Euro Fluctuations and Currant Account Imbalances in Oil Exporting Countries: A DSGE Framework Analysis*

Ali Dib[†]
Bank of Canada

Bachir Mazouz[‡]
ENAP, Université du Québec

February 14, 2005

Abstract

This paper develops a New-Keynesian DSGE model of a small open oil-exporting economy. The model is calibrated to Algeria and used to quantitatively evaluate dynamic effects of the recent euro appreciation on oil-exporting economies. It is assumed that the country exports only oil, at prices set in the U.S. dollar, and borrows and imports in the euro currency. The simulation results show that the recent euro appreciation have led to large fluctuations of the terms of trade and current account, and to high increases in external debt valuation and interest payments. In contrast, parallel increases in oil prices, in the world markets, have offset the negative effects of the euro appreciation. Furthermore, the monetary authority can conduct devaluationary and/or monetary policies to isolate the economy from these external shocks.

JEL classification: E31, F2, F3
Keywords: Euro currency appreciation; oil-exporting economy; current account fluctuations

* This paper is prepared for the First International Conference "Euro and Arabic Countries Economics : Opportunities and Threats" April 18-20, 2005, held at University Amar Telidji, Laghouat, Algeria. The views expressed in this paper are those of the authors. No responsibility for them should be attributed to the Bank of Canada.

† Corresponding author: Ali Dib, International Department, Bank of Canada, 234 Wellington St. Ottawa, ON, K1A 0G9, Canada. http://www.bankofcanada.ca/adib, e-mail adib@bankofcanada.ca, tel. (613) 782-7851.

‡ ENAP, Universite du Quebec, e-mail: bachir_mazouz@enap.uquebec.ca, Montreal, QC, Canada. Tele. 1-514-849 3989 poste 2907.

1. Introduction

Since 2001, there have been rapid and significant appreciations of the major currencies relative to the U.S. dollar and currencies pegged to it. The Euro Area currency (euro), which has become one of the most important currencies, appreciated by more than 25% in less than eighteen months relative to the U.S. dollar. Evidence, based on experiences of the exchange rates of several currencies, indicate that these appreciations are largely driven by the forces of multilateral adjustments to the large U.S. current account and fiscal imbalances.[1] The U.S. economy occupies a predominant position in the world economy. Therefore, when it incurs an unsustainable current account deficit, all other major currencies will appreciate relative to the U.S. dollar to facilitate global adjustment to the U.S. imbalances.[2] Thus, the underlying forces behind these appreciations are not driven by real fundamentals, normally identified as shifts in the demand for and supply of countries' produced goods relative to those produced in the U.S. economy, but by exogenous factors.

The pirpose of this paper is to study the dynamic effects of the recent euro appreciations on the emerging oil-exporting economies; particularly, those that trade almost only with the Euro Area. The oil-exporting economies differ from other developing small-open economies in different aspects. They rely heavily on oil for their exports earnings, and are highly dependent on imported consumption and capital goods and intermediate inputs for domestic production. They also have more volatile business cycles, and are more crisis prone than small-open developed countries. In light of these features, fluctuations in world oil prices, terms of trade and world interest rates have significant roles on their business cycle fluctuations.

In theory, if a country's export earnings are in the U.S. dollar, to which it pegs its home currency, and borrows and imports in the euro, an exogenous appreciation of the euro affects its current account position through four channels.[3] First, the euro appreciation creates valuation effects on the external debts. The value of countries liabilities increases in terms of the domestic currency and U.S. dollar, even when the country does not borrow fresh funds. Second, the increases in the value of external debt lead to a higher risk premium. Therefore, the country is facing higher interest rates in the international financial markets, which significantly increases the costs of its external borrowing. Third, an exogenous appreciation of the euro deteriorates the terms of trade; prices of exports become lower what reduces the country's export earnings. Finally, the depreciation of the home currency implies that it is more costly to import in the euro. Thus, if imports, priced in the euro, slowly adjust, the current account incurs a deficit, at least, in the short term.

Therefore, to investigate the recent euro-appreciation effects, we develop a quantitative dynamic-optimizing model of a small open oil-exporting economy with microeconomic foundations, price rigidities, and several domestic and world shocks. This model is a class of New-Keynesian dynamic and stochastic general equilibrium (DSGE) models that have become the main tool used in macroeconomics to answer different questions related to business cycle fluctuations in both closed and open economies. Several central banks use these structural

[1] Bailliu, Dib and Schambri (2004) study the impacts of multilateral adjustments to the U.S. imbalances on the Canadian dollar. The results show that these imbalances account for the recent appreciation of the Canadian dollar.

[2] In 2004, the United States was running a current account deficit of roughly 6% of its gross domestic product. Many observers felt was unsustainable at the existing exchange rate levels.

[3] The effects of the euro appreciations should be modest on the oil-exporting economies that mostly export, import, and borrow in the U.S. dollar, because these euro appreciations do not affect their terms of trade or the valuation of their external debt.

DSGE models for policy analysis.[4] These models are structural because their equilibrium conditions are derived from the agents' optimization problems, and their deep parameters do not depend on the behavior of the economic agents. Also, introducing price rigidities implies non-neutral monetary policy in the short term and allows the deviation from the law of one price in the import sector.

The model developed in this paper is based on recent studies that have developed models for small open developed and emerging economies (Kollmann 2001, Bergin 2003, Dib 2003b, Devereux and Yetman 2003, and others). We model the recent euro appreciations as exogenous shocks to the nominal exchange rate. This is similar to modelling speculative forces that drive movements in the nominal exchange rate. These shocks, besides oil-price shocks, are another important source of fluctuations of the terms of trade (defined as relative export prices to import prices). Therefore, any exogenous appreciation of the euro increases import prices, which in turn decreases the terms of trade, deteriorates the country's current account, and slows down the economic activity.

The model is calibrated to Algeria (an oil-exporting country). The main features of its economy are: (1) the country pegs its domestic currency (the Algerian dinar) to the U.S. dollar; (2) oil accounts for roughly 95% of its exports with prices denominated in the U.S. dollar and set in the world markets; (3) most of its imports are from the Euro Area; (4) the country is a net debtor to the rest of the world, with at least 60% of its foreign debt in currencies other than the U.S. dollar;[5] and (5) its current account position highly depends on oil-price fluctuations.

To build a DSGE model for the Algerian economy, we make several assumptions. First, oil is the only tradable goods with prices, denominated in the U.S. dollar, evolve exogenously in the world markets. Second, imported goods are exclusively from the Euro Area and invoiced in the euro currency at world prices. Third, the value of the Algerian dinar relative to the U.S. dollar evolves exogenously following a stochastic process. Fourth, the country has access to the international financial market where it can buy or sell non-contingent one period euro-denominated bonds at prices that depend on the world interest rate and a country-specific risk premium. Finally, the monetary authority (a central bank) may manage the value of the Algerian dinar relative to the U.S. dollar and money supply to respond to shocks disturbing the economy. The monetary authority intervenes to optimally reallocate the resources in the economy.

The simulation results show that euro-appreciation and oil-price shocks are the main resources of business cycle fluctuations of the Algerian economy. Furthermore, as expected by the theory, the euro-appreciation shocks have deteriorated the country's terms of trade and the current account, as they increase the external debt and reduce export earnings. In contrast, parallel oil-price shocks have offset the major negative impacts of the euro appreciations. The movements of the nominal exchange rate also generate high volatility in the economy and their negative effects are persistent. Nevertheless, the monetary authority may use devaluationary and monetary policies to neutralize the negative effects of the euro-appreciation shocks.

The remainder of the paper is organized as follows. Section 2 develops a theoretical model of a small open oil-exporting economy. Section 3 discusses the procedures of parametrization. Section 4 discusses the

[4]The bank of Canada, The US Federal Reserve Bank, the European Central Bank, the Bank of Norway, and the International Monetary Funds have already developed DSGE models to use for projection and policy analysis.

[5]In 2003, only 39% of Algerian external debt is in the US dollar, see the Algerian central bank report of 2003.

empirical results. Section 5 concludes.

2. The Model

We consider a small open economy model composed of five agents: households, an aggregator, an oil producer, a continuum of non-oil producers and importers, and a monetary authority (a central bank). The home agents take the world nominal interest rate, oil price, and imported-goods prices as given. Domestic households have access to incomplete international financial markets, but they must pay, in addition to the world interest rate, a country-specific risk premium that is increasing in the foreign-debt-to-export ratio. Oil producer, which is perfectly competitive in the world market, produces oil output for export only, using capital and a natural-resource factor. Oil price is set in the world markets in the U.S. dollar. Non-oil producers and importers, however, are monopolistically competitive with nominal price rigidities. Each producer produces, for the home market only, a distinct non-tradable domestic-intermediate good using capital and labour as inputs. The importers import a homogeneous good produced abroad to produce a differentiated imported-intermediate good for the home market. We assume that most imported goods are from the Euro Area and priced in the euro currency. The aggregator uses the domestic- and imported-intermediate goods to produce domestic- and imported-composite goods, which it turns into a final good. The final good is divided between home consumption and investment in the oil and non-oil sectors. The monetary authority conducts its monetary policy by managing money supply and/or the value of the home currency relative to the U.S. dollar (devaluationary policy).

