



Inflation Targeting and Economic Performance: Application of the New Keynesian Small Open Economy DSGE

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ABSTRACT

Bank Al-Maghrib aim to adopt the inflation targeting regime to keep pace with changes in the monetary policy environment. The challenge for the central bank is to meet the prerequisites of inflation targeting to ensure the anchoring of expectations, and thus achieve the inflation target and real stability. The objective of this paper is to propose an optimal model for Morocco's successful transition to inflation targeting. To do so, we build a New Keynesian Small Open Economy DSGE model, characterized by financial frictions, imperfect exchange rate pass-through, unemployment, fiscal rule and new shocks. The results of our simulations lead us to assert that it would be wise to choose the most complete model, since it provides credibility, stability and growth.

Keywords: anchoring expectations, inflation targeting, economic growth, DSGE, financial frictions.

INTRODUCTION

Moroccan monetary policy suffers from four main problems, namely central bank autonomy, the transition to a flexible exchange rate regime, monetary policy transmission, and financial stability. These monetary problems coincide with the preconditions of inflation targeting regime. So trying to solve them is implicitly meeting the precondition.

Inflation targeting policy is based on the ability of the monetary authorities to forecast inflation dynamics using sufficiently powerful econometric models and to take into account the macroeconomic variables that may influence the expectations of economic agents. Monetary DSGE models are widely used because they fit the data well and can be used to address important policy issues.

In this paper, we propose to empirically study the different trade-offs of inflation targeting models in Morocco, in order to determine which model is likely to succeed in the eventual transition to this new regime.

To do so, we will first present a review of the literature, and then we will construct a New Keynesian Small Open Economy DSGE model, where the canonical representation is similar to that of the closed economy, including a New Keynesian Phillips curve, a dynamic IS equation and an interest rate rule. The natural levels of output and the real rate are a function of both foreign and domestic shocks. As for monetary policy, it consists of fully stabilizing domestic inflation while taking into account exchange rate developments, financial and fiscal stability [1].

DSGE MODEL AND MONETARY POLICY: A REVIEW OF THE LITERATURE

We will identify articles that have addressed the issue of monetary policy in general or one of the conditions of inflation targeting using the DSGE model for the Moroccan economy.

Said, Aziz, and Zakaria [2] investigate the choice of the optimal monetary rule for the Moroccan economy. Comparing the standard Taylor rule and the Taylor rule with an exchange rate regime, they found that exchange rate targeting, in addition to inflation, stabilizes the macroeconomic framework. The monetary policy rule proposed by these authors is intermediate exchange rate targeting.

After a historical presentation of DSGE models, Mossadak [3] explained the theoretical and empirical foundations of Keynesian modeling with market rigidity while performing Bayesian estimation of monetary policy. He found that an increase in the interest rate results in an immediate decrease in macroeconomic variables. While a positive demand shock pushes up inflation and the interest rate, but this impact is cancelled out after 6 quarters.

In another work, Mossadak [4] analyzed the impact of the interaction between monetary and fiscal policy on inflation and output. He found that the fiscal shock is more dangerous than the monetary shock since its duration is longer. Moreover, a positive shock to government spending leads to an increase in the output gap, inflation and the interest rate, while a monetary shock has the opposite effect on these variables. However, both shocks lead to a decrease in consumption and investment.

Zakaria [5] addressed the issue of the financial friction mechanism, given the importance of the credit market in financing investment. He found that the Taylor rule augmented with asset prices provides macroeconomic stability, even though the credit market suffers from imperfections that amplify the impact of shocks.

The informal sector was introduced to the DSGE model by Ait Lahcen [6]. The estimation results suggest a relatively small role for price rigidities in the non-tradable goods sector. This also implies a much more aggressive response of the central bank to inflationary pressures than to output and exchange rate fluctuations. The study of Bayesian functions showed that the informal sector absorbs the productivity shock but not the interest rate or foreign demand shock. We note that the exchange rate regime specified in this model is a fixed exchange rate regime.

After the explicit announcement of the monetary authorities of their eventual adoption of a more flexible exchange rate regime, Loukili and Echcharfi [7] have addressed the impact of this transition on the independence of the central bank. By distinguishing between the administered exchange rate rule and the pure exchange rate rule, and after estimating a neo-Keynesian small-scale model, the authors showed that the floating exchange rate leads to very negative results on central bank autonomy.

