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**Monetary Policy and the Dutch Disease  
in a Small Open Oil Exporting Economy**

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Décembre 2011

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# Monetary Policy and the Dutch Disease in a Small Open Oil Exporting Economy.

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## Abstract

In this paper, we compare, first, the impact of a windfall and a boom sectors on the economy of an oil exporting country and their welfare implications; in a second step, we analyze how monetary policy should be conducted to insulate the economy from the main impact of these shocks, namely the Dutch Disease. To do so, we built a Multisector DSGE model with nominal and real rigidities. The main finding is that Dutch disease effect arise after spending and resource movement effects in the following cases: i) flexible prices and wages both in the case of a windfall and in the case of a boom; ii) flexible wage and sticky price only in the case of a fixed exchange rate. In other cases, Dutch disease effect can be avoided if: prices are sticky and wages are flexible when the exchange rate is flexible; iii) prices and wages are sticky whatever the objective of the central bank is in both cases: windfall and boom. We also compare the source of fluctuation that leads to Dutch disease effect and we conclude that the windfall leads to a strong effect in terms of de-industrialization compared to a boom. The choice of flexible exchange rate regime also helps to improve welfare.

Keywords: Monetary Policy, Dutch Disease, Oil Prices, Small Open Economy.

JEL classification: E52; F41;Q40.

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## 1 Introduction

The Dutch Disease theory was developed after the Netherlands found large sources of natural gas in the North Sea in the 1960's. Large capital inflows, from increased export revenues caused, demand for the Dutch florin to rise, which, in turn, led to an appreciation of the Dutch exchange rate. This appreciation made it difficult for the manufacturing sector to compete in international markets.

This theory has been the subject of abundant theoretical literature since the beginning of the 80's. It has been developed in a partial equilibrium framework and can be presented in two forms: the spending effect and the resource movement effect. Both effects lead to a decline of the manufacturing sector. This decline occurs because of the fall of output in this sector. Indeed, if the oil supply is inelastic, a rise of oil price leads to an increase of the demand of labor and capital in the oil sector and increases wages and capital return in this sector. If the production factors are mobile, capital and labor will move from the manufacturing sector to the oil and services sectors which will cause de-industrialization.

In their original work, Corden and Neary (1982) present the spending effect as the consequence of exchange rate appreciation on manufacturing sector production. According to these authors, the appreciation is due to an increase in the relative price stemming from increased demand in the service sector. Indeed, when manufacturing output falls, its price does not change because it is determined on the international market and the economy is considered as small. Demand for services will, therefore, increase along with its price. This leads to a rise in the price of non-tradables relative to tradables and to a real appreciation.

Regarding the resource movement effect, Corden and Neary (1982) explain that it is a consequence of perfect mobility of capital and labor from the manufacturing sector to the oil and services sectors. The resource movement effect occurs because an increase in oil prices generates a rise in wages and/or profits and generates a rise in aggregate demand in the economy. To the extent that a part of this demand will move toward the service sector, the price of non-tradable goods will rise. Consequently, the real exchange rate appreciates and generates a de-industrialization for the reasons explained above.

Two types of external shocks generate these effects: windfall and boom. Although they are both positive external shocks, a windfall shock (a rise of price of natural resource) does not incur costs while a boom shock (an increase in the stock of oil resources) does incur costs<sup>1</sup>.

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<sup>1</sup>The search for new resource and its extraction requires costs while the rise of price of oil not.

Recent studies like Sosunov and Zamulin (2007), Lartey (2008), Batt et al (2008), Acosta et al (2009) and Lama and Medina (2010) have used DSGE models to assess the impact of a positive external shock in the case of a small open economy<sup>2</sup>. These articles discuss the impact of a positive external shock as an increase of capital inflow (Lartey (2008)), remittances (Acosta et al (2009)) or of commodity prices (Sosunov and Zamlin (2007), Batt et al (2008) and Lama and Medina (2010)). These shocks are defined in the literature of the Dutch disease as windfall shocks. A boom shock which requires costs has not been studied. Indeed, none of these papers is directly concerned with the effect of boom shocks and even less by a comparison between both sources of Dutch disease. In addition, none of them assesses the role of monetary policy in each case. Finally, none of these models directly analyze oil-exporting economies, which are the most vulnerable to this type of shocks.

In this context, we build a small open oil-exporting economy model with four sectors while the above-mentioned contributions build DSGE models with only tradable and non-tradable sectors. In this paper we add an oil sector to better reflect the mechanisms of the Dutch disease described in the literature by Corden and Neary (1982). The latter assume that the economy is composed of three sectors: i) the booming sector: after the discovery of a new resource or a technological progress in the commodity sector or a rise of natural resource price; ii) the lagging sector: generally refers to the manufacturing sector but can also refer to agriculture; iii) the non-tradable sector: includes services, utilities, transportation, etc.

To investigate the impact of the two main sources of Dutch Disease namely the wind-fall sector (an increase in oil prices) and the boom sector (an increase of oil resource) in a general equilibrium framework, we develop a Multisector Dynamic Stochastic General equilibrium (MDSGE) model with microeconomic foundations and price and wage rigidities. The model is based on recent studies that have developed models for small open economies (Dib (2008), Bouakez, Rebei and Vencatachellum (2008), Acosta, Lartey and Mandelman (2009) and Lama and Medina (2010)). Drawing on these papers, we assume that the economy is inhabited by households, oil producing firms, non-tradable and tradable good producers, intermediate foreign goods importers, a central bank and a government. We also assume, as in Bouakez et al (2008), that the domestic oil price is given by a convex combination of the current world price expressed in local currency and the last period's domestic price. We adopt, finally, a Taylor-type monetary policy rule where it is assumed that the monetary authority adjusts the short-term nominal

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<sup>2</sup>Table 5 summarizes these papers focusing on the structure of models as well as the main assumptions and results.

interest rate in response to fluctuations in CPI inflation and exchange rate.

The main finding is that the Dutch disease under both spending and resource movement effects are realized in the following cases: i) flexible prices and wages both in the case of a windfall and in the case of a boom; ii) flexible wages and sticky prices only in the case of a fixed exchange rate. In other cases, the simulations indicate that Dutch disease effects do not arise when prices are sticky, wages and the exchange rate are flexible; iii) prices and wages are sticky whatever the objective of the central bank is. We also compare the source of fluctuations that leads to a Dutch disease and we conclude that the windfall leads to a stronger de-industrialization compared to a boom.

In this paper, it appears that the flexible exchange rate seems to be the best way to avoid the Dutch disease both in the cases of a windfall and a boom, but also to improve a social welfare. In other words, it is preferable for a central bank, in an oil exporting economy, to adopt inflation targeting regime to prevent the impact of oil shocks.

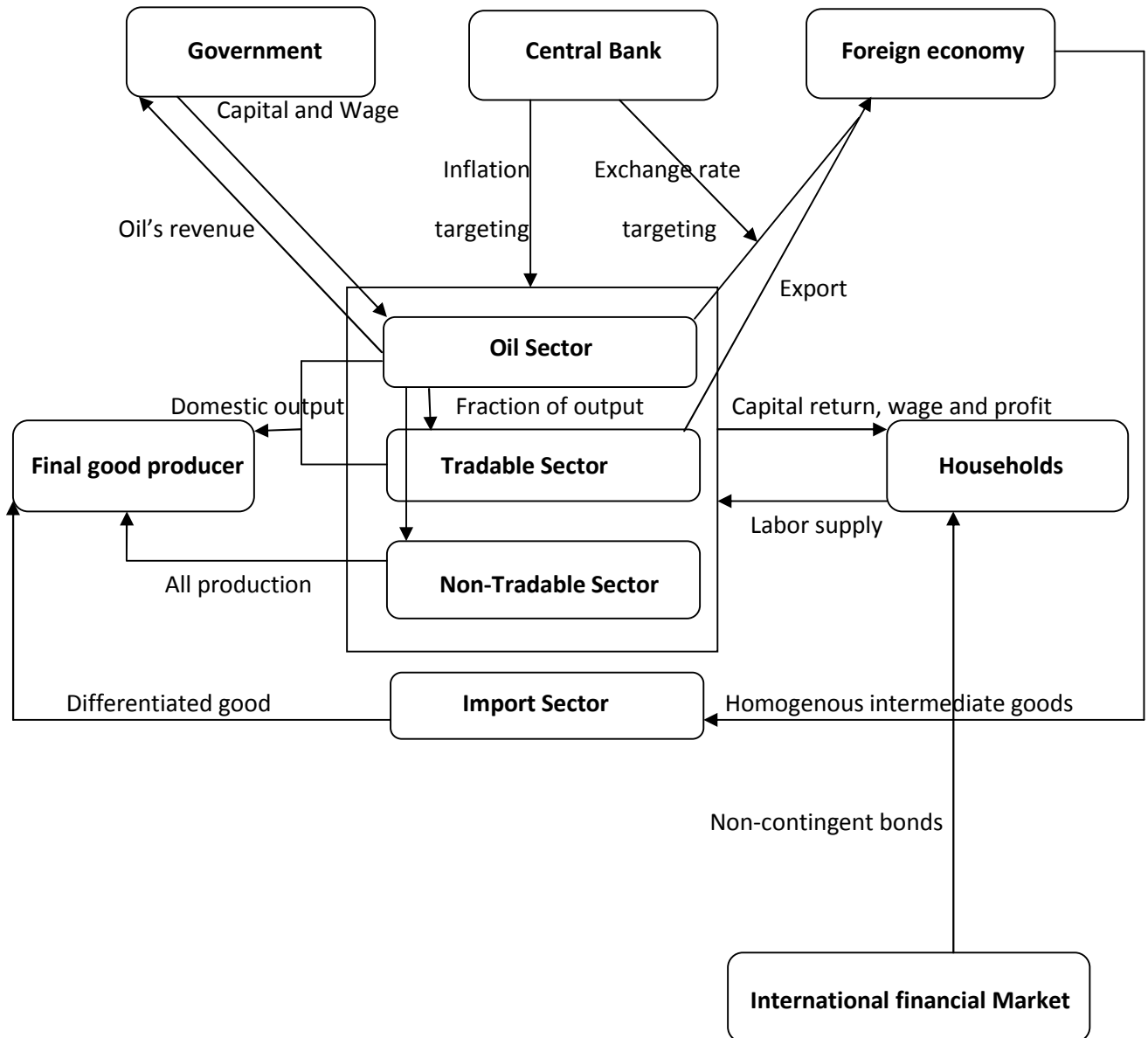
The rest of the paper is organized as follows. In Section 2, we present the details of the model. Section 3 discusses the parameters calibration. Section 4 presents the results. Section 5 measures the welfare effect of both windfall and boom under alternative monetary policy rules. Section 6 concludes.

## **2 Small Open Oil Exporting Economy Model**

In this section, we model an oil exporting economy based on recent small open economy models (Dib (2008), Acosta, Lartey and Mandelman (2009) and Lama and Medina (2010)). We assume that the economy is inhabited by eight agents: households, oil producing firm, non-tradable and tradable goods producers, an intermediate foreign goods importer, a final good producer, a central bank and a government.

Households have access to international financial markets where they can buy or sell foreign non-state contingent bonds. They can also revise their nominal wages à la Calvo (1983) and Yun (1996). In both oil, tradable and final goods sectors, each producer operates under perfect competition, while in the non-tradable goods and imports sectors, there is a continuum of monopolistically-competitive firms. These firms set their prices à la Calvo (1983) and Yun (1996). The central bank follows a Taylor-type rule, aimed at stabilizing the CPI inflation rate and changes in the nominal exchange rate.

**Figure A : Flow chart for the economy**





## 2.1 Households

There is a continuum of households indexed by  $\iota \in (0, 1)$ . Each household supplies differentiated labor services to the three production sectors, namely oil, tradable and non-tradable sectors. As in Erceg, Henderson and Levin (2000), a representative labor aggregator (or "employment agency") combines households' hours in the same proportions as firms would choose optimally. Thus, in each sector  $j$ , the demand curve for each type of labor is:

$$h_{j,t}(\iota) = \left( \frac{W_{j,t}(\iota)}{W_{j,t}} \right)^{-\theta} h_{j,t}. \quad (1)$$

variables  $h_{o,t}$ ,  $h_{T,t}$  and  $h_{nT,t}$  denote aggregate labor supplies to oil, tradable and non-tradable sectors, respectively.  $\theta > 1$  denotes the constant elasticity of substitution between different types of labor services,  $W_{j,t}(\iota)$  is the wage rate set by the household  $\iota$  and  $W_{o,t}$ ,  $W_{T,t}$  and  $W_{nT,t}$  are the aggregate wage index, or the unit cost of sales to the oil, tradable and non-tradable sectors, respectively.

The aggregate wage index  $W_{j,t}$  in sector  $j$  is given by:

$$W_{j,t} = \left( \int_0^1 W_{j,t}(\iota)^{1-\theta} d\iota \right)^{\frac{1}{1-\theta}} \quad (2)$$

,from (1) and (2), we consider  $W_{j,t}$  and  $h_{j,t}$  as given.

