no access to the international capital market (bonds in foreign currency) by either households or the government.

10 Here, agriculture is a shortcut for non-oil exporting sectors.
a ‘non-tradable’ sector \((N)\) that produces a good that is only traded within the region: from WAEMU to Nigeria and the other way round.

While the price of the agricultural product is given internationally, that of the non-tradable sector is set by the producers on a monopolistic competition market. The Nigerian economy also produces oil (designated with an \((O)\) subscript), which comes as a pure endowment and the production of which requires no input. The price of oil is given internationally.

In each country, households consume a ‘non-tradable’ domestic good \((N)\), a ‘non-tradable’ good produced in the other country \((N^*)\) and a good imported from international markets, designated with an \((M)\) subscript (for ‘manufactured’, although the scope of this good can be expanded at no cost, for instance, to include imported food products). Households do not consume oil nor agricultural products that are assumed to be entirely exported to the rest of the world (ROW). \(^{11}\)

Money demand is introduced via a cash constraint on household consumption. Money supply is related to the monetary/exchange-rate regime. The non-neutrality of monetary policy is insured through the introduction of nominal rigidities. Additionally, only a fraction of households have access to the financial market to smooth consumption intertemporally. There is no public sector, except a stabilisation fund in Nigeria that taxes current income to redistribute later to financially constrained households.

The next subsections present the equations for Nigeria. \(^{13}\) The model is the same for WAEMU, except that there is no oil sector.

### 3.2 Households

Two categories of households are distinguished. Optimising households, denoted by \(opt\), have access to financial markets and can buy and sell all kinds of assets and securities. In our framework, this implies that they can hold plain-vanilla domestic and foreign bonds (respectively \(B\) and \(B^*\)).

\(^{11}\) In reality, the oil sector is capital intensive. Here, we assume that capital does not adjust in the short term: the oil windfall derives from a fixed production with variable world price.

\(^{12}\) Relaxing these simplifying assumptions would not change the results qualitatively.

\(^{13}\) In order to keep a parsimonious presentation, first-order conditions are not reported. The details of the model, as well as the sensitivity to the main parameters, are available on request from the authors.
However, there is a (potentially large) fraction $\mu$ of constrained households, labelled no (for non-optimising), who do not own any asset nor have any liability: their consumption in each period is constrained by their current income, be it their labour income or transfers they may receive from the oil-stabilisation fund.

The presence of optimising households may appear at odds with the relatively limited development of financial markets in the region. However, the households sector here includes the government, which is not modelled otherwise but for the oil-stabilisation fund. The government does have some capacity to smooth consumption over time, although it also suffers from financial constraints.

### 3.2.1 Inter-temporal optimisation

Both types of households maximise the following inter-temporal utility function:

$$U_{x,t} = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} u_{x,s} \right\},$$

where $0 < \beta < 1$ is the discount factor, $E_t$ denotes the mathematical expectation at time $t$ and $x = \text{opt, no}$ is the household’s type. Let $\sigma > 0$ be the inverse of the inter-temporal elasticity of substitution, and let $\kappa$ and $\phi$ be two positive parameters. The instantaneous utility function in period $s$, $u_{x,s}$, is given by

$$u_{x,s} = u(C_{x,s}, H_{x,s}) = \frac{C_{x,s}^{1-\sigma}}{1-\sigma} - \kappa \frac{H_{x,s}^{1+\sigma}}{1+\sigma}.$$

Optimising and constrained households differ in their budget constraints. The budget constraint of the representative optimising household, expressed in the domestic currency, is the following:

$$p_t C_{\text{opt},t} + B_{\text{opt},t} + e_t B_{\text{opt},t}^* + M_{\text{opt},t} = w_t H_{\text{opt},t} + \Pi_{\text{opt},t} + T_{\text{opt},t}$$

$$+ e_t p_{O,t}^* Y_{O,\text{opt}} + (1 + r_{t-1})B_{\text{opt},t-1}^*$$

$$+ e_t (1 + r_{t-1}^*) B_{\text{opt},t-1}^* + M_{\text{opt},t-1}. \tag{3}$$

where $M_{\text{opt},t}$, $B_{\text{opt},t}$ and $B_{\text{opt},t}$ denote the representative optimising household’s net holdings in domestic money, domestic bonds and foreign
bonds, respectively, at the end of period $t$. Here $B_{opt,t}$ is negative (net debt) and its counterpart lies on the asset side of the central-bank balance sheet (see Section 3.5); $B_{opt,t}^*$ can be either positive or negative and its counterpart lies in the ROW.

Here $r_{t-1}$ and $r_{t-1}^*$ are the nominal returns of domestic and foreign bonds between $t-1$ and $t$ (set in $t-1$) respectively; $e_t$ is the nominal exchange rate (number of domestic currency units in one foreign currency unit), $p_t$ the consumption price index, $w_t$ the nominal wage, $C_{opt,t}$ the consumption level of the representative optimising household and $H_{opt,t}$ the number of hours of work supplied during period $t$. Finally, $\Pi_{opt,t} + e_t p_{O,t}^* Y_{O,opt} + T_{opt,t}$ holds for those sources of income that are independent from the household’s decisions, namely per capita firms profits ($\Pi_{opt,t}$), transfers from the central bank ($T_{opt,t}$; see Section 3.4) and per capita oil revenues ($e_t p_{O,t}^* Y_{O,opt}$ where $p_{O,t}^*$ is the oil price in foreign currency and $Y_{O,opt}$ the per capita oil production, both being exogenous).

