Oil Exporting Countries and Economic Diversification: The Role Of Monetary and Fiscal Policies

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Oil exporting countries and economic diversification : the role of monetary and fiscal policies

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Abstract

In this study, we examined the role of monetary and fiscal policies in the diversification of oil-dependent economies. Indeed, the change in external condition due to recent pandemic event and international political frictions have profoundly impacted oil-exporting countries. On the demand side, they have endured an abrupt fall in world oil consumption due to lockdowns during pandemic crisis and are facing a potential decline of world oil demand as a result of a shift toward green production to reduce pollution to the planet. On the supply side, they are facing negative supply shocks on imported goods due to the disruption of the global value chain and the resulting stagnation of global supply chain. To provide some policy responses to the need for diversification of oil-exporting economies, we built a DSGE model including two production sectors and a banking system. We simulated different scenarios aiming at orienting monetary and fiscal policies towards supporting production in the non-oil sector. Our main results show that monetary policy loses its efficiency facing negative oil price shocks. The effects of oil exports on bank's liquidity and credit in the market are much greater than Central Bank's adjustment on the standard interest rate. However, by supporting the non-oil sector, fiscal policy is efficient to reduce the contraction risk for oil-exporting economies.

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1 Introduction

Emerging oil exporting countries are often exposed to external shocks, which can have a significant impact on their economies. In the short term, fluctuations in the prices of imported goods, but also of oil, have a significant impact on the macroeconomic balances of these countries. In the case of Algeria, for example, since 2014, the downward trend in oil prices, intensified by the Covid 19 pandemic, has caused a drastic drop in foreign exchange reserves, which reached 44 billion at the end of 2021, while they exceeded 190 billion in 2014. Similarly, the sovereign wealth fund, known as the revenue regulation fund, had exceeded 32 billion in 2014 and was completely drained in 2018[1]. As for the banking system, it found itself in need of financing after a long period of excess liquidity, particularly from 2001 to 2014. More recently, because of the war in Ukraine, the global food import bill has risen dramatically, contributing to current account imbalances.

In the long term, oil-exporting economies may suffer from the decline in global oil demand. Indeed the world economy, especially developed countries are shifting toward a more ecological production. New energy resources are now made on to the calendar and the demand for polluting energy such as petrol will potentially decrease in the coming years. Also, the resource-rich country is at the peak of oil production and oil revenue horizon is relatively short. To avoid the negative consequences of such a situation, oil dependent countries should diversify their economies, by improving their non-oil production capacity and reducing their dependence on imported products.

The main objective of this study is to provide policy recommendations aiming to facilitate the transition from an oil-dependent economy to a more diversified one. To do so, we propose a DSGE model including 6 agents: households, an oil firm, non-oil producing firms, a final good producer, a banking sector and a public sector including the government and the central bank. We calibrate the model to Algeria and simulate two main scenarios: a negative oil price shock and a positive import price shock. In each scenario, we evaluate the role of three instruments: conventional monetary policy, non-conventional monetary policy and fiscal policy. We also evaluate the welfare effect of these three instruments under each scenario.

Our paper is related to the literature studying the effectiveness of fiscal and monetary policies in oil exporting economies using dynamic stochastic general equilibrium (DSGE) models. Most of the literature focuses on the conduct of monetary and fiscal policies, the assessment of the macroeconomic effects of oil price increases and the role of modeling in dealing with these different shocks (mainly interest rates, exchange rates and oil prices). On the monetary and fiscal policy side, Algozhina (2015), Allegret and Benkhodja (2015) and Ferrero and Seneca (2019) have examined a range of policies for small open oil-exporting

[1] The data on foreign exchange reserves and the revenue regulation fund are based on data from the bank of Algeria and the ministry of finance.

economies. Algozhina (2015), built a DSGE model to determine an adequate policy rule for an oil exporting economy combined with a pro/counter/acyclical fiscal stance based on a loss measure. Allegret and Benkhodja (2015) evaluated the effectiveness of a set of monetary policy rules against external shocks by estimating a DSGE model using the Bayesian method and Ferrero and Seneca (2019) constructed a simple model of an oil-exporting economy to assess the optimal monetary policy response to a commodity price shock in a resource-rich economy. According to Algozhina (2015), the best policy combination is inflation targeting under a flexible exchange rate regime with a countercyclical fiscal stance. This allows to stabilize inflation, aggregate output and the real exchange rate. Allegret and Benkhodja (2015) found that, over the period 1990Q1-2010Q4, core inflation monetary rule allows the best combination in terms of price stability and low volatility of production. Ferrero and Seneca (2019) model's shows that the optimal policy involves a reduction in the interest rate following a decline in the oil price. In contrast, a central bank with a mandate to stabilize consumer price inflation may raise interest rates to limit the inflationary impact of an exchange rate depreciation.

The literature on macroeconomic effects provides different indications. Indeed, oil-exporting countries experience varying responses to a positive oil price shock. These include higher output and prices (Allegret and Benkhodja (2015)), higher output and lower prices (Ferrero and Seneca (2019)), lower output and higher prices (Romero et al. (2008)), and lower output and prices (Bergholt et al. (2019)). This difference in results can be explained by the prevailing exchange rate regime, the degree of the country's dependence on oil, the nature of the monetary policy response to structural shocks, and the modeling strategy of the researchers. Compared to existing literature, the innovation in our paper is that we establish a theoretical framework, with explicit banking sector who invests in multi-sectoral industries, i.e. oil sector and non-oil sector. The interest of the banking system in this study is to capture the liquidity from oil exports. Indeed, during episodes of rising oil prices, banks hold abundant liquidity that allows them to play an active role in financing the economy. On the other hand, during episodes of falling oil prices, bank liquidity becomes scarce and can contribute to worsening the macroeconomic effects of falling oil prices by reducing credit to the economy. To the best of our knowledge, the banking system as an amplifier of the effects of oil shocks has not yet been taken into account. We calibrate the model to Algeria, and study the interaction between oil and non-oil sector and try to see whether consolidating the non-oil sector makes the economy more resilient to external shock. We also incorporate an import sector in the economy, as imported manufacturing goods play an important role in the domestic consumption and we analyse the effects of negative supply shocks for imported goods. Our work is the first that copes with a rich dynamics between different industrial sectors, the financial market, and global supply chain in a small open oil-exporting economy.

Our results show that there is a much larger impact from negative external supply shock (import price shock) than from the demand shock on oil products. The supply shock affects essentially the non-oil sector. Facing an increase in imports price, fiscal policy to support the non-oil sector are more efficient compared to conventional monetary policy.

On the welfare side, the effects of fiscal policy are much better for households. The reason is that fiscal policy directly increases capital in non-oil firms, which increases the wage level and consumption of workers. The suggestion is that in case of oil shocks, if the policy maker wants to maximize social welfare, then a fiscal policy that supports the non-oil sector would be a good choice.

Under negative supply shocks on imported goods, our simulation shows that compared to the oil price shock, the supply shock has a more profound impact on the economy, in which neither unconventional monetary policy nor the fiscal policy could have significant effects to mitigate. This fact gives a strong signal to the policy makers that supporting domestic economy and makes the economic structure more balances and less dependent to the external world, should be the priority in the coming decade.

The rest of the paper is organized as follow. Section 2 presents the model. Section 3 explains the calibration. Section 4 discusses the simulation and results. Section 5 effectuates the welfare analysis. Section 6 concludes.

2 The model

We model an oil exporting economy by using a two-sector open economy DSGE model. We introduce nominal rigidities by assuming the existence of 6 agents: a representative household, an oil good producer, a non-oil goods producers, a private bank, an importer and a public sector including government and central bank.

2.1 Household

The representative household derives utility from consumption C_t^H and leisure $L_t^H = 1 - N_t^H$ where N_t^H corresponds to labor supply. They maximize the following lifetime sum of discounted expected value of utility

$$E_t \sum_{\tau=0}^{\infty} \beta^{\tau} U\left(C_{t+\tau}^H, N_{t+\tau}^H\right) \tag{1}$$

where β represents the discount rate. The utility function is defined as :

$$U(\cdot) = \frac{\left(C_t^H\right)^{1-\sigma_H^c}}{1-\sigma_H^c} - \frac{\left(N_t^H\right)^{1+\sigma_H^n}}{1+\sigma_H^n}$$

Parameters σ_H^c and σ_H^n represent the inverse of intertemporal elasticity of substitution for consumption and labor supply repectively.

A representative household faces each period the following budget constraint:

$$P_{C,t}C_t^H = W_{O,t}N_{O,t} + W_{NO,t}N_{NO,t} + (1-\sigma_B)NW_t + DIV_t - T_t, \tag{2}$$

where $W_{O,t}$ and $W_{NO,t}$ represent the nominal wages in the oil and non-oil sectors. $P_{C,t}$ denotes the consumer price index defined in the section 3 and T is a lump-sum tax. The dividend payment received from non-oil and import sectro are $DIV_{NO,t} + DIV_{I,t} = DIV_t$. $(1-\sigma_B)$ represents the probability that banks will default and the net wealth NW_t will be returned to households.

We assume that the total hours worked N_t is defined by the following CES integration:

$$N_t = \left(\mu_N^{1/\varepsilon}(N_{O,t})^{(\varepsilon-1)/\varepsilon} + (1-\mu_N)^{1/\varepsilon}(N_{NO,t})^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}, \tag{3}$$

where $N_{O,t}$ and $N_{NO,t}$ represent hours worked by the household at time t in oil and non-oil sectors respectively, and μ_N the share of hours worked in the oil sector. Households maximize their lifetime sum of discounted expected value of utility (1) subject to the budget constraints (2). Given initial value, the representative household chooses $\left\{C_t^H, N_{O,t}, N_{NO,t}\right\}$ to maximize its lifetime utility function. This is subject to capital accumulation equation and the budget constraint. We assume that households do not make deposits to the private bank and deposits in the economy comes from oil-exporting firms.
The first-order condition of this maximization problem is given by :

$$\lambda_t = \left(C_t^H\right)^{-\sigma_H^c}, \tag{4}$$

$$w_{O,t} = \mu_N^{\frac{1}{\epsilon}} \frac{N_t^{\sigma_H^n + \frac{1}{\epsilon}} N_{O,t}^{-\frac{1}{\epsilon}}}{\lambda_{H,t}}, \tag{5}$$

$$w_{NO,t} = (1-\mu_N)^{\frac{1}{\epsilon}} \frac{N_t^{\sigma_H^n + \frac{1}{\epsilon}} N_{NO,t}^{-\frac{1}{\epsilon}}}{\lambda_{H,t}}, \tag{6}$$

where $w_{O,t} = \frac{W_{O,t}}{P_{C,t}}$ and $w_{NO,t} = \frac{W_{NO,t}}{P_{C,t}}$ represent the real wage in each sector and λ_t denotes the budget multiplier associated with the budget constraint.

2.2 Oil Firm

The oil firms are state-owned. To model oil production $Y_{O,t}$, we assume that oil firm operates in perfect competition and uses labor $N_{O,t}$, capital $K_{O,t}$ and crude oil O_t. The production function is characterized by the following Cobb-Douglas technology:

$$Y_{O,t} = O_t^{\alpha_O} K_{O,t-1}^{\beta_O} N_{O,t}^{\theta_O}, \tag{7}$$

The international price of crude oil $P_{O,t}^*$ is set in international oil market and is labeled in US Dollar. If we define S_t the exchange rate, we get the following FOC's of the oil firm maximization problem :

$$r^L_{O,t} = (1-\tau_O)\, s_t p^*_{O,t}\beta_O \frac{Y_{O,t}}{K_{O,t-1}}, \quad (8)$$

$$w_{O,t} = (1-\tau_O)\, s_t p^*_{O,t}\theta_O \frac{Y_{O,t}}{N_{O,t}}, \quad (9)$$

$$p^O_t = (1-\tau_O)\, s_t p^*_{O,t}\alpha_O \frac{Y_{O,t}}{O_t}, \quad (10)$$

where $w_{O,t} = \frac{W_{O,t}}{P_{C,t}}, p^*_{O,t} = \frac{P^*_{O,t}}{P^*_{C,t}}, p^O_t = \frac{P^O_t}{P_{C,t}}$ and $s_t = \frac{S_t P^*_{C,t}}{P_{C,t}}$ denote respectively the real wage in oil sector, the international real oil price, the domestic real oil price and the real exchange rate.