2.1 Households

The representative household derives utility from consumption c_t, real balances (money) M_t/p_t, and leisure $1-h_t$. Its preferences are described by the following expected utility function:

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, M_t/p_t, h_t\right), \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, M_t is holdings of nominal balances, h_t is labour supply to non-oil intermediate-goods producers, and p_t is the consumer price level. The single-period utility function is specified as:

$$u(\cdot) = \frac{\gamma}{\gamma-1}\log\left[c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}}\left(\frac{M_t}{p_t}\right)^{\frac{\gamma-1}{\gamma}}\right] + \eta\log\left(1-h_t\right), \tag{2}$$

where $\gamma > 0$ is the constant elasticity of substitution between consumption and real balances, while $b > 0$ and $\eta > 0$ denote the weight on real balances and leisure in the utility function, respectively. We introduce money in the utility function to derive a standard money demand function with the interest elasticity equal to $-\gamma$.

The household's revenue flows come from many resources. First, it enters period t with nominal money balances M_{t-1}, and nominal net foreign bonds (debt) B^*_{t-1}, denominated in the foreign (euro) currency.[6] During period t, the household may sell or purchase new foreign bonds B^*_t on international financial markets while

[6] B^*_t is the stock of the foreign debt if it is negative $(B^*_t < 0)$.

receiving payments from (or paying interest on) previous period foreign bond holdings. It also earns a wage rate, W_t, from supplying labour to non-oil intermediate-goods producers and rent payments, p_{Lt}, from the oil producer for using the natural-resource factor (Land) L_t. Furthermore, it receives a lump-sum nominal transfer T_t from the monetary authority, and dividend payments from the monopolistically competitive producers and importers, $D_t^d = \int_0^1 D_t^d(j)dj$ and $D_t^f = \int_0^1 D_t^f(j)dj$. Finally, it accumulates k_{xt} and k_{dt} units of capital stocks that are used in the oil and non-oil sectors for rental rates R_{xt} and R_{dt}, respectively.[7]

Household uses some of its funds to purchase, at nominal price p_t, consumption and investment. Investment is divided between the two production sectors: i_{xt} and i_{dt} are for the oil and non-oil sectors, respectively. The evolution of the capital stocks in each sector is given by:

$$k_{jt+1} = (1-\delta)k_{jt} + i_{jt} - \Psi_j(k_{jt+1}, k_{jt}), \text{ for } j = \{d, x\} \tag{3}$$

where $\delta \in (0,1)$ is the common depreciation rate and $\Psi_j(\cdot) = \frac{\psi j}{2}\left(\frac{k_{jt+1}}{k_{jt}} - 1\right)^2 k_{jt}$ is capital-adjustment cost functions that satisfy $\Psi_j(0) = 0$, $\Psi_j'(\cdot) > 0$ and $\Psi_j''(\cdot) < 0$. The adjustment cost parameters ψ_d and ψ_x are positive. With this specification, both total and marginal costs of adjusting capital are zero in the steady-state equilibrium.

Then, the period budget constraint of the representative household is given by:

$$\begin{aligned} p_t(c_t + i_t) \quad + \quad & M_t + e_t\xi_t B_t^*/R_t \leq R_{dt}k_{dt} + W_t h_t + R_{xt}k_{xt} + p_{Lt}L_t + M_{t-1} \\ & + e_t\xi_t B_{t-1}^* + T_t + D_t^d + D_t^f. \end{aligned} \tag{4}$$

Here e_t is the endogenous nominal exchange rate [the price of foreigners' currency (one euro) in domestic currency (Algerian dinar)] that is determined by real fundamentals of the domestic economy, while ξ_t denotes euro -appreciation shocks (exogenous shocks to the nominal exchange rate of the euro). These shocks reflect any appreciation or depreciation of the euro relative to the Algerian dinar contributed to exogenous factors; R_t denotes the gross nominal interest rate of the external debt (foreign bonds) between t and $t+1$. Thus, the domestic household sells (or purchase) foreign bonds B_t^* at $(R_t)^{-1}$ units of foreign output.[8]

Domestic households have access to incomplete international financial markets, but they must pay an endogenous country-specific risk-premium terms, κ_t, in addition to the world interest rate R_t^*. Hence, $R_t = \kappa_t R_t^*$, which reflects departures from the uncovered interest rate parity. The risk-premium terms is increasing in the foreign-debt-to-export ratio, and evolves according to:

$$\kappa_t = \exp\left(-\varphi \frac{\tilde{B}_t^*}{y_{xt}}\right), \tag{5}$$

where φ is a parameter measuring the level of risk premium, $\tilde{B}_t^* < 0$ is the average real stock of external debt, and y_{xt} denotes exports.[9] The euro -appreciation shocks, ξ_t, and the world gross nominal interest rate, R_t^*, evolve according to:

[7]We assume that the two capital stocks are non-transferable between sectors.

[8]We assume that foreigners purchase only the bonds denominated in their own currancy.

[9]When an economy is a net debtor ($\widetilde{B}_t^* < 0$) It must pay a risk-premium terms, κ_t, in addition to the world interest rate, R_t^*.

$$\log(\xi_t) = \rho_\xi \log(\xi_t) + \varepsilon_{\xi t}, \tag{6}$$

and

$$\log(R_t^*) = (1 - \rho_{R^*}) \log(R^*) + \rho_{R^*} \log(R_{t-1}^*) + \varepsilon_{R^* t}, \tag{7}$$

where $\xi = 1$ and $R^* > 1$, ρ_ξ and $\rho_{R^*} \in (-1, 1)$ are the autocorrelation coefficients, and $\varepsilon_{\xi t}$ and $\varepsilon_{R^* t}$ are normally distributed with zero mean and standard deviations σ_ξ and σ_{R^*}, respectively.

The household chooses $\{c_t, h_t, M_t, k_{dt+1}, k_{xt+1}, B_t^*\}$ to maximize the expectation of the discounted sum of its utility flows subject to the equations (3) and (4). The first-order conditions are:

$$\frac{c_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}} (M_t/p_t)^{\frac{\gamma-1}{\gamma}}} = \lambda_t; \tag{8}$$

$$\frac{\eta}{1 - h_t} = \frac{\lambda_t W_t}{p_t}; \tag{9}$$

$$\frac{b^{\frac{1}{\gamma}} (M_t/p_t)^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}} (M_t/p_t)^{\frac{\gamma-1}{\gamma}}} = \lambda_t - \beta E_t \left(\frac{p_t \lambda_{t+1}}{p_{t+1}} \right); \tag{10}$$

$$\beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\frac{R_{dt+1}}{p_{t+1}} + 1 - \delta + \psi_d \left(\frac{k_{dt+2}}{k_{dt+1}} - 1 \right) \frac{k_{dt+2}}{k_{dt+1}} \right) \right] = \psi_d \left(\frac{k_{dt+1}}{k_{dt}} - 1 \right) + 1; \tag{11}$$

$$\beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\frac{R_{xt+1}}{p_{t+1}} + 1 - \delta + \psi_x \left(\frac{k_{xt+2}}{k_{xt+1}} - 1 \right) \frac{k_{xt+2}}{k_{xt+1}} \right) \right] = \psi_x \left(\frac{k_{xt+1}}{k_{xt}} - 1 \right) + 1; \tag{12}$$

$$\frac{1}{R_t} = \beta E_t \left[\frac{e_{t+1} \xi_{t+1} p_t \lambda_{t+1}}{e_t \xi_t p_{t+1} \lambda_t} \right]; \tag{13}$$

in addition to the budget constraint, and where λ_t is the Lagrangian multiplier of the budget constraint.

Equations (8) and (9) equate the marginal rate of substitution between consumption and labour to the real wage. Equation (10) stipulates that the marginal utility of real money balances is equal to the difference between the current and marginal utility of consumption and the expected future marginal utility of consumption adjusted for the expected inflation rate. Equations (11) and (12) correspond to the optimal distribution of capital between the two production sectors. Equation (13) implies the uncovered interest rate parity condition.[10]

2.2 Aggregator

We assume that the aggregator, which acts in a perfectly competitive market, uses domestic-composite non-oil output, y_{dt}, and composite imports, y_{ft}, to produce a final good, z_t, according to the following CES technology:

$$z_t = \left[(1 - \omega_f)^{\frac{1}{\nu}} y_{dt}^{\frac{\nu-1}{\nu}} + \omega_f^{\frac{1}{\nu}} y_{ft}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}, \tag{14}$$

[10] Because $\beta E_t \left[\frac{p_t \lambda_{t+1}}{p_{t+1} \lambda_t} \right]$ is the inverse of the domestic nominal gross interest rate.

where $\omega_f > 0$ denotes the share of imports in the final good, and $\nu > 0$ is the elasticity of substitution between domestic and imported goods. It also denotes the price elasticity of domestic and imported goods demand functions. Similarly, both inputs are produced using the CES technology:

$$y_{dt} = \left(\int_0^1 y_{dt}(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \text{ and } y_{ft} = \left(\int_0^1 y_{ft}(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{15}$$

where $\theta > 1$ is the constant elasticity of substitution between the intermediate goods in the aggregation of composite goods. The demand function for the domestic- and imported-intermediate goods are:

$$y_{dt}(j) = \left(\frac{p_{dt}(j)}{p_{dt}} \right)^{-\theta} y_{dt} \text{ and } y_{ft}(j) = \left(\frac{p_{ft}(j)}{p_{ft}} \right)^{-\theta} y_{ft}. \tag{16}$$

Domestic and import prices that are the producer- and importer-price index (PPI and IPI) satisfy

$$p_{dt} = \left(\int_0^1 p_{dt}(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \text{ and } p_{ft} = \left(\int_0^1 p_{ft}(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}}. \tag{17}$$

Given the final-good price, p_t, and given p_{dt} and p_{ft}, the aggregator chooses y_{dt} and y_{ft} to maximize its profit. The maximization problem is

$$\max_{\{y_{dt}, y_{ft}\}} p_t z_t - p_{dt} y_{dt} - p_{ft} y_{ft}, \tag{18}$$

subject to (14). Profit maximization implies the following demand functions for domestic- and imported-composite goods:

$$y_{dt} = (1 - \omega_f) \left(\frac{p_{dt}}{p_t} \right)^{-\nu} z_t \quad \text{and} \quad y_{ft} = \omega_f \left(\frac{p_{ft}}{p_t} \right)^{-\nu} z_t. \tag{19}$$

Thus, as the relative prices of domestic and imported goods rise, the demand for domestic and imported goods decreases.