In turn, financially constrained households have no access to financial instruments (i.e., domestic and foreign bonds). They are thus unable to optimise inter-temporarily. In Nigeria, however, financially constrained households benefit from an oil-stabilisation fund that saves a large part of oil windfall when the oil price $p_{O,t}^*$ is high compared to a certain threshold $p_{thresh}$ and pays more transfers to households in the opposite situation. In Nigeria, the representative constrained household maximises the utility function subject to a budget constraint that includes transfers from the stabilisation fund as follows:

$$ p_t C_{no,t} + M_{no,t} = w_t H_{no,t} + \Pi_{no,t} + e_t p_{thresh} Y_{O,no} + M_{no,t-1} + \zeta_1 e_t (p_{O,t}^* - p_{thresh}) Y_{O,no} + \zeta_2 e_t (1 + r_{t-1}^*) F_{no,t-1}^* . \quad (4) $$

with $0 \leq \zeta_1, \zeta_2 \leq 1$. In WAEMU, the same budget constraint holds except that $Y_{O,no} = F_{no,t-1}^* = 0$.

14 Only financially constrained households receive transfers from the oil-stabilisation fund. Transfers to unconstrained households would be neutral in the model since these households are able to re-allocate their income inter-temporally. Since households are not explicitly distinguished from the public sector, the model behaves the same way whether the fund makes transfers or spends directly on consumption goods. We consider a ‘well-behaved’ stabilisation fund that does provide transfers to households when the oil price falls below a certain threshold. Naturally, an ill-behaved stabilisation would not provide the stabilisation properties highlighted in our model.

15 We assume that $\Pi_{no,t} = \Pi_{opt,t}$ and $Y_{O,no} = Y_{O,opt}$. Both types of households are subject to a cash constraint.
All households are also submitted to the following cash constraint:\textsuperscript{16}

\[ M_{x,t} \geq p_t C_{x,t}. \] (5)

### 3.2.2 Consumption allocation

Both types of households consume imported tradables $M$ and non-tradable goods $NT$:\textsuperscript{17}

\[
C = \left[ \alpha_m^{1/\eta_m} C_M^{(\eta_m-1)/\eta_m} + (1 - \alpha_m)^{1/\eta_m} C_{NT}^{(\eta_m-1)/\eta_m} \right] \eta_m/\eta_m - 1, \] (6)

where $C$, $C_M$ and $C_{NT}$ represent total consumption, consumption of imported tradables and consumption of non-tradables, respectively; $\eta_m > 0$ is the elasticity of substitution between $M$ and $NT$ goods; and $0 < \alpha_m < 1$. Non-tradable goods can be domestically produced ($N$) or imported from another West African country or zone ($N^*$):

\[
C_{NT} = \left[ \alpha_n^{1/\eta_n} C_N^{(\eta_n-1)/\eta_n} + (1 - \alpha_n)^{1/\eta_n} C_{N^*}^{(\eta_n-1)/\eta_n} \right] \eta_n/\eta_n - 1, \] (7)

where $\eta_n > 0$ and $0 < \alpha_n < 1$.

### 3.3 Firms and unions

There are two productive sectors in the economy: the tradable one (agricultural good) and the ‘non-tradable’ one. We also assume only one production factor: labour. While simplifying a great deal our analysis, this hypothesis can be justified by considering land as an important factor of production, whereas capital intensity is low in developing economies such as WAEMU countries or Nigeria. Both land and capital are neither mobile across sectors nor flexible in the short run. As labour is the only mobile factor, one can merge technology, land endowment and capital endowment in the productivity factor.

\textsuperscript{16} Cash holding is introduced for the purpose of a nominal anchor. Money holding and consumption decisions are assumed contemporaneous. The non-neutrality of monetary policy comes from price and wage rigidities.

\textsuperscript{17} We do not consider oil in both the consumption and production function. However, our conclusions would not be different, since the elasticity of substitution of oil with then other inputs is low in the short-run. Since oil price variations have small allocative implications, this channel does not impact the choice of monetary policy.
The tradable sector operates under perfect competition. There is a single representative firm whose labour demand is denoted by $L_A$ and production by $Y_A$. There are decreasing returns to scale and the production function is modelled as follows:

$$Y_A = \psi_A \frac{L_A^\gamma}{\gamma},$$

(8)

where $\psi_A > 0$ is a fixed exogenous productivity factor and $\gamma > 0$. Profit maximisation under perfect competition yields

$$w = ep_A^* \psi_A L_A^{\gamma-1}.$$  

(9)

The non-tradable sector undergoes monopolistic competition: there is a continuum of firms $\{i, i \in [0, 1]\}$ producing imperfectly substitutable varieties. Each individual firm $i$ has the same production function as follows:

$$Y_N(i) = \psi_N \frac{L_N(i)^\gamma}{\gamma},$$

(10)

where $\psi_N > 0$ is an exogenous productivity factor. The non-tradable good bundle is defined over varieties, with a constant elasticity of substitution across varieties. Firms set their price à la Calvo (1983). This means that, at each period, a fraction of the firms are unable to adjust their prices. Each firm supplies all the demand it faces at current price, and its labour demand is set accordingly.

Wage rigidity is introduced here through the presence of unions that, contrasting with individual households, can extract a rent from the fact that labour demand is not infinitely elastic to the wage rate. Although unions are perhaps not a major feature of West African countries, non-market wage setting in the public sector exerts some leading role for wages in the private sector. The use of unions allows us to conveniently introduce a wage rigidity (the way unions set the same wage for constrained and unconstrained households is detailed in Galí et al. (2007)). Due to this rigidity, the labour market will not clear in the short run after a shock, which appears a reasonable feature.

3.4 Macroeconomic policy

Macroeconomic policy covers here two areas: (i) the Nigerian stabilisation fund and (ii) the union’s exchange-rate regime and monetary policy.
3.4.1 Oil-stabilisation fund

Consistent with the Nigerian saving fund, the stabilisation fund here is fed by retaining a fraction of those ‘excess’ oil revenues that otherwise would immediately be given to constrained households. ‘Excess’ oil revenues are defined as those revenues that appear when the oil price exceeds a certain exogenous price threshold $p_{\text{thresh}}^*$. The stabilisation fund’s assets, labelled $F^*$, are held in the form of foreign-denominated bonds. A fraction of the return is distributed to constrained households in each period. Hence, the funds’ asset holdings, measured per constrained household, are accumulated as follows (in foreign currency):

$$F_{no,t}^* = (1 + r_{t-1}^*)(1 - z_2)F_{no,t-1}^* + (1 - z_1)(p_{O,t}^* - p_{\text{thresh}}^*)Y_{O,\text{no}},$$

where $z_1$ and $z_2$ are positive parameters that reflect the rules set for the fund. In each period, financially constrained households receive oil revenues in three parts (see Equation (4)): (i) a ‘medium-run’ oil revenue based on the threshold price $p_{\text{thresh}}^*$; (ii) a fraction $z_1$ of revenues above this threshold price and (iii) a fraction $z_2$ of the fund’s total assets at the beginning of the period. The higher $z_1$, the quicker the excess oil revenues transferred to constrained households.