In our economy, the oil firm deposits in its bank account its revenues net of the oil revenue tax τ_O.

$$D^O_t = (1-\tau_O)\, S_t P^*_{O,t} Y_{O,t}. \quad (11)$$

We also assume that the firm is state-owned.

Finally, we assume that the real oil price, the real exchange rate and crude oil follow an exogenous stochastic process:

$$log\left(p^*_{O,t}\right) = (1-\rho_{p^*_O}) log\left(\bar{p}^*_O\right) + \rho_{p^*_O} log\left(p^*_{O,t-1}\right) + \varepsilon_{p^*_O,t} \quad (12)$$

$$log\left(O_t\right) = (1-\rho_o) log\left(\bar{O}\right) + \rho_o log\left(O_{t-1}\right) + \varepsilon_{o,t}, \quad (13)$$

$$log\left(s_t\right) = (1-\rho_s) log\left(\bar{s}\right) + \rho_s log\left(s_{t-1}\right) + \varepsilon_{s,t}, \quad (14)$$

2.3 Non-oil firm

In the economy, there is a continuum of non-oil firms, which produces goods for domestic consumption. We assume that the sector applies Cobb-Douglas production function :

$$Y_{NO,t}(i) = K^{\alpha_{NO}}_{NO,t-1}(i)\, N^{\beta_{NO}}_{NO,t}(i) \quad (15)$$

The firm borrows new capital $K_{NO,t}$ from the bank, which will be used in the next period. The non-oil firm's dividend is given by :

$$DIV_{NO} = \widetilde{P}_{NO} Y_{NO} - r^L_{NO} K_{NO} - w_{NO} N_{NO},$$

Then, the first order conditions give the demand of capital and labor :

$$r^L_{NO,t} = \alpha_{NO} mc_{NO,t} \frac{Y_{NO,t}(i)}{K_{NO,t-1}(i)}, \quad (16)$$

$$w_{NO,t} = \beta_{NO} mc_{NO,t} \frac{Y_{NO,t}(i)}{N_{NO,t}(i)}. \quad (17)$$

where $r^L_{NO,t} = \frac{R^L_{NO,t}}{P_{C,t}}$, $w_{NO,t} = \frac{W_{NO,t}}{P_{C,t}}$ and $mc_{NO,t} = \frac{MC_{NO,t}}{P_{C,t}}$ denote respectively the real capital return, the real wage and the real marginal cost.

The capital accumulation has the following dynamic :

$$K_{NO,t} = I_{NO,t} + (1-\delta)K_{NO,t-1} + x_t(B_t + s_t p^f_{o,t} Y_{o,t} + T + (r^D_t - 1)D_{O,t-1}) \qquad (18)$$

where $x_t(B_t + s_t p^f_{o,t} Y_{o,t} + T + (r^D_t - 1)D_{O,t-1})$ is the subsidy from government, which we explain later in the government budget constraint.

We assume that the non-oil firm has the ability to adjust its price with probability $(1-\phi_{NO})$. This means that the price of the non-oil good remains unchanged for $\frac{1}{1-\phi_{NO}}$ periods. The optimal pricing condition is given by:

$$\widetilde{p}_{NO,t}(i) = \frac{\vartheta}{\vartheta-1} \frac{E_0 \sum\limits_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{t+s} mc_{NO,t+s} p^{\vartheta}_{NO,t+s} Y_{NO,,t+s}}{E_0 \sum\limits_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{t+s} Y_{NO,t+s} p^{\vartheta}_{NO,t+s}}, \qquad (19)$$

where $p_{NO,t+s} = \frac{P_{NO,t+s}}{P_{C,t+s}}$, and $\widetilde{p}_{NO,t}(i) = \frac{\widetilde{P}_{NO,t}(i)}{p_{C,t}}$ denote respectively the relative price and the real optimized price for non-oil goods.

We rewrite the optimal pricing condition as follows :

$$\widetilde{p}_{NO,t} = \frac{\vartheta}{\vartheta-1} \frac{V^1_{NO,t}}{V^2_{NO,t}}, \qquad (20)$$

where $V^1_{NO,t}$ and $V^2_{NO,t}$ are two auxiliary variables:

$$V^1_{NO,t} = \lambda_t Y_{NO,t} mc_{NO,t} p^{\vartheta}_{NO,t} + \beta\phi_{NO} E_t V^1_{NO,t+1}, \qquad (21)$$

and,

$$V^2_{NO,t} = \lambda_t Y_{NO,t} p^{\vartheta}_{NO,t} + \beta\phi_{NO} E_t V^2_{NO,t+1}. \qquad (22)$$

2.4 Import sector

In this section, we assume the existence of a continuum of intermediate importers, indexed by $i \in (0,1)$, producing a composite imported good, $Y_{I,t}$, using a differentiated good $Y_{I,t}(i)$. To do so, each importer uses a homogeneous intermediate good produced abroad and imported for the world price P^*_t and invoiced in the dollars S_t. Following Monacelli (2003), we assume that intermediate importing firms behave as a monopolistic firm when setting home currency price of imported goods $P_{I,t}(i)$ which is supposed to be sticky *à la* Calvo (1983) and Yun (1996). 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 past inflation rate.

$$P_{I,t}(i) = \left(\frac{P_{I,t-1}}{P_{I,t-2}}\right)^{\gamma_I} P_{I,t-1}(i) = (\Pi_{I,t-1})^{\gamma_I} P_{I,t-1}(i)$$

where the parameter γ_I measures the degree of indexation to past inflation. Importers that are allowed to set prices maximize the following discounted sum of their expected profits:

$$\max_{\widetilde{P}_{I,t}(i)} E_t \sum_{s=0}^{\infty} (\beta\phi_I)^s \left(\widetilde{P}_{I,t}(i) X_{ts} - S_{t+s} P^*_{t+s}\right) Y_{I,t+s}(i), \tag{23}$$

subject to the following sequence of demand constraint :

$$Y_{I,t+s}(i) = \left(\frac{\widetilde{P}_{I,t}(i) X_{ts}}{P_{I,t+s}}\right)^{-\frac{1+\lambda_{I,t}}{\lambda_{I,t}}} Y_{I,t+s}. \tag{24}$$

where

$$X_{ts} = \begin{cases} \Pi_{I,t}^{\gamma_I}.\Pi_{I,t+1}^{\gamma_I}.\ldots.\Pi_{I,t+s-1}^{\gamma_I} \text{ for } s \geq 1 \\ 1 \text{ for } s = 0 \end{cases}$$

and $(1 + \lambda_{I,t})$ denotes the time-varying markup of prices over marginal costs at intermediate importer's level. The latter is assumed to evolve according to:

$$ln(1 + \lambda_{I,t}) = ln(1 + \lambda_I) + \eta_{I,t} \quad \text{where} \quad \eta_{I,t} \rightsquigarrow \mathcal{N}(0, \sigma^2_{\lambda_I}) \tag{25}$$

where $\eta_{I,t}$ represents cost-push shock on import prices that reflects supply shock on imported goods. The optimal pricing decision of intermediate importers is the result of this maximization problem. That is,

$$E_t \sum_{s=0}^{\infty} (\beta\phi_I)^s \left[\tilde{P}_{I,t}(i) X_{ts} - (1 + \lambda_{I,t+s}) S_{t+s} P^*_{t+s}\right] Y_{I,t+s}(i) = 0 \tag{26}$$

Therefore, the optimal pricing condition is given by:

$$\widetilde{p}_{I,t}(i) = \frac{E_t \sum_{s=0}^{\infty} (\beta\phi_I)^s (1 + \lambda_{I,t+s}) mc_{I,t+s} Y_{I,t+s}(i)}{E_t \sum_{s=0}^{\infty} (\beta\phi_I)^s Y_{I,t+s} \frac{X_{ts}}{P_{C,t+s}/P_{C,t}}}, \tag{27}$$

where $\widetilde{p}_{I,t}(i) = \frac{\widetilde{P}_{I,t}(i)}{P_{C,t}}$ is the relative optimal price of imports and $mc_{I,t} = S_t P^*_t / P_{C,t}$ is the real marginal cost which is equal to the real exchange rate. The non-linear recursive form of Eq (27) can be written as follow:

$$\widetilde{p}_{I,t} = \frac{V^1_{I,t}}{V^2_{I,t}}, \tag{28}$$

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

$$V^1_{I,t} = (1 + \lambda_{I,t}) mc_{I,t} Y_{I,t} + \beta\phi_I E_t \left\{V^1_{I,t+1}\right\}, \tag{29}$$

$$V^2_{I,t} = Y_{I,t} + \beta\phi_I E_t \left\{\frac{\Pi^{\gamma_I}_{I,t}}{\Pi_{t+1}} V^2_{I,t+1}\right\}. \tag{30}$$

where $\Pi_{I,t} = \frac{P_{I,t}}{P_{I,t-1}}$ and $\Pi_t = \frac{P_{C,t}}{P_{C,t-1}}$ represents the import price index (IPI) and consumer price index (CPI) inflation rate, respectively.
Finally, given that all importing firms that adjust in period t choose the same optimal price $\tilde{p}_{I,t}$, whereas those that do not simply index prices to past inflation, the aggregate import price index $p_{I,t}$ evolves according to:

$$p_{I,t} = \left[\phi_I \left(\frac{\Pi_{I,t-1}^{\gamma_I}}{\Pi_t} p_{I,t-1} \right)^{-\frac{1}{\lambda_{I,t}}} + (1 - \phi_I) \left(\tilde{p}_{I,t} \right)^{-\frac{1}{\lambda_{I,t}}} \right]^{-\lambda_{I,t}} \tag{31}$$

2.5 Final good producer

The final good producer uses the following CES technology that includes non-oil output, $Y_{NO,t}$, and imports, $Y_{I,t}$:

$$Z_t = \left[\chi_{NO}^{\frac{1}{\tau}} Y_{NO}^{\frac{\tau-1}{\tau}} + \chi_I^{\frac{1}{\tau}} Y_I^{\frac{\tau-1}{\tau}} \right]^{\frac{\tau}{\tau-1}}, \tag{32}$$

The elasticity of substitution between non-oil output and imported goods τ is strictly positive; the share of non-oil and imported goods in the final good $\chi_{NO} + \chi_I = 1$. The maximization problem solution yields the following demand functions :

$$Y_{I,t} = \chi_I \left(\frac{P_{I,t}}{P_t} \right)^{-\tau} Z_t, \quad \text{and} \quad Y_{NO,t} = \chi_{NO} \left(\frac{P_{NO,t}}{P_t} \right)^{-\tau} Z_t, \tag{33}$$

where $P_{C,t}, P_{I,t}, P_{NO,t}$ are given. The zero profit condition implies the following final good price :

$$P_{C,t} = \left[\chi_I P_{I,t}^{1-\tau} + \chi_{NO} P_{NO,t}^{1-\tau} \right]^{\frac{1}{1-\tau}}. \tag{34}$$

2.6 Banks

For the modelling of the banking sector, we adopt the method as in Gertler and Karadi (2011) and Auray et al. (2018), banks first choose the optimum total asset size, and then they choose to invest in different assets : non-polluting sector, polluting sector, or government bonds. The banks' balance sheet is :

$Asset_t$ = total assets of banks	$D_{O,t}$ = domestic deposits
	NW_t = net worth

where $Asset_t$ is a portfolio that contains investment in polluting sector, non polluting sector, and government bonds.