The zero-profit condition implies that the final-good price level, which is the consumer-price index (CPI), is linked to domestic- and imported-goods prices through:

$$p_t = \left[(1 - \omega_f) p_{dt}^{1-\nu} + \omega_f p_{ft}^{1-\nu} \right]^{1/(1-\nu)}. \tag{20}$$

The final good is divided between consumption and investment in the oil and non-oil sectors, so that $z_t = c_t + i_{xt} + i_{dt}$.

2.3 Oil (export) producer

Production in oil sector is modelled to capture the importance of natural resources in oil output. In this sector, there is a producer that produces oil output, y_{xt}, using capital, k_{xt}, and a natural-resource factor called land, L_t. Oil output is produced using the following Cobb-Dauglas technology

$$y_{xt} \leq k_{xt}^{\alpha_x} L_t^{1-\alpha_x}, \quad \alpha_x \in (0,1)\,, \tag{21}$$

where α_x is the share of capital in the oil output.

Oil output is totally exported abroad at the price, p_{xt}^*, that is set in the world markets in the U.S. dollar. Therefore, multiplying p_{xt}^* by the exchange rate of the U.S. dollar relative to the home currency, χ_t, yields the oil producer's revenues (export earnings in the Algerian dinar).

Given p_{xt}^*, χ_t, R_{xt}, and p_{Lt}^*, the price of the natural-resource factor (rent of the land paid to the representative household), the oil producer chooses k_{xt} and L_t that maximize its real profit flows. Its maximization problem is

$$\max_{k_{xt},L_t}\{\frac{\chi_t p_{xt}^*}{p_t} y_{xt} - \frac{R_{xt}}{p_t} k_{xt} - \frac{p_{Lt}}{p_t} L_t\}$$

subject to the production technology, equation (21).

Oil prices are given in the world markets and the natural resource factor is exogenous, so we assume that p_{xt}^* and L_t evolve according to stochastic processes given by

$$\log(p_{xt}^*) = (1-\rho_{px})\log(p_x^*) + \rho_{px}\log(p_{xt-1}^*) + \varepsilon_{pxt}, \tag{22}$$

and

$$\log(L_t) = (1-\rho_L)\log(L) + \rho_L\log(L_{t-1}) + \varepsilon_{Lt}, \tag{23}$$

where p_x^* and $L > 0$, ρ_{px} and $\rho_L \in (-1,1)$, and ε_{pxt} and ε_{pxt} are uncorrelated and normally distributed with zero mean and standard deviations σ_{px} and σ_L, respectively.

Since the beginning of the 1990's, Algeria has followed a managed (pegged) exchange rate regime, under which the nominal value of the Algerian dinar is pegged to the U.S. dollar. Consequently, devaluationary policy allows the monetary authority to manage χ_t to respond to shocks affecting the economy. We assume that the devaluationary policy shock, χ_t, evolves according to

$$\log(\chi_t) = (1-\rho_\chi)\log(\chi) + \rho_\chi\log(\chi_{t-1}) + \varepsilon_{\chi t}, \tag{24}$$

where $\chi > 0$, $\rho_\chi \in (-1,1)$, and $\varepsilon_{\chi t}$ is normally distributed with zero mean and standard deviation σ_χ. This shock, which is interpreted as a devaluationary (reevaluationary) policy shock, implies an increase (decrease) of the nominal U.S. dollar value in terms of the Algerian dinar. Devaluation or reevaluation are captured by positive or negative innovations on $\varepsilon_{\chi t}$.

The first-order conditions derived from the oil producer's optimization problem are:

$$\frac{\chi_t p_{xt}^*}{p_t}\frac{\alpha_x y_{xt}}{k_{xt}} = \frac{R_{xt}}{p_t}; \tag{25}$$

$$\frac{\chi_t p_{xt}^*}{p_t}\frac{(1-\alpha_x) y_{xt}}{L_t} = \frac{P_{lt}}{p_t}; \tag{26}$$

$$k_{xt}^{\alpha_x} L_t^{1-\alpha_x} = y_{xt}. \tag{27}$$

These first-order conditions give the optimal choice of inputs that maximize the oil producer's profits flows. Thus, the marginal cost of each input must be equal to its marginal productivity. Because the economy is small, the demand for domestic exports and their prices are completely determined in the world markets and domestic exports is a negligible fraction in world consumption.

2.4 Domestic intermediate-goods producers

In the non-oil sector, there are a continuum of domestic-intermediate goods producing firms indexed by $j \in [0,1]$. Each firm j uses capital stock, $k_{dt}(j)$, and hires $h_t(j)$ units of labour from the representative household to produce a differentiated intermediate good, $y_t(j)$, according to the following constant-return-to-scale technology:

$$y_t(j) \leq k_{dt}(j)^{\alpha} \left[A_t h_t(j)\right]^{1-\alpha}, \quad \alpha \in (0,1)\,, \tag{28}$$

where A_t is an exogenous technology shock that is identical for all domestic producers. This shock follows the process

$$\log A_t = (1-\rho_A)\log(A) + \rho_A \log(A_{t-1}) + \varepsilon_{At}, \tag{29}$$

where $\rho_A \in (-1,1)$, $A > 0$, and ε_{At} is normally distributed with zero mean and standard deviation σ_A. The domestic-intermediate good is only used by the aggregator to produce the final good z_t.

As in Dib (2003b), each producer j sells its output at price $\bar{p}_{dt}(j)$, on monopolistically competitive market. Following Calvo (1983), the producer cannot change its prices unless it receives a random signal. The probability that such a signal appears is constant and given by (1-ϕ). Therefore, on average the price remain unchanged for $1/(1-\phi)$ periods.

If the producer is allowed to change its price, it chooses $k_{dt}(j)$ and $h_t(j)$, and sets the price $\bar{p}_{dt}(j)$ that maximize the expected discounted flow of its profits. Its maximization problem is:

$$\max_{\{k_{dt}(j), h_t(j), \bar{p}_{dt}(j)\}} E_0 \left[\sum_{t=0}^{\infty} (\beta\phi)^l \lambda_{t+l} D_{t+l}^d(j)/p_{t+l}\right], \tag{30}$$

subject to (28) and the following demand function:

$$y_{dt+l}(j) = \left(\frac{\bar{p}_{dt}(j)}{p_{dt+l}}\right)^{-\theta} y_{dt+l} \tag{31}$$

where the profit function is

$$D^d_{t+l}(j) = \bar{p}_{dt}(j) y_{t+l}(j) - R_{dt+l} k_{dt+l}(j) - W_{t+l} h_{t+l}(j). \tag{32}$$

The domestic producer's discount factor is given by the stochastic process ($\beta^l \lambda_{t+l}$), where λ_{t+l} denotes the marginal utility of consumption in period $t+l$.

The first-order conditions are:

$$\frac{R_{dt}}{p_t} = \frac{\alpha y_t(j) q_t}{k_{dt}(j)}; \tag{33}$$

$$\frac{W_t}{p_t} = \frac{(1-\alpha) y_t(j) q_t}{h_t(j)}; \tag{34}$$

$$\bar{p}_{dt}(j) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{dt+l}(j) q_{t+l}/p_{t+l}}{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{dt+l}(j)/p_{t+l}}, \tag{35}$$

where q_t is the real marginal cost of the firm in units of final output.

The aggregate domestic price is

$$p_{dt}^{1-\theta} = \phi p_{dt-1}^{1-\theta} + (1-\phi) \bar{p}_{dt}^{1-\theta}. \tag{36}$$

The equations (33) and (34) state that the marginal cost of the inputs must equal to their marginal product weighted by the real marginal cost. The equation (35) relates the optimal price to the expected future price of the final good and to expected future real marginal costs. This condition together with (36) allows us to derive a New-Keynesian Phillips curve that relates the current and expected domestic-output inflation to the marginal cost.

2.5 Importers

In the home country, a continuum of domestic importers indexed by $j \in [0,1]$ import a homogeneous intermediate good produced abroad for the foreign price p_t^*. Each importer uses this imported good to produce a different good, $y_{ft}(j)$, which is sold in a home monopolistically-competitive market to produce the imported-composite good y_{ft}. As in the non-oil sector, importers can only change their prices when they receive a random signal. The constant probability of receiving such a signal is also (1-ϕ).