3.4.2 Monetary policy

The central bank’s balance sheet is composed of money supply $M^*$ (liability side), backed by domestic bonds $D$ (exogenous) and foreign bonds or reserves $R^*$ (exogenous or endogenous depending on the exchange-rate regime) on the asset side. Three monetary regimes are successively considered for the monetary union as a whole:

- a flexible exchange-rate regime with fixed money supply ($R^* = R_0^*$);
- a flexible exchange-rate regime with current-account surpluses inflating money supply ($R^* = R_0^* + \text{NFA}_t^*$, where NFA$_t$ denotes the net foreign asset position of the monetary union);
- a fixed exchange-rate regime backed by foreign exchange interventions.

3.5 Market equilibria

The sizes of Nigeria and WAEMU, in terms of the number of households, are denoted by $N_{\text{Nig}}$ and $N_{\text{WAEMU}}$, respectively. Assuming the same share $\mu$ of financially constrained households in both countries, aggregate variables are recovered as follows: $C_{\text{Nig}} = N_{\text{Nig}}(\mu C_{\text{no}}^{\text{Nig}} + (1 - \mu)C_{\text{opt}}^{\text{Nig}})$, $B_{\text{Nig}}^* =$
(1 − µ)N_{Nig,B_{opt}}^{N_{Nig}}, F^* = \mu N_{Nig}^{N_{Nig}}F_{no}^{N_{Nig}}, Y_O = N_{Nig}(\mu Y_{O,no} + (1 − \mu)Y_{O,opt}),

etc.

3.5.1 Balance of payments

Net foreign assets (NFA) are divided between central bank’s reserves $R^*$, households’ net foreign assets held in the form of foreign bonds $B^*$ and, in the case of Nigeria, assets held by the stabilisation fund $F^*$. Except for oil exports, Nigeria and WAEMU share the same trade pattern. They both export all their tradable production (agricultural goods) on the world market at the international price $p^*_A,t$. Hence, the balance of payments of the union at the end of period $t$ (in foreign currency) is given by

$$B_{Nig}^* + B_{WAEMU}^* + F^* + R^*$$

$$= (1 + r_{t-1}^*) \cdot (B_{Nig}^*_{t-1} + B_{WAEMU}^*_{t-1} + R^*_{t-1} + F^*_{t-1}) + p_{A,t}^* (Y_{A,t}^{Nig} + Y_{A,t}^{WAEMU}) + p_{O,t}^* - p_{M,t}^* (C_{M,t}^{Nig} + C_{M,t}^{WAEMU}),$$

(12)

where $Y_A$ denotes agricultural exports, $Y_O$ oil exports and $C_M$ manufactured good imports, and $p_{A,t}^*$, $p_{O,t}^*$ and $p_{M,t}^*$ are their corresponding prices in foreign currency. Here $R^*$, $F^*$ and $B^*$ are also expressed in foreign currency.

3.5.2 Domestic bond market

As already mentioned, the counterpart of optimising households’ net domestic assets ($B_t$) appears on the asset side of the central bank’s balance sheet ($D_t$). The domestic bond market equilibrium reads

$$D_t + B_{Nig}^* + B_{WAEMU}^* = 0.$$  

(13)

3.5.3 Money market

Money demand is given by the cash constraint integrated over optimising and constrained households (equations (5)). At equilibrium, one gets

$$M_t = D_t + e_t R_t^*.$$  

(14)

As the central bank earns interest on its assets, we assume a lump-sum transfer $T_t$ to optimizing households in order to keep the balance sheet in equilibrium (i.e., equation (14)) whatever the monetary rule. The
budget constraint of the central bank writes\textsuperscript{18}

\[
(1 - \mu)(N_{\text{Nig}}^{T_{\text{opt},t}} + N_{\text{WAEMU}}^T_{\text{opt},t}) \\
= [(1 + r_{t-1}^*)e_t - e_{t-1}]R_{t-1}^\ast + r_{t-1}D_{t-1}. 
\]

\textit{3.5.4 Goods market}

World demand for the tradable good $A$ is assumed to be perfectly elastic at the world price $p_A^\ast$. As for the non-tradable good, the market equilibrium writes

\[
Y_{\text{Nig},t}^N = C_{\text{Nig},t}^N + C_{\text{WAEMU},t}^N, \quad (16) \\
Y_{\text{WAEMU},t}^N = C_{\text{WAEMU},t}^N + C_{\text{Nig},t}^N, 
\]

\textit{3.5.5 Labour market}

Given the wage rate that is set by the unions, total labour demand determines the employment $L_t$ as follows:

\[
L_t = L_{A,t} + L_{NT,t} \quad (18) 
\]

The calibration of the model is based on the main economic features of Nigeria and WAEMU (see Table 1), as well as standard parameters used in the literature (see Appendix A).

\textbf{4. The impact of an oil-price increase}

In this section we compare the impact of a 50\% increase in the oil price under three differing monetary regimes: (i) a flexible exchange rate with constant money supply; (ii) a flexible exchange rate with an accommodating monetary policy (i.e., endogenous money supply); and (iii) a fixed exchange rate.\textsuperscript{19} The shock progressively fades away, with a 65\%
autoregressive pattern (see Section 6 for the calibration of the shocks). It has no impact on the steady state of the economy. In the short run and medium run, the presence of nominal rigidities means that the impact of the shock is different across the three monetary regimes.

