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

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TERM OF TRADE SHOCKS IN A MONETARY UNION: AN APPLICATION TO WEST-AFRICA

NON-TECHNICAL SUMMARY

ABSTRACT

This paper presents a two-country model of the Dutch disease in a monetary union calibrated on Nigeria and WAEMU. Three monetary regimes are successively studied at the union level: a flexible exchange rate with constant money supply, a flexible exchange rate with endogenous money supply, and a fixed exchange rate regime. We find that the Dutch disease is more difficult to cure within a monetary union. Furthermore, WAEMU can be affected by oil shocks if the monetary union has a flexible exchange rate vis-à-vis the rest of the world. Finally, monetary union with Nigeria makes it more difficult for WAEMU to grasp the benefits from and increase in non-oil commodity prices. On the whole, the two zones are likely to disagree on the common monetary regime if oil-price shocks are dominant, although much less the case if non-oil commodity price shocks are also important.

JEL Classification: E52, F41, Q33.

Keywords: Dutch disease, DSGE, Monetary union, Optimal monetary policy.
RÉSUMÉ NON TECHNIQUE

RÉSUMÉ COURT

Cet article présente un modèle DSGE à deux zones en union monétaire calibré sur le Nigéria et l’UEMOA. Face à la volatilité du prix du pétrole et des matières premières agricoles, trois régimes monétaire sont envisagés : un régime de change flexible où la masse monétaire est constante, un régime de change flexible où les surplus courants viennent alimenter la création monétaire et un régime de change fixe. Les résultats montrent que la maladie hollandaise est plus difficile à éviter au sein d’une zone monétaire. Selon l’importance relative des deux types de chocs, les zones sont susceptibles d’être en désaccord sur le régime monétaire à adopter en union monétaire.

Classification JEL : E52, F41, Q33.

Mots clés : Maladie hollandaise, DSGE, Union monétaire, Politique monétaire optimale.
TERM OF TRADE SHOCKS IN A MONETARY UNION: AN APPLICATION TO WEST-AFRICA

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1. INTRODUCTION

Since 1993, monetary union has been an objective of the Economic Community of West-African States (ECOWAS), a regional trade area comprising the West African Economic and Monetary Union (WAEMU)‡, Nigeria and a number of smaller west-African countries. In 2000, an impetus was given to this project through the creation of the West-African Monetary Zone (WAMZ) which groups together Nigeria and other non-WAEMU members of ECOWAS. The project was to proceed to monetary union within this sub-group by 2003 and then organize monetary union with WAEMU. Monetary union within the WAMZ was several times re-scheduled. In June 2007, a 'single-track' approach was adopted to proceed to monetary union directly at the ECOWAS level in 2012.

Although WAEMU countries are used to monetary union (WAEMU is part of the CFA zone with a fixed peg on the euro), monetary union between WAEMU and WAMZ raises specific difficulties. Specifically, Nigeria, which weighs heavily in ECOWAS, is highly specialized in oil exports (90% of total exports), whereas the other countries export various commodities (minerals and plantation crops), but have relatively limited oil endowments. This paves the way for asymmetric shocks within the future monetary area. More specifically, Nigeria may become less equipped to face oil-price volatility, including the risk of a Dutch disease; symmetrically, WAEMU may suffer more from oil-price shocks due to its belonging to the monetary union.

To our knowledge, the question of how to tackle commodity-price volatility in a monetary union has not been studied in the literature. Indeed, models of the Dutch disease concentrate on the single-county case (see Section 2). This is not surprising since large oil or gas producers (Saudi

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2ECOWAS includes Bénin, Burkina Faso, Côte d’Ivoire, Guinean Bissau, Mali, Niger, Sénégal, Togo.
3Gambia, Ghana, Guinea, Nigeria and Sierra Leone. Liberia was initially part of this group but left due to the civil war.

4The concept of a Dutch disease was introduced by Corden and Neary (1982). It relates to an eviction of non-oil exporting sectors when the price of oil increases. See Section 2.
Arabia, Russia, Norway, Venezuela...) have retained independent currencies, and the United Kingdom has stayed away from the Euro area. The Netherlands, where the Dutch disease originates, does belong to the Euro area, but it is a relatively small country with diversified exports. Only countries of the CAEMC (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).

In this paper, we intend to study the implication of oil and non-oil commodity price volatility in a monetary union. We simulate a stylized two-country model applied to ECOWAS that extends the one-country Dutch disease models proposed in the literature (Collier and Gunning, 2005; Adam and Goderis, 2008; Adam et al., 2006; Sosunov and Zamulin, 2007). Specifically, we propose a dynamic stochastic general equilibrium model whereby Dutch disease effects are mainly demand-pull, based on several assumptions. Monetary policy is introduced through a money-supply behavior that is related to the exchange-rate regime, together with some nominal rigidities à la Calvo and a proportion of financially-constrained households. The model is calibrated and simulated using the key structural characteristics of Nigeria and the 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 monetized), and (iii) a fixed exchange-rate regime with unsterilized official interventions. We also study the implication of having a stabilization 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 isolated from in the case of a fixed exchange rate.5 In contrast, Nigeria would of course benefit from the shock, although it would suffer from a Dutch disease.

In the face of oil shocks, the two zones would likely disagree on the common monetary regime, because a fixed money-supply regime is more stabilizing in Nigeria whereas a fixed exchange rate is more stabilizing in WAEMU. Introducing an oil-stabilization fund would help solving this disagreement since the fund in itself would be stabilizing by allowing financially-constrained household in Nigeria to save part of the oil windfall.

Finally, we find that both economies would behave similarly, although in different magnitudes, in the face of non-oil commodity shocks, and that they would be best stabilized by a fixed money-supply regime.

We conclude that, in the presence of a well-functioning oil stabilization fund, the fixed money supply regime (with a flexible exchange rate) seems to be the best for both economies. However, should the stabilization fund not play its role in allowing non-optimizing households to smooth

5Here we disregard the negative effect of the oil-price shock in WAEMU through domestic oil consumption in order to focus on the role of monetary policy.
their consumption inter-temporally, a disagreement may arise between the two economies, be-
cause a fixed money supply is more stabilizing in Nigeria while a fixed exchange rate is more
stabilizing in WAEMU.

The rest of the paper is organized as follows. Section 2 provides some basic stylized facts on the
Dutch disease in Nigeria during the past oil price surges. Section 3 presents the model. Section
4 and 5 analyze the impact of an increase in the oil price and in the non-oil commodity price,
successively. Section 6 performs sensitivity analysis. Section 7 presents welfare analysis and
Section 7 concludes.

2. THE DUTCH DISEASE IN NIGERIA AND HOW TO MITIGATE IT

2.1. Nigeria and the Dutch disease

The Dutch disease phenomenon was first pointed out by Corden and Neary (1982), Corden
(1984) and van Wijnbergen (1984). It happens when a rise in the price of oil (or of whatever
commodity) crowds out the non-oil sectors of a resource-abundant country through an a real
appreciation of the currency that reduces the price competitiveness of non-oil exports. More
specifically, the Dutch disease derives from two separate mechanisms. Firstly, the rise in oil-
export receipts induces a higher demand for non-oil goods and services (usually non-tradables),
thereby implying an increase in the relative price of non-traded goods relative to non-oil traded
items (demand-side effect). Secondly, the surge in the oil price triggers factor reallocation away
from non-oil traded goods (whose relative price declines) towards the oil sector (supply-side
effect). In practice, the Dutch disease translates into an increase in the share of public spending
in aggregate demand, a rise in the fiscal deficit (on a cash basis), a rise in employment, wages
and capacity utilization in the non-traded sectors, a fall in price competitiveness in the non-oil
exporting sectors, and a real exchange-rate appreciation.