When an importer j is allowed to change its price, it sets the price, $\bar{p}_{ft}(j)$, that maximizes its weighted expected profits, given the price of the imported-composite output, p_{ft}, the nominal exchange rate (euro/dinar), e_t, and the foreign price level, p_t^*. The maximization problem is:

$$\max_{\{\bar{p}_{ft}(j)\}} E_0 \left[\sum_{t=0}^{\infty} (\beta\phi)^l \lambda_{t+l} D^f_{t+l}(j)/p_{t+l} \right], \tag{37}$$

subject to

$$y_{ft+l}(j) = \left(\frac{\bar{p}_{ft}(j)}{p_{ft+l}} \right)^{-\theta} y_{ft+l}, \tag{38}$$

where the profit function is

$$D^f_{t+l}(j) = \left(\bar{p}_{ft}(j) - e_{t+l}\xi_{t+l}p^*_{t+l}\right) y_{ft+l}(j). \quad (39)$$

In period t, the importer's nominal marginal cost is $e_t\xi_t p^*_t$, so that its real marginal cost is the real exchange rate $s_t = e_t\xi_t p^*_t/p_t$. The importer's discount factor is also given by the stochastic process ($\beta^l\lambda_{t+l}$). The first-order condition of this optimization problem is:

$$\bar{p}_{ft}(j) = \frac{\theta}{\theta-1}\frac{E_t\sum_{l=0}^{\infty}(\beta\phi)^l\lambda_{t+l}y_{ft+l}(j)s_{t+l}}{E_t\sum_{l=0}^{\infty}(\beta\phi)^l\lambda_{t+l}y_{ft+l}(j)/p_{t+l}}. \quad (40)$$

The aggregate import price is

$$p^{1-\theta}_{ft} = \phi p^{1-\theta}_{ft-1} + (1-\phi)\bar{p}^{1-\theta}_{ft}. \quad (41)$$

The equation (40) governs the optimal setting of the new import price over time. In the absence of price rigidity ($\phi = 0$), imported-goods prices are flexible, and the real exchange rate is constant and equal to $(\theta-1)/\theta$. This equation together with (41) allows us to derive the New Keynesian Phillips curve that relates the current and expected import-inflation rates to the real exchange rate. The presence of price rigidity implies that the response of the imported goods price to exogenous shocks is gradual. Thus, there is incomplete pass-through of exchange rate changes to the levels of the prices in the economy. Devereux and Yetman (2003) found that there is incomplete exchange rate pass-through in the emerging economies, including Algerian economy.

2.6 Monetary authority

The monetary authority conducts its monetary policy by adjusting nominal money supply. The central bank, therefore, manages the nominal money stock by making lump-sum transfers to the representative household, so that $M_t - M_{t-1} = T_t$, where M_t is the per capita nominal money stock. Monetary policy evolves according to the rule:

$$\log(\mu_t) = (1-\rho_\mu)\log(\mu_t) + \rho_\mu\log(\mu_{t-1}) + \varepsilon_{\mu t}, \quad (42)$$

where $\mu_t = M_t/M_{t-1}$ denotes the gross growth rate in period t, $\rho_\mu \in (-1,1)$ is an autoregressive coefficient and the serially uncorrelated shock $\varepsilon_{\mu t}$ is normally distributed with zero mean and standard deviation σ_μ.

Thus, the monetary authority may affect the economic activity by using its devaluationary policy and/or its monetary policy. The devaluationary policy consists in managing χ_t (the nominal exchange rate of the Algerian dinar relative to the U.S. dollar), while the monetary policy allows managing μ_t (the money-supply growth rate).

2.7 New-Keynesian Phillips curves and the current account

Equations (35) and (40) involve infinite summations. By linearizing these equations together with (36) and (41) around the steady-state values of the variables, we obtain two New-Keynesian Phillips curves that relate the current and expected inflation to real marginal costs. The New-Keynesian Phillips curve that relates the current and expected PPI inflation, $\pi_{dt} = p_{dt}/p_{dt-1}$, to the real marginal cost in the non-oil sector, $\widehat{q}_t$, is given by

$$\widehat{\pi}_{dt} = \beta E_t[\widehat{\pi}_{dt+1}] + \frac{(1-\phi)(1-\beta\phi)}{\phi}\widehat{q}_t. \tag{43}$$

Similarly, the New-Keynesian Phillips curve relates the current and expected IPI inflation, $\pi_{ft} = p_{ft}/p_{ft-1}$, to the real exchange rate, $s_t\xi_t$, is

$$\widehat{\pi}_{ft} = \beta E_t[\widehat{\pi}_{ft+1}] + \frac{(1-\phi)(1-\beta\phi)}{\phi}(\widehat{s}_t + \widehat{\xi}_t). \tag{44}$$

Substituting the resource constraints, money transfer, and firms' profit equations into the household budget constraint allows us to derive an equation that describes the evolution of the current account, which measures, over a period, the change in the value of a country's claims on the rest of the world–the change in its net foreign assets. The current account is the main channel through which foreign shocks affect domestic small open economies. The current account of an oil-exporting country, in real terms, derived in this model is given by

$$ca_t = B_t^* - B_{t-1}^* = \left(1 - \frac{1}{R_t}\right) B_t^* + \left(\frac{\chi_t \widetilde{p}_{xt}}{s_t \xi_t}\right) y_{xt} - y_{ft}. \tag{45}$$

The equation (45) states that the current account depends on interest payments $(1 - 1/R_t)\, B_t^*$, export earnings $\left(\frac{\chi_t \widetilde{p}_{xt}}{s_t \xi_t}\right) y_{xt}$, and imports y_{ft}. In each period, the country uses a fraction $(1 - 1/R_t)$ of its new external debt, $B_t^* < 0$, to pay back interests on its previous debt. The interest payments positively depend on B_t^* and $1/R_t$, the price of foreign bonds that negatively depends on the world interest rate and the risk-premium terms. Thus, increases in the external debt, world interest rate and/or risk premium lead to an increase in the external debt burden (the interest payment on the external debt), implying deterioration of the current account. Tille (2003) analyzes the impact of exchange rate movements on the U.S. current account.

On the other hand, the fluctuations in export earnings have a direct impact on the current account. The sources of these fluctuations are driven either by variations in the terms of trade (the relative prices of exports to imports) given by $\frac{\chi_t \widetilde{p}_{xt}}{s_t \xi_t}$ or by changes in exports. Positive shocks to χ_t or $\widetilde{p}_{xt}$ increase the terms of trade, which leads to an improvement in the current account. Nevertheless, endogenous or exogenous depreciations of the home currency relative to the Euro (increases in s_t or ξ_t) imply deterioration of the current account. Finally, import fluctuations have a direct influence on the current account movements.

In light of the paper's purpose, we first focus on the dynamic effects of Euro-appreciation, oil-price, and devaluationary policy shocks on the current account. Then, we analyze how these shocks are transmitted to the economy.

2.8 Equilibrium, definitions and model solution

In the equilibrium, all domestic-intermediate producers and importers are identical, so that $y_t = y_t(j)$, $y_{dt} = y_{dt}(j)$, $y_{ft} = y_{ft}(j)$, $k_{dt} = k_{dt}(j)$, $h_t = h_t(j)$, $p_{dt} = p_{dt}(j)$, $p_{ft} = p_{ft}(j)$, $D_t^d = D_t^d(j)$, and $D_t^f = D_t^f(j)$

for all $j \in [0,1]$ and during each period $t \geq 0$. Furthermore, the market-clearing conditions $M_t = M_{t-1} + T_t$, $\tilde{B}_t^* = B_t^*$, and the transversality conditions regarding household accumulation of money and bonds must hold for all $t \geq 0$.

Let $r_{xt} = R_{xt}/p_t$, $r_{dt} = R_{dt}/p_t$, $w_t = W_t/p_t$, $\tilde{p}_{Lt} = p_{Lt}/p_t$, and $m_t = M_t/p_t$ denote the real rental rate on capital services in the oil and non-oil sectors, real wages, real price of the natural-resource factor, and real balances, respectively. Let also $\tilde{p}_{dt} = p_{dt}/p_t$, $\tilde{p}_{ft} = p_{ft}/p_t$, and $\tilde{p}_{xt} = p_{xt}/p_t$ denote the relative prices of domestic, imported and exported goods, respectively.

The equilibrium system is composed of an allocation and a sequence of prices and co-state variables that satisfy the first-order conditions of the households and the oil and non-oil producers, the aggregate resource constraints, the money supply rule, the two New-Keynesian Phillips curves, the current account equation, and the stochastic processes of the shocks.[11]

The model is too complex to permit an analytical solution. We, therefore, resolve it numerically by log-linearizing the equilibrium conditions around the deterministic steady state to obtain a system of linear difference equations. Then, the solution was found using Blanchard and Kahn's (1980) procedure.[12] The state-space solution is of the form:

$$\widehat{\mathbf{s}}_{t+1} = \Phi_1 \widehat{\mathbf{s}}_t + \Phi_2 \varepsilon_{t+1}, \tag{46}$$

$$\widehat{\mathbf{d}}_t = \Phi_3 \widehat{\mathbf{s}}_t, \tag{47}$$

where $\widehat{\mathbf{s}}_t$ is a vector of state variables that includes predetermined and exogenous variables; $\widehat{\mathbf{d}}_t$ is the vector of control variables; and the vector ε_{t+1} contains exogenous innovations to the stochastic processes.[13] The elements of matrices Φ_1, Φ_2, and Φ_3 depend on the structural parameters of the model that describe household's preferences, technologies, and monetary policy. The state-space solution in (46)–(47) is used to simulate the model for the Algerian economy.

3. Parametrization

The numerical simulations entail assigning numerical values to the model's structural parameters. For this, we use a combination of calibration and ordinary-least-squared (OLS) estimations. Some parameters are resorted to calibrated values based on previous studies,[14] while others are set to match the model's steady-state ratios to those observed in the data. The parameters of the money demand function and the exogenous stochastic

[11] The allocation is $\{y_t, c_t, y_{xt}, y_{ft}, k_{dt}, k_{xt}, z_t, m_t, h_t, B_t^*\}_{t=0}^{\infty}$. The sequence of prices and co-state variables is $\{w_t, r_{dt}, r_{xt}, \tilde{p}_{Lt}, \tilde{p}_{dt}, \tilde{p}_{ft}, \tilde{p}_{xt}, \pi_t, \pi_{dt}, \pi_{ft}, \lambda_t, q_t, s_t\}_{t=0}^{\infty}$.
The stochastic processes are $\{\xi_t, \widetilde{p}_{xt}, \chi_t, \mu_t, A_t, L_t, R_t^*\}$.