Each household derives utility from consumption  $c_t(\iota)$  and disutility from labor  $h_t(\iota)$ :

$$U_0(\iota) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t(\iota), h_t(\iota)), \quad (3)$$

where  $\beta$  is the subjective discount factor ( $0 < \beta < 1$ ). The instantaneous utility function,  $u(\cdot)$ , is:

$$u(\cdot) = \frac{1}{1-\gamma} c_t(\iota)^{1-\gamma} - \frac{h_t(\iota)^{1+\sigma}}{1+\sigma}, \quad (4)$$

where the preference parameters are  $\gamma > 1$  and  $\sigma > 0$ . The first parameter,  $\gamma$ , is the inverse of the elasticity of intertemporal substitution of consumption and the second

parameter,  $\sigma$ , denotes the inverse of the wage elasticity of labor supply. Aggregate labor supply,  $h_t(\iota)$ , depends on sector-specific labor supplies according to:

$$h_t(\iota) = h_{o,t}(\iota)^{\alpha_{ho}} h_{T,t}(\iota)^{\alpha_{hT}} h_{nT,t}(\iota)^{\alpha_{hnT}}, \quad (5)$$

where  $h_{o,t}(\iota)$ ,  $h_{T,t}(\iota)$  and  $h_{nT,t}(\iota)$  represent hours worked by the household  $\iota$  at time  $t$  in oil, tradable and non-tradable sectors, respectively. The parameters  $\alpha_{ho}$ ,  $\alpha_{hT}$  and  $\alpha_{hnT}$  denote the elasticity of substitution of labor in the three sectors, where  $\alpha_{ho} + \alpha_{hT} + \alpha_{hnT} = 1$ .

Households have access to domestic and international financial markets. Each household enters period  $t$  with holdings of domestic bonds denominated in units of domestic currency,  $B_{t-1}^d(\iota)$ , and foreign bonds denominated in units of foreign currency,  $B_{t-1}^f(\iota)$ . These bonds are not state contingent. This assumption is crucial. In oil exporting economies, household's consumption is not smooth and there is no international risk sharing. Also, since the dynamics of exchange rate and the current account play a central role in explaining the spending effect, the assumption of incomplete international financial markets is necessary.<sup>34</sup>

During period  $t$ , household  $\iota$  pays a lump-sum tax,  $\Gamma_t(\iota)$ , to finance government spendings, and sells or buys  $B_t^f(\iota)$  for the price that depends on a country-specific risk-premium and the world interest rate. Buying foreign bonds entails paying a risk premium,  $\kappa_t$ , of which the functional form is borrowed from Dib (2008):

$$\kappa_t = \exp\left(-\phi \frac{e_t \widetilde{B}_t^f / P_t^f}{P_t Y_t}\right), \quad (6)$$

where  $\phi$  measures the risk premium,  $e_t$  denotes the nominal exchange rate defined as the price of the foreign currency expressed in the domestic currency,  $\widetilde{B}_t^f$  is the average stock of external nominal debt, which is positive if the domestic economy is a net borrower or negative if the domestic economy is a net lender. Finally,  $Y_t$  is the total real GDP and  $P_t^f$  is the foreign price index. This functional form ensures stationarity of the model.<sup>5</sup>

Household  $\iota$  in period  $t$  earns nominal wages,  $W_{o,t}(\iota)$ ,  $W_{T,t}(\iota)$  and  $W_{nT,t}(\iota)$  for its labor supply, respectively to the oil, tradable and non-tradable good producers. It also

<sup>3</sup>In fact, one important implication of the incomplete markets framework is that it allows us to characterize the dynamics of the current account. See, among others, Chari, Kehoe and MacGrattan (2002), Benigno (2004) and Benigno and Theonissen (2006).

<sup>4</sup>See Kollmann (1996), Schmitt-Grohé and Uribe (2003) and Corsetti and Pesenti (2005) for more details about the implications of complete and incomplete international financial markets.

<sup>5</sup>See Schmitt-Grohé and Uribe (2003) for alternative ways of ensuring stationary paths in a small open economy.

receives dividend payments from both non-tradable,  $D_{nT,t}(\iota)$ , and import,  $D_{I,t}(\iota)$ , sectors so that  $D_t(\iota) = D_{nT,t}(\iota) + D_{I,t}(\iota)$  and a factor payment of oil resources,  $\varpi(\iota) P_{O,t} O_t$ , where  $P_{O,t}$  is the nominal price of oil resource input  $O_t$  and  $\varpi(\iota)$  is the share of household  $\iota$  in oil resource payments with  $\int_0^1 \varpi(\iota) d\iota = 1$ .

Finally, household  $\iota$  accumulates  $k_{o,t}(\iota)$ ,  $k_{T,t}(\iota)$  and  $k_{nT,t}(\iota)$  units of capital stocks, used in the oil, tradable and non-tradable sectors and receives nominal rentals  $Q_{o,t}$ ,  $Q_{T,t}$  and  $Q_{nT,t}$  respectively. The evolution of capital stock in each sector is given by:

$$k_{j,t+1}(\iota) = (1 - \delta)k_{j,t}(\iota) + i_{j,t}(\iota) - \Psi_j(k_{j,t+1}(\iota), k_{j,t}(\iota)), \quad (7)$$

where  $\delta$  is depreciation rate, common to all sectors ( $0 < \delta < 1$ ) and  $\Psi_j(k_{j,t+1}(\iota), k_{j,t}(\iota))$  is an adjustment cost paid by households and satisfies  $\psi_j(0) = 0$ ,  $\psi'_j(\cdot) > 0$  and  $\psi''_j(\cdot) < 0$ . The functional form of  $\Psi_j(\cdot)$  is taken from Ireland (2003):

$$\Psi_{j,t}(\cdot) = \frac{\psi_j}{2} \left( \frac{k_{j,t+1}(\iota)}{k_{j,t}(\iota)} - 1 \right)^2 k_{j,t}(\iota). \quad (8)$$

The presence of the capital adjustment cost implies that, out of the steady state, the price of newly installed capital differs from the price of investment goods, i.e. Tobin's  $Q$  differs from 1. This form also allows to have both total and marginal costs of adjusting capital equal to zero in the steady state.

The expenditures and revenues presented above give us the following household's budget constraint:

$$P_t(c_t(\iota) + i_t(\iota)) + \frac{B_t^d(\iota)}{R_t} + \frac{e_t B_t^f(\iota)}{R_t^f \kappa_t} \leq B_{t-1}^d(\iota) + e_t B_{t-1}^f(\iota) + \sum_{j=o,T,nT} Q_{j,t} k_{j,t}(\iota) + \sum_{j=o,T,nT} W_{j,t} h_{j,t}(\iota) + \varpi(\iota) P_{O,t} O_t + D_t(\iota) - \Gamma_t(\iota), \quad (9)$$

where  $i_t(\iota) = i_{o,t}(\iota) + i_{T,t}(\iota) + i_{nT,t}(\iota)$  denotes total investment.  $P_t$  is the consumption price index (CPI), defined below.

### 2.1.1 Consumption decision

Given initial values, household  $\iota$  chooses  $\{c_t(\iota), k_{o,t+1}(\iota), k_{T,t+1}(\iota), k_{nT,t+1}(\iota), B_t^d(\iota)$  and  $B_t^f(\iota)\}$  to maximize equation (4) subject to equations (7), (8) and (9) and the no-Ponzi game restriction.

First-order conditions of the household problem are:

$$\lambda_t(\iota) = c_t^{-\gamma}(\iota), \quad (10)$$

$$\lambda_t(\iota) = \frac{\beta E_t \left[ \lambda_{t+1}(\iota) \left( \psi_j \left( \frac{k_{j,t+2}(\iota)}{k_{j,t+1}(\iota)} - 1 \right) \frac{k_{j,t+2}(\iota)}{k_{j,t+1}(\iota)} - \frac{\psi_j}{2} \left( \frac{k_{j,t+2}(\iota)}{k_{j,t+1}(\iota)} - 1 \right)^2 + q_{j,t+1} + 1 - \delta \right) \right]}{\psi_j \left( \frac{k_{j,t+1}(\iota)}{k_{j,t}(\iota)} - 1 \right) + 1}, \quad (11)$$

for  $j = (o, T, nT)$

$$\lambda_t(\iota) = \beta E_t \left( \frac{\lambda_{t+1}(\iota)}{\pi_{t+1}} \right) R_t, \quad (12)$$

$$\frac{\lambda_t(\iota) s_t}{R_t^f \kappa_t} = \beta E_t \left( \frac{\lambda_{t+1}(\iota) s_{t+1}}{\pi_{t+1}^f} \right), \quad (13)$$

where  $q_{j,t} = \frac{Q_{j,t}}{P_t}$ ,  $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ ,  $\pi_{t+1}^f = \frac{P_{t+1}^f}{P_t^f}$  and  $s_t = \frac{e_t P_t^f}{P_t}$  represent the real capital return in each sector, the CPI inflation rate, the foreign inflation rate and the real exchange rate, respectively. In addition,  $\lambda_t(\iota)$  denotes the budget multiplier associated with the budget constraint.

By combining equations (12) and (13) we obtain equation (14) which represents a modified uncovered interest rate parity (UIP) condition:

$$\frac{R_t}{R_t^f \kappa_t} = \frac{e_{t+1}}{e_t}. \quad (14)$$

### 2.1.2 Wage Setting:

Following Erceg *et al.* (2000) and Dib (2008), we suppose that wages are sticky *à la* Calvo (1983) and Yun (1996). In each period, the constant probability of changing the nominal wages is given by  $(1 - \varphi_j)$ . Therefore, on average, the wage remains unchanged for  $\frac{1}{1-\varphi_j}$  periods. However, if household  $\iota$  is not allowed to adjust its wage, it updates it according to the following rule:

$$W_{j,t} = \bar{\pi} W_{j,t-1},$$

where  $\bar{\pi} > 1$  is the long run average gross rate inflation.

For the production sectors  $j = o, T, nT$ , household  $\iota$  chooses  $W_{j,t}(\iota)$  to maximize:

$$\max_{\tilde{W}_{j,t}(\iota)} E_t \left[ \sum_{s=0}^{\infty} (\beta\varphi_j)^s (U(c_{t+s}(\iota), h_{t+s}(\iota)) + \lambda_{t+s} \pi^s W_{j,t+s}(\iota) h_{j,t+s}(\iota) / P_{t+s}) \right], \quad (15)$$

subject to:

$$h_{j,t+s}(\iota) = \left( \frac{\pi^s W_{j,t}(\iota)}{W_{j,t+s}} \right)^{-\theta} h_{j,t+s}. \quad (16)$$

The first-order condition gives:

$$\tilde{w}_{j,t}(\iota) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta\varphi_j)^s \lambda_{t+s} h_{j,t+s} \Lambda_{j,t+s} w_{j,t+s}^\theta \prod_{k=1}^s \pi^{-\theta s} \pi_{t+k}^\theta}{E_t \sum_{s=0}^{\infty} (\beta\varphi_j)^s \lambda_{t+s} h_{j,t+s} w_{j,t+s}^\theta \prod_{k=1}^s \pi^{s(1-\theta)} \pi_{t+k}^{\theta-1}}. \quad (17)$$

Where  $\tilde{w}_{j,t}(\iota) = \frac{\tilde{W}_{j,t}(\iota)}{P_t}$  and  $w_{j,t+s} = \frac{W_{j,t+s}}{P_{t+s}}$  denote the real optimized wage and the real wage in sector  $j$  respectively, and for each sector  $j$ ,  $\Lambda_{j,t} = \alpha_{j,t} \frac{h_t^{1+\sigma}}{h_{j,t} \lambda_t}$ .

The aggregate real wage index in sector  $j$  evolves according to:

$$(w_{j,t})^{1-\theta} = \varphi_j \left( \pi \frac{w_{j,t-1}}{\pi_t} \right)^{1-\theta} + (1 - \varphi_j) (\tilde{w}_{j,t})^{1-\theta} \quad (18)$$

where  $\pi$  is the long run average gross rate of inflation.

Following Schmitt-Grohé and Uribe (2007), equation (17) is rewritten recursively.

The real optimized wage,  $\tilde{w}_{j,t}$ , in the sector  $j$ , is:

$$\tilde{w}_{j,t} = \frac{\theta}{\theta - 1} \frac{x_{j,t}^1}{x_{j,t}^2}, \quad (19)$$

where  $x_{j,t}^1$  and  $x_{j,t}^2$  are two auxiliary variables:

$$x_{j,t}^1 = \lambda_t h_{j,t} \Lambda_{j,t} w_{j,t}^\theta + \beta\varphi_j E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^\theta x_{j,t+1}^1 \right]. \quad (20)$$

and

$$x_{j,t}^2 = \lambda_t h_{j,t} w_{j,t}^\theta + \beta\varphi_j E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^{\theta-1} x_{j,t+1}^2 \right]. \quad (21)$$

Finally,  $R_t^f$  and  $\pi_t^f$  denoting respectively the foreign interest rate and the world inflation rate, evolve exogenously according to the following AR(1) process:

$$\log(R_t^f) = (1 - \rho_{R^f}) \log(R^f) + \rho_{R^f} \log(R_{t-1}^f) + \varepsilon_{R^f,t} \quad (22)$$

$$\log(\pi_t^f) = (1 - \rho_{\pi^f}) \log(\pi^f) + \rho_{\pi^f} \log(\pi_{t-1}^f) + \varepsilon_{\pi^f,t} \quad (23)$$

where removing the time index denotes steady state values and  $\varepsilon_{R^f,t}$  and  $\varepsilon_{\pi^f,t}$  are uncorrelated and normally distributed innovations with zero mean and standard deviations  $\sigma_{R^f}$  and  $\sigma_{\pi^f}$  respectively.

## 2.2 Sectors

In this section, we model different sectors, as in Corden and Neary (1982) and Corden (1984). The economy is divided into four sectors: oil, tradable, non-tradable goods and import sectors. Modelling these sectors and assuming the factor mobility between them, is essential to analyze the Dutch disease effect.

### 2.2.1 Oil sector

A single oil firm operates in a perfect competition market and combines capital,  $k_{o,t} = \int_0^1 k_{o,t}(\iota) d\iota$ , labor,  $h_{o,t} = \int_0^1 h_{o,t}(\iota) d\iota$ , and oil resource,  $O_t$ , to produce crude oil. Oil output is totally exported abroad for the international price  $P_{o,t}^f$  denominated in the foreign currency.