The balance sheet satisfies :

$$Asset_t = D_{O,t} + NW_t \tag{35}$$

The dynamic of net wealth NW_t follows :

$$NW_{t+1} = \sigma_B \left[r_{t+1}^{Asset} Asset_t - r_t^D D_{O,t} \right] \tag{36}$$

where r_t^{Asset} is the real composite return of the portfolio $Asset_{t-1}$, and r_t^d is the real deposit interest rate. From the last two equations, the dynamic of bank's net wealth follows :

$$NW_{t+1} = \sigma_B \left[\left(r_{t+1}^{Asset} - r_t^D \right) Asset_t + r_t^D NW_t \right] \tag{37}$$

The stochastic discount rate is $\beta_{t,t+1} = \beta U_{C,t+1}/U_{C,t}$:

The banks' optimization problem is :

$$V_t = E_t \left\{ \beta_{t,t+1} \left[(1 - \sigma_B) N_{t+1} + \sigma_B V_{t+1} \right] \right\} \tag{38}$$

The banks can divert a fraction α of its total assets, hence the incentive condition is :

$$V_t \geq \alpha Asset_t. \tag{39}$$

This incentive condition is binding in equilibrium. The initial guess of the solution is :

$$V_t = \gamma_t^{asset} Asset_t + \gamma_t NW_t. \tag{40}$$

and the incentive condition therefore simplified as :

$$\phi_t NW_t \geq Asset_t \tag{41}$$

where

$$\phi_t = \gamma_t / \left(\alpha - \gamma_t^{Asset} \right). \tag{42}$$

is defined as the bank's leverage ratio. We substitute the constraint in the guessed solution gives $V_t = \left(\gamma_t^{Asset} \phi_t + \gamma_t \right) NW_t$. Plug the expression into the value function of accumulation of net worth N_{t+1}, we have

$$V_t = E_t \left\{ \Lambda_{t,t+1} NW_{t+1} \right\} \tag{43}$$

$$= E_t \left\{ \Lambda_{t,t+1} \left[\left(r_{t+1}^{Asset} - r_t^d \right) Asset_t + r_t^d NW_t \right] \right\} \tag{44}$$

where

$$\Lambda_{t,t+1} = \beta_{t,t+1} \left[1 - \sigma_B + \sigma_B \left(\gamma_{t+1}^{Asset} \phi_{t+1} + \gamma_{t+1} \right) \right]. \tag{45}$$

This allows to identify the arguments of the value function:

$$\gamma_t^{Asset} = E_t \left\{ \Lambda_{t,t+1} \left(r_{t+1}^{Asset} - r_t^D \right) \right\} \text{ and } \gamma_t = E_t \left\{ \Lambda_{t,t+1} r_t^d \right\} \tag{46}$$

We define q_t^{no}, q_t^o and q_t^b as the prices of investment in non-oil sector, oil sector and government bonds, and q_t^{Asset} as the price of the portfolio. The banks minimize the cost :

$$q_t^{Asset} Asset_t = q_t^{NO} K_{NO,t} + q_t^O K_{O,t} + q_t^B B_t. \tag{47}$$

$$Asset_t = \left(\mu^{1/\varepsilon} (K_{NO,t})^{(\varepsilon-1)/\varepsilon} + \eta_B^{1/\varepsilon} (K_{O,t})^{(\varepsilon-1)/\varepsilon} + (1 - \eta_B - \mu)^{1/\varepsilon} B_t^{(\varepsilon-1)/\varepsilon} \right)^{\varepsilon/(\varepsilon-1)}. \tag{48}$$

In this equation, μ is the steady-state relative weights of loans in non-oil sector in the portfolio, and ε is the elasticity of substitution between assets. Given that real asset prices are inversely related to their real expected rates of return, the optimal allocation of funds that results from the banks choice is thus

$$K_{NO,t} = \mu E_t \left\{ \left(\frac{r^L_{NO,t}/\pi_{t+1}}{r^{Asset}_t} \right)^{\varepsilon} \right\} Asset_t, \tag{49}$$

$$K_{O,t} = \eta_B E_t \left\{ \left(\frac{r^L_{O,t}/\pi_{t+1}}{r^{Asset}_t} \right)^{\varepsilon} \right\} Asset_t, \tag{50}$$

$$B_t = (1 - \eta_B - \mu) E_t \left\{ \left(\frac{r^B_t/\pi_{t+1}}{r^{Asset}_t} \right)^{\varepsilon} \right\} Asset_t, \tag{51}$$

The real composite portfolio return is :

$$r^{Asset}_t = \left(\mu E_t \left\{ \left(\frac{r^L_{NO,t}}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} + \eta_B E_t \left\{ \left(\frac{r^L_{O,t}}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} + (1 - \eta_B - \mu) E_t \left\{ \left(\frac{r^B_t}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} \right)^{\frac{1}{\varepsilon-1}}.$$

2.7 Public sector

In this section, we present the government's budget constraint and the central bank's monetary policy rule.

2.7.1 Government budget constraint

The government's budget constraint is given by:

$$[B_t + s_t p^f_{o,t} Y_{o,t} + T + (r^D_t - 1) D_{O,t-1}](1 - x_t) = R_t B_{t-1} + w_{o,t} N_{O,t} + p_{O,t} O_t, \tag{52}$$

where the left hand side represents the government's revenue that includes bonds B_t, receipts from selling oil $s_t p^f_{o,t} Y_{o,t}$, lump-sum taxes T and the real return on deposits $\left(r^D_t - 1\right) D_{O,t-1}$. The right hand side represents the government spending that include payment both wages $w_{O,t} N_{O,t}$ and the extraction cost $p_{O,t} O_t$ and the burden debt $R_t B_{t-1}$. x_t is the proportion of government revenue invested in the lending to non-oil sector. For simplicity, we assume that in steady state $x_t = 0$.

2.7.2 Conventional Monetary policy

The central bank adjusts the short-term nominal interest rate, R_t, in response to fluctuation in CPI inflation, π_t, and the output gap according to the following Taylor-type monetary policy rule :

$$\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}} \right)^{\rho_R} \left(\left(\frac{Y_t}{Y_{t-1}} \right)^{r_y} \left(\frac{\pi_t}{\overline{\pi}} \right)^{r_\pi} \right)^{1-\rho_R} \exp(\varepsilon_R),$$

where $\overline{R}$,and $\overline{\pi}$are the steady state values of R_t,and π_t. The policy coefficient, r_y and r_π measuring central bank response to deviation of Y_t, and π_t from their last period and steady state levels respectively.

3 Calibration

In what follows, we calibrate the model using the standard values of the structural parameters related to the business cycle literature, the steady state values of our key variables and the Algerian data[2]. We choose Algeria for two main reasons. First, the ratios of oil exports to total exports (more than 95%) and oil exports to GDP (about 20%) clearly show the structural fragility of the Algerian economy which is particularly vulnerable to oil price fluctuations. Second, as a result, monetary policy in Algeria is largely dependent on the oil revenues.

Table 1 lists the values of the following 21 parameters of our baseline model.
$\left[\beta_H, \sigma_H^c, \sigma_H^n, \sigma_B, \mu_N, \varepsilon, \alpha_O, \beta_O, , \theta_O, \tau_O, \alpha_{NO}, \beta_{NO}, \rho_{P_O^*}, \rho_o, \delta, \phi_{NO}, \vartheta, \phi_I, \chi_I, \chi_{NO}, \tau, \alpha, \mu, \eta_B, \rho_R, r_y, r_\pi\right]$,
The subjective discount factor β is set at 0.99 which implies an annual steady-state interest rate of about 4.04%. The inverse of the elasticity of the intertemporal substitution of labor σ_H^n is set at 10. From the steady state calculation, the value of the inverse of elasticity of intertemporal substitution of consumption $\sigma_H^c = 10.09707$ and the fraction of total asset α $= 0.0138$. The capital depreciation rate is set at $\delta = 0.025$ and the share of capital, β_O and α_{NO}; used as an input in the production of oil and non-oil sectors respectively, are set at 0.3. The share of labor in the oil sector μ_N, it is set at 0.13, meaning that 13% of total employment is in the oil sector. According to the Algerian statistics office, the share of employment in the industry sector is about 13% of total employment [3] The share of crude oil in the oil production is $\theta_O = 1 - \beta_O - \alpha_O$.

Following the literature on nominal rigidities, we set the parameters denoting the degree of monopoly power in the intermediate good market, ϑ, equal to 8. Then, the steady-state price markup is equal to 14%. Also, the price elasticity of demand for imported and non-oil goods, τ, is set at 0.8. The share of imports, χ_I and non-oil goods, χ_{NO}, according to steady-state calculation, are calibrated to 0.65 and 0.35 respectively. These values are chosen given the value of the average ratio of both imports and non-oil goods production to GDP of Algerian economy[4].

The tax on oil income τ_O (or the tax on hydrocarbon income) is set at 0.3, representing a value of 30% of oil income, which corresponds to the average of this tax in Algeria[5].

Regarding the financial parameters, we set the value of the parameter measuring the default

[2]The data on the Algerian economy comes from the Bank of Algeria, the Ministry of Finance and the IMF database.

[3]see https://www.ons.dz/IMG/pdf/emploichommai2019.pdf

[4]Since the Algerian economy exports an insignificant fraction of non-oil goods, the average ratio of total non-oil production to GDP could be approximated by the value of the domestic production.

[5]see https://pwcalgerie.pwc.fr/fr/files/pdf/2020/01/fr-algerie-pwc-loi-hydrocarbure-2020.pdf

Table 1: Calibration of structural parameters

Description	Parameters	Values
Structural Parameters		
Subject discount factor	β	0.99
The inverse of the elasticity of intertemporal substitution of consumption	σ_H^c	10.09707
The inverse of the Frish wage elasticity of labour supply	σ_H^n	10
Probability of bank's default	$(1-\sigma_B)$	$(1-0.972)$
Share of hours worked in the oil sector.	μ_N	0.13
The depreciation rate of capital.	δ	0.025
Elasticity of substitution between assets.	ε	4
Share of crude oil in the oil firm's production	α_O	0.5
Share of capital in the oil firm's production	β_O	0.3
Share of labor in the oil firm's production	θ_O	0.2
Oil income tax rate.	τ_O	0.3
Share of capital in the non-oil firm's production	α_{NO}	0.3
Share of labor in the non-oil firm's production	β_{NO}	0.7
Calvo price parameter in the non-oil sector	ϕ_{NO}	0.75
Calvo price parameter in the import sector	ϕ_I	0.75
The degree of monopoly power in the intermediate good market	ϑ	8
The share of imported goods in the final good.	χ_I	0.35
The share of non-oil goods in the final good.	χ_{NO}	0.65
Elasticity of substitution between non-oil output and imported goods	τ	0.8
The fraction of total asset diverted by the representative bank.	α	0.0138
Weight of loans in non-oil sector	μ	0.4
Weight of loans in oil sector	η_B	0.5
Autocorrelation parameter : discount rate	ρ_R	0.1
Autocorrelation parameter : international oil price	$\rho_{P_O^*}$	0.75
Autocorrelation parameter : crude oil	ρ_o	0.75

risk σ_B at 0.972 as in Gertler and Karadi (2011). This implies that the bank survives, on average, 9 years with an annual risk of default of about 11%. The elasticity of substitution between assets ε, is calibrated at 4. The parameters μ and η_B denote the share of loans in oil and non-oil sectors in Algeria. According to the Bank of Algeria quarterly statistics[6], the loans to both private and public sectors is about 50% for each of them. Then, the value of μ is set at 0.4 to exclude the public sector and η_B at 0.5. We assume in our model that public debt is fully held by the banking sector. This value is then equal to 10%.
As in the standard literature of DSGE models, we set the parameter of Calvo price setting equal to 0.75. This value is the same across sectors (import, ϕ_I, and non-oil sectors, ϕ_{NO}), this means that, on average, price adjustment occurs every 4 quarters.
Finally, we set standard values for the autoregressive parameters and standard deviations for both TFP shocks such as $\rho_{P_O^*}, \rho_Z$ and $\rho_o, = 0.75$ and $\sigma_{P_O^*}, \sigma_Z$ and $\sigma_o = 0.01$.

4 Simulations

We first simulate a negative shock on oil price, which represents the potential declining demand for oil in the rest of the world (demand shock). Then we give a positive shock on the price of imported goods, which represents the contraction of supply of imported goods, due to the rise of transportation costs (supply shock).

4.1 Oil price shock and policy instruments

From historical oil prices, the average annual growth of oil price is around 10%, so the quarterly growth rate is around 2.5%. In our counterfactural experiment, we give a negative shock of -2.5% on oil price, consistent to the scale of historical average. As the ecological transition is a structural change in the world economy, therefore, we try to give a persistent negative oil price shock in the model with inertia coefficient set to 0.9. Figure 1 shows the results.

The black solid curve represents IRFs to -2.5% oil price shock. With the potential shrinking demand of oil products from the rest of the world, represented by a fall of oil price in our simulation, the production of oil sector falls, and oil sector makes less profits. As a result, the deposits to private banks decline and there is less credit in the private market and all the interest rates rise. As the cost of capital becomes more expensive, price of the final goods rises. Therefore, inflation rate rises above steady state in short run.