4.1 Impact of the shock on Nigeria

The impulse–response functions for Nigeria are reported in Appendix B, Figure B1 (a). We first consider the case without a stabilisation fund, i.e., when the oil windfall is fully distributed to both constrained and optimising households (dotted lines). For the former, this immediately translates into higher consumption, whatever the monetary regime of the union. Due to the cash constraint, these households raise their demand for money. The impact on the interest rate, and thus also on optimisers’ consumption, depends on the monetary regime.

- If money supply is given at the union level, then the nominal interest rate rises (see panel (c)). With limited inflation in this first regime, the real interest rate increases by almost as much as the nominal one. This induces unconstrained households to save more through an inter-temporal substitution effect. The net impact of the shock on their consumption is theoretically ambiguous since higher inter-temporal income allows them to consume more. Here, the consumption of optimisers declines in the short run.
- With endogenous money supply, the oil windfall causes money supply to increase gradually. This produces a marked depreciation of the nominal exchange rate, which is rationally expected in the short run and hence causes the nominal interest rate to rise sharply. The real

Table 1: Main Relevant Aggregates for the Nigeria and WAEMU, Average 2004–2006

<table>
<thead>
<tr>
<th>Variable</th>
<th>WAEMU</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual GDP (billion USD in PPP)</td>
<td>88.2</td>
<td>202.8</td>
</tr>
<tr>
<td>Share in the union</td>
<td>(30%)</td>
<td>(70%)</td>
</tr>
<tr>
<td>Total population, in million inhabitants</td>
<td>79.2</td>
<td>129.2</td>
</tr>
<tr>
<td>Share in the union</td>
<td>(38%)</td>
<td>(62%)</td>
</tr>
<tr>
<td>Imports (percentage of final non-oil demand)</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>Share of non-oil exports (percentage of GDP)</td>
<td>25%</td>
<td>1%</td>
</tr>
<tr>
<td>Oil exports (net, percentage of GDP)</td>
<td>−10%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: IMF, World Economic Outlook.

a We use this proxy to estimate the share of imported goods in consumption bundle.

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interest rate also increases in the short run, despite high inflation. However, this rise in the real interest rate is short lived: after a few quarters, the real interest rate falls below its reference level. The profile of the real interest rate leads optimising households to progressively increase their consumption level before falling back to baseline.

- Finally, when the nominal exchange rate is held constant through unsterilised foreign exchange interventions, the nominal interest rate stays constant too and the real interest rate slightly falls in the short run. In this case, the consumption of unconstrained households' increases slightly in the short run due to the rise in the inter-temporal income.

Under the three monetary regimes, aggregate consumption increases, although less so under the fixed money-supply regime than under the fixed exchange-rate regime, and less so under the latter than with an endogenous money supply. Since part of consumption falls on non-tradables, the price of the latter increases. As for the imported manufactured product, its price expressed in the home currency depends on the exchange rate: it stays constant under a fixed exchange-rate regime, falls with a fixed money supply (because the nominal exchange-rate appreciates) and rises with endogenous money supply (in this case, the exchange-rate depreciates). Hence, with a fixed money supply, consumption is partially re-allocated towards imports, whereas with an endogenous money supply, it is re-allocated towards non-tradables.

Like the price of imported manufactured goods, the price of the non-oil export sector (agriculture) stays constant in domestic currency under a fixed exchange-rate regime, falls when money supply is constant and rises if money supply is endogenous. Since the price of non-tradables increases in the three regimes, there is a re-allocation of labour from agriculture to non-tradables. Only under an endogenous money supply does employment increase in agriculture (although much less than in the non-tradable sector and only in the short run). In the two other regimes, the agricultural sector shrinks following the shock and Nigeria exhibits a Dutch disease. The impact of the shock on total employment then also depends on the monetary regime.

- Under a fixed money supply, the fall in employment in the agricultural sector compensates for the rise in the non-tradable sector, so that total

---

20 The model assumes no restriction on capital flows, which leaves no room for an independent monetary policy in a fixed exchange-rate regime.
employment is almost unaffected by the shock. In fact, this regime isolates the rent, oil sector from the productive economy: the oil-price shock increases consumption and welfare with little effect on aggregate employment, although the non-tradable sector expands to the detriment of agriculture.

- Under a fixed exchange rate, total employment rises slightly, thanks to higher demand for non-tradables (in this case, there is less re-allocation in favour of imported goods) and to a more limited contraction of the agricultural sector (whose price does not fall in the domestic currency).
- Finally, it is with an endogenous money supply that total employment rises the most. This is due to the large increase in consumption that feeds the non-tradable sector, and to the depreciation of the exchange rate that both redirects consumption to domestic goods and makes agriculture more profitable.

In brief, the monetary regime that stabilises most of the Nigerian economy (in terms of both consumption and employment) after an oil-price shock is the fixed money-supply regime, although this is also the regime yielding the highest instability in agricultural employment. The endogenous money-supply regime yields the highest volatility of the economy after a shock and the fixed exchange-rate regime lies in between the other two regimes.

### 4.2 Impact of the shock on WAEMU

The impulse-response functions for WAEMU are reported in Appendix B, Figure B1 (b). The shock faced by Nigeria affects WAEMU through two distinct channels: regional trade and the single monetary policy as follows:21

- **Regional trade**: Part of the increased consumption in Nigeria falls on goods that are imported from WAEMU. These goods are the so-called non-traded goods: they are not traded with the ROW but still traded regionally. The trade channel is always positive for WAEMU. It is maximised with endogenous money supply, because in this case the Nigerian demand for non-tradables increases the most (income effect), and so does the Nigerian price of non-tradables (substitution effect).
- **Single monetary policy**: Depending on the monetary regime, WAEMU experiences a change in the interest rate, in the exchange rate and/or in available cash. Hence, this second channel of spillover can be positive, negative or neutral for WAEMU as follows:

21 Remember that the imported input channel is not considered here.
– With endogenous money supply, the additional domestic liquidity spreading on the Nigerian economy owing to higher oil receipts also spreads on WAEMU (due to higher receipts on sales of ‘non-tradables’). Additional liquidity is welcome by both types of households because it alleviates their cash constraints.