The firm maximizes profits and solves the following problem:

$$\max_{k_{o,t}, h_{o,t}, O_t} \left[ e_t P_{o,t}^f Y_{o,t} - Q_{o,t} k_{o,t} - W_{o,t} h_{o,t} - P_{O,t} O_t \right], \quad (24)$$

where  $e_t P_{o,t}^f Y_{o,t}$  denotes total sale revenues in terms of domestic currency, subject to the following production function:

$$Y_{o,t} \preceq k_{o,t}^{\alpha_o} h_{o,t}^{\beta_o} O_t^{\theta_o}, \quad (25)$$

where  $\alpha_o, \beta_o$  and  $\theta_o \in (0, 1)$  and  $\alpha_o + \beta_o + \theta_o = 1$ .

Thus, given  $e_t, P_{o,t}^f, P_{o,t}, Q_{o,t}, W_{o,t}$  and  $P_{O,t}$ , the oil producing firm chooses  $\{k_{o,t}, h_{o,t}, O_t\}$  to maximize (24) subject to (25).

First-order conditions are:

$$q_{o,t} = \alpha_o s_t p_{o,t}^f \frac{Y_{o,t}}{k_{o,t}}, \quad (26)$$

$$w_{o,t} = \beta_o s_t p_{o,t}^f \frac{Y_{o,t}}{h_{o,t}}, \quad (27)$$

$$p_{O,t} = \theta_o s_t p_{o,t}^f \frac{Y_{o,t}}{O_t}, \quad (28)$$

where  $q_{o,t} = \frac{Q_{o,t}}{P_t}$ ,  $w_{o,t} = \frac{W_{o,t}}{P_t}$ ,  $p_{o,t} = \frac{P_{o,t}}{P_t}$ ,  $p_{o,t}^f = \frac{P_{o,t}^f}{P_t^f}$  and  $p_{O,t} = \frac{P_{O,t}}{P_t}$  denote respectively the real capital return, the real wage, the real domestic oil price, the real international oil price and the real price of the oil resource. Equations (26) – (28) represent the demand for  $k_{o,t}$ ,  $h_{o,t}$  and  $O_t$  respectively.

Note that foreign oil's price,  $P_{o,t}^f$ , and oil resource,  $O_t$ , evolutions are given by the following stochastic processes:

$$\log(P_{o,t}^f) = (1 - \rho_{P_o^f}) \log(P_o^f) + \rho_{P_o^f} \log(P_{o,t-1}^f) + \varepsilon_{P_o^f,t}, \quad (29)$$

$$\log(O_t) = (1 - \rho_O) \log(O) + \rho_O \log(O_{t-1}) + \varepsilon_{O,t}, \quad (30)$$

where  $P_o^f$  and  $O$  are steady state values of  $P_{o,t}^f$  and  $O_t$ ,  $\rho_{P_o^f}$  and  $\rho_O$  are the autocorrelation coefficients, and  $\varepsilon_{P_o^f,t}$  and  $\varepsilon_{O,t}$  are uncorrelated and normally distributed innovations with zero mean and standard deviations  $\sigma_{P_o^f}$  and  $\sigma_O$  respectively.

### 2.2.2 Tradable sector

In this sector, the tradable good is a manufactured good. Again, tradable good producer operates on perfect competition markets. The firm produces its tradables using capital,  $k_{T,t} = \int_0^1 k_{T,t}(\iota) d\iota$ , labor,  $h_{T,t} = \int_0^1 h_{T,t}(\iota) d\iota$ , and refined oil input<sup>6</sup>,  $Y_{o,t}^{IT}$ . Their production function is given by:

$$Y_{T,t} \preceq k_{T,t}^{\alpha_T} h_{T,t}^{\beta_T} Y_{o,t}^{\theta_T}, \quad (31)$$

where  $\alpha_T, \beta_T$  and  $\theta_T \in (0, 1)$  and  $\alpha_T + \beta_T + \theta_T = 1$ .

Thus, given  $e_t, P_{T,t}, P_{o,t}, Q_{T,t}$ , and  $W_{T,t}$ , the tradable firm chooses  $\{k_{T,t}, h_{T,t}$  and  $Y_{o,t}^{IT}\}$  to solve its maximization problem. The first order conditions are:

$$q_{T,t} = \alpha_T s_t p_{T,t} \frac{Y_{T,t}}{k_{T,t}}, \quad (32)$$

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<sup>6</sup>See section 5 for more details about refined oil.

$$w_{T,t} = \beta_T s_t p_{T,t} \frac{Y_{T,t}}{h_{T,t}}, \quad (33)$$

$$p_{o,t} = \theta_T s_t p_{T,t} \frac{Y_{T,t}}{Y_{o,t}^{I_T}}, \quad (34)$$

where  $q_{T,t} = \frac{Q_{T,t}}{P_t}$ ,  $w_{T,t} = \frac{W_{T,t}}{P_t}$ ,  $p_{T,t} = \frac{P_{T,t}}{P_t^f}$ ,  $s_t = e_t \frac{P_t^f}{P_t}$  and  $p_{o,t} = \frac{P_{o,t}}{P_t}$  denote respectively the real capital return, the real wage, the real tradable price, the real exchange rate and the real domestic oil.

The price of tradable good  $p_{T,t}$ , is given by (32) – (34) and (31) :

$$s_t p_{T,t} = \frac{q_{T,t}^{\alpha_T} w_{T,t}^{\beta_T} \theta_T p_{o,t}}{\alpha_T^{\alpha_T} \beta_T^{\beta_T} \theta_T^{\theta_T}}. \quad (35)$$

### 2.2.3 Non-tradable sector

In this sector, non-tradable good producers operate under monopolistic competition. There is a continuum of firms indexed by  $i \in (0, 1)$ . Each firm  $i$  produces non-tradable good using the following production function:

$$Y_{nT,t}(i) \leq k_{nT,t}^{\alpha_{nT}}(i) h_{nT,t}^{\beta_{nT}}(i) Y_{o,t}^{I_{nT} \theta_{nT}}(i), \quad (36)$$

where  $k_{nT,t}(i)$ ,  $h_{nT,t}(i)$  and  $Y_{o,t}^{I_{nT}}(i)$  are used by firms to produce the non-tradable goods. Note also that  $\alpha_{nT}, \beta_{nT}$  and  $\theta_{nT} \in (0, 1)$  and  $\alpha_{nT} + \beta_{nT} + \theta_{nT} = 1$ .

To maximize its profit, the producer  $i$  chooses  $\{K_{nT,t}(i), h_{nT,t}(i) \text{ and } Y_{o,t}^{I_{nT}}(i)\}$  and sets its price,  $\tilde{P}_{nT,t}(i)$  à la Calvo (1983) and Yun (1996). Following a stochastic time dependent Calvo (1983) rule, the producer faces, in each period, a constant probability of changing its price. This probability is given by  $(1 - \phi_{nT})$ . Therefore, on average, the price remains unchanged for  $\frac{1}{1 - \phi_{nT}}$  periods. However, if non-tradable firm is not allowed to adjust its price, it updates it according to the following rule:

$$P_{nT,t} = \bar{\pi} P_{nT,t-1},$$

The non-tradable firms' maximization problem can be written as follow:

$$\max_{k_{nT,t}(i), h_{nT,t}(i), P_{nT,t}(i)} E_0 \sum_{s=0}^{\infty} [(\beta \phi_{nT})^s \lambda_{t+s} D_{nT,t+s}(i) / P_{t+s}], \quad (37)$$

subject to (36) and the following demand function:



$$Y_{nT,t+s}(i) = \left( \frac{\pi^s \tilde{P}_{nT,t}(i)}{P_{nT,t+s}} \right)^{-\vartheta} Y_{nT,t+s}, \quad (38)$$

with  $D_{nT,t+s}(i)$  the profit function:

$$D_{nT,t+s}(i) = \pi^s \tilde{P}_{nT,t}(i) Y_{nT,t+s}(i) - Q_{nT,t+s} k_{nT,t+s}(i) - W_{nT,t+s} h_{nT,t+s}(i) - P_{o,t} Y_{o,t}^{I_{nT}}(i),$$

where  $\beta^s \lambda_{t+s}$  is the producer's discount factor and  $\lambda_{t+s}$  the marginal utility of consumption in period  $t+s$ .

The first-order conditions of the maximization problem are:

$$q_{nT,t} = \alpha_{nT} \frac{Y_{nT,t}(i)}{k_{nT,t}(i)} mc_{nT,t}, \quad (39)$$

$$w_{nT,t} = \beta_{nT} \frac{Y_{nT,t}(i)}{h_{nT,t}(i)} mc_{nT,t}, \quad (40)$$

$$p_{o,t} = \theta_{nT} \frac{Y_{nT,t}(i)}{Y_{o,t}^{I_{nT}}(i)} mc_{nT,t}, \quad (41)$$

where  $q_{nT,t} = \frac{Q_{nT,t}}{P_t}$ ,  $w_{nT,t} = \frac{W_{nT,t}}{P_t}$ ,  $mc_{nT,t} = \frac{MC_{nT,t}}{P_t}$  and  $p_{o,t} = \frac{P_{o,t}}{P_t}$  denote respectively the real capital return, the real wage, the real marginal cost and the real domestic oil price. We obtain the real marginal cost,  $mc_{nT,t}$ , by replacing (39) – (41) in (36) :

$$mc_{nT,t} = \frac{q_{nT,t}^{\alpha_{nT}} w_{nT,t}^{\beta_{nT}} p_{o,t}^{\theta_{nT}}}{\alpha_{nT}^{\alpha_{nT}} \beta_{nT}^{\beta_{nT}} \theta_{nT}^{\theta_{nT}}}. \quad (42)$$

The optimal pricing condition is given by the maximization of (37):

$$\tilde{p}_{nT,t}(i) = \frac{\vartheta}{\vartheta - 1} \frac{E_0 \sum_{s=0}^{\infty} (\beta \phi_{nT})^s \lambda_{t+s} Y_{nT,t+s} p_{nT,t+s}^{\vartheta} mc_{nT,t+s} \prod_{k=1}^s \pi^{-s\vartheta} \pi_{t+k}^{\vartheta}}{E_0 \sum_{s=0}^{\infty} (\beta \phi_{nT})^s \lambda_{t+s} Y_{nT,t+s} p_{nT,t+s}^{\vartheta} \prod_{k=1}^s \pi^{s(1-\vartheta)} \pi_{t+k}^{\vartheta-1}}, \quad (43)$$

where  $p_{nT,t+s} = \frac{P_{nT,t+s}}{P_{t+s}}$ ,  $mc_{nT,t+s} = \frac{MC_{nT,t+s}}{P_{t+s}}$ ,  $\tilde{p}_{nT,t}(i) = \frac{\tilde{P}_{nT,t}(i)}{p_t}$  and  $\pi_{t+s} = \frac{P_{t+s}}{P_t}$  denote respectively the relative price of non-tradable good, the real marginal cost in the non-tradable sector, the real optimized price for non-tradable good and the CPI inflation

rate.

We rewrite the optimal pricing condition as follows:

$$\tilde{p}_{nT,t} = \frac{\vartheta}{\vartheta - 1} \frac{V_{nT,t}^1}{V_{nT,t}^2}, \quad (44)$$

where  $V_{nT,t}^1$  and  $V_{nT,t}^2$  are two auxiliary variables:

$$V_{nT,t}^1 = \lambda_t Y_{nT,t} m c_{nT,t} p_{nT,t}^\vartheta + \beta \phi_{nT} E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^\vartheta V_{nT,t+1}^1 \right], \quad (45)$$

and,

$$V_{nT,t}^2 = \lambda_t Y_{nT,t} p_{nT,t}^\theta + \beta \phi_{nT} E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^{\vartheta-1} V_{nT,t+1}^2 \right]. \quad (46)$$

Note finally that the aggregate real non-tradable price index evolves according to:

$$(p_{nT,t})^{1-\vartheta} = \phi_{nT} \left( \pi \frac{p_{nT,t-1}}{\pi_t} \right)^{1-\vartheta} + (1 - \phi_{nT}) (\tilde{p}_{nT,t})^{1-\vartheta}. \quad (47)$$

#### 2.2.4 Import sector

The final good producer uses an imported-composite good,  $Y_{I,t}$ , purchased in a domestic monopolistically competitive market. To produce  $Y_{I,t}$ , the firm uses differentiated goods,  $Y_{I,t}(i)$ , that are produced by a continuum of domestic importers, indexed by  $i \in (0, 1)$ , using a homogeneous intermediate good produced abroad for the world price  $P_t^f$ . The differentiated goods are sold at price  $P_{I,t}(i)$  subject to Calvo (1983) and Yun (1996) contracts.<sup>7</sup> Therefore, the importer faces, in each period, a constant probability  $(1 - \phi_I)$  of changing its price as in Calvo (1983). Following Yun (1996), we assume that if importers are not able to change their price, they index them to the steady state CPI inflation rate.