![Figure 1 – Oil Dependency of Nigeria](image)

Since the seventies, oil has been a dominant factor in the Nigerian economy, accounting for
90% of the country’s exports, representing almost four-fifths of fiscal revenues and amounting
to 47% of GDP (see Figure 1 taken from Budina and van Wijnbergen (2008)). The cumulated oil rent (defined as the returns in excess production costs) over the last 30 years is estimated USD 231 bn (Ross, 2003). Figure 2, from van Wijnbergen et al. (2007), shows that public expenditures in Nigeria have generally absorbed the entire oil windfalls (if not more) since the first oil price shock, in 1974. Furthermore, current expenditures have proved much more cyclical than public investment. Figure 3, from Sala-i-Martin and Subramanian (2003), illustrates the failure of Nigeria to translate the oil-price surges into sustained non-oil growth: the share of agriculture in GDP declined from 70 % in 1965 to 40 % since 1981; that of the manufacturing was never able to significantly exceed 10%; meanwhile, the share of non-tradable sectors (including the government) increased from 20 % in 1965 to more than 40% in the 1990s. In addition to domestic inflation rates spiking at levels about 30 %, Nigeria’s exports collapsed from 20 % of GDP during the seventies to 9.5 % in 1983. Finally, (Sala-i-Martin and Subramanian, 2003), Ayadi (2005) and Adejumo and Olomola (2006) present evidence 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 (though the strength of the relationship is still a matter of discussion).

Figure 2 – Nigeria: Expenditure and oil revenue (% of non-oil GDP)

Source: van Wijnbergen et al. (2007)

Considering the recent period of oil price increases (from 2004 to 2008), studies from the World Bank report that a substantial part of the 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). Furthermore, the Government accumulated domestic payments arrears, meaning that despite comfortable oil revenues, the true non-oil primary deficit might be higher than recorded.

Whether Nigeria has truly experienced a Dutch disease during the past oil windfalls is nevertheless debated in the literature (Pinto, 1987; Gelb, 1988; Sala-i-Martin and Subramanian, 2003;
van Wijnbergen et al., 2007; Collier et al., 2008). While there is an agreement that Nigeria has been a victim of an oil natural resource curse, opinions are still divided over the origin of the country’s impoverishment. Some authors see poor institutional quality stemming from oil as the main cause of the poor economic performance (see Sala-i-Martin and Subramanian (2003)). Others argue that we cannot distinguish between the Dutch disease and misguided policies, for instance those leading to debt overhang (van Wijnbergen et al., 2007). It is also suggested that the key problem is not that of Dutch disease, but of oil-price volatility, which is especially detrimental when monetary authorities have an exchange rate target and try to stabilize inflation (Adam et al., 2006). In fact, the literature, although not discarding the Dutch disease hypothesis, tends to draw the attention on possible ‘omitted’ that could have contributed to the hollowing out of non-oil exports in Nigeria.

Here, we adopt an ‘agnostic’ view: although it may be difficult to discriminate between Dutch disease, misguided policies, and poor institutions, there have been symptoms of the former at least during the period ranging from the early seventies to the mid-nineties (Ezeala-Harrison, 1993). Furthermore, the surge in the crude oil price from 2004 to 2008 triggered a strong, real appreciation of the Nigerian naira from 2005 to 2008 and a deterioration of the fiscal balance. Hence, we consider the Dutch disease as a very relevant risk as far as Nigeria is concerned.

2.2. The role of fiscal and monetary policies to mitigate the Dutch disease

There are several ways to combat the Dutch disease. One is the adoption of fiscal rules. Three different fiscal rules are usually envisaged for managing oil revenues in order to avoid the Dutch disease, all of them relate to smoothing of intertemporal consumption. First, a stabilization fund can be built up, with funds saved in booming times and drawn out when the oil price decreases. Clearly, a disadvantage is the risk of exhaustion of the fund if the actual price moves down below the benchmark price. A second scheme is to set up a saving fund which requires a percentage of oil revenues to be saved. The third solution consists in setting up a financing fund. This latter
rule is referred as 'the Norwegian model' and apprehended as a 'below-the-line’ scheme in the sense that oil revenues are used to finance non-oil deficits.

Nigeria has recently set up a mixture of stabilization, saving and financing funds. Indeed, since 2004, the Government has applied an oil-price based fiscal rule (OPFR) whereby current spending is linked to a medium-term oil price (USD 40/b in 2007 and USD 62/b in 2008). The windfall oil revenues in excess of the budget reference price are saved in an 'excess crude oil account’ (ECOE). Savings are used for clearing foreign debt, thereby allowing a reduction in government’s global deficit in booming times. For instance, in the context of huge price increases during 2006-2007, the balance of the excess crude account stood at USD 9.64 bn in 2007. The well-functioning of the Nigerian fund relies on credible fiscal actions from the government that refrains from raising public spending when the oil price is rising. In their letter of policy statement at the IMF in 2007, the Nigerian authorities committed to (i) cutting primary expenditure; (ii) increasing in the import content of capital expenditure; (iii) covering fully public spending by medium-run fiscal revenues based on a moving-average of historical oil prices (see IMF (2007)). Additionally, a Fiscal Liquidity Assessment Committee (FLAC) was created, comprising the Central Bank of Nigeria (CBN) and representatives of the Ministry of Finance and Budget, in order to monitor the liquidity implications of fiscal spending.

Still, during this recent oil-price boom, the consolidated non-oil primary balance declined from +11 % in 2005 to +6 % in 2006 and +1 % in 2007. Meanwhile, foreign exchange reserves increased sharply, from USD 22 bn in 2005 to USD 42.62 bn in 2007, as a result of increased export receipts and capital inflows in a context of a managed float exchange-rate regime. Consistently, the nominal effective exchange rate did not appreciate; but buoyant domestic demand resulted in a marked real exchange-rate appreciation. Indeed, the real effective exchange rate index jumped from 105.8 (in 2004) to 124.2 (in 2005), 133.1 (in 2006) and 129.3 (in 2007). This observation is in line with the empirical findings of the literature that changes in oil prices do affect the real exchange rate in Nigeria.6 These observations illustrate the limitations of the saving fund in preventing the Dutch Disease to hurt Nigeria. In late 2008, the rapid fall in oil prices (in the wake of the global financial crisis) raised controversies about the possible depletion of the oil windfall account in a context of low prices.

On the monetary policy side, the main choice concerns the exchange-rate regime. In a floating regime, the inflationary effect of an oil-price increase (through booming domestic demand) can be compensated by a depreciation of the nominal exchange rate, preserving price competitiveness. This is no longer the case in a fixed exchange-rate regime, which reinforces spending and resource movements in favor of the non-tradable sector at the expense of tradable goods (see, Lartey et al. (2008)). However, the depreciation of the nominal exchange rate following an oil-price increase is far from granted in a floating regime, since capital inflows (rushing for the control of oil resources) can trigger a nominal exchange-rate appreciation instead of a depreci-

6 Using a VAR model on quarterly data, Olomola and Adejuno (2006) find that shocks to oil prices explain about 48 % of shocks to the real exchange rate in the first quarter, 33 % in the 8th quarter and 32 % in the tenth quarter.
ation, which further deteriorates the competitiveness of non-oil exporting sectors.

Although Nigeria’s exchange rate policy has undergone significant changes since the discovery of oil, all the experimented regimes were types of fixed or quasi-fixed regimes (fixed exchange rate during the sixties, pegged arrangement between the seventies and the mid-eighties and a regime of managed float since 1986). In order to compensate for the rise in the non-traded price level, several options are possible; for instance, a devaluation of the domestic currency (which amounts to changing the parity), a sterilization of foreign reserves (through the money market, by selling government securities in exchange for domestic currency), or by reducing the existing stock of debt (this amounts to absorbing but not spending the oil revenues). Which options did the Nigerian monetary authorities choose during the different episodes of oil price increases?