– With fixed money supply, the additional liquidity spreading on the Nigerian economy thanks to higher oil receipts involves money contraction in WAEMU. Such contraction meets the fall in money demand stemming from lower consumption by optimising households, the latter being confronted to a higher interest rate. The demand for WAEMU’s non-tradables then falls, and so does the wage rate for both types of households. Additionally, the home-currency price of agriculture falls, which reduces labour demand in this sector (an ‘imported’ Dutch disease). The fall in the wage rate leads non-optimising households to also reduce their labour supply and consumption level.

– Finally, a fixed exchange rate tends to isolate WAEMU from the shock since the interest rate and the exchange rate are then unaffected. Consumption and total employment slightly increase thanks to the regional trade channel.

### 4.3 The oil shock in brief, absent stabilisation fund

Table 2 summarises the impact of an oil-price increase on both Nigeria and WAEMU, depending on the monetary regime. From this table, it can be inferred that the different monetary regimes do not have the same impact on both economies:

- The fixed money-supply regime is the one providing the best stabilisation properties for Nigeria; but it magnifies the asymmetric feature of oil shocks: with this regime, an oil-price increase has a detrimental impact on WAEMU because of the sharp increase in the common interest rate and the associated exchange-rate appreciation.
- With endogenous money supply, monetary policy acts in a pro-cyclical way in both economies.
- Finally, a fixed exchange rate is less stabilising than the fixed money-supply regime for Nigeria, but it provides a buffer for WAEMU.
In brief, Nigeria and WAEMU are unlikely to have the same preferences in terms of monetary regime when Nigeria is hit by oil shocks: Nigeria will prefer a fixed money supply whereas for WAEMU, a fixed exchange rate will be preferred.

4.4 The role of the stabilisation fund

We now study how the introduction of a stabilisation fund in Nigeria modifies the reactions of the two economies to the same 50% increase in the oil price (see Figure B1 (a–c) in Appendix B, solid lines).

With a stabilisation fund, financially constrained households in Nigeria almost keep the same levels of consumption and labour supply as in the baseline (except with an endogenous money supply, in which case their consumption and labour supply still increase substantially). As a result, money demand is less reactive.

In the fixed money-supply regime, the introduction of the stabilisation fund limits the interest-rate increase, and optimisers no longer reduce their consumption following the shock in Nigeria. The exchange rate now hardly appreciates.\(^{22}\) Hence, there is less substitution of consumption in favour of the imported good and less substitution of production away from agriculture. The combination of a stabilisation fund and a fixed money supply almost perfectly stabilises the shock for Nigeria. For WAEMU, the lack of interest-rate increase and of exchange-rate appreciation makes this

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\(^{22}\) The stabilisation fund buys foreign bonds instead of allowing constrained households to consume more.
regime very close to that of a fixed exchange rate, i.e., it isolates the economy from the indirect impact of the oil shock.

With endogenous money supply, the oil shock still stimulates the Nigerian economy, but much less than without a stabilisation fund. The consumption of both types of households increases in the short run, but the stabilisation fund halves the impact of the shock on aggregate consumption and employment. The exchange-rate depreciation is also halved. For WAEMU, this means more reallocation of consumption in favour of imported goods (which limits the boom of the non-tradable sector), but also less stimulation of agriculture. As for Nigeria, the impact of the oil shock on aggregate consumption and employment is halved compared with the case without a stabilisation fund, although the economy is much less stabilised than with the other two regimes.

Finally, the fixed exchange-rate regime now yields the same results as the fixed money-supply regime, i.e., an almost complete stabilisation of both economies, whereas without a stabilisation fund, the fixed money-supply regime stabilises Nigeria but not WAEMU while the fixed exchange-rate regime stabilises WAEMU but not Nigeria (see Table 2).

It can be concluded that the introduction of a stabilisation fund reduces the divergence of both economies concerning the choice of a monetary regime: while without a fund, Nigeria would prefer a fixed money supply and WAEMU a fixed exchange rate, both regimes yield the same results in terms of stabilisation when a fund is introduced. However, this conclusion is valid only to the extent that the subcontinent is hit only by oil prices, which is obviously not the case.

5. The impact of an increase in the agricultural price

We now turn to the impact of a 50% increase in the world price of agricultural tradables under the same three monetary regimes.

Two main differences appear in comparison with oil price shocks. First, contrary to the oil pure endowment sector, the agricultural sector employs labour. Therefore, labour can flow to this sector when its relative price increases. Second, the two regions are less asymmetric for agriculture than for oil: Nigeria also exports agricultural products, although to a lesser extent than does WAEMU. The impulse-response functions (IRFs) for Nigeria and WAEMU are reported in Figure B2.

In the fixed money-supply regime, employment in agriculture rises in both economies. The real wage increases essentially thanks to the exchange-
rate appreciation (the home-currency price of imported manufactures declines). This increase in the real wage triggers higher labour supply. Both categories of households hence benefit from higher income; but only non-optimisers increase their consumption level. Indeed, optimisers react to the shock by consuming slightly less, because the rise in the interest rate induces them to save more (inter-temporal substitution effect). Aggregate consumption increases in both economies, but more so in WAEMU than in Nigeria, because of a higher relative size of agriculture in WAEMU. The demand for non-tradables rises in WAEMU but less so in Nigeria where the (limited) increase in aggregate consumption is netted out by its reallocation towards cheaper imported manufactured goods. This first regime is the most stabilising for both economies.

In the endogenous money-supply regime, the increase in export receipts in both countries triggers money expansion. The nominal exchange rate gradually depreciates before falling back to baseline. Consistent with the uncovered interest parity, the nominal interest rate increases in the short run, and then falls below its baseline level. Consumption increases markedly in both economies and for both types of households, which triggers a boom in non-tradable sectors all the more so that consumption is re-allocated away from imported manufactured products that become more expensive due to the exchange-rate depreciation. In parallel, the depreciation accentuates the rise in profitability in agriculture. Hence, labour demand increases strongly in both non-tradables and agriculture. Wages increase to encourage more labour supply. Like for the oil-price shock, this regime is the least stabilising one when the economies are hit by shocks.