The maximization problem of importers can be written as follows:

$$\max_{\tilde{P}_{I,t}(i)} E_0 \sum_{s=0}^{\infty} (\beta \phi_I)^s \lambda_{t+s} \left( \pi^s \tilde{P}_{I,t}(i) - e_{t+s} P_{t+s}^f \right) Y_{I,t+s}(i), \quad (48)$$

where  $Y_{I,t+s}(i)$  is chosen by firms to maximize their profit:

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<sup>7</sup>Introducing price rigidities allows the deviation from the law of one price in the import sector, leading to incomplete pass-through effects of exchange rate movements.

$$Y_{I,t+s}(i) = \left( \frac{\pi^s \tilde{P}_{I,t}(i)}{P_{I,t+s}} \right)^{-\vartheta} Y_{I,t+s}. \quad (49)$$

The zero-profit condition gives the importer price index:

$$P_{I,t+s} = \left( \int_0^1 \pi^s \tilde{P}_{I,t}(i)^{1-\vartheta} di \right)^{\frac{1}{1-\vartheta}}. \quad (50)$$

Replacing (49) in (48), we get the optimal pricing condition:

$$\tilde{p}_{I,t}(i) = \frac{\vartheta}{\vartheta - 1} \frac{E_0 \sum_{s=0}^{\infty} (\beta \phi_I)^s \lambda_{t+s} Y_{I,t+s} p_{I,t+s}^{\vartheta} mc_{I,t+s} \prod_{k=1}^s \pi^{-s\vartheta} \pi_{t+k}^{\vartheta}}{E_0 \sum_{s=0}^{\infty} (\beta \phi_I)^s \lambda_{t+s} Y_{I,t+s} p_{I,t+s}^{\vartheta} \prod_{k=1}^s \pi^{s(1-\vartheta)} \pi_{t+k}^{\vartheta-1}}, \quad (51)$$

where  $p_{I,t+s} = \frac{P_{I,t+s}}{P_{t+s}}$  is the relative price of imports,  $mc_{I,t+s} = \frac{e_t P_{t+s}^f}{P_{t+s}} = s_t$  is the real marginal cost which is equal to the real exchange rate,  $\tilde{p}_{I,t}(i) = \frac{\tilde{P}_{I,t}(i)}{p_t}$  is the optimized price in import sector and  $\pi_{t+s} = \frac{P_{t+s}}{P_t}$  is the CPI inflation rate.

The aggregate real import price index evolves according to:

$$(p_{I,t})^{1-\vartheta} = \phi_I \left( \pi \frac{p_{I,t-1}}{\pi_t} \right)^{1-\vartheta} + (1 - \phi_I) (\tilde{p}_{I,t})^{1-\vartheta}, \quad (52)$$

The non-linear recursive form of Eq(51) can be written as follow:

$$\tilde{p}_{I,t} = \frac{\vartheta}{\vartheta - 1} \frac{V_{I,t}^1}{V_{I,t}^2}, \quad (53)$$

where  $V_{I,t}^1$  and  $V_{I,t}^2$  are two auxiliary variables that take the following form:

$$V_{I,t}^1 = \lambda_t Y_{I,t} mc_{I,t} p_{I,t}^{\vartheta} + \beta \phi_I E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^{\vartheta} V_{I,t+1}^1 \right], \quad (54)$$

$$V_{I,t}^2 = \lambda_t Y_{I,t} p_{I,t}^{\vartheta} + \beta \phi_I E_t \left[ \left( \frac{\pi_{t+1}}{\pi} \right)^{\vartheta-1} V_{I,t+1}^2 \right]. \quad (55)$$

### 2.3 Final good producer

We assume that the producer of the final good operates under perfect competition. It uses the following CES technology that includes a fraction of tradable output,  $Y_{T,t}^d$ , which is domestically-used, the non-tradable output,  $Y_{nT,t}$ , and imports,  $Y_{I,t}$ :

$$z_t = \left[ \chi_T^{\frac{1}{\tau}} Y_T^d \frac{\tau-1}{\tau} + \chi_{nT}^{\frac{1}{\tau}} Y_{nT} \frac{\tau-1}{\tau} + \chi_I^{\frac{1}{\tau}} Y_I \frac{\tau-1}{\tau} \right]^{\frac{\tau}{\tau-1}}, \quad (56)$$

where  $\tau > 0$  denotes the elasticity of substitution between the fraction of tradable output, the non-tradable output and imported goods and  $\chi_T$ ,  $\chi_{nT}$ ,  $\chi_I$  represent the shares of tradable, non-tradable and imported goods in the total expenditure of final good, where  $\chi_T + \chi_{nT} + \chi_I = 1$ . To maximize its profit, the final good producer chooses  $\{Y_{I,t}, Y_{T,t}^d \text{ and } Y_{nT,t}\}$ .

The maximization problem is:

$$\max_{Y_{I,t}, Y_{T,t}^d, Y_{nT,t}} P_t z_t - P_{I,t} Y_{I,t} - P_{T,t} Y_{T,t}^d - P_{nT,t} Y_{nT,t},$$

subject to (56). Solving this problem, we get the following demand functions:

$$Y_{I,t} = \chi_I \left( \frac{P_{I,t}}{P_t} \right)^{-\tau} z_t, \quad Y_{T,t}^d = \chi_T \left( \frac{P_{T,t}}{P_t} \right)^{-\tau} z_t, \quad Y_{nT,t} = \chi_{nT} \left( \frac{P_{nT,t}}{P_t} \right)^{-\tau} z_t. \quad (57)$$

where  $P_t, P_{I,t}, P_{T,t}, P_{nT,t}$  are given. Note also that the zero profit condition implies that the price of the final good is given by:

$$P_t = \left[ \chi_I P_{I,t}^{1-\tau} + \chi_T P_{T,t}^{1-\tau} + \chi_{nT} P_{nT,t}^{1-\tau} \right]^{\frac{1}{1-\tau}}, \quad (58)$$

Finally, the final good is split between total consumption and total investment so that  $z_t = c_t + i_{o,t} + i_{T,t} + i_{nT,t}$ .

## 2.4 Central Bank

It is assumed that the central bank adjusts the short-term nominal interest rate,  $R_t$ , in response to fluctuation in CPI inflation,  $\pi_t$ , and exchange rate changes  $\Delta e_t$ . As in Bouakez *et al* (2008), we use the following Taylor-type policy rule to close the model:

$$\log \left( \frac{R_t}{R} \right) = \zeta_\pi \log \left( \frac{\pi_t}{\pi} \right) + \zeta_e \log \left( \frac{\Delta e_t}{\Delta e} \right). \quad (59)$$

where  $\pi, \Delta e$ , and  $R$  are the steady-state values of inflation ( $\pi_t$ ), exchange rate ( $\Delta e_t$ ) and nominal interest rate ( $R_t$ ) respectively. The policy coefficients,  $\zeta_\pi$  and  $\zeta_e$ , measure the central bank responses to deviation of ( $\pi_t$ ) and ( $\Delta e_t$ ) from their steady state levels. When  $\zeta_e = 0$  and  $\zeta_\pi = \infty$ , the central bank responds only to inflation movements (and the exchange rate regime is floating). When  $\zeta_\pi = 0$  and  $\zeta_e = \infty$  the central bank

manages its rate to respond only to exchange rate fluctuation (and the exchange rate regime is fixed).

## 2.5 Government

In an oil exporting economy<sup>8</sup>, the oil domestically used (refined oil),  $Y_{o,t}^I$ , is mostly produced abroad. For this, we assume that the government, which is the owner of the oil firm, buys it from the world market for the international price,  $P_{o,t}^f$ , denominated in the foreign currency. The refined oil is sold domestically to the tradable and non-tradable firms at price  $P_{o,t}$  which can be considered as the domestic fuel prices. The latter is supposed to be subsidized by the government. For this purpose, we follow Bouakez *et al.* (2008) and assume that the domestic oil price  $P_{o,t}$  is a convex combination of the current world price expressed in local currency and previous period domestic price. It is given by:

$$p_{o,t} = (1 - v)(p_{o,t-1}/\pi_t) + vs_t p_{o,t}^f, \quad (60)$$

where  $v \in (0, 1)$ , and  $p_{o,t}^f$  denotes the real world oil price, determined in the world market and denominated in units of foreign currency.

Thus, when  $v = 1$ , there is no subsidy and the pass-through from the world oil price is complete. However, when  $v = 0$ , the domestic oil price is fully subsidized and there is no pass-through. Thus, all domestic firms will buy oil at price  $p_{o,t}$ .

Following this, the government's budget constraint can be written as follow:

$$p_{o,t}Y_{o,t}^I + s_t p_{o,t}^f Y_{o,t} + \Gamma_t = s_t p_{o,t}^f Y_{o,t}^I + w_{o,t}h_{o,t} + q_{o,t}k_{o,t} + P_{O,t}O_t, \quad (61)$$

where the left-hand side represents the government's revenues that include lump-sum taxes,  $\Gamma_t$ , and receipts from selling oil to domestic,  $p_{o,t}Y_{o,t}^I$ , and foreign,  $s_t p_{o,t}^f Y_{o,t}^{ex}$ , firms. The right-hand side represents the government spending and include payments of both wages and capital returns ( $w_{o,t}h_{o,t} + q_{o,t}k_{o,t}$ ) in the oil sector and the amount of imported refined oil,  $s_t p_{o,t}^f Y_{o,t}^I$ .

## 2.6 Aggregation and Equilibrium

In a symmetric equilibrium, all households, importers and non-tradable good producers make the same decision so that:  $c_t(\iota) = c_t, h_t(\iota) = h_t, h_{o,t}(\iota) = h_{o,t}, h_{T,t}(\iota) = h_{T,t}, h_{nT,t}(\iota) = h_{nT,t}, b_t(\iota) = b_t, b_t^f(\iota) = b_t^f, k_{o,t}(\iota) = k_{o,t}, k_{T,t}(\iota) = k_{T,t}, k_{nT,t}(\iota) = k_{nT,t}, w_{o,t}(\iota) = w_{o,t}, w_{T,t}(\iota) = w_{T,t}, w_{nT,t}(\iota) = w_{nT,t}, D_{nT,t}(\iota) = D_{nT,t}, D_{I,t}(\iota) =$

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<sup>8</sup>It's the case of Algeria and other countries as Iran for example.

$D_{I,t}, i(t) = i, Y_{nT,t}(i) = Y_{nT,t}, Y_{o,t}^{InT}(i) = Y_{o,t}^{InT}, \tilde{p}_{nT,t}(i) = \tilde{p}_{nT,t}, Y_{I,t}(i) = Y_{I,t}, \tilde{p}_{I,t}(i) = \tilde{p}_{I,t}$  for all  $t$  and  $i \in (0, 1)$ , where  $b_t = \frac{B_t}{P_t}, b_t^f = \frac{B_t^f}{P_t^f}$  are the real net domestic and foreign currency bonds respectively. Thus, a symmetric equilibrium for this economy is composed of an allocation  $\{c_t, i_t, i_{o,t}, i_{T,t}, i_{nT,t}, Y_{o,t}, Y_{nT,t}, Y_{T,t}, Y_{o,t}^I, Y_{o,t}^{IT}, Y_{o,t}^{InT}, Y_T^d, Y_T^{ex}, Y_{I,t}, Y_t, Y_{nT,t}^{va}, Y_{T,t}^{va}, z_t, k_{o,t}, k_{T,t}, k_{nT,t}, h_t, h_{o,t}, h_{T,t}, h_{nT,t}, b_t^f, \kappa_t, \Lambda_{o,t}, \Lambda_{T,t}, \Lambda_{nT,t}\}_{t=0}^\infty$  and a sequence of prices and co-state variables  $\{w_{o,t}, w_{T,t}, w_{nT,t}, \tilde{w}_{o,t}, \tilde{w}_{T,t}, \tilde{w}_{nT,t}, q_{o,t}, q_{T,t}, q_{nT,t}, p_{o,t}, p_{T,t}, p_{nT,t}, \tilde{p}_{nT,t}, p_{I,t}, \tilde{p}_{I,t}, p_{O,t}, \pi_t, \pi_{nT,t}, \pi_{I,t}, s_t, e_t, R_t, \lambda_t, mc_{nT,t}, mc_{I,t}\}_{t=0}^\infty$  satisfying households, oil, tradable and non-tradable first-order conditions, the aggregate resources constraints, the monetary policy rules, the current account equation and the stochastic processes  $\{p_{o,t}^f, O_t, R_t^f, Y_T^f, \pi_t^f\}_{t=0}^\infty$  of the shocks and the following market clearing conditions  $b_t = b_{t-1} = 0, b_t^f = \tilde{b}_t^f$  and:

$$Y_{o,t}^I = Y_{o,t}^{IT} + Y_{o,t}^{InT} \quad (62)$$

$$Y_{T,t} = Y_{T,t}^d + Y_{T,t}^{ex} \quad (63)$$

Finally, the home economy exports part of its tradable output. According to McCallum and Nelson (1999)<sup>9</sup> and Gertler, Gilchrist and Natalucci (2003), we assume that the foreign demand for the tradable goods,  $Y_{T,t}^{ex}$ , is given by :

$$Y_{T,t}^{ex} = \nu_T \left( \frac{e_t P_{T,t}}{P_t^f} \right)^{-\omega_T} Y_{T,t}^f \quad (64)$$

where the foreign production of tradable goods,  $Y_{T,t}^f$ , is exogenous and evolves according to the following stochastic processes:

$$\log(Y_{T,t}^f) = (1 - \rho_{Y_T^f}) \log(Y_T^f) + \rho_{Y_T^f} \log(Y_{T,t-1}^f) + \varepsilon_{Y_T^f,t} \quad (65)$$

where  $Y_T^f > 0$  is the steady-state values of  $Y_{T,t}^f$  and  $\rho_{Y_T^f}$  the autoregressive coefficients and  $\varepsilon_{Y_T^f,t}$  the uncorrelated and normally distributed innovations with zero mean and standard deviation  $\sigma_{Y_T^f}$ .