Between 1970 and 1976 (this period includes the 1974 oil price shock), the Nigerian authorities embarked in expansionary monetary policies, which accentuated the spending boom stemming from the first oil shock in a context of restriction on consumer goods imports. Meanwhile, the exchange rate policy shifted from a fixed regime in the 1960s to a pegged arrangement in the 1970s and early 1980s, backed by foreign exchange controls. This policy resulted in strong over-valuation of the Nigerian currency. Similarly, a ‘bad’ monetary policy (over-valued exchange rate with loose monetary policy) resulted in an exacerbated Dutch disease during the second oil-price shock, in 1979.

In the 1990s, two important reforms were introduced in Nigeria: the adoption of an autonomous foreign exchange market in 1995, and the introduction of an inter-bank foreign exchange market in 1999. Though the main objective was to maintain a realistic exchange rate by diversifying the supply of foreign exchange in the economy, these policies failed to prevent the real appreciation of the Naira when the oil price increased again, due to expansionary fiscal policies and the persistence of excess liquidity.

In 2000s, the monetary strategy changed substantially, with the adoption of inflation stabilization as the main target of monetary policy. The central bank of Nigeria (CBN) also adopted a reserve money target allowing sterilization of oil reserves through open market operations, and set up a Dutch auction system that helped nominal exchange rates to converge. As a consequence, despite the oil price spike, CPI inflation followed a declining path, standing below two digits in 2006 (8.5%) and 2007 (5.9%). Furthermore, the CBN managed to avoid fiscal dominance through a higher coordination with fiscal authorities, in particular through the FLAC, and through the decision to use extra oil revenues to reimburse the country’s outstanding debt. Nigeria has been shown to be in a monetary dominance regime (Baldini and Ribeiro, 2008). Finally, the managed float regime provided more latitude to adjust the nominal exchange rate in order to correct accumulated price increases.

The example of Nigeria shows that fiscal and monetary policies can be powerful to mitigate the Dutch disease, as they can also accentuate it if ill-designed. Then, a radical change in the macroeconomic policy framework implied by a move to monetary union with the WAEMU
group needs careful examination for this change not to prevent Nigeria to use macro policies to mitigate the Dutch disease. Additionally, the case of WAEMU countries needs to be scrutinized to find out whether these countries may in fact import the Dutch disease from Nigeria through sharing the same currency.

3. A DSGE MODEL OF THE DUTCH DISEASE IN A MONETARY UNION

3.1. Overview

Here we present a stylized, two-country model comprising one oil-exporting country (Nigeria, representing the bulk of the West-African Monetary Zone or 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.

The model is inspired by Sosunov and Zamulin (2007) who only consider a single country. Here, both Nigeria and WAEMU are considered small open economies: they take the world interest rate and the world price of commodities as given, and their currency is not held by non-residents. In each country, there are two production sectors:

- an agricultural sector (henceforth designated as \( A \)) that produces a good that is not consumed locally but only exported out of the region;
- 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.

Both goods are produced using a single production factor: labor. This simplifying assumption is in line with the relatively low level of capital per worker in the region.

While the price of the agricultural product is given internationally, that of the non-tradable sector is set by the producers in a monopolistic competition market. The Nigerian economy also produces oil (designated as \( O \) in the following), 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 and a good imported from international markets, labeled \( M \) (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 agriculture products that are assumed to be entirely exported towards the rest of the world (ROW).

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

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7 Additionally, Sosunov and Zamulin (2007) do not study the implication of sovereign funds for the Dutch disease.
8 In fact, the production of oil requires some capital; but capital adjusts slowly while we are interested in short-run fluctuations. Furthermore, capital is not used in the other sectors, so it can be omitted in our analysis.
9 Relaxing these simplifying assumptions would not change the results qualitatively.
is insured through the introduction of nominal rigidities à la Calvo: each period, only a fraction $\nu_p$ of non-tradable sector producers and a fraction $\nu_w$ of workers are able to change their prices (resp. wages) consistent with profit maximization. Additionally, only a fraction of households have access to the financial market to smooth consumption inter-temporally. There is no public sector, except a saving fund in Nigeria that taxes current income to redistribute later to financially-constrained households.

The next subsections detail the equations for each of the two countries.

### 3.2. Households

Two categories of households are distinguished. Optimizing households, denoted $opt$, 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 $B^*$). However there is a (potentially large) fraction $\mu$ of constrained households, labeled $no$ (for non-optimizing), who do not own any asset nor have any liability: their consumption in each period is constrained by their current income, be it their labor income or transfers they may receive from the oil stabilization fund. Note that both types of households do optimize intra-temporally (between consumption and leisure, as well as across consumption goods), although only $opt$-type households can optimize inter-temporally.

The presence of optimizing 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 modeled otherwise but for the oil stabilization fund. The government does have some capacity to smooth consumption over time, although it also suffers from financial constraints.

#### 3.2.1. Optimizing households

The budget constraint of the representative optimizing household, expressed in the domestic currency, is the following:

$$p_t C_{opt,t} + B_t + e_t B^*_{t,t} + M_{opt,t} = w_t H_{opt,t} + \Pi_t + T_t + e_t p^*_{O,t} Y_{O,t} + (1 + r_t - 1) B_{t-1} + e_t (1 + r^*_{t-1}) B^*_{t-1} + M_{opt,t-1}$$

where $M_t$, $B_t$ and $B^*_{t}$ denotes the representative household’s net holdings in domestic money, domestic bonds and foreign bonds respectively, at the end of period $t$. $B_t$ is negative (net debt) and its counterpart lie on the asset-side of the central-bank balance sheet (see Section 3.6.). $B^*_{t}$ can be either positive or negative and its counterpart lies in the rest of the world.

$r_{t-1}$ and $r^*_{t-1}$ are the returns of domestic and foreign bonds between $t - 1$ and $t$ (set in $t - 1$); $e_t$ 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, $C_t$ the consumption level and $H_t$ the number of working hours supplied during period $t$. Finally, $\Pi_t + e_t p^t_o Y^t_o + T_t$ holds for those sources of income that are independent from household’s decisions, namely firms profits ($\Pi_t$), transfers from the central bank ($T_t$, see Section (3.6.)), and oil revenues ($e_t p^t_o Y^t_o$), where $p^t_o$ is the oil price and $Y^t_o$ the oil production, both being exogenous.

Household’s instantaneous utility in period $t$ is given by the following:

$$u_{opt,t} = u(C_{opt,t}, H_{opt,t}) = C^{1-\sigma}_{opt,t} - \sigma - \kappa H_{opt,t}^{1+\phi}$$

where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, $\kappa$ and $\phi$ are positive parameters. Each optimizing household maximizes the following intertemporal utility function, where $0 < \beta < 1$ is the discount factor:

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

subject to the budget constraint (1) and the following cash constraint:

$$M_{opt,t} \geq p_t C_{opt,t}$$

Due to the cash constraint, the relation between marginal utility of wealth (i.e. the Lagrange multiplier on the budget constraint (1)) and marginal utility of consumption involves a forward-looking term:

$$\lambda_{opt,t} = \frac{C^{1-\sigma}_{opt,t}}{p_t} - \beta r_t E_t \{ \lambda_{opt,t+1} \}$$

The pricing kernel (the stochastic discount factor) of optimizing households, $q^{opt}_{t,s}$ and the marginal rate of substitution between wealth and leisure, $\text{mrs}_{opt,t}$, are given by:

$$q^{opt}_{t,s} = \beta^s \frac{\lambda_{opt,t+s}}{\lambda_{opt,t}}$$

$$\text{mrs}_{opt,t} = \kappa \frac{H_{opt,t}^\phi}{\lambda_{opt,t}}$$

\[^{10}\text{See for instance Walsh (2003) Chapter 3.3.}\]
In the model, households are assumed to rent their labor to unions that will set wages on a monopolistic competition market (see Section (3.3.)). Solving the household’s program then reduces to the two following first-order conditions:

\[ E_t \{ q_{t,t+1}^{opt}(1 + r_t) \} = 1 \]  

\[ E_t \{ q_{t,t+1}^{opt}(1 + r_t^* e_{t+1} e_t) \} = 1 \]  

Equation (8) is the Euler condition that expresses the inter-temporal substitution of consumption as a function of the real interest rate compared to the subjective discount factor. Equation (9) arises from the arbitrage between domestic and foreign bond holdings. It is the uncovered interest parity.