In a Bank Al-Maghrib working paper, Bennouna et al [8] analyzed the transmission channels of monetary policy. After a graphical analysis of the economy, the authors estimated two models SVAR and NKM to measure the magnitude of the shocks. The results of their study show that the transmission is negatively influenced by a relatively low rate of bancarization, a high rate

of non-performing loans, and a low number of listed firms. However, projects on participatory finance, Casa Finance City, and financial inclusion could improve the transmission of monetary decisions, especially through credit and interest rate channels.

Lakhchen and Laoui[9] draw on the previous paper to criticize the use of the standard New Keynesian model in the study of the Moroccan economy, since the standard Taylor rule does not reflect the characteristics of the interest rate. In contrast, the augmented Taylor rule replicates inflation and output data.

THEORETICAL CONSTRUCTION OF THE NEW KEYNESIAN MODEL FOR THE OPEN ECONOMY

This model allows us to take into account the empirical dynamics of the main macroeconomic aggregates and to perform policy simulations.

In this section, we present a New Keynesian model for a small open economy. This model incorporates a basic neo-Keynesian model, the rest of the world and financial frictions.

In an open-economy environment, the policy problem is more complex, because domestic price fluctuations are linked to fluctuations in exchange rates and terms of trade. An economy is said to be small if it does not affect international prices and interest rates.

This model introduces additional nominal rigidities not present in the basic model, such as staggered wage contracts and price and wage indexation. The real frictions that encapsulate the notion of the financial friction are introduced by capital accumulation as well as investment adjustment costs and variable capital utilization. Household preferences are modeled with habit formation in consumption [10].

This model is composed of households, firms, capital producers, entrepreneurs, monetary and fiscal authorities, and the rest of the world. In the following developments, we have drawn mainly on the work of Gali & Monacelli [11], Adolfson & al [12], and Christiano & al [13].

Households

The utility function of a representative household is: $E_0 \sum_{t=0}^{\infty} \beta^t \exp g_t \left(\frac{C_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{\gamma}{1+\sigma} L_t^{1+\sigma} \right)$

With C: aggregate consumption, L: employment and g the domestic demand shock.

Under duress: $\frac{W_t}{P_t} L_t + \frac{B_{t-1}}{P_t} + \frac{T_t}{P_t} - C_t - \frac{B_t}{R_t P_t}$

Where B: bonds, R: nominal interest rate; W: nominal wage; and T: lump-sum net transfers from government.

In this case, households face two problems: static and dynamic. It is assumed that one part of households is Ricardian, i.e. maximizes its expected lifetime utility from consumption and leisure, and has access to financial markets to smooth its consumption over time. While the other party is non-Ricardian.

Static problem

Consumption is composed of domestic (H) and foreign (F) goods: $C_t = \left((1 - \alpha)^{\frac{1}{\eta}} (C_H)^{1 - \frac{1}{\eta}} + (\alpha)^{\frac{1}{\eta}} (C_F)^{1 - \frac{1}{\eta}} \right)^{\frac{\eta}{\eta - 1}}$

Where α is the share of imported goods in the consumption basket and η is the elasticity of substitution between goods H and F.

Optimal consumption is a mixture of domestic and foreign goods. Thus the price paid by households can be written as : $P_t = \left((1 - \alpha)(P_H)^{1 - \eta} + \alpha(P_F)^{1 - \eta} \right)^{\frac{1}{1 - \eta}}$

We assume a pass-through of foreign prices : $P_F = e_t P_t^*$. Where e is the nominal exchange rate, P^* is the price of foreign goods.

Knowing that the real exchange rate is : $RER_t = \frac{e_t P_t^*}{P_t}$, the price equation becomes : $1 = (1 - \alpha) \left(\frac{P_H}{P_t} \right)^{1 - \eta} + \alpha RER_t^{1 - \eta}$

Dynamic problem

To address this problem, we incorporate two marginal rates of substitution:

The marginal rate of substitution between future consumption and current consumption, we

obtain the following utility function: $\beta E_t \left(\frac{\exp g_{t+1}}{\exp g_t} \right) \left(\frac{C_{t+1}}{C_t} \right)^{-\frac{1}{\sigma}} \left(\frac{P_t}{P_{t+1}} \right) R_t = 1$

The marginal rate of substitution between leisure and labor that is equal to the real wage:

$$\gamma L^\sigma C_t^{\frac{1}{\sigma}} = \frac{W_t}{P_t}$$

Companies

Firms face two problems: the production of local goods and the management of the risk of the opening of the country.