The non-oil sector prospers as it becomes relatively more profitable compared to the oil sector as banks lend more credit to the non-oil sector. Intuitively, when oil price falls, the imports become less expensive due to the falling transport costs. In our model, the import sector does not depend on oil price, but it captures the dynamics that the economy imports

[6] see https://www.bank-of-algeria.dz/pdf/Bulletin_49f.pdf

more as oil price declines. In the present model, this effect comes from the complementarity of non-oil goods and imported goods. The production of imported goods $Y_{I,t}$ increases, supply effect becomes dominant thus price $P_{I,t}$ falls. If we integrate the impact of oil price in the imports sector, this effect would be even stronger. Production in non-oil sector and imports rise which is explained in the previous paragraph. In medium and long run, inflation rate falls below the steady state level, due to the rising supply of final goods.

The blue dashed curve represents the scenario in which there is -2.5% oil price shock followed by the Central Bank reducing its key interest rate by 1%. The domestic production Y_t is measured by the sum of production in oil and non-oil sector : $Y_t = p^*_{O,t} Y_{O,t} + p_{NO,t} Y_{NO,t}$. The effects are standard : interest rates fall and more credit enter the private market. As a result, production in both oil and non-oil sectors rise. However, effects from this conventional monetary policy are not very efficient. The blue dashed curves are almost the same as the black solid curves except for the interest rates. In other words, the effects of oil exports on bank's liquidity and credit in the market are much greater than Central Bank's adjustment on the standard interest rate.

So far, we showed that Central Bank's conventional monetary policy loses its efficiency in front of oil price shocks. However, there also exists an alternative strategy : turn the arrow from outward to inward, i.e. from being dependent on the demand of external world to be independent and develop its own domestic economy - the non-oil sector. Concretely, it means that the government of oil-exporting countries could use a part of its revenue, to invest in the development of its domestic non-oil sector, especially the green/non-polluting manufacturing production under today's world economic background, or the service sector.

This part of intervention goes directly to the firms' capital. Under the context of fiscal intervention, in our model, government budget constraint becomes :

$$[B_t + s_t p^f_{o,t} Y_{o,t} + T + (r^D_t - 1) D_{O,t-1}](1 - x_t) = R_t B_{t-1} + w_{o,t} N_{O,t} + p_{O,t} O_t, \qquad (53)$$

where x_t is the proportion of government revenue injected directly to the non-oil sector. For the non-oil firms, their production function becomes:

$$Y_{NO,t}(i) = \hat{K}^{\alpha_{NO}}_{NO,t}(i) \, N^{\beta_{NO}}_{NO,t}(i) \ , \qquad (54)$$

where

$$\hat{K}_{NO,t} = K_{NO,t} + x_t[B_t + s_t p^f_{o,t} Y_{o,t} + T + (r^D_t - 1) D_{O,t-1}], \qquad (55)$$

the capital factor in non-oil firm's production function equals to loans from private banks, plus the injection of money from government.

The red dashed curve represents the scenario with negative oil price shocks and fiscal subvention to the domestic non-oil sector. The fiscal subsidy in our model, is captured by the fact that government inject 10% of its revenue from oil exports and pay-roll taxes, to the non-oil firms. Our simulation shows that effects from fiscal subsidy to domestic non-oil firms are the most efficient to cope with negative oil price shocks, i.e. negative demand shocks from the external world. The consumption falls in this scenario as there is less transfer from the government to households (via oil sector, see the government's budget constraint) because a part of government revenue is used to finance non-oil firms. The results show that, facing oil price shocks, subsidy to domestic non-oil firms turn the domestic economy more stable and solid in front of external shocks, as non-oil sector is supported and get more credit from the government, naturally the lending interest rate to non-oil sector falls. As the private bank arbitrates among different assets, interest rate for the lending to oil-sector and interest rate of government bonds fall as well. The effects are much stronger compared to the effects of conventional monetary policy (the blue dashed curve).

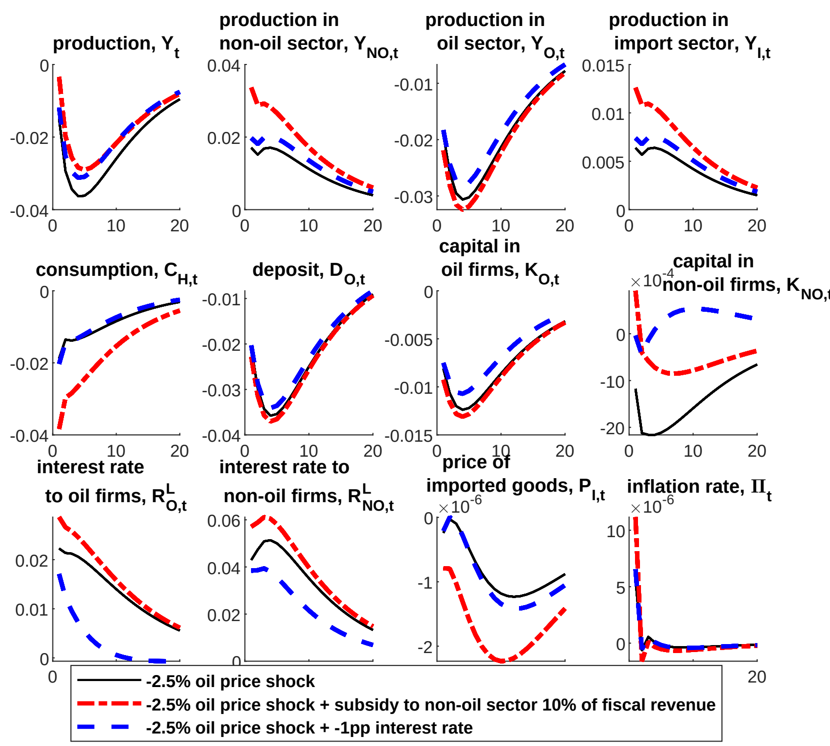

Figure 1: -2.5% oil price shock and fiscal subsidy to non-oil sector

4.2 Negative shocks on imports due to increased costs (supply shock)

In this sector, we analyze the impacts of supply shock on imported goods. Recently, as the supply chains in international trade are highly impacted by the pandemic crisis, countries face a potential challenge of rising costs of imported goods. In our model, this is captured by a cost-push shock that rises of price of imported goods. We use the European import price index from April to November 2021 as proxies for the changes of imported good price, which is around 4% in a quarterly basis. Figure 2 shows the results. The black solid curve represents the scenario in which there is a negative supply shock on imported goods, captured by a rise of imported goods price by +4% in our simulation.

In Figure 2, we see that the impacts from oil price shocks are much greater than the impacts from import price shocks (supply shock). It is illustrated by the fact that in our simulation, the red and blue dashed curves are almost identical. In other words, when there are demand and supply shocks, the demand shock is dominant. It means that for the oil-exporting economies, the potential risk from the shrinking demand of oil products will be a more important challenge than the shrinking supply chain, although both are essentiel issues.

Under the negative supply shock on imported goods, the import sector in domestic country falls essentially, which impacts the non-oil sector. As the return from non-oil sector declines, private bank tends to lend more credit to the oil sector, and the production of oil sector rises compared to the non-oil sector.

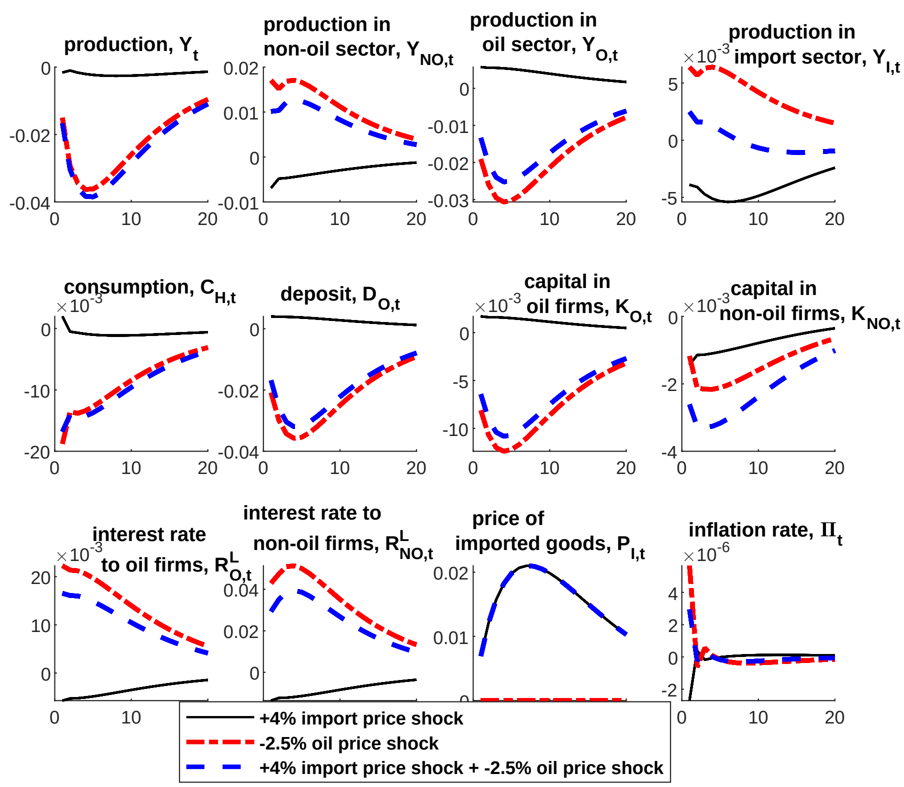

Figure 2: +4% import price shock and -2.5% oil price shock

We then simulate the effects of conventional monetary policies and fiscal subsidies facing a rise import price. Figure 3 shows the results. The black solid curve represents the scenario in which we have +4% shock on the price of imported goods, i.e. the negative supply shock that pushes up the price of imported goods. The red dashed curve represents the scenario in which we have both negative supply shock and fiscal subsidy that supports the domestic non-oil sector. The blue dashed curve represents the scenario in which we have both negative supply shock and the conventional monetary policy from the Central Bank. Just like in the previous sector, fiscal subsidy that supports the non-oil sector is more efficient to reduce interest rates and stimulate production in the economy. Given that the adjustment of interest rate from the CB cannot be inferior to zero and the interest rates in most oil-exporting economies are at their historical low level, fiscal subsidy is an efficient alternative of conventional monetary policies.

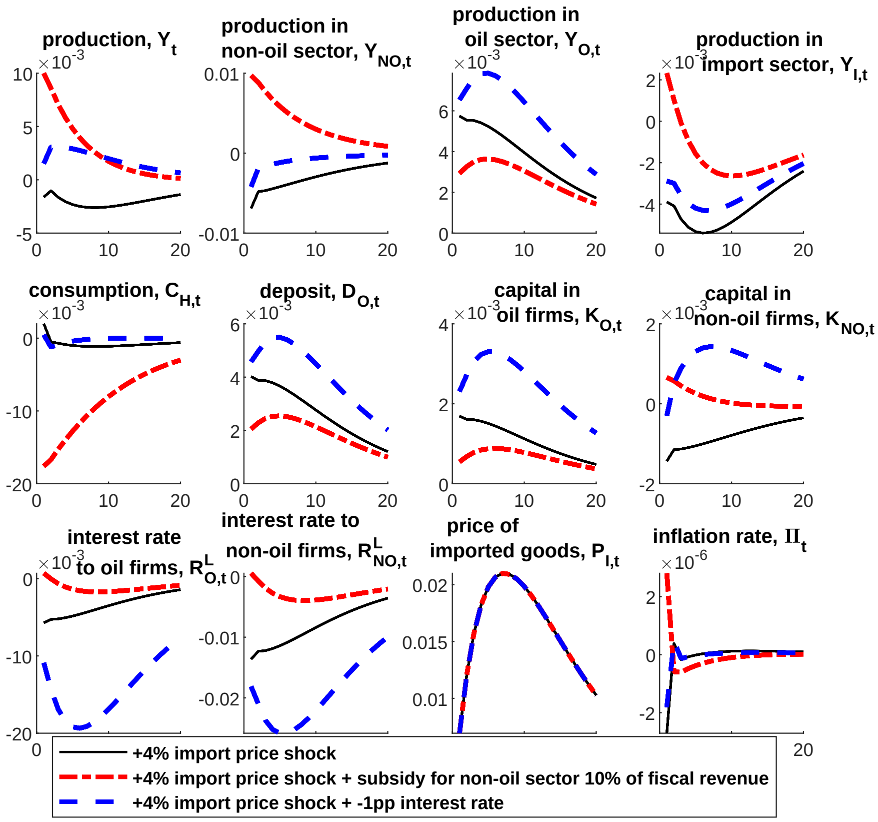

Figure 3: +4% import price shock, conventional monetary policy, and fiscal subsidy to non-oil sector

An essential message from this exercise is that the impact of demand shock is more important for the oil-exporting economies and the development of non-oil sector that balances its economic structure can not only mitigate shocks from the decline of oil price, but also makes the economy more solid/stable facing negative supply shocks and helps the economy to be more independent in its production structure. The development of its non-oil sector also means that makes the production of domestic goods less dependent on imports. Once this aspect is balanced, the economy will become more stable in front of external shocks.