### 3.2.2. Rule-of-thumb households and the oil stabilisation fund

As stated earlier in this section, a fraction \( \mu \) of households are financially constrained and have not access to financial instrument (i.e. domestic and foreign bonds) to optimize inter-temporarily. In Nigeria, however financially-constrained households benefit from an oil-stabilization fund that saves part of oil windfalls when the oil price is high and pays transfers to constrained households when the oil price is low.\(^{11}\)

#### The stabilization fund.

Consistent with the Nigerian saving fund, the stabilization fund here is fed by a fraction of excess oil revenues of constrained households, defined as those revenues that exceed a certain price threshold \( p_{\text{thresh}}^* \). The stabilization fund’s assets, labeled \( F^* \), 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 are accumulated as follows (in foreign currency):

\[ F_t^* = (1 + r_{t-1}^*)(1 - \zeta_2)F_{t-1}^* + (1 - \zeta_1)\mu(p_{O,t}^* - p_{\text{thresh}}^*)Y_{O,t} \tag{10} \]

where \( \zeta_1 \) and \( \zeta_2 \) are positive parameters that reflect the rules set for the fund, and \( \mu \) is the share of financially-constrained households. In each period, households receive oil revenues in three parts: (i) a ’medium-run’ oil revenue based on the threshold price \( p_{\text{thresh}}^* \); (ii) a fraction \( \mu \zeta_1 \) of revenues above this threshold price, and (iii) a fraction \( \zeta_2 \) of the fund’s total assets at

\(^{11}\)Only financially-constrained households receive transfers from the oil stabilization fund; transfers to unconstrained households would be neutral in the model since these households are able to reallocate their income inter-temporarily.
the beginning of the period. The higher $\zeta_1$, the quicker excess oil revenues are transferred to rule-of-thumb households. The steady-state value of the stabilization fund, $\bar{F}^*$, is such as:

$$
\bar{F}^* = \mu \frac{(1-\zeta_1)(\bar{p}_O - p_{\text{thresh}}^*)}{1 - (1 + r^*)(1 - \zeta_2)} \bar{Y}_O
$$

where $\bar{p}_O$ and $\bar{Y}_O$ denote the steady-state levels of the oil price and output, respectively.

**Household program.** Constrained households maximize their intertemporal utility subject to a budget constraint and a cash constraint:

$$
p_t C_{no,t} + M_{no,t} = w_t H_{no,t} + \Pi_t + e_t p_{\text{thresh}}^* Y_{O,t} + M_{no,t-1} + \zeta_1 e_t (p_{O,t}^* - p_{\text{thresh}}^*) Y_{O,t} + e_t (1 + r_{t-1}^*) \zeta_2 F_{t-1}^*/\mu
$$

$$
M_{no,t} \geq p_t C_{no,t}
$$

By assuming (13) is always binding, consumption and money holding dynamics are the mechanical results of the two constraints. The marginal utility of income is given by:

$$
\lambda_{no,t} = \frac{1}{2} \left( \frac{C_{no,t}^{-\sigma}}{p_t} + \beta \mathbb{E}_t \{ \lambda_{no,t+1} \} \right)
$$

The value of the pricing kernel and marginal rate of substitution between leisure and income have the same expressions as for unconstrained households:

$$
q_{t,s}^{no} = \beta^s \frac{\lambda_{no,t+s}}{\lambda_{no,t}}
$$

$$
\text{mrs}_{no,t} = \kappa H_{no,t}^\phi \frac{\lambda_{no,t}}{\lambda_{no,t}}
$$

\[12\] Contrary to non financially constrained households, a strictly positive nominal interest rate is not a sufficient condition. As the steady state value of the Lagrange multiplier on the cash constraint in strictly positive, it will be always binding for small enough shocks.
3.3. Unions, wage setting and the labor market

Wage rigidity is introduced here through the introduction of unions that, contrasting with individual households, can extract a rent from the fact that labor 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 à la Calvo (1983). Due to this rigidity, the labor market will not clear in the short run after a shock, which appears a reasonable feature.

Households are assumed to rent hours $H$ to unions. Each union $u$ aggregates hours in union-specific labor supply $L(u)$ according to a one-for-one technology. This labor supply in turn is rent to firms on a monopolistic competition market. Let $L$ denote the aggregate labor supply and $w$ the aggregate price of labor (the average unit wage). We have:

$$L^{w-1} = \int uL(u)^{w-1} \, du$$

and

$$w^{1-\epsilon_w} = \int uw(u)^{1-\epsilon_w} \, du$$

where $\epsilon_w > 1$ is the elasticity of labor demand to the wage rate. Unions set their wage à la Calvo (1983): at each period, a fraction $\nu_w$ of unions, taken at random, is unable to modify its wage rate. This wage rigidity means that the labor market does not clear in the short run: unions set the unit wages, and employment is determined by labor supply for this level of unit wage. Labor rationing is assumed to be equally distributed amongst households, despite differing marginal rates of substitution between consumption and leisure for optimizing and constrained households.

Due to differing pricing kernel and their marginal rate of substitution between optimizing and financially-constrained households, the optimization programme of the union is not trivial. We follow Galí et al. (2007) in assuming a convex combination of the programmes the union would solve should it face only one type of households. At time $t$, a union $u$ that can change its wage accounts for its expected future inability to change it for several periods. Accordingly, the optimal wage $w_t$ set at time $t$ is such that:

$$\max_{w_t(u)} \mathbb{E}_t \left\{ \mu \sum_{s=t}^{+\infty} \nu_w^{s-t} q_{no,t}^s \left( \tilde{w}_t(u) - \text{mrs}_{no,s}(u) \right) L_{no,s}(u) + (1-\mu) \sum_{s=t}^{+\infty} \nu_w^{s-t} q_{opt,t}^s \left( \tilde{w}_t(u) - \text{mrs}_{opt,s}(u) \right) L_{opt,s}(u) \right\}$$

(17)

where $\mu$ is the proportion of constrained households, and $L_{no,s}(u), L_{opt,s}(u)$, denote labor demand by union $u$ that is equally addressed at time $s$ to constrained and optimizing households, respectively.
Since a proportion \( \nu_w \) of unions cannot adjust their price from one period to another, the aggregate wage dynamics is the following:

\[
w_t = \left[ \nu_w (w_{t-1})^{1-\epsilon_w} + (1-\nu_w)(\tilde{w}_t)^{1-\epsilon_w} \right]^{\frac{1}{1-\epsilon_w}}
\]  

(18)

3.4. Firms

There are two productive sectors in the economy: the tradable one (agriculture good) and the ’non-tradable’ one.\(^{13}\) We also assume only one production factor: labor. While simplifying a great deal our analysis, this hypothesis can be justified by considering that lands are an important factor of production whereas capital intensity is low in developing economies such as WAEMU countries or Nigeria and not mobile across sectors. As labor is the only mobile factor, one can merge technology, land endowment and capital endowment in the productivity factor.