[12] For each variable x_t, $\widehat{x}_t = \log(x_t/x)$, where x is the steady-state value of x_t.

[13] $\widehat{\mathbf{s}}_{t+1} = (\widehat{k}_{dt+1}, \widehat{k}_{xt+1}, \widehat{m}_t, \widehat{B}_t^*, \widehat{\widetilde{p}}_{dt}, \widehat{A}_t, \widehat{\mu}_t, \widehat{\widetilde{p}}_{xt}, \widehat{L}_t, \widehat{\chi}_t, \widehat{R}_t^*, \widehat{\xi}_t, \widehat{\chi}_t)'$;
$\widehat{\mathbf{d}}_t = (\widehat{\lambda}_{t+1}, \widehat{q}_{t+1}, \widehat{m}_t, \widehat{\widetilde{p}}_{ft}, \widehat{\widetilde{p}}_{Lt}, \widehat{y}_t, \widehat{r}_{dt}, \widehat{r}_{xt}, \widehat{c}_t, \widehat{y}_{xt}, \widehat{y}_{ft}, \widehat{\pi}_t, \widehat{w}_t, \widehat{h}_t, \widehat{\pi}_t, \widehat{\pi}_{dt}, \widehat{\pi}_{ft}, \widehat{s}_t)'$;
and $\varepsilon_t = (\varepsilon_{At}, \varepsilon_{\mu t}, \varepsilon_{pxt}, \varepsilon_{\chi t}, \varepsilon_{Lt}, \varepsilon_{R^*t}, \varepsilon_{\xi t})'$.

[14] For example, Dib (2003a) and Christiano, Eichenbaum and Evans (2005).

processes (autoregressive coefficients and standard deviations of the shocks) are estimated using some quarterly Algerian, Euro Area, and U.S. data.[15]

First, we summarize the parameter values fixed by the calibration. The parameter η, denoting the weight put on leisure in the utility function, is set at 1.315, so that the representative household spends roughly one third of its time in market activities. The shares of capital in the oil and non-oil sectors, α_x and α_d, the depreciation rate, δ, are assigned values of 0.12, 0.33, and 0.025, respectively. These values are commonly used in the RBC literature. The parameter θ that measures monopoly power in domestic- and imported-intermediate-goods markets is set equal to 6, implying a steady-state markup of price over marginal costs equal to 20%. The parameter ϕ determining the degree of nominal price rigidity in the domestic and import sectors, is set equal to 0.66. Thus, on average the domestic and imported goods prices remain unchanged for 3 quarters. The parameter ν, measuring the elasticity of substitution between domestic and imported goods in final output, is set equal to 0.5. Thus, domestically produced goods are only slightly substitutable for foreign goods. This reflects the nature of Algerian imports. It is widely believed that it is less costly to adjust the stock of capital in the oil sector than in the non-oil sector, so we set the capital adjustment cost parameters ψ_x and ψ_d equal to 0.1 and 0.5, respectively.[16]

The discount factor, β, is set equal to 0.9897, implying an annual steady-state real interest rate on external debts of 4.16% that matches the average observed in the data for the period 1992:1–2003:4. The steady-state domestic and world gross inflation rates are set equal to 1.015 and 1.0054, the averages observed in the data of the Algerian and Euro Area economies. The parameter in the risk-premium terms, φ, is set equal to 0.0034 implying an annual risk premium of 2% (200 basis points). 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 31 per cent, which is close to that observed in the data. The fraction of imported goods in the final goods, ω_f, is set at 0.24, so that the steady-state ratio of import-to-GDP matches its historical average of Algeria for the period 1992:1–2003:4.

Table 1 reports the OLS estimation results of the money demand function and the exogenous stochastic processes. The individual parameters are all statistically significant at the 5% level. The estimate of γ, the constant elasticity of substitution between consumption and real balances, is 0.081.[17] The parameter b, which is with γ determining the steady-state velocity is set equal to 0.29, implying a steady-state ratio of real balances to GDP matches that in the data. Except for money supply process, the stochastic processes are highly persistent, with AR(1) parameters above 0.70. The standard deviations of the innovations to the processes vary widely in magnitude, ranging from 0.001 in the case of the world interest rate to 0.11 in the case of oil-price shocks. The oil-price shocks are highly persistent and largely volatile, with an autoregressive coefficient of 0.81 and standard deviation of 0.11 that is larger than the standard deviation of any other forcing process in the model. The large persistence and high volatility of the oil-price shocks suggest the importance of these shocks for the business cycle fluctuations of the Algerian economy. The euro-appreciation and devaluationary policy shocks

[15] The series used in the estimation of the exogenous stochastic processes are either stationary or HP-filtred. The sample is from 1992:1 to 2003:4.

[16] Mendoza (1991) assume that the capital-adjustment cost parameter is 0.1 in a small open economy model. Bernanke, Gertler and Gilchrist (2000), however, assume it equal to 0.5 in a closed economy.

[17] We have estimated the money demand function using the log of real balances, real GDP, and the Algerian deposit interest rate.

also play a significant role in the short-term fluctuations of the Algerian economy. However, the autoregressive coefficient of the money supply shock is negative, this reflects the tightening of monetary policy that happened during the 1990's to control inflation.

The data used are from many sources. The Algerian data are mostly from the IMF financial statistics report (2004), while those of the U.S. and Euro Area are from St. Louis Federal Reserve Bank (USA) and the OCDE, respectively. The series of Algerian GDP, imports, exports, foreign debt, money, and the current account are real expressed in per capita terms (dividing by the Algerian population). We are only interested in the cyclical fluctuations of the Algerian economy, so we extract the cyclical component of each series using Hodrick-Prescott filter (HP-filter).

4. Simulation Analysis

To evaluate the performance of the model, we calculate and analyze the unconditional second moments and autocorrelations of some key variables of the model. We also simulate the dynamic response of the Algerian economy to exogenous shocks; our analysis, however, particularly focuses on real effects of shocks to the euro appreciations, oil prices, devaluationary policy, and money supply. We also show and discuss how exchange rate effects are passed through to importer and consumer prices.

4.1 Volatility and autocorrelations

Table 2 summarizes some standard deviations (unconditional second moments), expressed in terms of percentage, and the autocorrelation coefficients (unconditional autocorrelations) computed in the data and generated by the model.[18] This statistics are reported for exports (oil output), imports, domestic non-oil output, real balances, inflation, and the real exchange rate. To compute the model's predictions, we use stochastic simulations with shocks generated using the standard deviations from Table 1, and imposing independence across the different types of shocks. The calculated statistics, both for the model and the data, are for HP-filtred series, except for the inflation rate.

In the data, exports, imports, real balances, and the real exchange rate are very highly volatile, having a standard deviations above 8%, while domestic non-oil production and inflation are relatively volatile (but still highly volatile compared to what observed in the Canadian economy, for example). The model slightly overpredicts the volatility of output in the oil (exports) and non-oil sectors, as their standard deviations exceed those in the data. The model, however, slightly underpredicts standard deviations of imports, inflation, and the real exchange rate, and reproduces little volatility of real balances. Overall, the model succeeds in reproducing the unconditional second moments of the key variables in the model.

Similarly, in the data all variables exhibit high persistence, as their AR(1) coefficients are all above 0.70. The model reproduces very well the unconditional autocorrelations, except for domestic non-oil output and inflation. For these variables, the model, however, generates only small autocorrelation coefficients. This may

[18]These statistics are calculated for the period 1992:1 to 2003:4.

reflect the fact that these variables are less affected by the exogenous shocks and because money growth is negatively autocorrelated.

4.2 The dynamic response of the economy to exogenous shocks

This section evaluates the model's performance using impulse response functions to a 1% transitory shock to the euro appreciation, oil prices, devaluationary policy, and money supply. The first three shocks are shocks to the terms of trade. We perform the impulse responses of exports, imports, risk-premium term, foreign debt, current account, the real exchange rate, non-oil production, import inflation, and CPI inflation. Each response is expressed as the percentage deviation of a variable from its steady-state level.

Figure 1 plots the impulse responses to a 1% positive euro -appreciation shock (an exogenous appreciation of the euro driven by an increase in ξ_t by 1%). This shock is interpreted as exchange rate movements driven by non-fundamentals (speculative forces). It deteriorates the country's terms of trade. Thus, by performing this analysis, we quantitatively study the dynamic effects of the recent appreciations of the euro on the Algerian economy. As expected by the economic theory, such a shock persistently depreciates the home currency and decrease the terms of trade. These two effects entail a decline of the home country's export earnings and an increase in the marginal costs of imports. Consequently, the imported goods prices increase and imports become more expensive. The euro appreciation also leads the an increase in the valuation of the external debts, denominated in the euro , in terms of the Algerian dinar and the U.S. dollar. Thus, if oil prices or exports remain unchanged, the home country must borrow from abroad, by selling further foreign bonds, to finance its external debt services and its import purchase. But, the increase in the borrowed funds reduces the price of the foreign bonds that the country supplies in the international financial markets, for the increase of risk premium.