5 Welfare Analysis

In this section, we analyse the welfare effect of demand and supply shocks. To do so, we simulates two scenarios : the response of our economy to fiscal and monetary policies in the case of 1) a demand shock and 2) a supply shock. This will allow us to assess the effectiveness of our fiscal and monetary instruments in both cases. The following table shows the welfare effects from different shocks compared to the baseline scenario, in which we give a +1pp shock on the productivity of non-oil sector. The table shows the percentage deviation from baseline scenario.

From Table 5, we find that the welfare effects from supply shock is relatively marginal compared to the effects from oil price shocks. Interestingly, fiscal subsidy has a much more positive welfare effects in the scenario of demand shocks and negative welfare effects in the scenario of supply shocks. Conventional monetary policy has negative effects in the scenario of oil price shocks but positive welfare effects in the scenario of supply shocks.

Demand shock		
OS (-2.5% oil price shock)	OS_fiscal	OS_MP
−3.34%	−1.8%	−3.07%
Supply shock		
PF (+4% import price shock)	PF_fiscal	PF_MP
-0.15%	-2.66%	0.018%

6 Conclusion

In this paper we analyzed the role that monetary and fiscal policies can play in stabilizing an oil exporting economy but also in boosting the non-oil sector to ensure the diversification. By establishing a DSGE model, we find that conventional monetary policy loses its efficiency facing negative oil price shocks. In other words, the effects of oil exports on bank's liquidity and credit in the market are much greater than Central Bank's adjustment on the standard interest rate. However, by supporting the non-oil sector, fiscal policy is efficient to reduce the contraction risk for oil-exporting economies.

On the other hand, due to the recent pandemic situation and environmental policies, international trade is highly impacted due to increasing import/transportation cost. In our simulation, facing negative import shocks due to increasing cost, fiscal subsidy to non-oil sector is more efficient to reduce the negative impacts of rising import costs. For the oil-exporting economies, developing its own non-oil sector and establishing a balanced economic structure between oil and non-oil sector seems to be a promising strategy for the coming years.

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Appendix

A Equilibrium conditions

Households :

$$
\begin{aligned}
P_{C,t}C_t^H &= W_{O,t}N_{O,t} + W_{NO,t}N_{NO,t} + (1-\sigma_B)NW_t + DIV - T, && (56)\\
N_t &= \left(\mu_N^{1/\varepsilon}(N_{O,t})^{(\varepsilon-1)/\varepsilon} + (1-\mu_N)^{1/\varepsilon}(N_{NO,t})^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}, && (57)\\
\lambda_{H,t} &= \left(C_t^H\right)^{-\sigma_H^c}, && (58)\\
w_{O,t} &= \mu_N^{\frac{1}{\epsilon}}\frac{N_t^{\sigma_H^n+\frac{1}{\epsilon}}N_{O,t}^{-\frac{1}{\epsilon}}}{\lambda_{H,t}}, && (59)\\
w_{NO,t} &= (1-\mu_N)^{\frac{1}{\epsilon}}\frac{N_t^{\sigma_H^n+\frac{1}{\epsilon}}N_{O,t}^{-\frac{1}{\epsilon}}}{\lambda_{H,t}}, && (60)\\
DIV_t &= DIV_{NO,t} + DIV_{I,t}, && (61)
\end{aligned}
$$

Non-oil firm :

$$
\begin{aligned}
Y_{NO,t} &= K_{NO,t}^{\alpha_{NO}}N_{NO,t}^{\beta_{NO}}, && (62)\\
r_{NO,t}^L &= \alpha_{NO}mc_{NO,t}\frac{Y_{NO,t}}{K_{NO,t}}, && (63)\\
w_{NO,t} &= \beta_{NO}mc_{NO,t}\frac{Y_{NO,t}}{N_{NO,t}}, && (64)\\
DIV_{NO,t} &= \widetilde{P}_{NO,t}Y_{NO,t} - R_{NO,t}^L K_{NO,t} - W_{NO,t}N_{NO,t}, && (65)\\
\widetilde{p}_{NO,t} &= \frac{\vartheta}{\vartheta-1}\frac{V_{NO,t}^1}{V_{NO,t}^2}, && (66)\\
V_{NO,t}^1 &= \lambda_{NO,t}Y_{NO,t}mc_{NO,t}p_{NO,t}^{\vartheta} + \beta\phi_{NO}E_tV_{NO,t+1}^1, && (67)\\
V_{NO,t}^2 &= \lambda_{NO,t}Y_{NO,t}p_{NO,t}^{\vartheta} + \beta\phi_{NO}E_tV_{NO,t+1}^2. && (68)
\end{aligned}
$$

Oil firm :

$$
\begin{aligned}
r_{O,t}^L &= (1-\tau_O)\, s_t p_{O,t}^f \beta_O \frac{Y_{O,t}}{K_{O,t}}, && (69)\\
w_{O,t} &= (1-\tau_O)\, s_t p_{O,t}^f \theta_O \frac{Y_{O,t}}{N_{O,t}}, && (70)\\
p_t^O &= (1-\tau_O)\, s_t p_{O,t}^f \alpha_O \frac{Y_{O,t}}{O_t}, && (71)\\
D_t^O &= (1-\tau_O)\, s_t P_{O,t}^* Y_{O,t}, && (72)
\end{aligned}
$$

$$
\begin{aligned}
log\left(P^*_{O,t}\right) &= (1-\rho_{P^*_O})log\left(\bar{P}^*_O\right) + \rho_{P^*_O}log\left(P^*_{O,t-1}\right) + \varepsilon_{P^*_O} && (73)\\
log\left(O_t\right) &= (1-\rho_o)log\left(\bar{O}\right) + \rho_o log\left(O_{t-1}\right) + \varepsilon_o && (74)\\
log\left(S_t\right) &= (1-\rho_Z)log\left(\overline{S}\right) + \rho_Z log\left(S_{t-1}\right) + \varepsilon_S && (75)
\end{aligned}
$$

Importer :

$$
\begin{aligned}
\widetilde{p}_{I,t} &= \frac{\vartheta}{\vartheta-1}\frac{V^1_{I,t}}{V^2_{I,t}}, && (76)\\
V^1_{I,t} &= \lambda_t Y_{I,t} mc_{I,t} p^{\vartheta}_{I,t} + \beta\phi_I E_t V^1_{I,t+1}, && (77)\\
V^2_{I,t} &= \lambda_t Y_{I,t} p^{\vartheta}_{I,t} + \beta\phi_I E_t V^2_{I,t+1}. && (78)\\
P_{I,t} &= \left[\phi_I P^{(1-\theta)}_{t-1} + (1-\phi_I)\,\widetilde{P}^{(1-\theta)}_t\right]^{\frac{1}{(1-\theta)}}, && (79)\\
DIV_I &= \left(\widetilde{p}_{I,t} - S_t\right) Y_{I,t}, && (80)
\end{aligned}
$$

Final good producer :

$$
\begin{aligned}
Z_t &= \left[\chi^{\frac{1}{\tau}}_{NO} Y^{\frac{\tau-1}{\tau}}_{NO} + \chi^{\frac{1}{\tau}}_{I} Y^{\frac{\tau-1}{\tau}}_{I}\right]^{\frac{\tau}{\tau-1}}, && (81)\\
Y_{NO,t} &= \chi_{NO}\left(\frac{P_{NO,t}}{P_t}\right)^{-\tau} Z_t, && (82)\\
Y_{I,t} &= \chi_I\left(\frac{P_{I,t}}{P_t}\right)^{-\tau} Z_t, && (83)\\
P_{C,t} &= \left[\chi_I P^{1-\tau}_{I,t} + \chi_{NO} P^{1-\tau}_{NO,t}\right]^{\frac{1}{1-\tau}} && (84)\\
\pi_t &= \frac{P_{C,t}}{P_{C,t-1}}, && (85)
\end{aligned}
$$

Private banks :

$$
\begin{aligned}
D_{O,t} &= (\phi_t - 1)\, NW_t, & (86)\\
\phi_t NW_t &= Asset_t, & (87)\\
NW_{t+1} &= \sigma_B \left[\left(r_{t+1}^{Asset} - r_t^D \right) Asset_t + r_t^D NW_t \right], & (88)\\
\phi_t &= \gamma_t / \left(\alpha - \gamma_t^{Asset} \right), & (89)\\
\gamma_t^{Asset} &= E_t \left\{ \Lambda_{t,t+1} \left(r_{t+1}^{Asset} - r_t^D \right) \right\}, & (90)\\
\gamma_t &= E_t \left\{ \Lambda_{t,t+1} r_t^D \right\}, & (91)\\
\Lambda_{t,t+1} &= \beta_{t,t+1} \left[1 - \sigma_B + \sigma_B \left(\gamma_{t+1}^{Asset} \phi_{t+1} + \gamma_{t+1} \right) \right], & (92)\\
K_{NO,t} &= \mu E_t \left\{ \left(\frac{r_{no,t}^L / \pi_{t+1}}{r_t^{Asset}} \right)^{\varepsilon} \right\} Asset_t, & (93)\\
K_{O,t} &= \eta_B E_t \left\{ \left(\frac{r_{o,t}^L / \pi_{t+1}}{r_t^{Asset}} \right)^{\varepsilon} \right\} Asset_t, & (94)\\
B_t &= (1 - -\eta_B - \mu)\, E_t \left\{ \left(\frac{r_t^b / \pi_{t+1}}{r_t^{Asset}} \right)^{\varepsilon} \right\} Asset_t, & (95)\\
r_t^{Asset} &= \left(\mu E_t \left\{ \left(\frac{r_{no,t}^L}{\pi_{t+1}} \right)^{\varepsilon - 1} \right\} + \eta_B E_t \left\{ \left(\frac{r_{o,t}^L}{\pi_{t+1}} \right)^{\varepsilon - 1} \right\} + (1 - \eta_B - \mu)\, E_t \left\{ \left(\frac{r_t^b}{\pi_{t+1}} \right)^{\varepsilon - 1} \right\} \right)^{\frac{1}{\varepsilon - 1}} & (96)
\end{aligned}
$$

Governement and central bank :

$$
[B_t + s_t p_{o,t}^f Y_{o,t} + T + (r_t^D - 1) D_{O,t-1}](1 - x_t) = R_t B_{t-1} + w_{o,t} N_{O,t} + p_{O,t} O_t, \qquad (97)
$$

$$
\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}} \right)^{\rho_R} \left(\left(\frac{Y_t}{Y_{t-1}} \right)^{r_y} \left(\frac{\pi_t}{\overline{\pi}} \right)^{r_\pi} \right)^{1 - \rho_R} \exp(\varepsilon_R), \qquad (98)
$$

B Derivatives

B.1 Households

The function value, V_t, of the representative household is:

$$
V_t(\iota) = \max_{C_t^H, N_{O,t}, N_{NO,t}} \left\{ \begin{array}{c} \dfrac{\left(C_t^H \right)^{1 - \sigma_H^c}}{1 - \sigma_H^c} - \dfrac{\left(N_t^H \right)^{1 + \sigma_H^n}}{1 + \sigma_H^n} + \beta E_t V_{t+1} - \dfrac{\lambda_{H,t}}{P_{C,t}} \{ P_{C,t} C_t^H \\ - W_{O,t} N_{O,t} - W_{NO,t} N_{NO,t} - (1 - \sigma_B) NW_t - DIV + T \}, \end{array} \right\}
$$