3.4.1. Tradable sector \( A \)

The tradable sector operates under perfect competition. There is a single representative firm, whose labor demand is denoted \( L_A \) and production \( Y_A \). There are decreasing returns to scale, and the production function is modeled as:

\[
Y_A = \psi_A L_A^\gamma
\]  

(19)

where \( \psi_A > \) is a fixed exogenous productivity factor and \( \gamma > 0 \). Profit maximization under perfect competition yields:

\[
w = e p_A^* \psi_A L_A^{\gamma-1}
\]  

(20)

3.4.2. Non-tradable sector \( N \)

Monopolistic competition 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:

\[
Y_N(i) = \psi_N L_N(i)^\gamma
\]  

(21)

\(^{13}\)We assume than non-tradable goods are traded between the two countries but not with the rest of the World. Thus, ’non-tradable’ means, in this context, ’not traded with the rest of the World’.
where $\psi_N > 1$ is a fixed exogenous productivity factor. The non-tradable good bundle is defined over varieties with $\epsilon_p > 1$ the elasticity of substitution across varieties.

$$Y_N = \left[ \int_0^1 Y_N(i)^{1-\frac{1}{\epsilon_p}} di \right]^{\frac{\epsilon_p}{\epsilon_p-1}}$$  (22)

Let $p_N = \left[ \int_0^1 p_N(i)^{1-\epsilon_p} di \right]^{\frac{1}{1-\epsilon_p}}$ be the aggregate price of the non-tradable sector. Firm-specific demand writes:

$$Y_N(i) = \left( \frac{p_N(i)}{p_N} \right)^{-\epsilon_p} Y_N$$  (23)

**Price setting** Firms set their price à la Calvo (1983). This means that at every period, a fraction of firms $\nu_p$, taken at random, is unable to modify its price. As prices are set by firms, each one supplies all the demand it faces and its labor demand is set accordingly (see equation 21). Consistent with rational expectations, a firm $i$ that can change its price accounts for its expected future inability to change again its price for several periods. Thus, its program is the following:

$$\max_{\tilde{p}_{N,t}(i)} \mathbb{E}_t \left\{ \sum_{s=t}^{+\infty} \nu_p^{s-t} \left[ \mu q_{n_o,t}^s + (1-\mu)q_{opt,t}^s \right] (\tilde{p}_{N,t}(i)Y_{N,s}(i) - w_s L_{N,s}(i)) \right\}$$  (24)

The labor demand of the whole non-tradable sector is given by:

$$L_{N,t} = \int_0^1 L_{N,t}(i) di$$  (25)

Since a proportion $\nu_p$ of firms cannot adjust their price from one period to another, the price dynamics of non-traded goods is the following:

$$p_{N,t} = \left[ \nu_p(p_{N,t-1})^{1-\epsilon_p} + (1-\nu_p)(\tilde{p}_{N,t})^{1-\epsilon_p} \right]^{\frac{1}{1-\epsilon_p}}$$  (26)

**3.5. Trade**

Except for oil exports, Nigeria and WAEMU share the same trade pattern. They both export all the tradable production (agricultural goods) on the world market at the international price $p_{A,t}^*$. 
Households consume imported tradables $M$, and non-tradable goods $NT$:

$$C = \left[ \frac{1}{\alpha_m} C_M^{\eta_m^{-1}} + (1 - \alpha_m) \frac{1}{\eta_m} C_{NT}^{\eta_m^{-1}} \right]^{\eta_m^{-1}} \tag{27}$$

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

$$C_{NT} = \left[ \frac{1}{\alpha_n} C_{N^*}^{\eta_n^{-1}} + (1 - \alpha_n) \frac{1}{\eta_n} C_N^{\eta_n^{-1}} \right]^{\eta_n^{-1}} \tag{28}$$

With $\eta_m > 0$, $\eta_n > 0$, $0 < \alpha_m < 1$ and $0 < \alpha_n < 1$. The consumer price index is defined by:

$$p = \left[ \alpha_m (e p_M^*)^{1-\eta_m} + (1 - \alpha_m) p_{NT}^{1-\eta_m} \right]^{\frac{1}{1-\eta_m}} \tag{29}$$

The consumer price index of non-tradables is:

$$p_{NT} = \left[ \alpha_n (p_{N^*})^{1-\eta_n} + (1 - \alpha_n) p_N^{1-\eta_n} \right]^{\frac{1}{1-\eta_n}} \tag{30}$$

Domestic demand addressed to each sector are given by:

$$C_M = \alpha_m \left( \frac{e p_M^*}{p} \right)^{-\eta_m} C \tag{31}$$

$$C_{N^*} = (1 - \alpha_m) \alpha_n \left( \frac{p_{N^*}}{p} \right)^{-\eta_n} \left( \frac{p_{N^*}}{p_{NT}} \right)^{-\eta_n} C \tag{32}$$

$$C_N = (1 - \alpha_m) (1 - \alpha_n) \left( \frac{p_{NT}}{p} \right)^{-\eta_m} \left( \frac{p_N}{p_{NT}} \right)^{-\eta_n} C \tag{33}$$

### 3.6. Monetary policy and the Central Bank

The central bank 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 ($R^* = R^*_0 + NFA_t$, where $NFA_t$ denotes the net foreign asset position of the monetary union);
• a fixed exchange-rate regime backed by foreign exchange interventions.

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 ($M^*_t = e_t R^*_t + D_t$). The budget constraint of the central banks writes:

$$T_t = [(1 + r^*_t - 1)e_t - e_{t-1}]R^*_{t-1} + r^*_{t-1}D^*_{t-1}$$

(34)

3.7. Market equilibria, calibration and benchmark steady state

3.7.1. Accounting identities

Net foreign assets 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, a saving fund $F^*$. Hence, the balance of payments at the end of period $t$ (assumed to be a quarter) writes (in foreign currency):

$$F^*_t + R^*_t + B^*_t = (1 + r^*_{t-1}) \cdot (B^*_{t-1} + R^*_{t-1} + F^*_{t-1}) + p^*_A Y_A,t + p^*_O Y_O,t - p^*_M C_M,t$$

(35)

where $Y_A$ denotes agricultural exports, $Y_O$ oil exports and $C_M$ manufactured good imports, and $p^*_A, p^*_O, p^*_M$ are their corresponding prices in foreign currency. $R^*$, $F^*$ and $B^*$ are also expressed in foreign currency. Note that $Y_O = 0$ and $F^* = 0$ for WAEMU.

3.7.2. Market equilibria

Domestic bond market As already mentioned, the counterpart of optimizing households’ net domestic assets (here, net debts) $B_t$ appears on the asset side of the central bank’s balance sheet ($D_t$). Together with official reserves $R^*_t$, $D_t$ constitutes the counterpart of money creation, $H_t$. Because optimizing households represent a fraction $(1 - \mu)$ of the population, the domestic bond market equilibrium reads:

$$D_t + (1 - \mu)B_t = 0$$

(36)

14Constrained households are assumed not to receive this transfer because this would amount for them to indirectly hold bonds; hence this would erase their difference to optimizing households.
Money market Money demand is given by the cash constraint integrated over optimizing and rule-of-thumb households (Equations 4 and 13). Money supply is described in Section 3.6. At equilibrium, one gets:

\[ M_t = D_t + e_t R_t^* \]  

(37)

Goods market Foreign demand for the tradable good \( A \) is assumed to be perfectly elastic at world price \( p_A^* \). As for the non-tradable good, the market equilibrium writes:

\[ Y_{N,t} = C_{N,t} + C_{N,t}^* \]  

(38)

Note that bilateral trade of ‘non-tradable’ goods between WAEMU and Nigeria needs not be balanced, even in the long-run where a bilateral imbalance can compensate for different imbalances between each country/zone and the rest of the world.

Labor market Total labor demand writes \( L_t^D = L_{A,t} + L_{N,t} \), which determines employment \( L_t \), given the wage rate that is set by the unions:

\[ L_t = L_{A,t} + L_{NT,t} \]  

(39)

3.7.3. Calibration and benchmark steady state

Before simulating the behaviors of these two economies when they are hit by shocks, one first needs to get a calibration of the main relevant parameters. A first set of parameters are calibrated such as to reproduce relevant macroeconomic ratios for the two countries at equilibrium. We assume that, absent oil rent, the two regions are perfectly symetric and only differs by their population. Introducing oil in Nigeria modifies the steady-state as the excess income leads to a higher consumption and a lower labor supply. We focus here on reproducing the relative size of the two economies (in terms of GDP and labor force), their openness ratios, and the relative size of their different production sectors (Table 1).