Intermediate goods companies

The producers are a continuum ($z \in [0, 1]$), with monopolistic power. The production function is given by: $Y_{Ht}(z) = A_t(z) L_t(z)$

To solve this function, firms must minimize cost and maximize profit. Under the producer subsidy assumption, the conditional cost or labor demand function is : $(1 - \tau) W_t \frac{Y_{Ht}}{A_t}$. The real

marginal costs deflated by the consumer price index are then given by : $MC_t = \frac{(1 - \tau) W_t}{A_t}$.

Producers maximize their profit by choosing the price at Calvo that maximizes the following function: $\max P_{Ht}(z) Y_{Ht}(z) - \text{coût}(z)$. This implies that : $Y_t(z) = \left(\frac{P_t(z)}{P_{Ht+i}} \right)^{-\varepsilon} Y_t$.

Resellers

Sell the final product produced by the intermediate goods firms. Therefore, they have an input minimization problem: $\min \int P_{Ht}(z)Y_{Ht}(z) dz$ which implies that : $Y_t = \left(\int_0^1 Y_{Ht}^{1-\frac{1}{\varepsilon}}(z)dz \right)^{\frac{\varepsilon}{\varepsilon-1}}$

and $P_{Ht} = \left(\int_0^1 P_{Ht}^{1-\varepsilon}(z)dz \right)^{\frac{1}{1-\varepsilon}}$.

Where $\varepsilon > 1$ denotes the elasticity of substitution between different types of domestic products. The demand for these goods is both local C_{Ht} as well as foreign (the rest of the world) C_{Ht}^* : $Y_t = C_{Ht} + C_{Ht}^*$.

Capital producers

It is a continuum of perfectly competitive producers. They buy investment goods and use them as inputs to produce new capital that can be sold to entrepreneurs in period $t+1$.

To optimize the loss function and maximize profits, the total amount of capital purchased by producers must equal the total undepreciated capital stock of the economy, which implies that the available capital is equal to : $K_{t+1} = (1 - \delta)K_t + \varepsilon_t(1 - \chi\left(\frac{l_t}{l_{t-1}}\right))l_t$.

l_t is the gross investment, X is the adjustment cost function, ε_t is the marginal efficiency shock to investment that affects the way investment is transformed into capital.

The function for maximizing the present value of future profits is given by : $\max E_t \sum_{\tau=0}^{\infty} \beta^{\tau} \Lambda_{t+\tau} \Pi_{t+\tau}^K$.

With Π_t^K are the profits of the capital producer during the period : $\Pi_t^K = Q_t P_t \left((1 - \delta)K_t + \varepsilon_t \left(1 - \chi \left(\frac{l_t}{l_{t-1}} \right) l_t \right) - K_t \right) - P_t l_t$.

Q_t is the real price of capital, $\Lambda_{t+\tau}$ is the marginal utility of income.

The first order condition to this problem gives the investment demand equation : $\left(1 - \chi \left(\frac{l_t}{l_{t-1}} \right) \right) \varepsilon_t Q_t + \beta E_t \left(\{Q_{t+1} \varepsilon_{t+1}\}^{\frac{\Lambda_{c,t+1}}{\Lambda_{c,t}}} \chi' \left(\frac{l_{t+1}}{l_t} \right) \left(\frac{l_{t+1}^2}{l_t^2} \right) \right)$.

Monetary Authority

The monetary rule is this time augmented by the real exchange rate e : $i_t = \rho i_{t-1} + \alpha(1 - \rho)\pi_t + \beta(1 - \rho)y_t + \partial \Delta e_t + \varepsilon_t^z$.

Tax rule

Government expenditures are financed by lump-sum taxes on Ricardian consumers, and evolve exogenously according to needs [14]. The budget is assumed to be balanced each period. The government thus faces the following budget constraint: $\frac{T}{Y} \tau_t + (1 - \chi) \frac{Y_{co}}{Y} (p_{co,t}^* - p_t^* + rer_t + y_{co,t}) + b_t^g = \frac{1}{\beta} b_{t-1}^g + \frac{G}{Y} (p_{H,t} - p_t + g_t)$

Solving this constraint gives us the following tax equation:
$$\frac{T}{Y}\tau_t + (1 - \chi)\frac{Y_{co}}{Y}(p_{co,t}^* - p_t^* + rer_t + y_{co,t}) = \phi_b b_{t-1}^g + \phi_g \frac{G}{Y}(p_{H,t} - p_t + g_t)$$

Risk of the international opening

In a small closed economy and incomplete international financial markets, the interest parity condition and the economy's net international investment position will be needed to describe the equilibrium.