The aggregate GDP is defined as:

$$Y_t = p_{T,t} Y_{T,t}^{va} + p_{nT,t} Y_{nT,t}^{va} + s_t p_{o,t}^f Y_{o,t}, \quad (66)$$

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<sup>9</sup>As in McCallum and Nelson (1999), we assume that the domestic economy's exports from an insignificant fraction of foreigners' consumption, and thus their weight in the foreign economy's aggregate price index is negligible.

where  $Y_{T,t}^{va}$  and  $Y_{nT,t}^{va}$  are the value-added output in tradable and non-tradable sectors respectively. These variables are constructed by subtracting oil input as follows:<sup>10</sup>

$$Y_{T,t}^{va} = Y_{T,t} - p_{o,t} \frac{Y_{o,t}^{IT}}{p_{T,t}}, \quad (67)$$

$$Y_{nT,t}^{va} = Y_{nT,t} - p_{o,t} \frac{Y_{o,t}^{InT}}{p_{nT,t}}. \quad (68)$$

Combining the households' budget constraint, the single period profit functions of non-tradable good producing firms and foreign good importers, the first-order conditions of the four sectors, and applying the market clearing conditions, we get the following current account equation:

$$\frac{b_t^f}{\kappa_t R_t^f} = \frac{b_{t-1}^f}{\pi_t^f} + p_{T,t} Y_{T,t}^{ex} + p_{o,t}^f Y_{o,t} - p_{o,t}^f Y_{o,t}^I - Y_{I,t}. \quad (69)$$

### 3 Calibration

We assign values to the structural parameters of the model, taken from the literature of DSGE models, and adapt them to characterize an oil exporting economy.<sup>11</sup> We also set the coefficients of correlation and standard deviation of the stochastic processes using OLS estimation.

There are 36 structural parameters in the model  $\{\beta, \sigma, \gamma, \alpha_{h_o}, \alpha_{h_T}, \alpha_{h_{nT}}, \psi_o, \psi_T, \psi_{nT}, \theta, \phi, \delta, v, \alpha_o, \beta_o, \theta_o, \alpha_T, \beta_T, \theta_T, \alpha_{nT}, \beta_{nT}, \theta_{nT}, \vartheta, \phi_{nT}, \phi_I, \varphi_o, \varphi_T, \varphi_{nT}, \chi_T, \chi_{nT}, \chi_I, \tau, \nu_T, \omega_T, \zeta_\pi, \zeta_e\}$ . The subjective discount factor,  $\beta$ , is set at 0.99 which implies an annual steady-state real interest rate of 4%. As in Bouakez *et al* (2008), Dib (2008) and Lartey (2008) the inverse of the elasticity of the intertemporal substitution of consumption  $\gamma$  is set at 2. Following Devereux *et al* (2006) among others, the inverse of the elasticity of the intertemporal substitution of labor  $\sigma$  is set at 1. The capital depreciation rate  $\delta$  is set at 0.025. This value is common to the three sectors of production (oil, tradable and non-tradable sectors).

The parameters  $(\alpha_o, \beta_o, \theta_o)$ ,  $(\alpha_T, \beta_T, \theta_T)$ , and  $(\alpha_{nT}, \beta_{nT}, \theta_{nT})$ , which are associated with the shares of capital, labor and a fraction of oil output in the output of each sector, are calibrated as in Macklem *et al.* (2000). We set the share of capital,  $\alpha_o$ , labor,  $\beta_o$ ,

<sup>10</sup> As in Dib (2008), our model suppose that tradable and non-tradable firms use refined oil as material inputs in their productions which is defined as gross output. Thus, value added output in each sector can be constructed by subtracting commodity inputs.

<sup>11</sup> We calibrate the model to match some features of oil exporting economies. Of these, Canadian and Algerian economies will be used to calibrate some parameters.

**Table 1:** Calibration of structural parameters

Description	Parameters	Values
Structural Parameters		
Subject discount factor	$\beta$	0.99
Labor elasticity of substitution	$\vartheta$	8
Intermediate good elasticity of substitution	$\theta$	6
The inverse of the elasticity of intertemp substi of cons	$\gamma$	2
The inverse of the Frish wage elasticity of labour supply	$\sigma$	1
Labor elasticity of substitution in the oil sector	$\alpha_{h_o}$	0.32
Labor elasticity of substitution in the tradable sector	$\alpha_{h_T}$	0.13
Labor elasticity of substitution in the non-tradable sector	$\alpha_{h_{nT}}$	0.55
Parameter measuring the risk premium	$\phi$	0.0015
The depreciation rate of capital	$\delta$	0.025
Share of capital in the production of oil	$\alpha_o$	0.31
Share of labor in the production of oil	$\beta_o$	0.24
Share of oil resource in the production of oil	$\theta_o$	0.45
Share of capital in the production of tradable goods	$\alpha_T$	0.33
Share of labor in the production of tradable goods	$\beta_T$	0.57
Share of oil input in the production of tradable goods	$\theta_T$	0.1
Share of capital in the production of non-tradable goods	$\alpha_{nT}$	0.23
Share of labor in the production of non-tradable goods	$\beta_{nT}$	0.52
Share of oil input in the production of non-tradable goods	$\theta_{nT}$	0.25
Oil price rule parameter	$\nu$	0.3
Calvo wage parameter for the oil sector	$\varphi_o$	0.65
Calvo wage parameter for the tradable sector	$\varphi_T$	0.65
Calvo wage parameter for the non-tradable sector	$\varphi_{nT}$	0.65
Capital adjustment cost parameter in oil sector	$\psi_o$	3
Capital adjustment cost parameter in tradable sector	$\psi_T$	3
Capital adjustment cost parameter in non-tradable sector	$\psi_{nT}$	3
Calvo price parameter in the non-tradable sector	$\phi_{nT}$	0.65
Calvo price parameter in the import sector	$\phi_I$	0.65
Elasticity of substitution between domestic and foreign goods	$\tau$	0.8
Share of imported goods in the final good	$\chi_I$	0.45
Share of tradable goods in the final good	$\chi_T$	0.2
Share of non-tradable goods in the final good	$\chi_{nT}$	0.35
Constant associated with the share of exports in home GDP	$\nu_T$	0.2
Elasticity of substitution between home and foreign goods	$\omega_T$	0.8
Inflation coefficient in the monetary policy rule	$\zeta_\pi$	0, $\infty$
Exchange rate coefficient in the monetary policy rule	$\zeta_e$	$\infty, 0$



and oil resources,  $\theta_o$ , in the production of oil to 0.41, 0.39 and 0.2 respectively. In the sector of tradable goods, the share of capital,  $\alpha_T$ , labor,  $\beta_T$ , and a fraction of oil output,  $\theta_T$ , are assigned values to 0.26, 0.63 and 0.11 respectively. We also set to 0.28, 0.66 and 0.06 the share of capital,  $\alpha_{nT}$ , labor,  $\beta_{nT}$ , and a fraction of oil output,  $\theta_{nT}$ , in the production of non-tradable goods.

As in Dib (2008), we set the parameters that represent the degree of monopoly power in the intermediate good market,  $\theta$ , and the labor market,  $\vartheta$ , equal to 6 and 8 respectively. The steady-state price and wage markup are equal to 20% and 14% respectively. The price elasticity of demand for imported, domestic tradable and non-tradable goods,  $\tau$ , is set at 0.8 as in Dib (2008). The share of imports,  $\chi_I$ , domestic tradable,  $\chi_T$ , and non-tradable goods,  $\chi_{nT}$ , in the production of final goods are set equal to 0.45, 0.2 and 0.35 respectively. These values are chosen given that the value of the average ratio of both imports and tradable good production<sup>12</sup> to GDP of Algerian economy. The share of non-tradable good is chosen by subtracting to the unit the previous values. We set values of the labor elasticity of substitution to match the shares of wages in the three sectors of the Algerian economy (oil, tradable and non-tradable), so that,  $\alpha_{h_o}$ ,  $\alpha_{h_T}$  and  $\alpha_{h_{nT}}$  are equal to 0.32, 0.13 and 0.55 respectively.<sup>13</sup>

As in the standard literature of DSGE models, we set the parameter of Calvo price setting equal to 0.65. Wage stickiness in the three sectors (oil,  $\varphi_o$ , tradable,  $\varphi_T$ , and non-tradable,  $\varphi_{nT}$ , goods sectors) are set at the same level. We assume that this value is the same across sectors (import,  $\phi_I$ , and non-tradable sectors,  $\phi_{nT}$ ). This means that, on average, price adjustment occurs every 2.85 quarters. As in Lartey (2008) and Devereux, Lane and Xu (2006), we set the capital adjustment cost equal to 3 in the three sectors (oil,  $\psi_o$ , tradable,  $\psi_T$ , and non-tradable,  $\psi_{nT}$ , sectors). All of these parameters are listed in Table 1.

Following Dib (2007), the steady-state of gross inflation rates,  $\pi$ ,  $\pi^f$  are set equal to 1.107, 1.017 respectively. These values are the annual observed averages in the data of the Algerian and Euro Area economies for the period 1990 – 2010. The parameter in the risk-premium terms  $\phi$  is set equal to 0.0015 implying an annual risk premium of 1.35%. This value is consistent with the average interest rates differential between Algeria and the Euro Area, and implies a steady-state foreign-debt-to-GDP ratio of 30%, which is close to that observed average ratio in the data.

Finally, Table 2 reports the results of different OLS estimations of the exogenous

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<sup>12</sup>Since the Algerian economy exports an insignificant fraction of tradable goods, the average ratio of total tradable production to GDP could be assimilated by the value of the domestic use. This is the case of many oil exporting countries.

<sup>13</sup>These values are computed by using ONS (national office of statistics) data.

stochastic processes. All parameters are statistically significant at the 5% level. Some of these stochastic processes are highly persistent while others are not.

**Table 2** : Calibration of the stochastic parameters

Shocks	Autocorrelations	Standard deviation
Foreign interest rate	$\rho_{R^f}$ 0.9886	$\sigma_{R^f}$ 0.1693
Foreign tradable output	$\rho_{Y_T^f}$ 0.9676	$\sigma_{Y_T^f}$ 0.1578
Foreign inflation	$\rho_{\pi^f}$ 0.9549	$\sigma_{\pi^f}$ 0.1999
Foreign oil output	$\rho_{Y_o^f}$ 0.2582	$\sigma_{Y_o^f}$ 0.0104
Foreign oil price	$\rho_{p_o^f}$ 0.2317	$\sigma_{p_o^f}$ 0.1975
Oil resources shock	$\rho_O$ 0.9899	$\sigma_O$ 0.2089

## 4 Simulations analysis

In this section, we analyze the effect of an increase of one percent in the price of oil (windfall) and oil resources (boom) on this economy. We attempt to verify if this increase generates a Dutch disease effect in both resource movement and spending effects and in which case the phenomenon of de-industrialization is the most important. Thus, we try to disentangle the source of fluctuation, between the windfall and the boom, which generates a Dutch disease effect. First, we conduct simulations under the hypothesis of perfect wage and price flexibility. Then, we consider the impact of an oil shock (price and resource) assuming that prices are sticky. Finally, we add the assumption of wage rigidity. In the two last cases, we analyse the response of some key variables under alternative monetary policy rules (fixed exchange rate rule (ER rule) and inflation targeting rule (IT rule)). The response of our selected variables will be relative to that of our baseline model. In these cases, this is the gap between both responses (baseline and sticky price-sticky wage models) that will provide information on the occurrence of the Dutch disease effect.

### 4.1 Flexible prices and wages setting

In the case of flexible prices, monetary policy plays no role. Simulation results show that an increase in the international price of oil leads to a decline in the manufacturing sector. Indeed, Figure 1 shows a decline in all selected variables (production, capital, investment, wage and hours worked) in the tradable good sector. This decrease is accompanied by a boom in the oil and non-tradable sectors. Indeed, the impact on other sectors is quite large. As Figure 1 shows, all variables, capital, investment and wage, for instance, respond positively to oil price shock. This expansion in the oil sector is the result of

the decline of manufacturing industry whose wages and capital decline. Hence, labor demand is much greater in the other sector (resource movement effect).

Figure 1 also shows an appreciation of the real exchange rate after the windfall. This is due to currency inflows due to the rise in oil price. This appreciation of exchange rate seems to contribute partly to the decline of the manufacturing industry through a decline in price competitiveness of the sector and, therefore, the decline of its exports. This is similar to the spending effect.

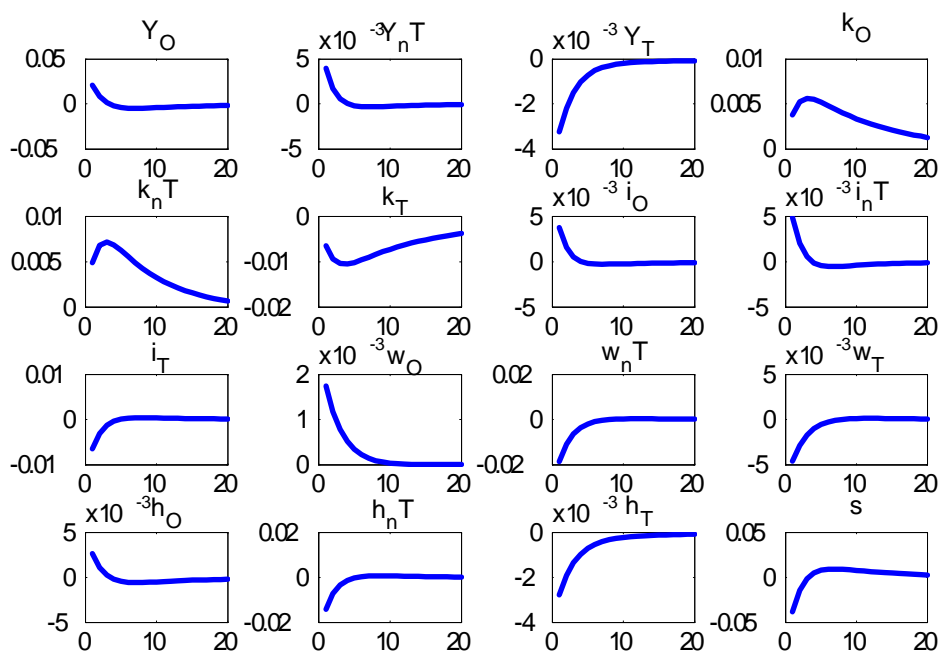


Figure 1: The effect of a 1% positive oil price shock (Baseline model)