The solution gives the following first order conditions:
- differentiation with respect to C_t^H yields:

$$
\frac{\partial V_t}{\partial C_t^H} = 0 \rightarrow \left(C_t^H \right)^{-\sigma_H^c} - \lambda_{Ht} = 0,
$$

$$\frac{\partial V_t}{\partial C_t} = 0 \rightarrow \lambda_{Ht} = \left(C_t^H\right)^{-\sigma_H^c}, \tag{99}$$

- differentiation with respect to $N_{O,t}$ yields:

$$\begin{aligned}
\frac{\partial V_t}{\partial N_{O,t}} &= 0 \rightarrow -(1+\sigma_H^n)\frac{\left(N_t{}^H\right)^{\sigma_H^n}}{1+\sigma_H^n}\frac{\varepsilon}{(\varepsilon-1)}\left(\mu_N^{\frac{1}{\varepsilon}}(N_{O,t})^{\frac{(\varepsilon-1)}{\varepsilon}} + (1-\mu_N)^{\frac{1}{\varepsilon}}(N_{NO,}\right. \\
\mu_N^{1/\varepsilon}\frac{(\varepsilon-1)}{\varepsilon}(N_{O,t})^{\frac{(\varepsilon-1)}{\varepsilon}-1} + \lambda_{H,t}w_{O,t} &= 0, \\
\frac{\partial V_t}{\partial N_{O,t}} &= 0 \rightarrow -\left(N_t{}^H\right)^{\sigma_H^n}\left(\mu_N^{1/\varepsilon}(N_{O,t})^{(\varepsilon-1)/\varepsilon} + (1-\mu_N)^{1/\varepsilon}(N_{NO,t})^{(\varepsilon-1)/\varepsilon}\right)^{\frac{1}{(\varepsilon-1}} \\
\mu_N^{1/\varepsilon}N_{O,t}{}^{\frac{-1}{\varepsilon}} + \lambda_{H,t}w_{O,t} &= 0, \\
\lambda_{H,t}w_{O,t} &= \left(N_t{}^H\right)^{\sigma_H^n}\left(N_t^H\right)^{\frac{1}{\varepsilon}}\mu_N^{\frac{1}{\varepsilon}}N_{O,t}{}^{\frac{-1}{\varepsilon}}, \\
w_{O,t} &= \mu_N^{\frac{1}{\varepsilon}}\frac{\left(N_t{}^H\right)^{\sigma_H^n+\frac{1}{\varepsilon}}N_{O,t}{}^{\frac{-1}{\varepsilon}}}{\lambda_{H,t}},
\end{aligned}$$

- differentiation with respect to $N_{NO,t}$ yields:

$$\begin{aligned}
\frac{\partial V_t}{\partial N_{NO,t}} &= 0 \rightarrow -(1+\sigma_H^n)\frac{\left(N_t{}^H\right)^{\sigma_H^n}}{1+\sigma_H^n}\frac{\varepsilon}{(\varepsilon-1)}\left(\mu_N^{\frac{1}{\varepsilon}}(N_{O,t})^{\frac{(\varepsilon-1)}{\varepsilon}} + (1-\mu_N\right. \\
(1-\mu_N)^{\frac{1}{\varepsilon}}\frac{(\varepsilon-1)}{\varepsilon}(N_{NO,t})^{\frac{(\varepsilon-1)}{\varepsilon}-1} + \lambda_{H,t}w_{NO,t} &= 0, \\
\frac{\partial V_t}{\partial N_{NO,t}} &= 0 \rightarrow -\left(N_t{}^H\right)^{\sigma_H^n}\left(\mu_N^{\frac{1}{\varepsilon}}(N_{O,t})^{\frac{(\varepsilon-1)}{\varepsilon}} + (1-\mu_N)^{\frac{1}{\varepsilon}}(N_{NO,t})^{\frac{(\varepsilon-1)}{\varepsilon}}\right) \\
(1-\mu_N)^{\frac{1}{\varepsilon}}N_{NO,t}{}^{\frac{-1}{\varepsilon}} + \lambda_{H,t}w_{NO,t} &= 0, \\
\lambda_{H,t}w_{NO,t} &= \left(N_t{}^H\right)^{\sigma_H^n}\left(N_t^H\right)^{\frac{1}{\varepsilon}}(1-\mu_N)^{\frac{1}{\varepsilon}}N_{NO,t}{}^{\frac{-1}{\varepsilon}}, \\
w_{NO,t} &= (1-\mu_N)^{\frac{1}{\varepsilon}}\frac{\left(N_t{}^H\right)^{\sigma_H^n+\frac{1}{\varepsilon}}N_{NO,t}{}^{\frac{-1}{\varepsilon}}}{\lambda_{H,t}},
\end{aligned}$$

B.2 Oil Firm

The maximization problem of the oil producer can be written as follow :

$$\max_{N_{O,t},K_{O,t},O_t}\left[(1-\tau_O)\,S_tP_{O,t}^*Y_{O,t} - W_{O,t}N_{O,t} - R_{O,t}^LK_{O,t} - P_t^OO_t\right]/P_{C,t}$$

subject to :

$$Y_{O,t} = O_t^{\alpha_O}K_{O,t}^{\beta_O}N_{O,t}^{\theta_O},$$

The first order conditions are :
- differentiation with respect to $K_{O,t}$ yields:

$$\frac{\partial \Delta_t}{\partial K_{O,t}} = 0 \to \left[(1-\tau_O) S_t P^f_{O,t} \beta_O O_t^{\alpha_O} K_{O,t}^{\beta_O - 1} N_{O,t}^{\theta_O} - R^L_{O,t} \right] / P_{C,t} = 0,$$

$$\frac{\partial \Delta_t}{\partial N_{O,t}} = 0 \to (1-\tau_O) s_t p^f_{O,t} \beta_O O_t^{\alpha_O} K_{O,t}^{\beta_O - 1} N_{O,t}^{\theta_O} - r^L_{O,t} = 0,$$

$$\frac{\partial \Delta_t}{\partial N_{O,t}} = 0 \to r^L_{O,t} = (1-\tau_O) s_t p^f_{O,t} \beta_O O_t^{\alpha_O} K_{O,t}^{\beta_O - 1} N_{O,t}^{\theta_O},$$

$$r^L_{O,t} = (1-\tau_O) s_t p^f_{O,t} \beta_O \frac{Y_{O,t}}{K_{O,t}},$$

- differentiation with respect to $N_{O,t}$ yields:

$$\frac{\partial \Delta_t}{\partial N_{O,t}} = 0 \to \left[(1-\tau_O) S_t P^f_{O,t} \theta_O O_t^{\alpha_O} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O - 1} - W_{O,t} \right] / P_{C,t} = 0,$$

$$\frac{\partial \Delta_t}{\partial N_{O,t}} = 0 \to (1-\tau_O) s_t p^f_{O,t} \theta_O O_t^{\alpha_O} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O - 1} - w_{O,t} = 0,$$

$$\frac{\partial \Delta_t}{\partial N_{O,t}} = 0 \to w_{O,t} = (1-\tau_O) s_t p^f_{O,t} \theta_O O_t^{\alpha_O} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O - 1},$$

$$w_{O,t} = (1-\tau_O) s_t p^f_{O,t} \theta_O \frac{Y_{O,t}}{N_{O,t}},$$

- differentiation with respect to O_t yields:

$$\frac{\partial \Delta_t}{\partial O_t} = 0 \to \left[(1-\tau_O) S_t P^f_{O,t} \alpha_O O_t^{\alpha_O - 1} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O} - P^O_t \right] / P_{C,t} = 0,$$

$$\frac{\partial \Delta_t}{\partial O_t} = 0 \to (1-\tau_O) s_t p^f_{O,t} \alpha_O O_t^{\alpha_O - 1} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O} - p^O_t = 0,$$

$$\frac{\partial \Delta_t}{\partial O_t} = 0 \to p^O_t = (1-\tau_O) s_t p^f_{O,t} \alpha_O O_t^{\alpha_O - 1} K_{O,t}^{\beta_O} N_{O,t}^{\theta_O},$$

$$p^O_t = (1-\tau_O) s_t p^f_{O,t} \alpha_O \frac{Y_{O,t}}{O_t},$$

B.3 Non-Oil Firm

The maximization problem of the non oil producers can be written as follow:

$$\begin{aligned}\Lambda &= \left(\widetilde{P}_{NO,t}\left(i\right)Y_{NO,t+s}\left(i\right) - R^{L}_{NO,t+s}K_{NO,t+s}\left(i\right) - W_{NO,t+s}N_{NO,t+s}\left(i\right)\right)/P_{C,t}, \\ & + \frac{\lambda_{NO,t}}{P_{C,t}}\left(Y_{NO,t}(i) - K^{\alpha_{NO}}_{NO,t}\left(i\right)N^{\beta_{NO}}_{NO,t}\left(i\right)\right),\end{aligned}$$

where $\lambda_{NO,t}$ denotes the lagrangian multiplier which can be defined as the nominal marginal cost, $MC_{NO,t}$, of the non-oil firm.
- differentiation with respect to $K_{NO,t}$ yields :

$$\frac{\partial\Lambda_t}{\partial K_{NO,t}\left(i\right)} = 0 \rightarrow -r^{L}_{NO,t} + mc_{NO,t}\alpha_{NO}\left(A_{NO,t}K^{\alpha_{no}-1}_{NO,t}\left(i\right)N^{\beta_{NO}}_{NO,t}\left(i\right)\right) = 0,$$

$$\frac{\partial\Lambda_t}{\partial K_{NO,t}\left(i\right)} = 0 \rightarrow -r^{L}_{NO,t} = mc_{NO,t}\alpha_{NO}\frac{Y_{NO,t}\left(i\right)}{K_{NO,t}\left(i\right)},$$

$$r^{L}_{NO,t} = \alpha_{NO}mc_{NO,t}\frac{Y_{NO,t}\left(i\right)}{K_{NO,t}\left(i\right)}, \tag{100}$$

- differentiation with respect to $N_{NO,t}$ yields :

$$\frac{\partial\Lambda_t}{\partial N_{NO,t}\left(i\right)} = 0 \rightarrow -w_{NO,t} + mc_{NO,t}(1-\alpha_{NO})\left(A_{NO,t}K^{\alpha_{no}}_{NO,t}\left(i\right)N^{\beta_{NO}-1}_{NO,t}\left(i\right)\right) = 0,$$

$$\frac{\partial\Lambda_t}{\partial N_{NO,t}\left(i\right)} = 0 \rightarrow w_{NO,t} = \beta_{NO}mc_{NO,t}\frac{Y_{NO,t}\left(i\right)}{N_{NO,t}\left(i\right)},$$

$$w_{NO,t} = \beta_{NO}mc_{NO,t}\frac{Y_{NO,t}\left(i\right)}{N_{NO,t}\left(i\right)}, \tag{101}$$