With higher risk premium, the country allocates a bigger portion of its newly borrowed funds to pay back the interest payments on its external debt. The simulation results show that the country's foreign debts significantly increase by 5% at the fourth quarter after the shock. This jump in the foreign debts is explained by the increase in the valuation and the interest payments (because the country is facing higher interest rate due to the increase in its country-specific risk-premium terms).

Therefore, the deterioration of the home current account by 0.75% after a euro-appreciation shock is mainly driven by the increase in the valuation of the external debts in terms of the Algerian and the U.S. dollar, the decline in the export revenues, by the jump in the foreign debt services, and by the increase in the imported-goods invoice. Similarly, the decline in the export revenues and the depreciation of the home currency reduce the home agents' demand of foreign goods, which leads to a decline of imports and to increases in IPI and CPI inflation rates. Nevertheless, production in the non-oil sectors significantly jumps up on the impact of the euro-appreciation shock due to the fact that home agents increase their demand of home goods that are relatively cheaper than the imported goods. Thus, even though an exogenous appreciation of the euro highly deteriorates the home country's current account, it improves production in both domestic oil and non-oil sectors.

Now, we investigate macroeconomic effects of a shock to the oil prices, $\tilde{p}_{xt}$. Figure 2 plots the impulse responses to a 1% positive oil-price shock (an increase in the oil price in the world market by 1%). Fluctuations in oil prices in the world markets are the main source of business cycles of oil-exporting countries. An increase in oil prices raises the oil-exporting country's revenues in the U.S. dollar. Figure 2 shows that a positive oil-price shock leads to an instantaneous appreciation of the home currency (the Algerian dinar) because the home country's reserves in foreign currencies have significantly increased. As export revenues jump up and the home currency appreciates, the country current account entails a significant instantaneous surplus. The country optimally uses a portion of this surplus to pay back some of its foreign debt, which leads to a gradual decline in the foreign debt and to a lower country-specific risk-premium terms. What, in turn, reduces the interest rate that the home county is facing in the international financial market. Thus, the decline in the foreign debt and a lower interest rate significantly reduce the foreign debt service, what leads to a further improvement in the current account even at few quarters after the shocks.

The oil-exporting country is richer after a positive oil-price shock and the imported goods are cheaper after the appreciation of the home currency. Therefore, the home country's demand of foreign goods (imports) increases faster and production in the domestic non-oil sector falls, reflecting that home agents substitute the home goods by the imported goods even though consumption and investment increase (expenditure-switching effect). The appreciation of the home currency reduces the importer and consumer prices, what implies a decline in the IPI and CPI inflation rates. The adjustment in the price levels lasts for many quarters because domestic and imported goods prices are rigid.

We now return to investigate whether the monetary authority is able to isolate the economy from exogenous euro-appreciation shock using its devaluationary and/or monetary policies. In theory, the monetary authority should react to neutralize the effects of non-fundamental exchange rate movements. The monetary authority, therefore, optimally reallocates the resource in the economy. We simulate the responses of the economy to devaluationary policy and money supply shocks. Figure 3 displays the impulse responses to a devaluationary shock (an increase in χ_t by 1%). This shock decreases (devaluates) the value Algerian dinar in terms of the U.S. dollar (the price of the U.S. dollar is higher). This shock slightly appreciates the real exchange rate upon impact. This appreciation and the exogenous devaluation of the Algerian dinar (the jump of χ_t) lead to an improvement in the terms of trade, which, in turn, increases the value of exports and generates a surplus in the current account.[19] Furthermore, after a devaluationary shock, the foreign debt and the risk-premium terms gradually decrease, while imports gradually increase. Consequently, the current account shows a surplus in the short term, but a deficit in the medium term. This shock, however, has very small effects on non-oil output and IPI and CPI inflation, as their collapses are very small in the short term.

In this model, domestic- and imported-goods prices are rigid. Money, therefore, is not neutral in the short term. The monetary authority may intervene to offset the negative impacts of exogenous shocks by managing the money supply in the economy. Figure 4 plots the impulse responses to a 1% money supply shock (an increase in money supply rate, μ_t, by 1%): an expansionary shock that increases the domestic aggregate demand. Following a positive monetary shocks, output in both sectors, imports, CPI inflation, foreign debt, and the risk-premium terms jump above their steady-state values. The positive responses of output and CPI last for only one or two quarters. The real exchange rate depreciates after a monetary policy shock because of the increase in the domestic price levels driven by inflation expectations. Imports positively respond upon impact to this shock before becoming negative, reflecting the fact that the depreciation of the exchange rate increase the marginal

[19] The recent depreciation of the US dollar relative to all main world currencies aims to increase the value of the US exports and, therefore, reduce the huge US currant account deficit.

cost of importing from abroad. Overall, a positive monetary policy shock leads to a significant surplus of the current account due to the instantaneous increase in domestic output and the lagged decrease in imports.

Thus, the simulation results indicate that monetary authority is able to insolate the economic activity from exogenous euro -appreciation shocks by conducting expansionary devaluationary and monetary policies. Furthermore, the country can reduce the effects of the euro-appreciation shocks by simply diversifies the provenance of its imports and external borrowing.

Figure 5 summarizes the model's predictions concerning the effects of an euro-appreciation shock on the nominal exchange rate and on import and consumer prices (the PPI and CPI prices). In response to this shock, the nominal exchange rate slightly overshoots (its short-terms response is quietly greater than its long-term response) and its the maximum response occurs immediately upon impact. Import prices, however, gradually increases in response to an euro-appreciation shock, because of import-price rigidity. In the long-term, import prices increase by about 4% after a 1% euro-appreciation shock. In contrast, the increases in the consumer prices are gradual and modest. The increases in import and consumer prices are gradual because, in this model, we deviate from the low of one price (PPP) by imposing price rigidity in the import sector.

5. Conclusion

We have developed a New-Keynesian DSGE model of a small open oil-exporting economy. The model is based on microfoundations and includes domestic- and imported goods price rigidities. An oil-exporting country export exclusively oil at a price set in the U.S. dollar in the world market, but borrows funds and imports goods in the euros. The country also pegs its currency to the U.S. dollar. The model is calibrated to the Algerian economy to investigate the dynamic effects of the recent appreciations of the euro relative to the U.S. dollar.

The simulation results show that an exogenous euro appreciation affects negatively the home country's terms of trade, which in turn, deteriorates the current account. This shock also increases the external debt burden, as the foreign debt valuation and the risk-premium terms rise. The depreciation of the home currency increases the cost of imports, so the homes agents substitute domestically produced goods for imported goods. Hence, imports jump down after a euro-appreciation shock, while domestic non-oil production increases.

On the other hand, positive oil-price shocks, by increasing the terms of trade and export earnings, offset the major negative effects of euro-appreciation shocks. The impacts of the euro movements is largely reduced by the parallel increase in the oil prices and by the decline of the world interest rates observed since 2001. An oil-exporting country can easily minimize the negative effects of euro-appreciation shocks by simply issuing foreign bonds denominated in the U.S. dollar and diversifies the provenance of its imports. Further, the monetary authority can intervene to isolate the economy from these exogenous shocks.

References

Ambler, S., A. Dib, and N. Rebei, 2003. Nominal Rigidities and Exchange Rate Pass-Through in a Stuructural Model of a Small Open Economy. Bank of Canada Woking Paper No. 2003-29.

Bailliu, J., A. Dib, and L. Schembri, 2004. Multilateral Adjustment and the Canadian Dollar. In *Canada in the Global*. Proceedings of a conference held by the Bank of Canada, November 2004. Forthcoming

Bergin, P. R., 2003. Putting the "New Open Economy Macroeconomics" to a Test. Journal of International Economics 60, 3–34. Expectations. Econometrica 48, 1305–11.

Bernanke, B. M. Gertler, and S. Gilchrist, 2000. The Financial Accelerator in a Quantitative Business Cycle Framework. in J. E. Taylor and M. Woodford (Eds). Handbook of Macroeconomics. North Holland.

Blanchard, J.-O., and Kahn, C.M., 1980. The Solution of Linear Difference Models under Rational Expectations. Econometrica 48, 1305–11.

Calvo, G. A., 1983. Staggered Prices in a Utility-Maximizing Framework. Journal of Monetary Economics 12, 383–98.

Christiano, L.J., Eichenbaum, M., and Evans, C., 2005. Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. Journal of Political Economy 113, 2-45.

Devereux, M., and J. Yetman, 2003. Price Setting and Exchange Rate Pass-Through: Theory and Evidence. In *Price Adjustment and Monetary Policy.* Proceedings of a conference held by the Bank of Canada, November 2002.. Journal of Political Economy, forthcoming.

Dib, A., 2003. An Estimated Canadian DSGE Model with Nominal and Real Rigidities. Canadian Journal of Economics 36, 949–72.

Dib, A., 2003. Monetary Policy in Estimated Models of Small Open and Closed Economies. Bank of Canada Woking Paper No. 2003-27.

Kolmann, R., 2001. The Exchange Rate in a Dynamic-Optimizing Business Cycles Model with Nominal Rigidities: A Quantitative Investigation. Journal of International Economics 55, 243–62.

Mendoza, E. G., 1991. Real Business Cycles in a Small Open Economy. American Economic Review 81, 797–818.

Rapports annuels de la Banque d'Algrie 2003. Chapitre III: Convertibilité, balance des paiements et dette exterieure. `http://www.bank-of-algeria.dz/communicat3.htm.`

Tille, C., 2003. The Impact of Exchange Rate Movements on U.S. Foreign Debt. Federal Reserve Bank of New York Current Issues 9, 1-8.