Table 2 reproduces the steady-state values of the main variables when oil is introduced in Nigeria. Due to money neutrality in the long run, they are the same whatever the monetary regime. Table 2 presents the case where there no stabilization fund (i.e. with \( \zeta_1 = 0 \)). Calibration assumes identical steady-state values for optimizing and non-optimizing households. it is performed so as to ensure rounded-up values for most WAEMU and Nigeria’s variables.
Table 1 – Main relevant aggregates for the Nigeria and WAEMU

<table>
<thead>
<tr>
<th>Variable</th>
<th>WAEMU</th>
<th>Nigerian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchasing power parity GDP, in billion USD, average for 2000 – 2006</td>
<td>88.2 (30%)</td>
<td>202.8</td>
</tr>
<tr>
<td>Total population, in million inhabitants</td>
<td>79.2 (38%)</td>
<td>129.2</td>
</tr>
<tr>
<td>Imports (percentage of final non oil demand(^{(a)}))</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>Non oil exports (percentage of GDP)</td>
<td>25%</td>
<td>2%</td>
</tr>
<tr>
<td>Oil exports (percentage of GDP)</td>
<td>0%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: IMF, *World Economic Outlook*. \(^{(a)}\) As the model ignore processing trade, we use this proxy to estimate the share of imported goods in consumption bundle.

Table 2 – Steady state variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>WAEMU</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C_{opt}, C_{iso})</td>
<td>1</td>
<td>1.18</td>
</tr>
<tr>
<td>(L_{opt}, L_{iso})</td>
<td>1</td>
<td>0.80</td>
</tr>
<tr>
<td>(C)</td>
<td>0.38</td>
<td>0.73</td>
</tr>
<tr>
<td>(L)</td>
<td>0.38</td>
<td>0.50</td>
</tr>
<tr>
<td>(Y_A)</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>(Y_{NT})</td>
<td>0.29</td>
<td>0.43</td>
</tr>
<tr>
<td>(RER)(^{(a)})</td>
<td>0.89</td>
<td>0.77</td>
</tr>
</tbody>
</table>

\(^{(a)}\) \(RER = \frac{e}{p}\), where \(e\) is the nominal exchange rate and \(p\) the consumer price index.

Thanks to oil revenues, welfare is higher in Nigeria than in WAEMU: consumption is higher while labor supply is lower. As a result, prices are also slightly higher in Nigeria than in WAEMU, which translates into a lower value of real exchange rate RER.\(^{15}\)

A second set of parameters are calibrated based on the literature. These are the probability of not being able to adjust prices or wages at each period, and the various elasticities of the model (see table 8 in Appendix). Section (6.) shows how the steady-state with oil is affected by the calibration of the three main elasticities: intertemporal elasticity of substitution \((1/\sigma)\), elasticity of labor supply \((1/\phi)\) and elasticity of substitution between domestic and imported goods in the consumption basket \((\eta_m)\).

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)\(^{15}\) The World Bank estimates than price level is 6% higher in Nigeria in 2007 and real consumption around 40% higher (See Lufumpa and Kasekende. (2007)).
a fixed exchange rate. The shock progressively fades away, with a 65% autoregressive pattern. 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. We compare the three regimes based on the impulse-response functions (IRFs). We then introduce a stabilization fund in Nigeria and compare our results with those obtained without a fund.

4.1. Impact of the shock on Nigeria

The IRFs for Nigeria are reported in Figures 6, panel (a) for the case without a stabilization fund, i.e. when the oil windfall is fully distributed to both ‘hand-to-mouth’ and ricardian households. 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 optimizers’ consumption, depends on the monetary regime:

- If money supply is given at the union’s 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 can also induce them to consume more. Here, the consumption of optimizers falls 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 interest rate to rise sharply. The real 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 optimizing households to progressively increase their consumption level before returning to baseline.

- Finally, when the nominal exchange rate is held constant through unsterilized foreign exchange interventions, the nominal interest rate stays constant too and the real interest rate slightly falls in the short run. In this case, Ricardian households’ consumption increases slightly in due to the rise in 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

\[ 16 \text{The model assumes no restriction on capital flows, which leaves no room for an independent monetary policy in a fixed exchange-rate regime.} \]
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 reallocated towards imports whereas with an endogenous money supply, it is reallocated towards non-tradables.

Like the price of imported manufactured goods, the price of the non-oil export sector (agriculture) stays constant 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 reallocation of labor 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 agriculture sector exceeds the rise in the non-tradable sector, so that total employment decreases after the shock. In fact, this regime isolates the rent, oil sector from the productive economy: an oil-price increase rises 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 reallocation in favor of imported goods) and to a lower contraction of the agriculture sector (whose price does not fall in 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 stabilizes most 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 for agriculture 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 two other regimes.

4.2. Impact of the shock on WAEMU

The IRFs for WAEMU are reported in Figures 6, panel (b). WAEMU "imports" the shock from Nigeria through two channels:

- The regional trade channel: the rise in consumption in Nigeria stimulates the demand for WAEMU’s "non-traded" goods, all the more so that the price of Nigeria’s non-traded goods rises.
The monetary channel: depending on the monetary regime, WAEMU will experience a change in the interest rate, in the exchange rate and/or in available liquidity.

The trade channel is always positive for WAEMU, and more so with endogenous money supply because this regime maximizes the impact of the shock on the demand for non-tradables in Nigeria. Conversely, the monetary channel can be positive, negative or neutral:

- With endogenous money supply, the additional domestic liquidity spreading on the Nigerian economy thanks to higher oil receipts also spreads on WAEMU (due to higher receipts on sales of "non-tradables"). Additional liquidity is welcome by both type of households, who want to spend their additional income.

- 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 optimizing 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 labor demand in this sector (an "imported" Dutch disease). The fall in the wage rate leads non-optimizing households to also reduce their labor supply an consumption level.

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

4.3. The oil shock in brief, absent stabilization fund

Table 3, summarizes the impact of an oil-price increase for 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 stabilization 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.

- With endogenous money supply, monetary policy acts in a pro-cyclical way in both economies.

- Finally, a fixed exchange rate is less stabilizing than the fixed money-supply regime for Nigeria, but it provides a buffer for WAEMU.

In brief, Nigeria and WAEMU will not 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.
Table 3 – Impact of an oil-price increase on Nigeria and WAEMU

<table>
<thead>
<tr>
<th>Monetary regime</th>
<th>Nigeria</th>
<th>WAEMU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>L</td>
</tr>
<tr>
<td>Without a stabilization fund</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed money supply</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Endogenous money supply</td>
<td>+ + +</td>
<td>+</td>
</tr>
<tr>
<td>Fixed exchange rate</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>With a stabilization fund</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fixed money supply</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Endogenous money supply</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fixed exchange rate</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

4.4. The role of the stabilization fund

We now study how the introduction of a stabilization fund in Nigeria modifies the reactions of the two economies to the same, 50% increase in the oil price (see Figures 7, panels (a) to (c) where dotted lines recall IRFs obtained without the stabilization fund).

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

In the fixed money-supply regime, the introduction of the stabilization limits the interest-rate increase and optimizers no longer reduce their consumption following the shock. The exchange rate now hardly appreciates following the shock. Hence, there is less substitution of consumption in favor of the imported good and less substitution of production away from agriculture. The combination of a stabilization and a fixed money supply almost perfectly stabilizes the shock. For WAEMU, the lack of interest-rate increase and of exchange-rate appreciation makes this 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 stabilization fund. The consumption of both types of households increases in the short run, but the stabilization 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 favor of imported goods (which limits the boom of the

17 The stabilization fund buys foreign currencies instead of allowing ‘house-to-mouth’ households to consume more.
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 to the case without a stabilization fund, although the economy is much less stabilized 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 stabilization of both economies, whereas without a stabilization fund, the fixed money supply regime stabilizes Nigeria but not WAEMU while the fixed exchange-rate regime stabilizes WAEMU but not Nigeria (see Table 3, bottom lines).