Finally, in the fixed exchange-rate regime, the nominal interest rate stays constant because the nominal exchange rate itself is constant (uncovered interest parity). Because the consumer price index increases, the real interest rate declines in both countries. Hence, optimisers raise their consumption level in the short run both due to a positive income effect and to an inter-temporal substitution effect. The consumption of financially constrained households is boosted by the increase in money supply, deriving from unsterilised foreign exchange interventions. The fixed exchange-rate regime has stabilising properties that lie in between the fixed money-supply and the endogenous money-supply regimes.

Table 3 summarises the preferred regimes for each country/zone in terms of the lowest medium-run consumption volatility, for each type of
shock. In the presence of a well-functioning oil-stabilisation fund, the fixed money-supply regime (with a flexible exchange rate) seems to be the best for both economies whatever the shocks. However, should the stabilisation fund not play its role in allowing non-optimising households to smooth their consumption inter-temporally, a disagreement may arise between the two economies, because a fixed money supply is more stabilising in Nigeria, whereas a fixed exchange rate is more stabilising in WAEMU.

6. Welfare analysis under observed past shocks

6.1 Historical oil- and agricultural-price shocks

After evaluating the behaviour of our model in the face of a simple deterministic price shock, we now turn to comparing the aforementioned three monetary regimes based on the historical behaviour of oil and agricultural prices from 1985Q3 to 2009Q3. We use the log-price of cocoa beans \( p_{cb} \) and cotton \( p_{ct} \) because those two products represent the bulk of agricultural exports for both Côte d’Ivoire, WAEMU’s largest economy, and Nigeria. The ADF test on the log-price of cocoa and cotton rejects the presence of a unit root at the 5% significance, but the log-price of Brent oil in USD \( p_{bo} \) exhibits a unit-root. In order to keep the same treatment for oil as for agricultural prices, the three series are de-trended with a Hodrick–Prescott filter with parameter \( \lambda = 50000 \) (see Figure 3): they now appear stationary (see Table C1 in Appendix C).\(^\text{23}\) The de-trended series are denoted by \( P_O \) for oil and \( P_A \) for agriculture. The latter is defined as a basket of 70% of cocoa

\(^\text{23}\) The parameter \( \lambda \) is chosen very large in order to keep both short and medium-run fluctuations and to avoid any downward bias in the persistence of shocks. Applying a HP filter to observed data is common in the DSGE literature: the long-run trend is considered as deterministic and perfectly anticipated by agents. Using a perturbation

Table 3: Preferred Policy Regime

<table>
<thead>
<tr>
<th></th>
<th>Nigeria</th>
<th>WAEMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil shocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without stabilisation fund</td>
<td>FMS</td>
<td>FEX</td>
</tr>
<tr>
<td>With stabilisation fund</td>
<td>FMS and FEX</td>
<td>FMS and FEX</td>
</tr>
<tr>
<td>Agricultural shocks</td>
<td>FMS</td>
<td>FMS</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.
FMS, fixed money supply; FEX, fixed exchange rate.
bean and 30% of cotton de-trended series (matching the relative shares of the two products in Ivorian exports).

In order to keep a parsimonious description of the data-generation process, we estimate a VARMA(1,1) model of oil and agricultural prices, following the procedure proposed by Lüthkepohl (2005, Chapter 12). As a first step, we estimate a VAR(4) model. Then we estimate a VARMA(1,1) with eight free parameters by maximum likelihood and drop all non-significant coefficient (at 5%), keeping an echelon form for the estimation. Figure C1 in Appendix C shows that the two residuals exhibit no sign of heteroscedasticity. However, the Chow test on the covariance of the two residuals exhibits a clear structural break in the beginning of the 2000s: Being almost independent before 2002, agricultural- and oil-price shocks are positively correlated during the last period. The structure of the shocks is important for assessing the welfare implication of a given monetary regime, and so we estimate the same VARMA(1,1) with the assumption of a structural break in 2002Q4 and keep the estimated variance–covariance after 2004Q4 for our simulations. Final estimation of the VARMA is presented in Table 4 and estimated residuals are reported in Figure C1.

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24 Four lags is found optimal based on Akaike, Schwartz and Hannan-Quinn information criteria.

25 Basic explanations for this fact are the higher importance of world demand shocks both for oil and agricultural prices and increasing speculation on commodity markets.
6.2 Welfare cost of terms-of-trade shocks

We use these estimates as calibrations for the structure of the shocks affecting our model, and perform a second-order Taylor expansion around the steady state to measure the impact of economic volatility on households’ welfare-equivalent one-period consumption changes. In order to compare monetary regimes, we compute the conditional expected welfare at time zero, when the monetary regime is decided. For given monetary and fiscal (stabilisation fund) policy rules $\mathcal{P}$, welfare $W_{\mathcal{P}}$ is defined as

$$ W_{\mathcal{P}} = E_0 \sum_{t=1}^{+\infty} \beta^t u_t(C_t, L_t). \quad (19) $$

Table 5 shows the one-period consumption variation which is equivalent to the welfare loss due to the shocks structure and the policy rules. It is defined as

$$ \Delta c = (W_{\mathcal{P}} - W_0)C_{0}^{-\sigma}, \quad (20) $$

where $W_0$ denotes the welfare level in the absence of shocks. The volatility of consumption and labour supply has three sources in our model:

- The volatility of commodity prices;
- Nominal rigidities, that introduce a discrepancy between prices and optimal prices for a given monetary rule.