Table 1: Autocorrelations and standard deviations of the stochastic processes: OLS estimations using quarterly data for the period 1992:1 to 2003:4.

Autocorrelations		Standard deviations	
ρ_ξ	0.78	σ_ξ	0.072
ρ_χ	0.76	σ_χ	0.057
ρ_{px}	0.81	σ_{px}	0.110
ρ_μ	-0.48	σ_μ	0.024
ρ_{R^*}	0.96	σ_{R^*}	0.001
ρ_A	0.71	σ_A	0.015
ρ_L	0.92	σ_L	0.028

Table 2: Volatility and autocorrelations: In the data and in the model: 1992:1 to 2003:4

	Volatility		Self-correlation	
Variables	Data	Model	Data	Model
y_{xt}	18.8	26.1	0.88	0.96
y_{ft}	8.3	6.1	0.86	0.92
y_{dt}	2.5	5.7	0.69	0.45
m_t	8.1	4.2	0.81	0.83
π_t	3.1	2.2	0.71	0.53
s_t	9.4	7.6	0.72	0.75

Figure 1: The effects of euro-appreciation shocks (to ξ_t)

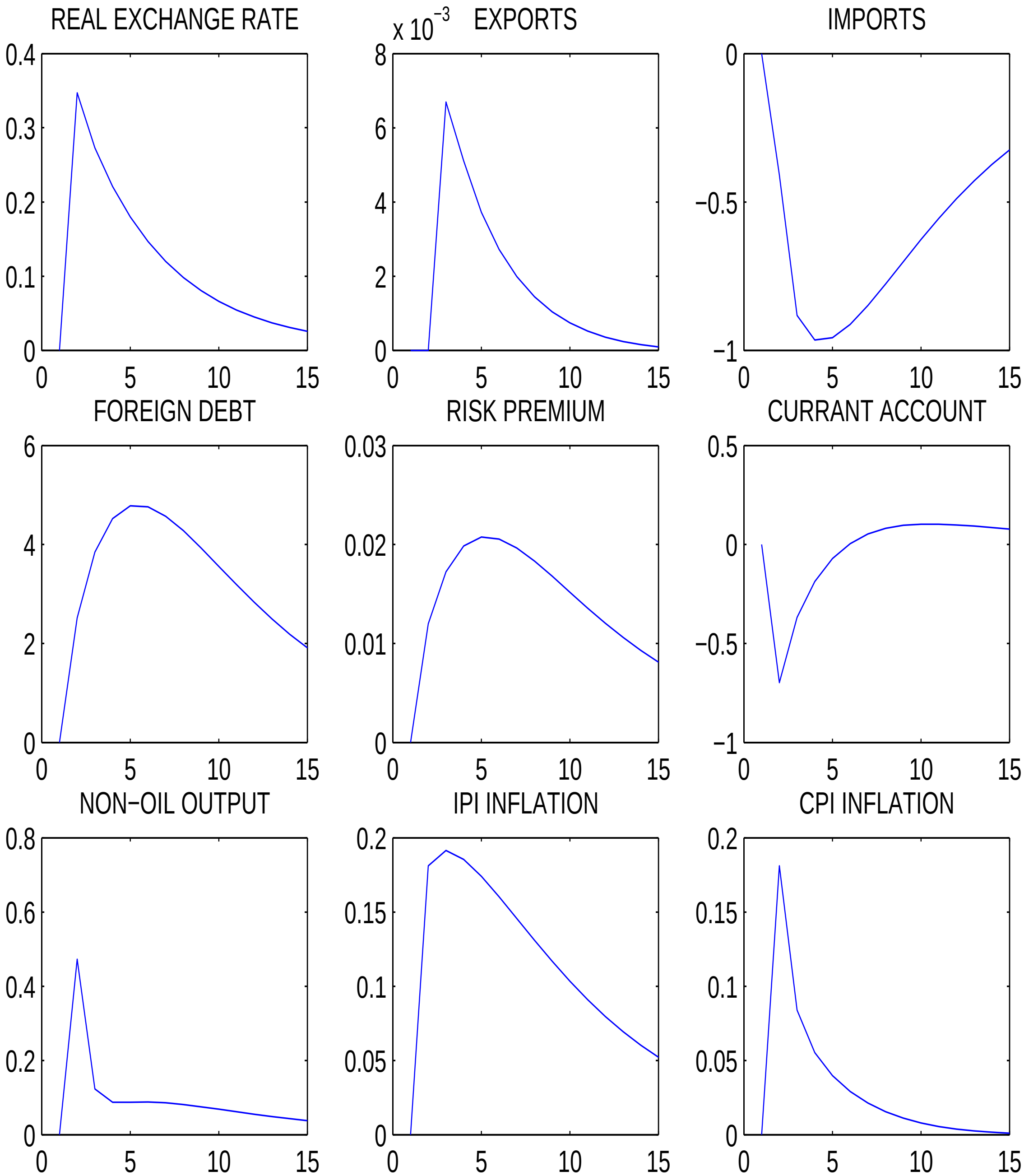


Figure 2: The effects of oil-price shocks (to $\tilde{p}_{xt}$)

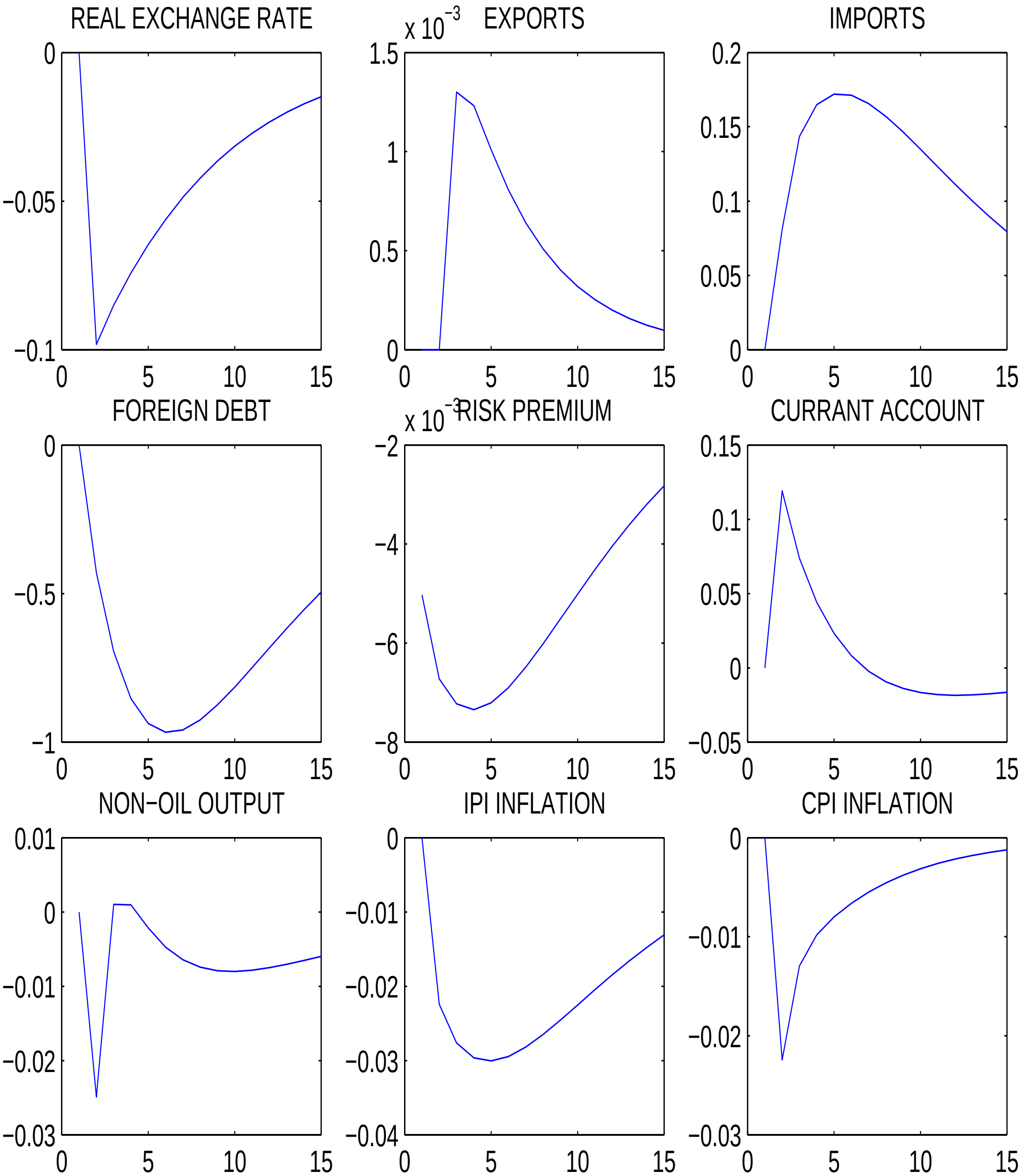


Figure 3: The effects of devaluationary policy shocks (to χ_t)