It can be concluded that the introduction of a stabilization 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 stabilization when a fund is introduced. However this conclusion is valid only to the extent that the sub-continent 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: (i) flexible exchange rate with fixed money supply, (ii) flexible exchange rate with endogenous money supply, and (iii) fixed exchange rate.

Two main differences appear in comparison with oil price shocks. First, contrary to the oil pure endowment sector, the agricultural sector employs factors of production. Therefore, labor 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 IRFs for Nigeria and WAEMU are reported in Figures 8.

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 labor supply. Both categories of households hence benefit from higher income. But only non-optimizers increase their consumption level. Indeed, optimizers react to the shock by consuming slightly less, because the rise in the interest rate induces them to save more (inter-temporal substitution effect). However, aggregate consumption increases in both economies, but more so in WAEMU than in Nigeria, because of a higher in relative size of agriculture in WAEMU (see Table 2). 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 stabilizing 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 and then falls 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, al the more that consumption is reallocated 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, labor demand increases strongly in both non-tradables and agriculture. Wages increase to encourage more labor supply. As for the oil-price shock, this regime is the less stabilizing 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, optimizers 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 unsterilized foreign exchange interventions. The fixed exchange-rate regime has stabilizing properties that lie in-between the fixed money supply and the endogenous money supply regimes.

Table 4 below summarizes the preferred regimes for each country in terms of the lowest medium-run consumption volatility, for each type of shock. In the presence of a well-functioning oil stabilization fund, the fixed money supply regime (with a flexible exchange rate) seems to be the best for both economies. However, should the stabilization fund not play its role in allowing non-optimizing households to smooth their consumption inter-temporally, a disagreement may arise between the two economies, because a fixed money supply is more stabilizing in Nigeria while a fixed exchange rate is more stabilizing in WAEMU.

Table 4 – Countries’ favorite 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 stab. fund</td>
<td>Fixed money supply</td>
<td>Fixed exch. rate</td>
</tr>
<tr>
<td>with stab. fund</td>
<td>both</td>
<td>both</td>
</tr>
<tr>
<td>Agriculture shocks</td>
<td>Fixed money supply</td>
<td>Fixed money supply</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

6. SENSITIVITY ANALYSIS

Among the numerous parameters of the model, three can be thought critical since their values can greatly affect the steady state when oil is introduced in Nigeria\(^\text{18}\) and the impulse response function of the economy: the intertemporal elasticity of substitution \(1/\sigma\), the elasticity of labor supply \(1/\phi\) and the elasticity of substitution between domestic and imported goods \(\eta_m\) (see Table 8).

\(^{18}\)absent oil rent in Nigeria, the two countries are identical except for their size. when oil rent is introduces, prices increase in Nigeria and the agricultural sector shranks.
6.1. How parameters modify the steady-state

In the basic calibration, $\sigma$, $\phi$ and $\eta_m$ have been set to 2, 1 and 0.75 respectively. We now evaluate how the steady-state with oil in Nigeria is modified when $\sigma$, $\phi$ and $\eta_m$ lies in the range $[0.8, 2]$. $\sigma$ and $\phi$ both play a major role in the impact of oil revenues on the steady state. The oil rent allows a higher consumption level leading to:

- an increase in the marginal rate of substitution: labor supply shrinks;
- an increase in labor demand in the non-tradable sector.

In order to re-equilibrate the labor market, the wage level and domestic price increase and labor demand in the agricultural sector shrinks. Figure (4,a) and (4,b) shows how the value of $\sigma$ and $\phi$ modifies employment in the agricultural sector. The larger $\sigma$, the highest the shift in the marginal rate of substitution. The lower $\phi$, the larger the employment drop in the agricultural sector.

As consumption increases and labor supply decreases, the real exchange rate has to appreciate to achieve internal equilibrium. If non-tradable and imported goods are complementary in consumption, the real exchange rate have to depreciate more (see Figure (4,c)).

![Figure 4 – Steady-state shifting sensitivity analysis](image)

Labor and consumption price in Nigeria, oil rent steady-state vs no oil steady-state

6.2. Effect of an oil-price shock

We now turn to the sensitivity of impulse response functions after an oil-price shock. According to our simulations, $\sigma$ and $\eta_m$ are the two main parameters that modify the dynamic of the economy.

**The role of $\sigma$**  The higher $\sigma$ (i.e. the lower the intertemporal elasticity of substitution), the less optimizing households are willing to sacrifice their current consumption to build assets in response to a real interest rate increase. After a positive oil price shock as the one simulated
here, optimizing households in Nigeria face an increase of permanent income, but the short run impact depends on the monetary regime:

- In the fixed money supply regime, the real interest rate increases; the rise of consumption in Nigeria is smaller the lower $\sigma$.
- In the fixed exchange rate regime, the real interest rate falls; the rise of consumption in Nigeria is magnified if $\sigma$ is low.

However, the general equilibrium effect depends on how the value of $\sigma$ modifies the real interest rate dynamic. Simulations show that the real interest rate is less reactive for low values of $\sigma$: consumption dynamic is therefore lightly influenced by the inter-temporal elasticity of substitution.

The role of $\eta_m$ We have assumed a low elasticity of substitution between non-tradable goods and imported goods ($\eta_m = 0.75$). Assuming a higher value of $\eta_m$ does not affect the main results of the simulation are not affected except that labor demand in the non-tradable sector may not increase after a positive oil-price shock in the fixed money supply regime: as the currency appreciates, the rise of consumption entirely weighs on imported goods.

7. Welfare analysis under observed past shocks

After evaluating the behavior of our model in the face of a simple deterministic price shock, we now turn to comparing the aforementioned three monetary regimes with estimated real shocks taken from past series of $p_O$ and $p_A$. More specifically, we estimate a $VAR(1)$ model to get an estimate of the persistence of the shocks on these two price variables, as well as an estimate of the variance of innovations. Specifically, we estimate a $VAR(1)$ model on the log-prices of oil and cocoa beans between 1990Q1 and 2008Q1 (both detrended with a Hodrick-Prescott filter with parameter $\lambda = 1600$, which is standard for quarterly data). We use the price of cocoa beans as a shortcut to $p_A$ because cocoa beans represent more than half of agricultural exports for both Côte d’Ivoire, WAEMU’s largest economy, and Nigeria (respectively 70% and 55% in 2003). The results are presented in Table 5. They show that oil prices and agricultural (export) prices are serially uncorrelated. Agricultural prices have a somewhat higher persistence than oil prices, and they are less volatile.

We then 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 the households’ welfare-equivalent one-period consumption changes.