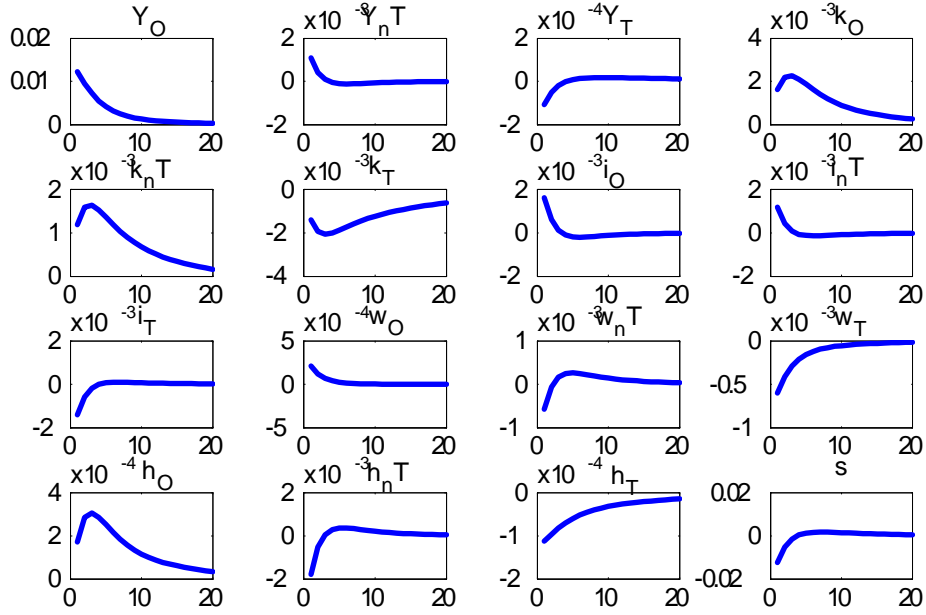


Figure 2: The effect of a 1% positive oil resource shock (Baseline model)

After the boom (increase in oil resource), Figure 2 depicts an increase in wages, and marginal product in the non-manufacturing sector (oil and non-tradable sectors) which leads to an increase in labor demand and therefore a rise in the production of oil goods and a decline in the manufacturing production. This second effect is defined as the resource movement effect. On the other hand, Figure 2 shows an increase in the real exchange rate due to the rise of oil price. Through the spending effect, the appreciation of the exchange rate has probably contributed to the de-industrialization of the tradable good sector.

Through these results, we can see that in both cases, windfall and boom, the economy undergoes de-industrialization and thus, Dutch disease effects with both spending and resource movement effects.

To compare the importance of de-industrialization in each case, boom and windfall, Figure 3 illustrates the impulse response functions of some key variables of the manufacturing sector facing an increase of one percent in oil prices and oil resources.

Figure 3 shows that the decline in the manufacturing sector is much larger in the case of windfall (oil price shock). Indeed, key variables, such as investment, production and wage decrease more significantly in the case of a windfall than in the case of a boom. Therefore, we conclude that, overall, Dutch disease effects are especially the consequence

of a windfall rather than a boom. Thus, the question we answer is: what is the exchange rate regime that would avoid the consequences of a windfall and/or of a boom? To do so, we jointly consider price and wage rigidities.

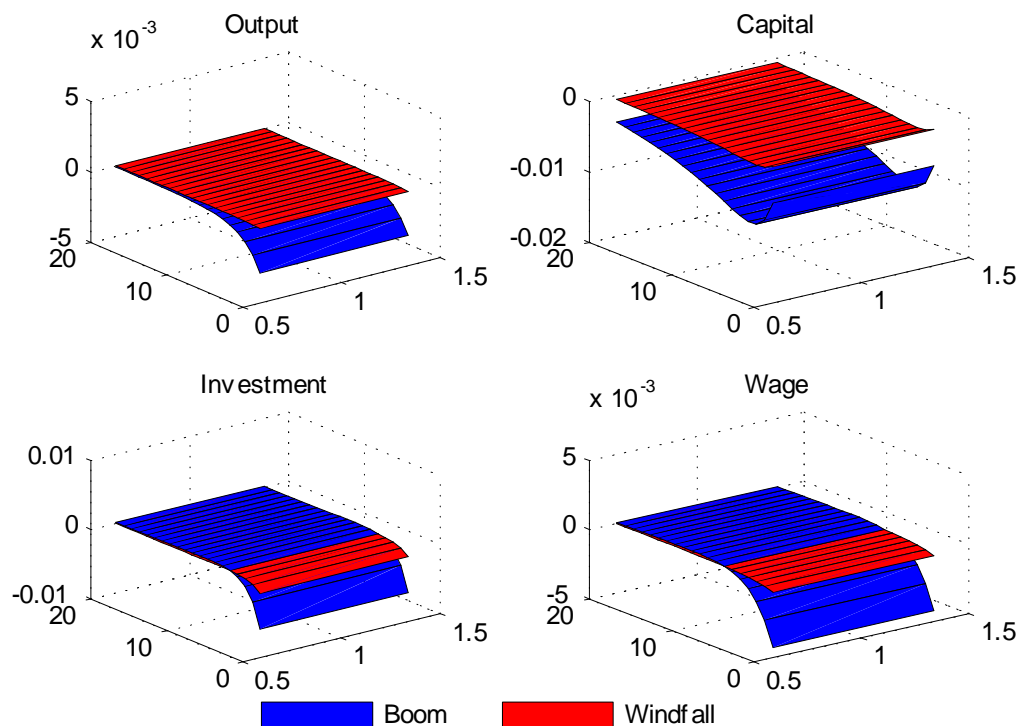


Figure 3: Comparison of the effect of a boom and windfall on the tradable sector

## 4.2 Sticky price model

In the case of sticky prices, the choice of the exchange rate regime plays a central role in the stabilization of the economy. We first simulate the impact of an increase in oil prices (and oil resource) in the case of a fixed exchange rate regime ( $\zeta_e = \infty$ ), then we simulate the impact of an increase in oil prices in the case of a flexible exchange rate regime ( $\zeta_e = 0$ ) (and oil resource).

### 4.2.1 Fixed exchange rate

As in the first case, Figure 4 shows a decline in the manufacturing sector compared to the other two sectors. Production of tradable goods, accumulation of capital and investment in this sector all experience a decline, comparatively to the baseline model, due to the increase in the oil price. In the two other sectors, the situation is different. This leads to an instantaneous increase in the production in the oil sector, which generates a large

inflow of foreign currency. Unlike the baseline model, the windfall does not lead to an appreciation of the real exchange rate. This response can be interpreted as the result of the intervention of the central bank in the foreign exchange market to stabilize the exchange rate. Therefore, we conclude that (i) the spending effect has not occurred and (ii) the decline of the manufacturing sector only results from the resource movement effect. As Figure 4 shows, the de-industrialization of the economy seems to be the result of the labor shift from the tradable sector toward the oil and non-tradable sectors.

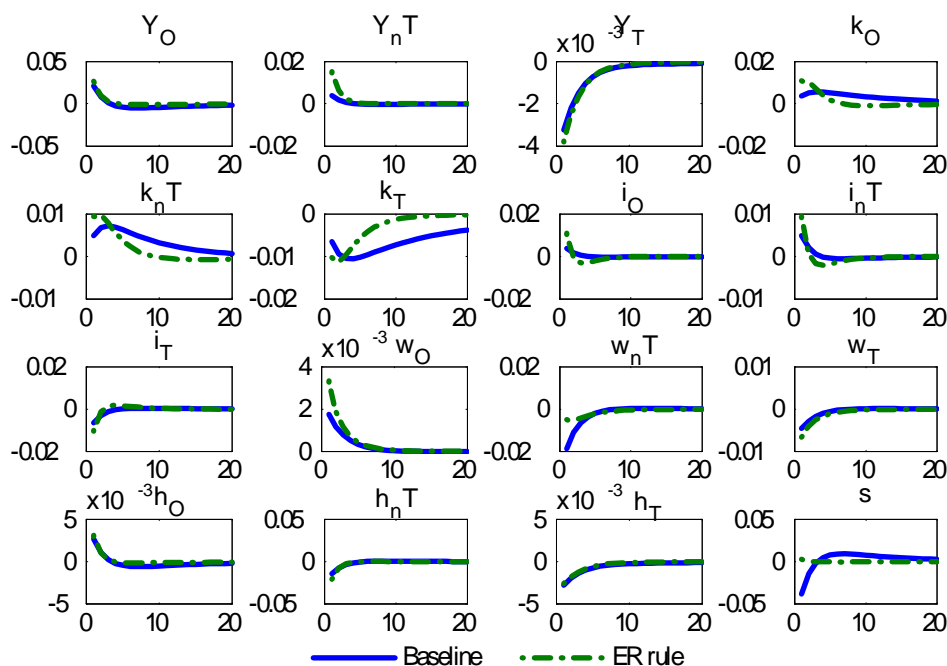


Figure 4: The effect of a 1% positive oil price shock (sticky price model)

Hours worked respond more after the shock in the oil sector relative to the manufacturing sector. This is due to rising wages in the oil sector that create a greater demand for labor in this sector. As a result, the production of the tradable sector declines.

In the case of a boom, Figure 5 also depicts a decline in the manufacturing sector due to an increase in oil resources. The oil and non-tradable sectors experience a rise in production and investment. As in the first case, the real exchange rate does not react to the shock. This is due to the fact that the appreciation is absorbed by the intervention of the monetary authority in the foreign exchange market. Therefore, the de-industrialization of the manufacturing sector can not be the result of the spending effect.

The resource movement effect is the most likely transmission channel. The increase in production in the oil sector leads to a significant increase in both wages and hours worked in this sector compared to the tradable sector.

Overall, we conclude that in the case of sticky prices and the fixed exchange rate, a boom or a windfall in the oil sector generates the Dutch disease effect driven by the resource movement effect.

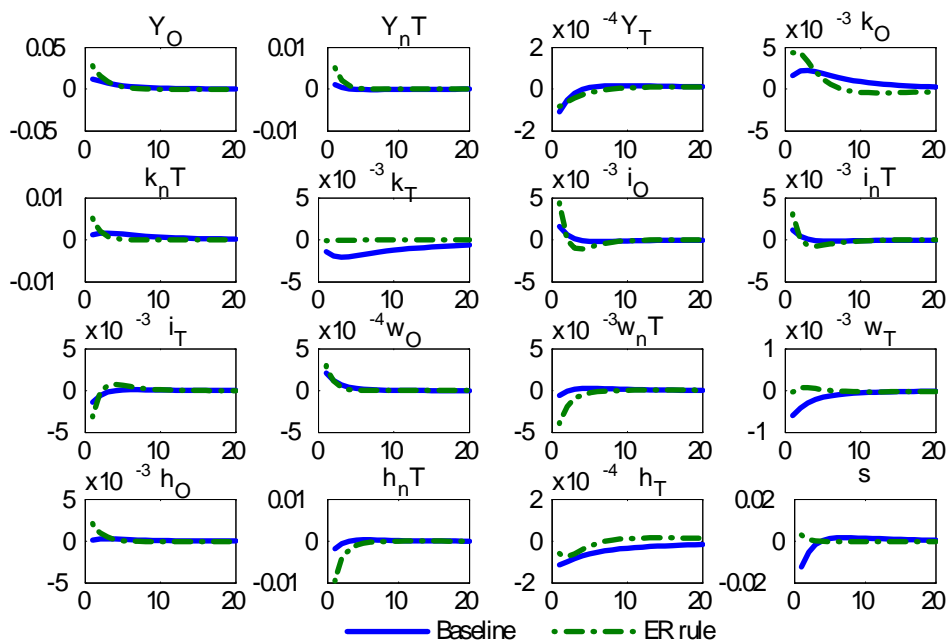


Figure 5: The effect of a 1% positive oil resource shock (sticky price model)

#### 4.2.2 Flexible exchange rate

Figure 6 and 7 show that Dutch disease effect does not occur in the case of both windfall and boom under flexible exchange rate. Indeed, compared to the baseline model, the tradable good sector does not witness a decline, even if the oil and non-tradable sectors witness a boom following these two exogenous shocks.

These results can be explained by the fact that inflation targeting prevents prices and wages increase in both the oil and non-tradable sectors. Indeed, relatively to the baseline model, wages in all sectors experienced stability after the oil shock. The resource movement effect is therefore avoided. So, flexibility of the exchange rate has not allowed the occurrence of the Dutch disease under its spending effect. Figure 6 and 7 show that the exchange rate appreciates in both cases (windfall and boom) but manufacturing

output does not decline. This can be attributed to the structure of the oil exporting countries' manufacturing sector which is characterized by a low level of industrialization relative to developed countries. In other words, the spending effect is not operational when the resource movement effect channel is locked. Therefore, exports of tradable goods are not affected by fluctuations of real exchange rate.