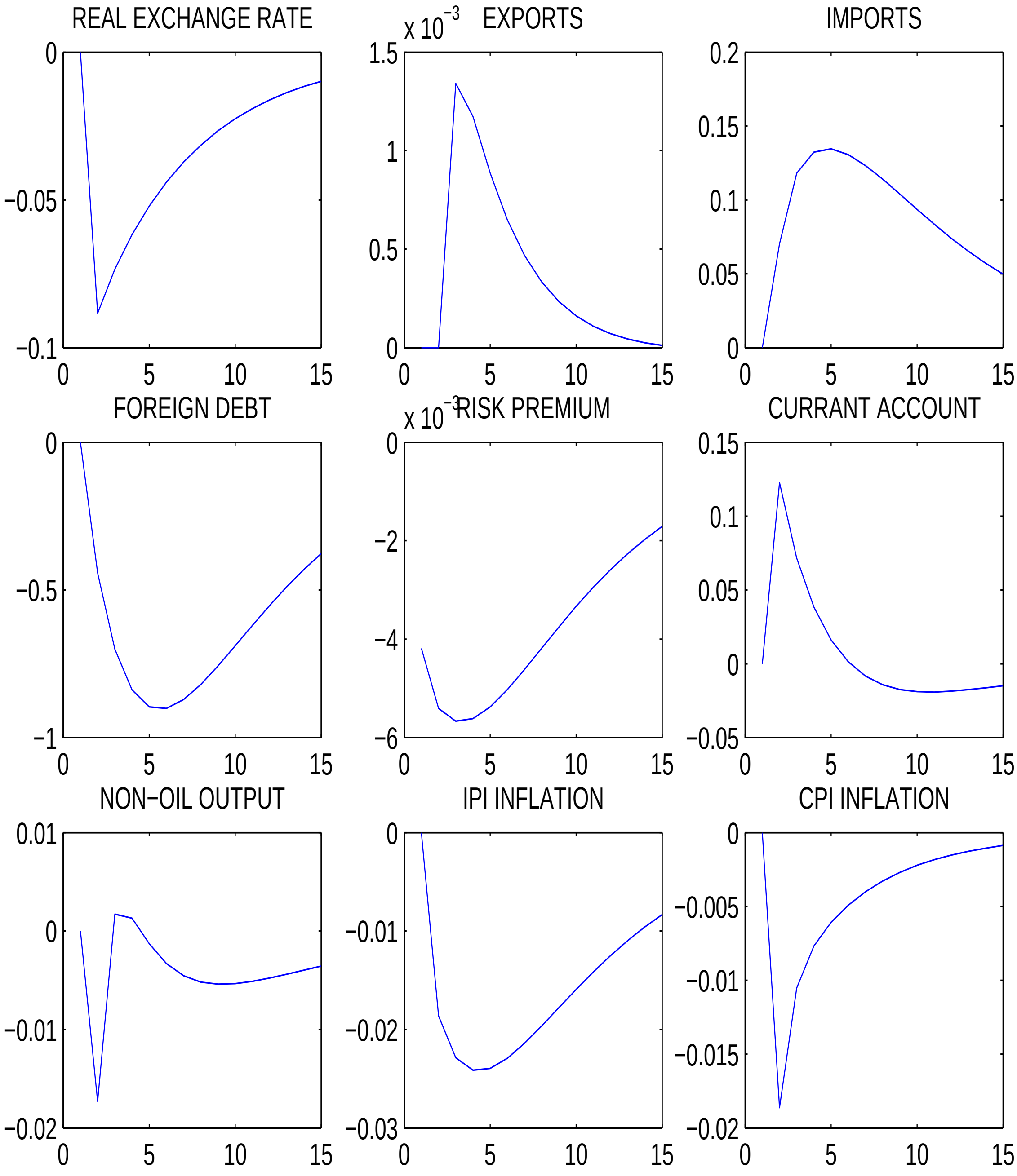


Figure 4: The effects of money supply shocks (to μ_t)

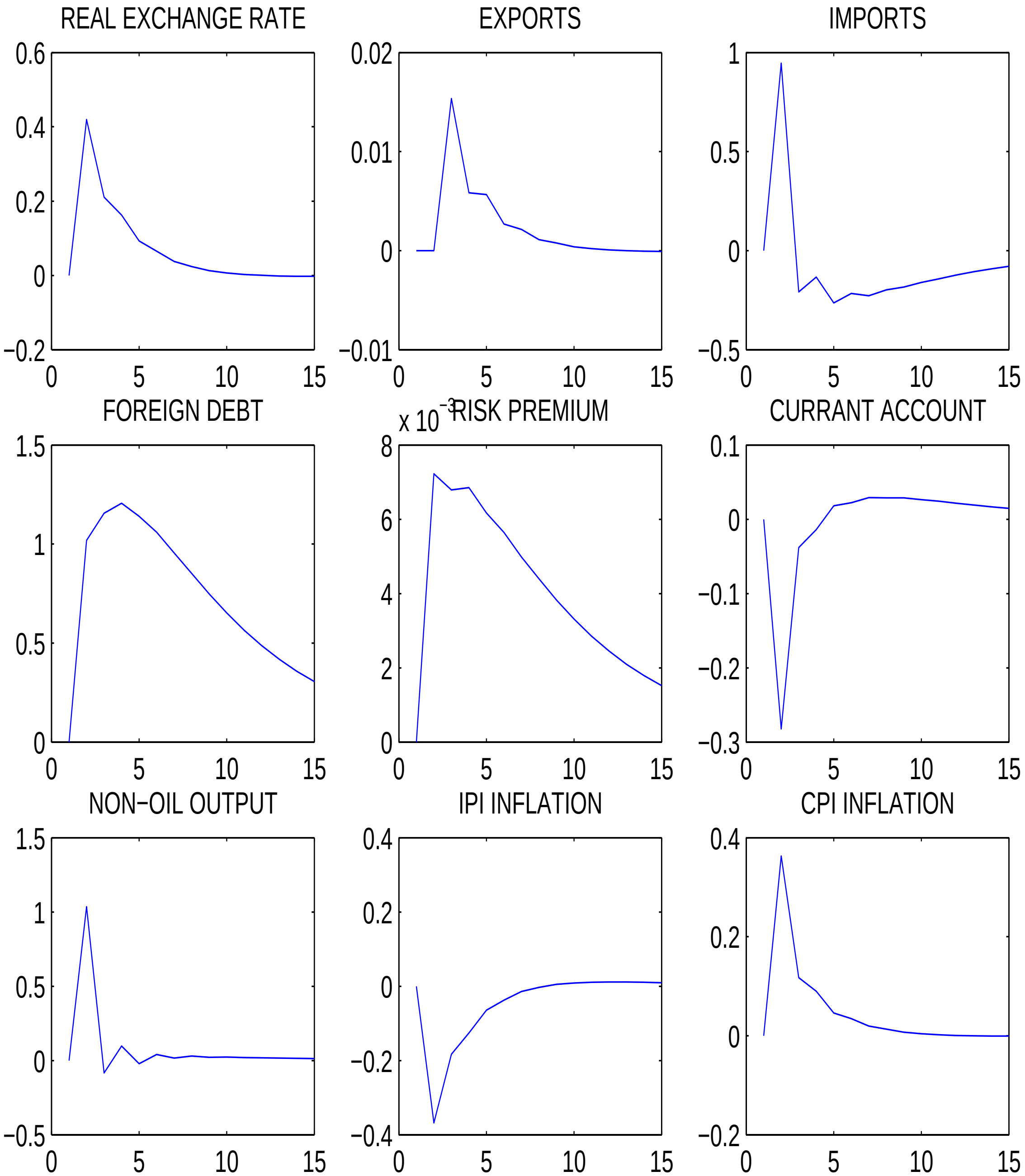
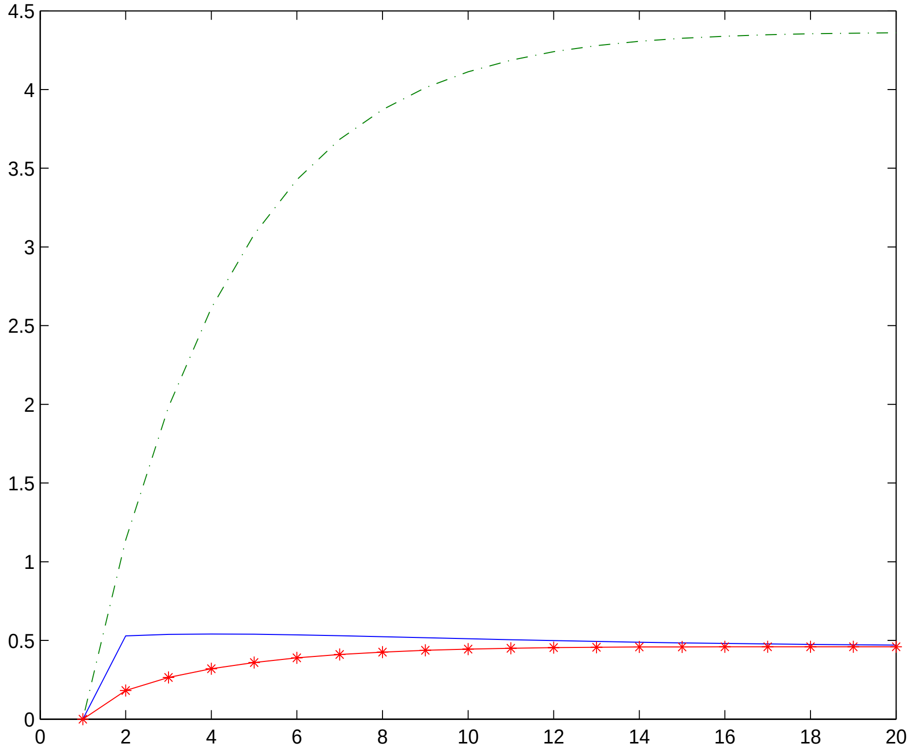


Figure 5: Pass-through of euro-appreciation shocks (to ξ_t)



Notes: Solid, dash, and asterisk lines respectively denote the Nominal exchange rate, import (IPI), and consumer (CPI) prices.