In order to compare monetary regime, we compute the conditional expected welfare at time

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19 Source: FAOSTAT.
Table 5 – VAR estimates

<table>
<thead>
<tr>
<th></th>
<th>$p_O$</th>
<th>$p_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_O(-1)$</td>
<td>0.65*</td>
<td>-0.03</td>
</tr>
<tr>
<td>$p_A(-1)$</td>
<td>-0.12</td>
<td>0.82*</td>
</tr>
<tr>
<td>Innovation variance</td>
<td>0.0149</td>
<td>0.0077</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.48</td>
<td>0.68</td>
</tr>
</tbody>
</table>

* indicates significance at the 5% level.

zero, when the monetary regime is decided.\(^{20}\) For given monetary and fiscal (stabilization fund) policy rules $\mathcal{P}$, welfare $W_\mathcal{P}$ is defined as:

$$W_\mathcal{P} = E_0 \sum_{t=1}^{+\infty} \beta^t u_t(C_t, L_t) \quad (40)$$

Let $W_0$ and $C_0$ the welfare and the consumption level in an economy facing no shocks. Tables (6) and (7) show the one-period consumption variation which is equivalent to the welfare loss due to the shock structure and the policy rules. It is defined as:

$$\Delta c = (W_\mathcal{P} - W_0)C_0^{-\sigma} \quad (41)$$

The volatility of consumption and labor supply has three origins in our model:

- The volatility of commodity prices;
- Price rigidities that introduce a discrepancy between prices and optimal prices;
- The monetary rule that is not necessarily optimal.\(^{21}\)

We depart from the optimal monetary policy literature in evaluating the welfare implication of the three ‘simple rules’ already studied in the previous section. Restricting our investigation to three simple rules seems 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 stabilization fund.

Table 6 presents 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

\(^{20}\)At time 0, the economy lies at the deterministic steady state; agents learn the structure of the shocks that will start hitting the economy at period 1; the monetary rule is decided and agents form their expectations. Then period 1 takes place.

\(^{21}\)Absent wage rigidity, there would still be a welfare loss coming from mark-up variations in the non-traded sector. The optimal monetary regime should therefore target non-traded prices: by stabilizing non-traded prices, monetary policy stabilizes mark-ups. However, in a monetary union experiencing asymmetric shocks, price stability in the non-traded sector cannot be achieved simultaneously in the two regions.
Table 6 – Welfare-equivalent, one-period consumption changes under different regimes, oil-price shocks only

<table>
<thead>
<tr>
<th>Monetary regime</th>
<th>Stab. fund</th>
<th>Nigeria</th>
<th>WAEMU</th>
<th>Union</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed no</td>
<td>-0.08%</td>
<td>-0.22%</td>
<td>-0.13%</td>
<td></td>
</tr>
<tr>
<td>Money supply yes</td>
<td>-0.01%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Endogenous no</td>
<td>-6.76%</td>
<td>-10.31%</td>
<td>-8.11%</td>
<td></td>
</tr>
<tr>
<td>Money supply yes</td>
<td>-2.33%</td>
<td>-4.13%</td>
<td>-3.01%</td>
<td></td>
</tr>
</tbody>
</table>

Exchange-rate and price variations both upwards and downwards. In this case, mis-allocations induced by the monetary policy are greater in WAEMU than in Nigeria because the agricultural sector is relatively larger than in Nigeria, so the labor allocation problem is more acute in this country.

Although the two economies would agree on rejecting the endogenous money-supply regime, they would unlikely agree on which regime to be chosen: according to Table 6, and consistent with Table 4 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.

By sterilizing part of oil export revenues, the stabilization fund helps mitigating money supply instability in the endogenous money supply regime. In fact, whatever the monetary regime, the stabilization 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.

Table 7 – Welfare-equivalent one-period consumption changes under different regimes, agricultural-price shock only

<table>
<thead>
<tr>
<th>Monetary regime</th>
<th>Nigeria</th>
<th>WAEMU</th>
<th>Union</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Money supply</td>
<td>0.02%</td>
<td>-0.88%</td>
<td>-0.32%</td>
</tr>
<tr>
<td>Endogenous Money supply</td>
<td>-22.51%</td>
<td>-48.52%</td>
<td>-32.40%</td>
</tr>
<tr>
<td>Fixed Exchange rate</td>
<td>-0.94%</td>
<td>-4.75%</td>
<td>-2.40%</td>
</tr>
</tbody>
</table>

We now considers the combination of oil and agricultural price shocks (sum of Table 6 and Table 7). WAEMU and Nigeria now clearly show the same preference for a fixed money-supply regime. Thus, considering both type of shocks, the gain for WAEMU to mitigate the agricultural price shocks with a fixed exchange rate 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 stabilization fund or not.
8. **Conclusion and Discussion**

We have built a two-country DSGE model calibrated on Nigeria and WAEMU to assess the impact of commodity-price shocks in a currency union. More specifically, 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 evaluate how the monetary regime (fixed exchange rate, floating exchange rate with exogenous money supply, floating exchange rate with endogenous money supply) of the currency union modifies the response of the oil-exporting and the non oil-exporting country to shocks. We also study whether a stabilization fund is able to reduce the volatility of both economies and the induced welfare losses.

To do so, we successively study the impulse-response functions and use stochastic simulations based on historical volatility of crude oil and cocoa bean prices.

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. Absent a stabilization fund, a flexible exchange rate with exogenous money supply (at the union level) produces the lowest level of volatility in consumption, whereas a fixed exchange rate 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.

Finally, we find that an oil-stabilization fund can be very successful in stabilizing both economies and reduce their possible disagreements on the common monetary policy.
BIBLIOGRAPHY


Lufumpa, C. L. and Kasekende., L. (2007). Comparative Consumption and Price Levels in


Table 8 – Calibration of the base model parameters

<table>
<thead>
<tr>
<th>Parameter description</th>
<th>Name</th>
<th>Value</th>
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</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>(\frac{1}{1+\tau})</td>
</tr>
<tr>
<td>Leisure preference parameters in the utility function</td>
<td>(\kappa)</td>
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</tr>
<tr>
<td>Inverse of the intertemporal elasticity of substitution of consumption</td>
<td>(\sigma)</td>
<td>2</td>
</tr>
<tr>
<td>Inverse of the elasticity of labor 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>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>
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<tr>
<td>Fraction of unions unable to reset wage at every period</td>
<td>(\nu_w)</td>
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<tr>
<td>Price elasticity of substitution in the NT sector</td>
<td>(\epsilon_p)</td>
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<tr>
<td>Share of international tradable in consumption</td>
<td>(\alpha_m)</td>
<td>0.3</td>
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<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}^n)</td>
<td>0.10</td>
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<tr>
<td>Share of Nigeria’s non-tradable in UEMOA’s non-tradable consumption</td>
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<tr>
<td>Elasticity of substitution between domestic and foreign NT goods</td>
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<td>AR coefficient of order 1 for the A sector price process</td>
<td>(\rho_{pA})</td>
<td>0.82</td>
</tr>
<tr>
<td>AR coefficient of order 1 for the oil price process</td>
<td>(\rho_{PO})</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Figure 5 – Overview of flows for the Nigerian part of the model
Figure 6 – Oil price IRFs under the three monetary regimes without stabilization fund

(a) Nigeria

(b) WAEMU

(c) Union variables

- **Fixed money supply**
- **Endogenous money supply**
- **Fixed exchange rate**

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Figure 7 – Oil price IRFs under the three monetary regimes with stabilization fund

(a) Nigeria

(b) WAEMU

(c) Union variables

<table>
<thead>
<tr>
<th></th>
<th>Fixed money supply</th>
<th>Endogenous money supply</th>
<th>Fixed exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_{opt}</td>
<td></td>
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<tr>
<td>L_{opt}</td>
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<tr>
<td>Imports</td>
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<tr>
<td>Real int. rate</td>
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<tr>
<td>C_{no}</td>
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<td>Real int. rate</td>
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<tr>
<td>Real int. rate</td>
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</tbody>
</table>

Real int. rate

Imports

C_{opt}

C_{no}

C

L_{opt}

L_{no}

L

L_{A}

L_{NT}

r

e

w

C opt

C no

L opt

L no

L A

L NT

Nigerian variables

WAEMU variables

Union variables

Three monetary regimes

Stabilization fund

Figure 7 – Oil price IRFs under the three monetary regimes with stabilization fund
Figure 8 – Agricultural price REPs under the three monetary regimes

(a) Nigeria

(b) WAEMU

(c) Union variables

- Fixed money supply
- Endogenous money supply
- Fixed exchange rate
LIST OF WORKING PAPERS RELEASED BY CEPII