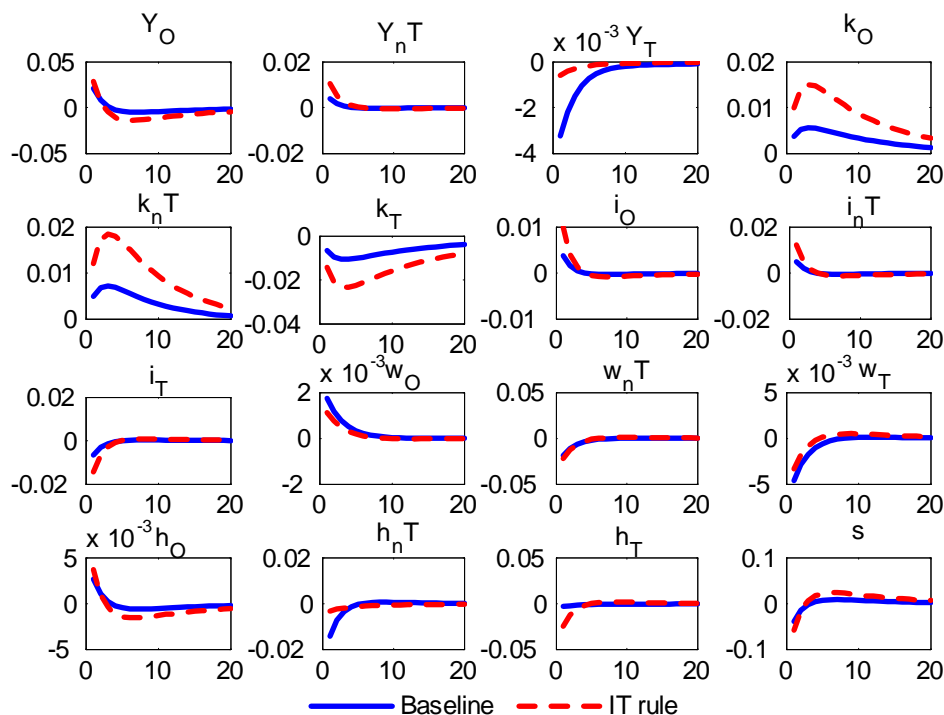


Figure 6: The effect of a 1% positive oil price shock (sticky price model)

One of the findings is that, in the case of an exogenous boom (either an increase in oil prices or a rise in oil resources), the flexible exchange rate regime insulate from Dutch disease effect to the extent that fluctuations of the real exchange rate is insufficient to trigger the spending effect. This is, maybe, due to the structural characteristic of an oil exporting economy.



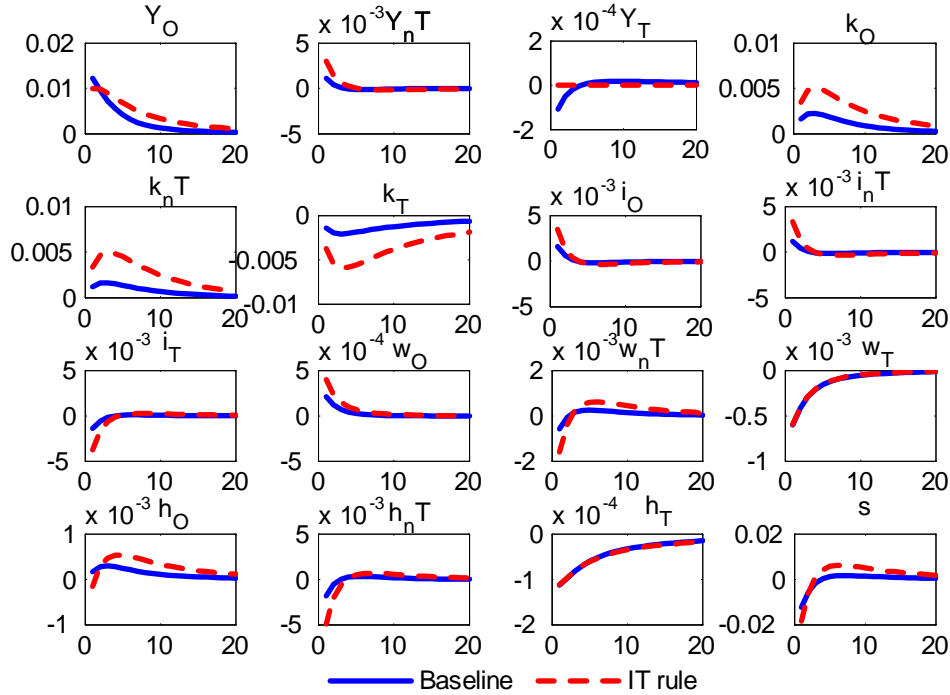


Figure 7: The effect of a 1% positive oil resource shock (sticky price model)

### 4.3 Sticky prices and wages

In this section we assume that wages are sticky by setting  $\varphi_j=0.65$ . In line with the work of Hausmann and Rigobon (2002) among others, we check the validity of the results obtained in the general equilibrium framework by comparing the results of a boom and windfall. As in the previous section, we assume, firstly, that the central bank targets the nominal exchange rate. Then, we compare the results to those obtained with a flexible exchange rate.

#### 4.3.1 Fixed exchange rate

In the case of a fixed nominal exchange rate, Figures 8 and 9 show an increase of both oil prices and production in the oil sector. This increase is less important than in the case of the baseline model. Also, manufacturing production does not decline implying that Dutch disease effects are absent. Figure 9 shows that manufacturing production increases and then slightly declines. The non-tradable and oil sectors follow a similar pattern.

Thus, in the case where wages and prices are sticky and where the central bank

targets the nominal exchange rate, Dutch disease effect does not rise. The main reason is that the spending effect channel is neutralized by the monetary policy. Fluctuations of the nominal exchange rate are contained by the monetary authority from the first quarter in both cases (boom and windfall). Then, the resource movement effect, consisting in a shift of labor and capital from the manufacturing sector toward both oil and non-tradable sectors, is avoided because of sticky wages that does not allows the oil and non-tradable sectors to become more attractive. Therefore, wages and prices stickiness together with fixed exchange rate completely offset Dutch disease effects.

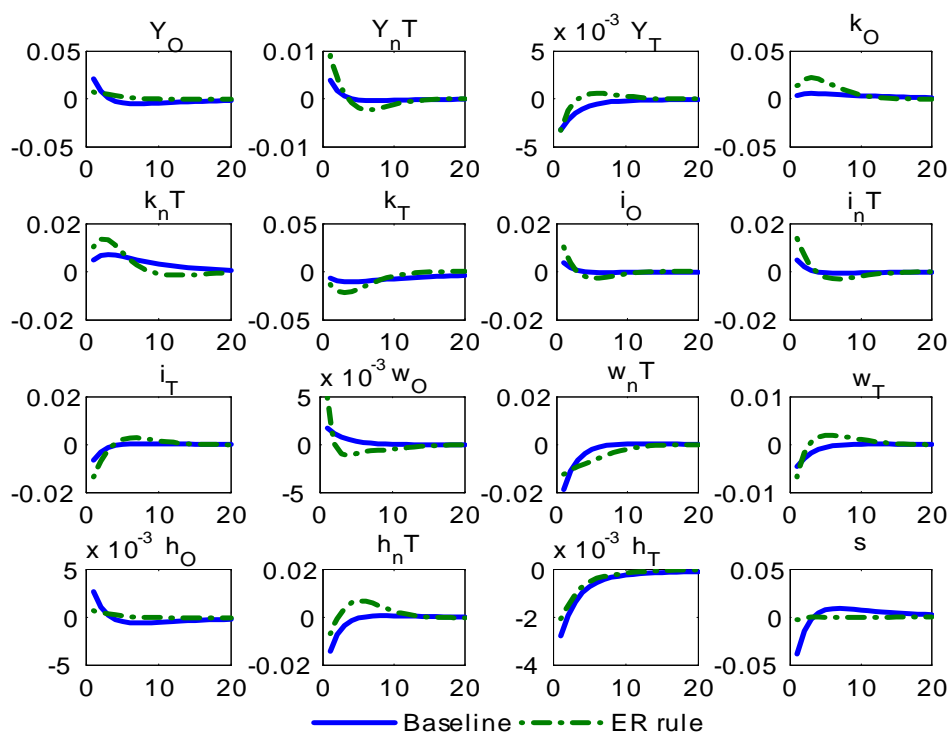


Figure 8: The effect of a 1% positive oil price shock (sticky price- wage model)

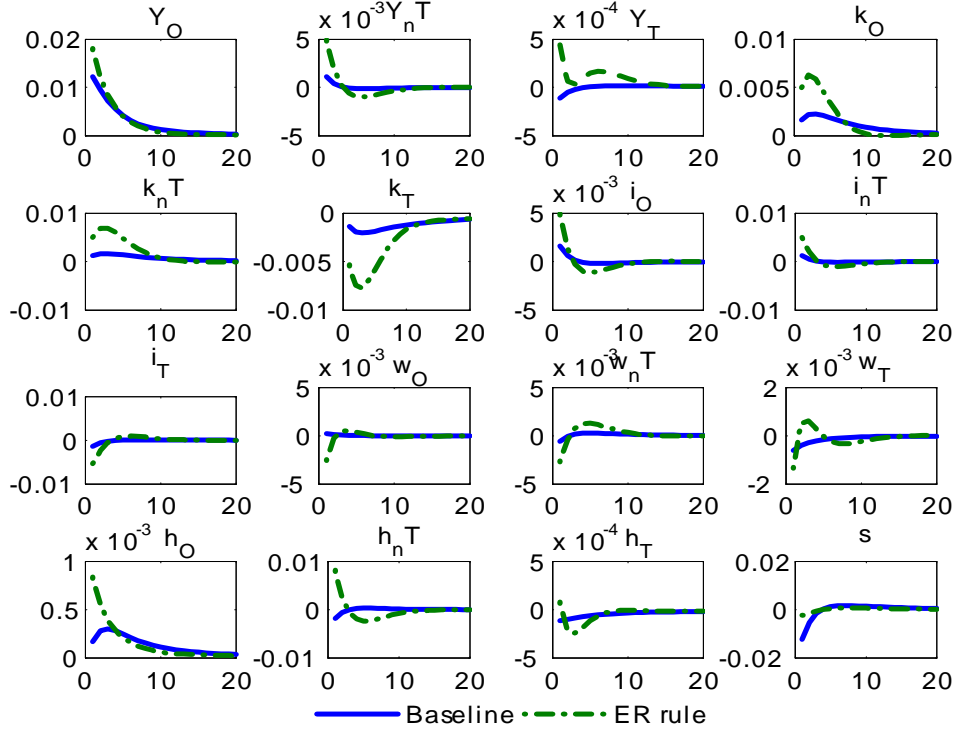


Figure 9: The effect of a 1% positive oil resource shock (sticky price- wage model)

#### 4.4 Flexible exchange rate

In the last case where the exchange rate regime is flexible, Dutch disease effect does not occur although the spending effect seems to be operational. Relatively to the baseline model, the manufacturing sector does not decline both in the case of a windfall or a boom as shown by Figures 10 and 11. Indeed, as in the case where only prices are sticky, exchange rate flexibility is not sufficient to allow the realization of the spending effect. Thus, in both cases (fixed exchange rates and flexible exchange rates) prices and wages rigidity insulate the economy from Dutch disease effects in the cases of either a windfall or a boom.

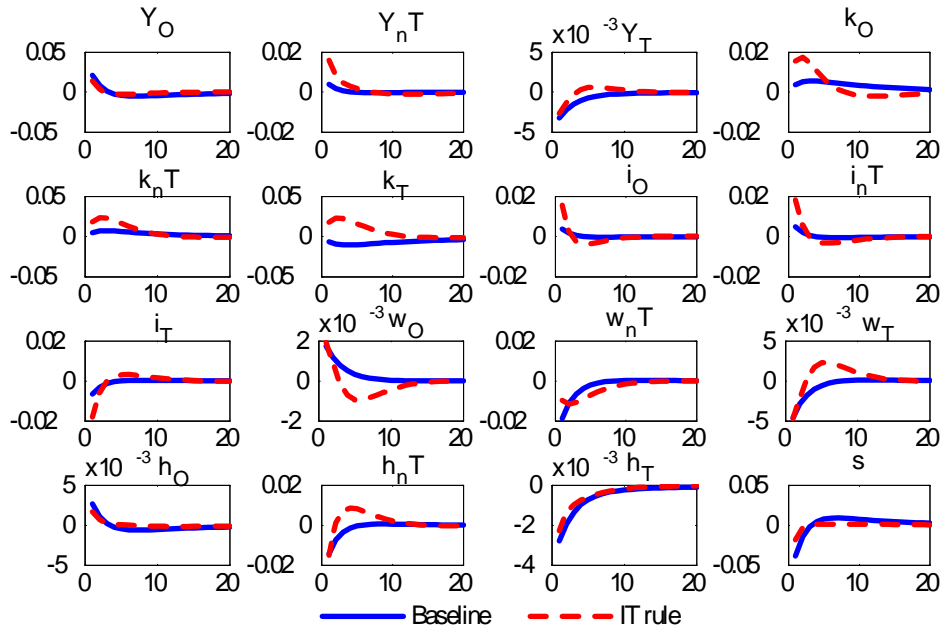


Figure 10: The effect of a 1% positive oil price shock (sticky price- wage model)

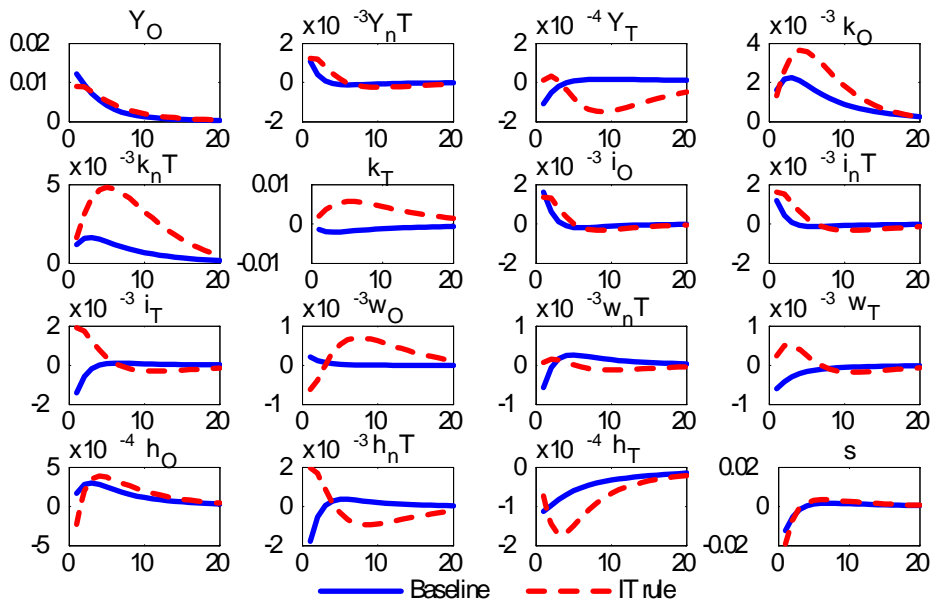


Figure 11: The effect of a 1% positive oil resource shock (sticky price- wage model)

## 5 Welfare effects

In this section, we compare the impact of a windfall and a boom on the welfare under alternative exchange rate regimes. We compute the welfare using the unconditional expectation of the utility function. To do this, we use a second-order approximation of the utility function around the deterministic steady state<sup>14</sup>.