B.4 Price setting

The non-oil firms' maximization problem can be written as following :

$$\max_{K_{NO,t}(i),N_{NO,t}(i),P_{NO,t}(i)} E_0\sum_{s=0}^{\infty}[(\beta\phi_{NO})^s\lambda_{NO,t+s}DIV_{NO,t+s}(i)/P_{C,t+s}], \tag{102}$$

subject to the production function and the demand function :

$$Y_{NO,t}\left(i\right) = K^{\alpha_{no}}_{NO,t}\left(i\right)N^{\beta_{NO}}_{NO,t}\left(i\right), \tag{103}$$

$$Y_{NO,t+s}\left(i\right) = \left(\frac{\widetilde{P}_{NO,t}\left(i\right)}{P_{NO,t+s}}\right)^{-\vartheta}Y_{NO,t+s}, \tag{104}$$

where $D_{NO,t+s}(i)$ is the profit function:

$$D_{NO,t+s}(i) = \left(\widetilde{P}_{NO,t}(i)\, Y_{NO,t+s}(i) - R^{L}_{NO,t+s} K_{NO,t+s}(i) - W_{NO,t+s} N_{NO,t+s}(i)\right) / P_{C,t},,$$

where $\beta^s \lambda_{t+s}$ the producer's discount factor and $\lambda_{NO,t+s}$ the marginal utility of consumption in period $t+s$.
The optimal pricing condition is given by :

$$\max_{\widetilde{P}_{NO,t}(i)} E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} \left[\frac{\widetilde{P}_{NO,t}(i)}{P_{NO,t+s}} \left(\frac{\widetilde{P}_{NO,t}(i)}{P_{NO,t+s}}\right)^{-\vartheta} Y_{NO,t+s} - MC_{NO,t+s} \left(\frac{\widetilde{P}_{NO,t}(i)}{P_{NO,t+s}}\right)^{-\vartheta} Y_{NO,t+s}\right]$$

$$\max_{\widetilde{P}_{NO,t}(i)} E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} \left[P^{\vartheta-1}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{1-\vartheta} Y_{NO,t+s} - MC_{NO,t+s} P^{\vartheta}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{-\vartheta} Y_{NO,t+s}\right],$$

$$E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} \left[(1-\vartheta) P^{\vartheta-1}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{-\vartheta} Y_{NO,t+s} + \vartheta MC_{NO,t+s} P^{\vartheta}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{-\vartheta-1} Y_{NO,t+s}\right] = 0,$$

$$E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} (1-\vartheta) P^{\vartheta-1}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{-\vartheta} Y_{NO,t+s} + E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} \vartheta MC_{NO,t+s} P^{\vartheta}_{NO,t+s} \widetilde{P}_{NO,t}$$

$$\vartheta E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} MC_{NO,t+s} P^{\vartheta}_{NO,t+s} \widetilde{P}_{NO,t}(i)^{-\vartheta-1} Y_{NO,t+s} = (\vartheta-1) E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} P^{\vartheta-1}_{NO,t+s} \widetilde{P}_{N}$$

$$\vartheta E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} MC_{NO,t+s} P^{\vartheta}_{NO,t+s} Y_{NO,t+s} = (\vartheta-1) E_t \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} P^{\vartheta-1}_{NO,t+s} \widetilde{P}_{NO,t}(i)\, Y_{NO,t+s}$$

we get finally:

$$\widetilde{p}_{NO,t}(i) = \left(\frac{\vartheta}{\vartheta-1}\right) \frac{E_0 \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} mc_{NO,t+s} p^{\vartheta}_{NO,t+s} Y_{NO,,t+s}}{E_0 \sum_{s=0}^{\infty} (\beta\phi_{NO})^s \lambda_{NO,t+s} Y_{NO,t+s} p^{\vartheta}_{NO,t+s}}, \qquad (105)$$

where $p_{NO,t+s} = \frac{P_{NO,t+s}}{P_{C,t+s}}$, $mc_{NO,t+s} = \frac{MC_{NO,t+s}}{P_{C,t+s}}$,and $\widetilde{p}_{NO,t}(i) = \frac{\widetilde{P}_{NO,t}(i)}{p_{C,t}}$ are respectively the relative price of non-oil goods, the real marginal cost in non-oil sector and the real optimized price for non-oil goods.
The methodology is the same for the import sector.

C Banks

The private bank optimisation problem is solved using the following equations :

$$V_t = \gamma_t^a Asset_t + \gamma_t N_t \tag{106}$$

and :

$$\phi_t N_t \geq Asset_t \tag{107}$$

where the laverage ratio $\phi_t = \gamma_t / \left(\alpha - \gamma_t^a\right)$. Substituting the binding constraint (41) in (134) yields :

$$\begin{aligned} V_t &= \gamma_t^a \phi_t N_t + \gamma_t N_t, \\ V_t &= \left(\gamma_t^a \phi_t + \gamma_t\right) N_t. \end{aligned} \tag{108}$$

Plugging the expression into the value function of accumulation of net worth N_{t+1}, we have

$$\begin{aligned} V_t &= E_t \left\{\Lambda_{t,t+1} N_{t+1}\right\} &(109) \\ &= E_t \left\{\Lambda_{t,t+1} \sigma_B \left[\left(R_{t+1}^a - R_t^d\right) Asset_t + R_t^d N_t\right]\right\} &(110) \end{aligned}$$

where $\Lambda_{t,t+1} = \beta_{t,t+1} \left[1 - \sigma_B + \sigma_B \left(\gamma_{t+1}^a \phi_{t+1} + \gamma_{t+1}\right)\right]$. This allows to identify the arguments of the value function:

$$\gamma_t^a = E_t \left\{\Lambda_{t,t+1} \sigma_B \left(R_{t+1}^a - R_t^d\right)\right\} \text{ and } \gamma_t = E_t \left\{\Lambda_{t,t+1} \sigma_B R_t^d\right\}$$

The FOC of the private bank are determined as follows :

Given the CES integration of different assets (equation (48)), the cost minimization of asset (equation (47)) gives the following equations :

$$K_{NO,t} = \mu E_t \left\{\left(\frac{r_{no,t}^L / \pi_{t+1}}{r_t^{Asset}}\right)^{\varepsilon}\right\} Asset_t, \tag{111}$$

$$K_{O,t} = \eta_B E_t \left\{\left(\frac{r_{o,t}^L / \pi_{t+1}}{r_t^{Asset}}\right)^{\varepsilon}\right\} Asset_t, \tag{112}$$

$$B_t = \left(1 - -\eta_B - \mu\right) E_t \left\{\left(\frac{r_t^b / \pi_{t+1}}{r_t^{Asset}}\right)^{\varepsilon}\right\} Asset_t, \tag{113}$$

That different assets provide identical contingent dividend $D_t = 1$ to shareholders. This is a strong assumption. However, it is not surprising to assume that the dividend is contingent and exogenous as in **?**. By having this assumption, the price of each asset is directly linked to the asset's interest rate. From the bond valuation theory, we have

$$q_t^a = \frac{D_t}{R_t^a - 1} \tag{114}$$

$$q_t^b = \frac{D_t}{R_{b,t}^L - 1} \tag{115}$$

$$q_t^g = \frac{D_t}{R_{g,t}^L - 1} \tag{116}$$

$$ \tag{117} $$

$$\phi_t NW_t = Asset_t, \tag{118}$$

$$ \tag{119} $$

$$\phi_t = \gamma_t / \left(\alpha - \gamma_t^{Asset}\right), \tag{120}$$

$$\gamma_t^{Asset} = E_t \left\{ \Lambda_{t,t+1} \left(r_{t+1}^{Asset} - r_t^D \right) \right\}, \tag{121}$$

$$\gamma_t = E_t \left\{ \Lambda_{t,t+1} r_t^D \right\}, \tag{122}$$

$$\Lambda_{t,t+1} = \beta_{t,t+1} \left[1 - \sigma_B + \sigma_B \left(\gamma_{t+1}^{Asset} \phi_{t+1} + \gamma_{t+1} \right) \right], \tag{123}$$

$$r_t^{Asset} = \left(\mu E_t \left\{ \left(\frac{r_{no,t}^L}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} + \eta_B E_t \left\{ \left(\frac{r_{o,t}^L}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} + \left(1 - \eta_B - \mu\right) E_t \left\{ \left(\frac{r_t^b}{\pi_{t+1}} \right)^{\varepsilon-1} \right\} \right)^{\frac{1}{\varepsilon-1}} \tag{124}$$

From the binding condition equation (41), we get the equation that determines the asset :

$$D_{O,t} = \left(\phi_t - 1\right) NW_t, \tag{125}$$

From ( ), () and (), we obtain :

$$Asset_t = D_{O,t} + NW_t \tag{126}$$

$$D_{O,t} = Asset_t - NW_t, \tag{127}$$

Using this result in :

$$NW_{t+1} = \sigma_B \left[r_{t+1}^{Asset} Asset_t - r_t^D D_{O,t} \right], \tag{128}$$

$$NW_{t+1} = \sigma_B \left[r_{t+1}^{Asset} Asset_t - r_t^D \left(Asset_t - NW_t \right) \right], \tag{129}$$

$$NW_{t+1} = \sigma_B \left[r_{t+1}^{Asset} Asset_t - r_t^D Asset_t + r_t^D NW_t \right], \tag{130}$$

$$NW_{t+1} = \sigma_B \left[\left(r_{t+1}^{Asset} - r_t^D \right) Asset_t + r_t^D NW_t \right], \tag{131}$$

This result represents the dynamic of bank's net worth. Combining it with the binding condition equation :

$$\phi_t NW_t = Asset_t \tag{132}$$

we get :

$$NW_{t+1} = \sigma_B \left[\left(r_{t+1}^{Asset} - r_t^D \right) \phi_t + r_t^D \right] NW_t, \tag{133}$$

From ( ), ( ) and ( ), we get the leverage ratio equation :

$$\alpha Asset_t = \gamma_t^{asset} Asset_t + \gamma_t NW_t. \tag{134}$$
$$\alpha \phi_t NW_t = \gamma_t^{asset} \phi_t NW_t + \gamma_t NW_t. \tag{135}$$
$$\alpha \phi_t NW_t = \left(\gamma_t^{asset} \phi_t + \gamma_t\right) NW_t. \tag{136}$$
$$\alpha \phi_t = \gamma_t^{asset} \phi_t + \gamma_t. \tag{137}$$
$$\left(\alpha - \gamma_t^{asset}\right) \phi_t = \gamma_t. \tag{138}$$
$$\phi_t = \frac{\gamma_t}{\left(\alpha - \gamma_t^{asset}\right)}. \tag{139}$$

Equation () and (), we determine γ_t^a and γ_t :

$$V_t =$$

As explained in the private bank section, plugging this expression into the value function of accumulation of net worth N_{t+1}, we get :

$$V_t = E_t \left\{\Lambda_{t,t+1} NW_{t+1}\right\} \tag{140}$$
$$\left(\gamma_t^{Asset} \phi_t + \gamma_t\right) NW_t = E_t \left\{\Lambda_{t,t+1} NW_{t+1}\right\} \tag{141}$$
$$\left(\gamma_t^{Asset} \phi_t + \gamma_t\right) NW_t = E_t \left\{\Lambda_{t,t+1} NW_{t+1}\right\} \tag{142}$$
$$= E_t \left\{\Lambda_{t,t+1} \left[\left(r_{t+1}^{Asset} - r_t^d\right) Asset_t + r_t^d NW_t\right]\right\} \tag{143}$$

where

$$\Lambda_{t,t+1} = \beta_{t,t+1} \left[1 - \sigma_B + \sigma_B \left(\gamma_{t+1}^{Asset} \phi_{t+1} + \gamma_{t+1}\right)\right]. \tag{144}$$

This allows to identify the arguments of the value function:

$$\gamma_t^{Asset} = E_t \left\{\Lambda_{t,t+1} \left(r_{t+1}^{Asset} - r_t^D\right)\right\} \text{ and } \gamma_t = E_t \left\{\Lambda_{t,t+1} r_t^d\right\} \tag{145}$$

Equation () is derived from equation () and ().
TO BE COMPLETED

D Analytical steady-state

The steady state is calculated in three steps: - the calibration of the structural parameters - assignment of historical values to the variables $\left[r^D, r_{O,t}^L r_{NO,t}^L, p_t^O, \overline{R}, \overline{\pi}\right]$ [7] - solving the equilibrium system analytically.
First, we normalize N_{NO} to 1. Thus, we can solve analytically our system of equations as follows :

[7] See section calibration for more details.