We depart from the optimal monetary policy literature in evaluating the welfare implications of the three simple rules already studied in the previous sections. Restricting our investigation to three simple rules seems

---

Table 4: VARMA(1,1) Estimation

$$ \begin{pmatrix} P_0 \\ P_{\alpha} \end{pmatrix} = A \begin{pmatrix} P_{(\alpha-1)} \\ P_{(\alpha-1)} \end{pmatrix} + M \begin{pmatrix} \varepsilon_{(\alpha-1)} \\ \varepsilon_{(\alpha-1)} \end{pmatrix} $$

<table>
<thead>
<tr>
<th>$A$</th>
<th>$M$</th>
<th>Variance–Covariance matrix of the shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.593</td>
<td>0</td>
<td>0.531</td>
</tr>
<tr>
<td>0.885</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

26 At time 0, the economy lies at the deterministic steady state; agents learn the structure of the shocks that will start hitting the economy in period 1; the monetary rule is decided and agents form their expectations. Then, period 1 takes place.
appropriate since such rules are easily implementable. This argument is highly appealing especially in countries where the ‘art of monetary policy’ is not as developed as in advanced economies. We also estimate the welfare implication of a stabilisation fund.

The first three columns of Table 5 present the results when considering only oil-price shocks. As expected, the endogenous money-supply policy causes large welfare losses in both countries as it exacerbates real exchange-rate and price variations both upwards and downwards. In this case, misallocations induced by the monetary policy are greater in WAEMU than in Nigeria because the agricultural sector is relatively larger than in Nigeria, and so the labour allocation problem is more acute. Being a large oil exporter, Nigeria is affected by oil-price shocks, but the monetary regime has less consequences in terms of welfare because the oil sector is a pure endowment one.\(^{27}\)

Although the two economies would agree on rejecting the endogenous money-supply regime, they would be unlikely to agree on which regime to be chosen: according to Table 5, and consistent with Table 3 above, Nigeria’s best rule is a fixed money supply, whereas WAEMU’s first choice is a fixed exchange rate as it insulates it from oil-price shocks.

\(^{27}\) The model assumes that production decisions in the agricultural sector are based on current agricultural prices, so that monetary policy has a huge factor allocation effect between the two labour-intensive sectors. Conversely, if decisions take place one or two periods in advance, the welfare cost induced by agricultural shocks or ill-designed monetary policies is mitigated. However, the conclusion of the analysis remains the same.
By sterilising part of oil export revenues, the stabilisation fund helps to mitigate money-supply instability in the endogenous money-supply regime. In fact, whatever the monetary regime, the stabilisation fund helps to greatly reduce the welfare loss induced by oil-price volatility. Even though the monetary regime ranking is not modified by the introduction of the fund, smaller losses are involved.

We now consider agricultural-price shocks (last three columns of Table 5). WAEMU and Nigeria now clearly show the same preference for a fixed money-supply regime.

When considering the welfare implication of oil and agricultural shocks simultaneously, it appears that the gain for WAEMU in mitigating the agricultural-price shocks with a fixed money supply is larger than the cost from suffering the exchange-rate volatility implied by oil shocks. In this case, the two countries can agree on a fixed money-supply rule, be there a stabilisation fund or not (see Table 6).

### Table 6: Welfare-Equivalent, One-Period Consumption Changes Under Different Regimes (Both Shocks)

<table>
<thead>
<tr>
<th></th>
<th>Nigeria (%)</th>
<th>WAEMU (%)</th>
<th>Union (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed money supply</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without stabilisation fund</td>
<td>$-0.10$</td>
<td>$-0.84$</td>
<td>$-0.38$</td>
</tr>
<tr>
<td>With stabilisation fund</td>
<td>$-0.03$</td>
<td>$-0.54$</td>
<td>$-0.22$</td>
</tr>
<tr>
<td><strong>Fixed exchange rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without stabilisation fund</td>
<td>$-3.19$</td>
<td>$-4.11$</td>
<td>$-3.54$</td>
</tr>
<tr>
<td>With stabilisation fund</td>
<td>$-1.51$</td>
<td>$-3.83$</td>
<td>$-2.39$</td>
</tr>
</tbody>
</table>

*Source: Authors’ calculation*

By sterilising part of oil export revenues, the stabilisation fund helps to mitigate money-supply instability in the endogenous money-supply regime. In fact, whatever the monetary regime, the stabilisation fund helps to greatly reduce the welfare loss induced by oil-price volatility. Even though the monetary regime ranking is not modified by the introduction of the fund, smaller losses are involved.

We now consider agricultural-price shocks (last three columns of Table 5). WAEMU and Nigeria now clearly show the same preference for a fixed money-supply regime.

When considering the welfare implication of oil and agricultural shocks simultaneously, it appears that the gain for WAEMU in mitigating the agricultural-price shocks with a fixed money supply is larger than the cost from suffering the exchange-rate volatility implied by oil shocks. In this case, the two countries can agree on a fixed money-supply rule, be there a stabilisation fund or not (see Table 6).

### 7. Concluding remarks

We have built a two-country DSGE model, calibrated on Nigeria and WAEMU, to assess the impact of commodity-price shocks in a monetary union that would cover the whole ECOWAS region, depending on the monetary regime of the union. We contrast the impact of an oil-price shock to that of an agricultural-price shock, accounting for the fact that only Nigeria has significant production of oil whereas both economies do produce agricultural commodities.

We find that an increase in the oil price has a positive impact on Nigerian consumption, although this economy suffers from a Dutch
disease that can hardly be erased by appropriate monetary regime in a monetary union. In the absence of a stabilisation fund, a flexible exchange rate with exogenous money supply (at the union level) produces the lowest level of volatility in consumption, whereas endogenous money supply leads to the highest volatility.

Conversely, the fixed money-supply regime produces the highest volatility of consumption in WAEMU in the face of oil-price shocks, whereas a fixed exchange-rate regime isolates the economy from the shock. However, the two economies are better off with a fixed money-supply regime if they are hit by both oil- and agricultural-price shocks, given the historical relative volatility of the two shocks and their correlation. All these results are robust to a change in the parameters of the model and the persistence of shocks.

Finally, we find that a well-designed oil-stabilisation fund can be very successful in stabilising both economies and reduce their possible disagreements on the common monetary policy.