Formally, the welfare criterion is derived from the following single-period utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t), \quad (70)$$

the second-order approximation result is given by:

$$\begin{aligned} \mu(\cdot) \simeq & \bar{\mu} + \bar{c}^{1-\gamma} E(\hat{c}_t) - \bar{h}^{1+\sigma} E(\hat{h}_t) - \\ & \frac{\gamma}{2} \bar{c}^{1-\gamma} E\left(\text{var}(\hat{c}_t) + \left[E(\hat{c}_t)^2\right]\right) - \frac{\sigma}{2} \bar{h}^{1+\sigma} E\left(\text{var}(\hat{h}_t) + \left[E(\hat{h}_t)^2\right]\right) \end{aligned} \quad (71)$$

where bars denote steady-state values and hats represent percentage deviations from the steady-state. The welfare cost is measured by the compensating variation which allows us to measure the percentage changes in consumption in the deterministic steady state.

We calculate the welfare effects for the flexible price-and-wage model, sticky price and sticky wage models under alternative exchange rate regimes both in the case of windfall and boom. Our main findings are summarized in Table 3.

**Table 3:** Welfare results (in % of the steady state of consumption)

	<b>Windfall</b>		<b>Boom</b>	
Flexible price and wage model	0.0012		0.0212	
<b>Exchange rate regime</b>	<b>Fixed</b>	<b>Flexible</b>	<b>Fixed</b>	<b>Flexible</b>
Sticky price model	0.015	0.0026	0.0124	0.0030
Sticky price-sticky wage model	0.0563	0.0013	0.0645	0.0070

Table 3 reports, in the flexible prices and wages model, that the boom has a far greater impact on welfare than the windfall. Indeed, welfare gain associated with a boom is around 0.012% of consumption in a deterministic steady-state, while with a

<sup>14</sup>For similar method see Schmitt-Grohé and Uribe (2004)

boom it is around 0.0212%. This is due to the fact that the windfall, as shown in section 3, leads to a strong effect of Dutch disease in terms of de-industrialization compared to a boom. Indeed, because of the fall of wages in the tradable sector (more important in the case of windfall), the households purchasing power is more important in the case of a boom. In this case, the welfare gain is higher than in the case of windfall.

In the two other models (sticky price model and sticky price and wage model) the results remain unchanged<sup>15</sup> such that, the welfare gain is more important following a boom rather than a windfall. Indeed, when the exchange rate regime is flexible, in the sticky price model, the welfare is equal to 0.0026% and 0.0030% in the case of windfall and boom respectively. In the case of sticky prices and wages model, the welfare is equal to 0.0013% and 0.0070% respectively in the case of a windfall and a boom. As shown by Table 3, the results are almost similar, in the case of fixed exchange rate in both windfall and boom.

The rest of the results shows that the flexible exchange rate regime helps to improve social welfare. Indeed, after a windfall, an increase in oil price generates a more important welfare gain when the exchange regime is fixed. Table 3 reports that, for the sticky price model, the welfare is estimated at 0.015% and 0.0026% of consumption in a deterministic steady-state, under a fixed exchange rate and a flexible exchange rate respectively. As for the sticky price and wage model, the welfare is around 0.0563% and 0.0013% in the cases of a fixed exchange rate regime and a flexible exchange rate regime respectively. In the case of a boom, the results show that welfare is lower when the central bank targets the CPI inflation. In other words, in the case of a fixed exchange rate, a rise in oil resources leads to a greater welfare gain. In the sticky price model, Table 3 reports values up to 0.0124% and 0.0030% in the cases of a fixed exchange rate and a flexible exchange rate respectively. Similarly, in the sticky price and sticky wage model, the welfare gain is equal to 0.0645% and 0.0070% respectively under a fixed exchange rate and a flexible exchange rate.

Thus, the flexible exchange rate regime improves the social welfare compared to the fixed exchange rate regime both in the case of a windfall and a boom. This result can be explained by the fact that CPI inflation targeting helps consumption smoothing by stabilizing prices and maintaining the purchasing power unchanged.

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<sup>15</sup>Except in the case of fixed exchange rate when prices are sticky.

## 6 Conclusion

In this paper, we have built a multisector DSGE model to model the Dutch disease phenomenon. To do so, the model takes into account the tradable good sector, the oil sector and the non-tradable good sector. The tradable good and oil sectors operate under perfect competition and the non-tradable goods sector operates under monopolistic competition. We have, thus, attempted to compare the response of the selected variables in the case of a windfall (increase in the oil price) and boom (increase in oil resources) and how monetary policy should be conducted to insulate the economy from the impacts of these shocks.

The main finding shows that the Dutch disease under both spending and resource movement effects seems to be realized in the following cases: flexible prices and wages both in the case of a windfall and in the case of a boom; flexible wages and sticky prices only in the case of fixed exchange rate. In others cases, simulations have shown that the Dutch disease could be avoided if: prices are sticky and wages are flexibles when the exchange rate is flexible; prices and wages are sticky whatever the objective of the central bank, in both cases: windfall and boom. Also, we compared the source of fluctuation that leads to a Dutch disease and we concluded that the windfall leads to a strong effect of Dutch disease in term of de-industrialization compared to a boom. The choice of flexible exchange rate regime also helps to improve the social welfare.

Finally, it appears that the flexible exchange rate seems to be the best way to avoid the Dutch disease both in the cases of a windfall and a boom but also to improve a social welfare. In other word, it is preferable for a central bank, in an oil exporting economy, to adopt inflation targeting regime to prevent the impact of oil shocks.

## References

- [1] Acosta, P.A. Lartey, E.K.K. Mandelman, F.S. (2009), "Remittances and the Dutch Disease," *Journal of international economics*. 79, 102-116.
- [2] Batte, L. Benassy-Quere, A. Carton, B. Dufrenot, G. (2009), "Term of Trade Shocks in a Monetary Union: an Application to West-Africa," Working Papers. 2009-07, CEPII research center
- [3] Benigno, G. (2004), "Real exchange rate persistence and monetary policy rules," *Journal of monetary economics*. 51 (3). 473-502.
- [4] Benigno, G. Thoenissen, C. (2006), "Consumption and Real Exchange Rates with Incomplete Markets and Non-traded Goods," *Journal of International Money and Finance*. 27, 926-948.
- [5] Bouakez, H. Rebei, N. Vencatachellum, D. (2008), "Optimal pass-through of oil prices in an economy with nominal rigidities," Working paper 08/31, CIRPEE.
- [6] Calvo, G. (1983), "Staggered prices in a utility-maximizing Framework," *Journal of Monetary Economics*. 12, 383-398.
- [7] Chari, V.V. Kehoe, P. J., McGrattan, E. R. (2002), "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates," *Review of Economic Studies* 69(3), 533-563.
- [8] Corden, W.M. Neary, J.P. (1982), "Booming Sector and De-Industrialisation in a Small Open Economy," *Economic Journal* 92, 825-848.
- [9] Corden, W. (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation," *Oxford Economic Papers*, 36, 359-80.
- [10] Corsetti, G. Pesenti, P. (2005), "International dimensions of optimal monetary policy," *Journal of Monetary Economics*, vol. 52(2), pages 281-305.
- [11] Devereux, M. Lane, P.R. Xu, J. (2006), "Exchange rate and monetary Policy in emerging market economies," *Economic journal* 116, 478-506.
- [12] Dib, A. (2007), "Dynamic Effects of the U.S. Dollar Fluctuations in a Small Open Oil Exporting Economy: The Case of Algeria". Manuscript, Bank of Canada.
- [13] Dib, A. (2008), "Welfare Effects of Commodity Price and Exchange Rate Volatilities in a Multi-Sector Small Open Economy Model," Bank of Canada working paper 2008-8.
- [14] Erceg, C. Henderson, D. Levin, A. (2000), "Optimal monetary policy with staggered wage and price contracts," *Journal of Monetary Economics* 46, 281-313.
- [15] Gertler, M. Gilchrist, S. Natalucci, F.M. (2003), "External Constraints on Monetary Policy and the Financial Accelerator," *Journal of Money, Credit and Banking*. 39,



295-330.

- [16] Hausmann, R. Rigobon, R. (2002), "An Alternative Interpretation of the 'Resource Curse': Theory and Policy Implications," NBER Working Papers 9424, National Bureau of Economic Research, Inc.
- [17] Ireland, P. (2003), "Endogenous Money or Sticky Prices?" *Journal of Monetary Economics*. 50, 1623–48.
- [18] Kollmann, R. (1996), "Incomplete Asset Markets and the Cross-Country Consumption Correlation Puzzle," *Journal of Economic Dynamics and Control*. 20(5), 945-961.
- [19] Kollmann, R. (2001), "The Exchange Rate in a Dynamic Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation," *Journal of International Economics*. 55, 243-262.
- [20] Lama, R. Madina, P. (2010), "Is Exchange Rate Stabilization an Appropriate Cure for the Dutch Disease?" IMF working paper, WP/10/182.
- [21] Lartey E.K.K. (2008), "Capital Inflows, Dutch Disease Effects and Monetary Policy in a Small Open Economy," *Review of international economics*. 16:5 671-689.
- [22] McCallum, B.T. Nelson, E. (1998), "Nominal Income Targeting in an Open-Economy Optimizing Market," NBER working paper 6675.
- [23] Schmitt-Grohé, S. Uribe, M. (2003). "Closing Small Open Economy Models," *Journal of International Economics*. 61, 163-185.
- [24] Schmitt-Grohé, S. Uribe, M. (2004), "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function," *Journal of Economic Dynamics and Control*. 28 (4), 755–75.
- [25] Scmitt Grohe, S. Uribe, M. (2007), "Optimal, Simple, and Implementable Monetary and Fiscal Rules," *Journal of Monetary Economics*. 54, 1702–25.
- [26] Sosunov, K. Zamulin, O. (2007), "Monetary Policy in an Economy Sick with Dutch Disease," Working Papers w0101. Center for Economic and Financial Research (CE-FIR).
- [27] Yun, T. (1996), "Nominal Price Rigidity, Money Supply Endogeneity, and the Business Cycles," *Journal of Monetary Economics*. 37, 345-370.

**Table 5:** Recent literature of the Dutch disease

	<b>Sectors</b>	<b>Main assumptions</b>	<b>Main results</b>
<b>Sosunov and Zamulin (2007)</b>	Non-tradable good sector	<ul style="list-style-type: none"> <li>- Endogenous rate of time preference;</li> <li>- Sticky price of non-tradable goods;</li> <li>- Russian economy;</li> <li>- Increase in commodity prices.</li> </ul>	<ul style="list-style-type: none"> <li>- The use of international reserve management as a tool to stabilize the economy only if a true fiscal stabilization fund is not available;</li> <li>- the monetary authority should respond primarily to inflation and then to the real exchange rate.</li> </ul>
<b>Lartey (2008)</b>	<ul style="list-style-type: none"> <li>- Tradable sector;</li> <li>- Non-tradable sector.</li> </ul>	<ul style="list-style-type: none"> <li>- Incomplete Financial market;</li> <li>- Sticky price of non-tradable goods;</li> <li>- Alternative monetary policy rules;</li> <li>- Increase in capital inflow.</li> </ul>	<ul style="list-style-type: none"> <li>- Dutch disease effects when monetary authority target the nominal exchange rate;</li> <li>- Welfare result reveal that a generalized Taylor rule outperforms a fixed nominal exchange rate regime.</li> </ul>
<b>Batt et al (2008)</b>	<ul style="list-style-type: none"> <li>- Monetary union DSGE model;</li> <li>- Tradable sector;</li> <li>- Non-tradable sector.</li> </ul>	<ul style="list-style-type: none"> <li>- Complete financial market;</li> <li>- Three monetary Policy rules;</li> <li>- Negeria economy;</li> <li>- Increase in oil price and non-oil price (agricultural price).</li> <li>- Sticly price and wage.</li> </ul>	<ul style="list-style-type: none"> <li>- The economy is affected by a Dutch diseas following the shocks;</li> <li>- Flexible exchange rate regime with exogenous money supply allow to avoid the Dutch disease in the absence of a stabilization fund;</li> </ul>
<b>Acosta et al (2009)</b>	<ul style="list-style-type: none"> <li>- Tradable sector;</li> <li>- Non-tradable sector.</li> </ul>	<ul style="list-style-type: none"> <li>- El Salvador economy;</li> <li>- Bayesian estimation;</li> <li>- Rise of level of Remittances.</li> <li>- VAR analysis.</li> </ul>	<ul style="list-style-type: none"> <li>- Decline of labor supply;</li> <li>- Increase in consumption demand;</li> <li>- Higher non-tradable prices and appreciation of real exchange rate.</li> <li>- The same results with a VAR's impulse responses.</li> </ul>
<b>Lama and Medina (2010)</b>	- Commodity sector	<ul style="list-style-type: none"> <li>- Learning-by-doing externality in tradable sector;</li> <li>- nominal rigidities;</li> </ul>	<ul style="list-style-type: none"> <li>- Learning against an appreciated exchange rate can prevent an inefficient loss of tradable output but at the cost of generating a misallocation of resource in other sectors;</li> <li>- Welfare is a decreasing function of exchange rate intervention.</li> </ul>