From (10) :

$$
\begin{aligned}
p^O &= (1-\tau_O)\, sp_O^f \alpha_O \frac{Y_O}{O}, \\
p^O O &= (1-\tau_O)\, sp_O^f \alpha_O Y_O,
\end{aligned}
$$

$$
Y_O = \frac{p^O O}{(1-\tau_O)\,\alpha_O}, \tag{146}
$$

From (8)

$$
\begin{aligned}
r_O^L &= (1-\tau_O)\, sp_O^f \beta_O \frac{Y_O}{K_O}, \\
K_O &= (1-\tau_O)\, \beta_O \frac{Y_O}{r_O^L}, \qquad (147)
\end{aligned}
$$

From (7)

$$
\begin{aligned}
Y_O &= O^{\alpha_O} K_O^{\beta_O} N_O^{\theta_O}, \\
N_O, &= \left(\frac{Y_O}{O^{\alpha_O} K_O^{\beta_O}}\right)^{\frac{1}{\theta_O}}, \qquad (148)
\end{aligned}
$$

From (9)

$$
w_O = (1-\tau_O)\,\theta_O \frac{Y_O}{N_O}, \tag{149}
$$

From (11)

$$
D^O = (1-\tau_O)\, Y_O. \tag{150}
$$

From (2.6)

$$
r^{Asset} = \left(\mu r \binom{L}{no}^{\varepsilon-1} + \eta_B \left(r_o^L\right)^{\varepsilon-1} + (1-\eta_B-\mu)\left(r^b\right)^{\varepsilon-1}\right)^{\frac{1}{\varepsilon-1}}, \tag{151}
$$

Then, we can rewrite the net worth, NW, equation from (37) and (41) :

$$
\begin{aligned}
\sigma_B\left[\left(r^{Asset}-r^D\right)\phi NW + r^D NW\right], &= NW, \\
\sigma_B\left(\left(r^{Asset}-r^D\right)\phi + r^D\right) NW, &= NW, \\
\sigma_B\left(\left(r^{Asset}-r^D\right)\phi + r^D\right), &= 1, \\
\sigma_B\left(r^{Asset}-r^D\right)\phi + \sigma_B r^D, &= 1, \\
\sigma_B\left(r^{Asset}-r^D\right)\phi &= 1-\sigma_B r^D, \\
\phi &= \frac{1-\sigma_B r^D}{\sigma_B\left(r^{Asset}-r^D\right)}, \qquad (152)
\end{aligned}
$$

Combining (35) and (41), we get :

$$\begin{aligned} D_O &= (\phi - 1)\, NW, \\ NW &= \frac{D_O}{(\phi - 1)}, \end{aligned} \tag{153}$$

From (41) :

$$Asset = \phi NW, \tag{154}$$

From (**??**),(51) and (15) :

$$K_{NO} = \mu \left(\frac{r^L_{no}}{r^{Asset}} \right)^{\varepsilon} Asset, \tag{155}$$

$$B = (1 - \eta_B - \mu) \left(\frac{r^b}{r^{Asset}} \right)^{\varepsilon} Asset, \tag{156}$$

$$Y_{NO} = K_{NO}^{\alpha_{NO}} N_{NO}^{\beta_{NO}}, \tag{157}$$

From (16) :

$$\begin{aligned} r^L_{NO} &= \alpha_{NO} mc_{NO} \frac{Y_{NO}}{K_{NO}}, \\ mc_{NO} &= \frac{r^L_{NO} K_{NO}}{\alpha_{NO} Y_{NO}}, \end{aligned} \tag{158}$$

From (17)

$$w_{NO} = (1 - \alpha_{NO}) mc_{NO} \frac{Y_{NO}}{N_{NO}}, \tag{159}$$

From (4) and (5), we get:

$$\begin{aligned} \mu_N^{\frac{1}{\varepsilon}} \frac{\left(N^H\right)^{\sigma_H^n + \frac{1}{\varepsilon}} N_O{}^{\frac{-1}{\varepsilon}}}{w_O} &= (1 - \mu_N)^{\frac{1}{\varepsilon}} \frac{\left(N^H\right)^{\sigma_H^n + \frac{1}{\varepsilon}} N_{NO}{}^{\frac{-1}{\varepsilon}}}{w_{NO}}, , \\ \mu_N^{\frac{1}{\varepsilon}} \frac{N_O{}^{\frac{-1}{\varepsilon}}}{w_O} &= (1 - \mu_N)^{\frac{1}{\varepsilon}} \frac{N_{NO}{}^{\frac{-1}{\varepsilon}}}{w_{NO}}, \\ \mu_N^{\frac{1}{\varepsilon}} \left(\frac{N_O}{N_{NO}} \right)^{\frac{-1}{\varepsilon}} &= (1 - \mu_N)^{\frac{1}{\varepsilon}} \frac{w_O}{w_{NO}}, \\ \mu_N &= \left(\left(\frac{N_O}{N_{NO}} \right)^{-1} \left(\frac{w_O}{w_{NO}} \right)^{-\varepsilon} + 1 \right)^{-1} \end{aligned} \tag{160}$$

From (3) :

$$N=\left(\mu_N^{\frac{1}{\varepsilon}}(N_{O,t})^{\frac{(\varepsilon-1)}{\varepsilon}}+(1-\mu_N)^{\frac{1}{\varepsilon}}(N_{NO,t})^{\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\frac{\varepsilon}{(\varepsilon-1)}}, \tag{161}$$

From (5) and (9) :

$$\begin{aligned}
\mu_N^{\frac{1}{\epsilon}}\frac{N^{\sigma_H^n+\frac{1}{\epsilon}}N_O^{-\frac{1}{\epsilon}}}{\lambda_H} &= (1-\tau_O)\,sp_O^f\theta_O\frac{Y_O}{N_O}, \\
\lambda_H &= \mu_N^{\frac{1}{\epsilon}}\frac{N^{\sigma_H^n+\frac{1}{\epsilon}}N_O^{-\frac{1}{\epsilon}+1}}{(1-\tau_O)\,sp_O^f\theta_O Y_O},
\end{aligned} \tag{162}$$

From (20):

$$\widetilde{p}_{NO}=\frac{\vartheta}{\vartheta-1}\frac{V_{NO}^1}{V_{NO}^2},$$

Knowing that from (21) and (22) :

$$\begin{aligned}
V_{NO}^1 &= \lambda_{NO}Y_{NO}mc_{NO}p_{NO}^{\vartheta}+\beta\phi_{NO}V_{NO}^1, \\
(1-\beta\phi_{NO})\,V_{NO}^1 &= \lambda_{NO}Y_{NO}mc_{NO}p_{NO}^{\vartheta}, \\
V_{NO}^1 &= \frac{\lambda_{NO}Y_{NO}mc_{NO}p_{NO}^{\vartheta}}{(1-\beta\phi_{NO})},
\end{aligned} \tag{163}$$

and,

$$\begin{aligned}
V_{NO}^2 &= \lambda_{NO}Y_{NO}p_{NO}^{\vartheta}+\beta\phi_{NO}V_{NO}^2. \\
(1-\beta\phi_{NO})\,V_{NO}^2 &= \lambda_{NO}Y_{NO}p_{NO}^{\vartheta}. \\
V_{NO}^2 &= \frac{\lambda_{NO}Y_{NO}p_{NO}^{\vartheta}}{(1-\beta\phi_{NO})}.
\end{aligned} \tag{164}$$

we get :

$$\begin{aligned}
\widetilde{p}_{NO} &= \frac{\vartheta}{\vartheta-1}\frac{\frac{\lambda_{NO}Y_{NO}mc_{NO}p_{NO}^{\vartheta}}{(1-\beta\phi_{NO})}}{\frac{\lambda_{NO}Y_{NO}p_{NO}^{\vartheta}}{(1-\beta\phi_{NO})}}, \\
\widetilde{p}_{NO} &= \frac{\vartheta}{\vartheta-1}\frac{\lambda_{NO}Y_{NO}mc_{NO}p_{NO}^{\vartheta}}{\lambda_{NO}Y_{NO}p_{NO}^{\vartheta}}, \\
\widetilde{p}_{NO} &= \frac{\vartheta}{\vartheta-1}mc_{NO},
\end{aligned} \tag{165}$$

At the steady state level, $p_{NO}=\widetilde{p}_{NO}$
From (52) :

$$T = \frac{RB + w_o N_O + p_O O}{(1-x)} - B - s p_O^f Y_O - (r^D - 1) D_O, \tag{166}$$

From (2.3) :

$$DIV_{NO} = \widetilde{P}_{NO} Y_{NO} - r_{NO}^L K_{NO} - w_{NO} N_{NO},$$

Combining (45) and (145) we find γ^a, γ, and Λ. Thus, we solve a system of three equations and three unknowns variables. This gives us :

$$\begin{aligned}
\gamma^a &= \Lambda \sigma_B \left(R^a - R^d\right) \\
\gamma &= \Lambda \sigma_B R^d \\
\Lambda &= \beta \left[1 - \sigma_B + \sigma_B \left(\gamma^a \phi + \gamma\right)\right]
\end{aligned}$$

Combining the two first equations with the third, we get Λ:

$$\begin{aligned}
\Lambda &= \beta \left[1 - \sigma_B + \sigma_B \left(\Lambda \sigma_B \left(R^a - R^d\right) \phi + \Lambda \sigma_B R^d\right)\right], \\
\Lambda &= \beta - \beta \sigma_B + \beta \sigma_B \left(\Lambda \sigma_B \left(R^a - R^d\right) \phi + \Lambda \sigma_B R^d\right), \\
\Lambda &= \frac{\beta \left(1 - \sigma_B\right)}{\left(1 - \beta \sigma_B \left(\sigma_B \left(R^a - R^d\right) \phi + \sigma_B R^d\right)\right)},
\end{aligned} \tag{167}$$

Replacing the last result in the two first equations, we find the values of γ^a and γ:

$$\gamma^a = \frac{\beta \left(1 - \sigma_B\right)}{\left(1 - \beta \sigma_B \left(\sigma_B \left(R^a - R^d\right) \phi + \sigma_B R^d\right)\right)} \sigma_B \left(R^a - R^d\right), \tag{168}$$

$$\gamma = \frac{\beta \left(1 - \sigma_B\right)}{\left(1 - \beta \sigma_B \left(\sigma_B \left(R^a - R^d\right) \phi + \sigma_B R^d\right)\right)} \sigma_B R^d, \tag{169}$$

Then :

$$\begin{aligned}
\phi &= \gamma / \left(\alpha - \gamma^a\right) \\
\phi \left(\alpha - \gamma^a\right) &= \gamma \\
\alpha &= \gamma / \phi + \gamma^a,
\end{aligned} \tag{170}$$

The importer's real marginal cost is :

$$mc_I = s,$$

From (28) :

$$\widetilde{p}_I = \frac{\vartheta}{\vartheta - 1} \frac{V_I^1}{V_I^2},$$

From (29) and (30) :

$$\begin{aligned} V_I^1 &= \lambda_I Y_I mc_I p_I^{\vartheta} + \beta\phi_I V_I^1, \\ (1-\beta\phi_I) V_I^1 &= \lambda_I Y_I mc_I p_I^{\vartheta}, \\ V_I^1 &= \frac{\lambda_I Y_I mc_I p_I^{\vartheta}}{(1-\beta\phi_I)}, \end{aligned} \tag{171}$$

and,

$$\begin{aligned} V_I^2 &= \lambda_I Y_I p_I^{\vartheta} + \beta\phi_I V_I^2. \\ (1-\beta\phi_I) V_I^2 &= \lambda_I Y_I p_I^{\vartheta}. \\ V_I^2 &= \frac{\lambda_I Y_I p_I^{\vartheta}}{(1-\beta\phi_I)}. \end{aligned} \tag{172}$$

we get :

$$\begin{aligned} \widetilde{p}_I &= \frac{\vartheta}{\vartheta-1}\frac{\frac{\lambda_I Y_I mc_I p_I^{\vartheta}}{(1-\beta\phi_I)}}{\frac{\lambda_I Y_I p_I^{\vartheta}}{(1-\beta\phi_I)}}, \\ \widetilde{p}_I &= \frac{\vartheta}{\vartheta-1}\frac{\lambda_I Y_I mc_I p_I^{\vartheta}}{\lambda_I Y_I p_I^{\vartheta}}, \\ \widetilde{p}_I &= \frac{\vartheta}{\vartheta-1} mc_I, \end{aligned} \tag{173}$$

At the steady state level :$p_I = \widetilde{p}_I$

From (33) :

$$\begin{aligned} Y_{NO} &= \chi_{NO}\left(p_{NO}\right)^{-\tau} Z, \\ Z &= \frac{Y_{NO}}{\chi_{NO}\left(p_{NO}\right)^{-\tau}}, \end{aligned} \tag{174}$$

Also, from (33) :

$$Y_I = \chi_I\left(p_I\right)^{-\tau} Z,$$

The importer's dividend is given by :

$$DIV_I = \left(\widetilde{p}_I - s\right) Y_I,$$

and then the totzl dividend :

$$DIV = DIV_{NO} + DIV_I,$$

Finally, from (2) :

$$C_t^H = w_O N_O + w_{NO} N_{NO} + (1-\sigma_B) NW + DIV - T,$$