Our results are consistent with the existing literature that has highlighted the heterogeneity of the ECOWAS grouping and its subsequent failure to meet the optimum currency area criteria (Masson and Pattillo, 2001; Bénassy-Quéré and Coupet, 2005; Tsangarides and Qureshi, 2008). They further show that should the region, nevertheless, proceed to a monetary union, the common central bank should avoid accommodating commodity-price shocks.Conditional on the existence of well-functioning stabilisation funds in the oil-exporting countries of the region (especially Nigeria), the best monetary regime for the union would be a flexible exchange rate with a solid internal anchor (such as a money-supply target). Such policy framework, however, would rely on strong fiscal discipline. As long advocated by the academic literature and recently experienced in Europe, fiscal discipline is indeed essential to the proper functioning of a monetary union. Enforcing fiscal discipline may in fact be the most difficult challenge for West African countries in the process of forming a monetary union.

**Acknowledgement**

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References


**Appendix A: Calibration**

The model is calibrated on a quarterly basis. A first set of parameters are calibrated so as to reproduce relevant macroeconomic ratios for the two zones at equilibrium. We assume that, absent oil rent, the two regions
are perfectly symmetric and only differ by their population. Introducing oil in Nigeria modifies the steady state as additional income leads to higher consumption and lower labour supply. We focus here on reproducing the relative sizes of the two economies (in terms of GDP and the labour force), their openness ratios and the relative size of their different production sectors (Table 1).

A second set of parameters are calibrated based on the literature, e.g. the probability of not being able to adjust prices or wages at each period, and the various elasticities of the model (Table A1).

Table A1: Calibration of the Base Model Parameters

<table>
<thead>
<tr>
<th>Parameter description</th>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riskless foreign interest rate</td>
<td>$r^*$</td>
<td>0.01</td>
</tr>
<tr>
<td>Rate of time preference</td>
<td>$\beta$</td>
<td>$1/(1+r^*)$</td>
</tr>
<tr>
<td>Inverse of the inter-temporal elasticity of substitution of consumption</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Inverse of the elasticity of labour supply</td>
<td>$\phi$</td>
<td>1</td>
</tr>
<tr>
<td>Share of non-Ricardian households in the population</td>
<td>$\mu$</td>
<td>0.75</td>
</tr>
<tr>
<td>Share of excess oil revenue given to the stabilisation fund</td>
<td>$\xi_1$</td>
<td>0/1</td>
</tr>
<tr>
<td>Share of stabilisation fund’s capitalisation given to households</td>
<td>$\xi_2$</td>
<td>0.015</td>
</tr>
<tr>
<td>Returns to scale in production</td>
<td>$\gamma$</td>
<td>0.65</td>
</tr>
<tr>
<td>Fraction of NT firms unable to reset price at every period</td>
<td>$\nu_p$</td>
<td>0.8</td>
</tr>
<tr>
<td>Fraction of unions unable to reset wage at every period</td>
<td>$\nu_w$</td>
<td>0.8</td>
</tr>
<tr>
<td>Price elasticity of substitution in the NT sector</td>
<td>$\epsilon_p$</td>
<td>7</td>
</tr>
<tr>
<td>Share of international tradable in consumption</td>
<td>$\alpha_m$</td>
<td>0.3</td>
</tr>
<tr>
<td>Elasticity of substitution between NT and M goods</td>
<td>$\eta_m$</td>
<td>0.75</td>
</tr>
<tr>
<td>Share of WAEMU’s non-tradable in Nigeria non-tradable consumption</td>
<td>$\alpha_{OA}$</td>
<td>0.10</td>
</tr>
<tr>
<td>Share of Nigeria’s non-tradable in WAEMU’s non-tradable consumption</td>
<td>$\alpha_{Nig}$</td>
<td>0.06</td>
</tr>
<tr>
<td>Elasticity of substitution between domestic and foreign NT goods</td>
<td>$\eta_n$</td>
<td>2</td>
</tr>
</tbody>
</table>

Appendix B: Impulse–response functions

Figures B1 and B2 give oil- and agricultural-price IRFs.
Figure B1: Oil-Price IRFs Under the Three Monetary Regimes with (Plain Lines) and without (Dotted Lines) a Stabilisation Fund
Figure B2: Agricultural-Price IRFs Under the Three Monetary Regimes
Appendix C: Estimation of terms-of-trade shocks

Table C1 gives ADF test estimates.

Table C1: ADF Test Estimates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Period</th>
<th>Model in ADF</th>
<th>Unit root</th>
<th>AR-coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_{cb}$</td>
<td>1985Q3–2009Q3</td>
<td>Drift + linear trend</td>
<td>No</td>
<td>0.83*</td>
</tr>
<tr>
<td>$\rho_{ct}$</td>
<td>1985Q3–2009Q3</td>
<td>Drift + linear trend</td>
<td>No</td>
<td>0.88***</td>
</tr>
<tr>
<td>$\rho_{bo}$</td>
<td>1985Q3–2009Q3</td>
<td>No drift no linear trend</td>
<td>Yes</td>
<td>1.01</td>
</tr>
<tr>
<td>$\rho_{cb}$</td>
<td>1985Q3–2009Q3</td>
<td>Drift + HP trend</td>
<td>No</td>
<td>0.75**</td>
</tr>
<tr>
<td>$\rho_{ct}$</td>
<td>1985Q3–2009Q3</td>
<td>Drift + HP trend</td>
<td>No</td>
<td>0.88**</td>
</tr>
<tr>
<td>$\rho_{bo}$</td>
<td>1985Q3–2009Q2</td>
<td>Drift + HP trend</td>
<td>No</td>
<td>0.75*</td>
</tr>
</tbody>
</table>

*, ** and *** indicate significance of the null hypothesis of the existence of a unit root at the 10%, 5% and 1% levels, respectively.

Source: Authors’ calculations.

Figure C1 shows the estimated residuals of the VARMA(1,1) and structural break tests.

Figure C1: Estimated Residuals of the VARMA(1,1) and Structural break Tests