The imperfect financial integration equation that also determines a condition for the real exchange rate: $i_t - E_t[\pi_{t+1}] = i_t^* - E_t[\pi_{t+1}^*] + E_t[rer_{t+1} - rer_t] + \zeta b_t^*$. With $b_t^* = \frac{1+\zeta}{\beta} b_{t-1}^* + a_1 her_t + a_2 y_t + a_3 y_t^* + a_4 (i_t^* - \pi_t^*)$.

i_t^* is the foreign interest rate, π_t^* foreign inflation rate, b_t^* is the net external liability relative to the rest of the world, ζ is the elasticity of the sovereign spread on external debt (it is necessary to include a sovereign spread sensitive to the accumulation of net external assets to obtain a stationary solution).

Financial market integration

The behavior of entrepreneurs is modeled as a BGG financial friction mechanism [15]. In this framework, financial frictions reflect the situation in which borrowers and lenders are heterogeneous agents, possessing different information, hence the risk of financial contract violations. Therefore, the model includes entrepreneurs who own and manage the capital stock QK, financed by both internal and external (i.e. borrowed) funds, via a contract that takes into account a premium over the opportunity cost of funds.

At the end of period t , each entrepreneur has a net worth equal to N . After investing in new capital, each entrepreneur receives a return on capital equal to ω QKRK. With ω is an idiosyncratic productivity parameter or shock.

Entrepreneurs combine their funds with unconditional debt (bank or bond debt) to buy new capital. The actual loan for this purpose is: $B = QK - N$. The entrepreneur commits to repay $RLB = RL(QK - N)$ before the idiosyncratic shock occurs. Financial intermediaries are assumed to be competitive.

As already announced, foreign currency denominated debt is also included in the model. The presence of foreign currency debt allows the model to take into account the effects of exchange rate depreciation triggered by external shocks on the economy, through the balance sheets of entrepreneurs.

Once entrepreneurs have settled their debt to the lender in period $t+1$ and the capital has been sold back to capital producers, the net worth of entrepreneurs in period $t+1$ is determined. At this point, entrepreneurs exit the economy with probability, $1 - \gamma$, and survive to continue another period. γ_{t+1} and survive to continue another period of activity with probability γ_t . Each period, new entrepreneurs enter in sufficient numbers to keep the population of entrepreneurs constant. New entrepreneurs entering in period $t+1$ receive a net start-up capital transfer W .

This process of entry and exit prevents entrepreneurs from accumulating enough net worth to escape financial frictions. Therefore, the overall net worth in $t+1$ is: $N_{t+1} = \gamma_t V_t + W$. With V_t the gross revenues of active entrepreneurs during the period minus their total payments to lenders.

By including financial frictions in the model we add the survival shock of entrepreneurs.

Model

Below is the NK model for an open economy with financial frictions and incomplete pass-through. All variables are in log-deviation from their respective values in steady state. The shocks follow an AR process.

$$\begin{aligned} y_t &= \frac{Y_H}{Y} y_{H,t} + \frac{Y_{co}}{Y} y_{co,t} \\ \pi_{F,t} &= \frac{\beta}{1 + \beta\chi_F} E_t[\pi_{F,t+1}] + \frac{\chi_F}{1 + \beta\chi_F} \pi_{F,t-1} + \frac{(1 - \theta_F)(1 - \beta\theta_F)}{\theta_F(1 + \beta\chi_F)} (e_t + p_t^* - p_{F,t}) \\ \pi_{H,t} &= \frac{\beta}{1 + \beta\chi_H} E_t[\pi_{H,t+1}] + \frac{\chi_H\beta}{1 + \beta\chi_H} \pi_{H,t-1} + \frac{(1 - \theta_H)(1 - \beta\theta_H)}{\theta_H(1 + \beta\chi_H)} (mc_t - p_{H,t} - p_t) \\ \pi_t^w &= \chi_w \pi_{t-1} + \frac{(1 - \theta_w)(1 - \beta\theta_w)}{\theta_w(1 + \varepsilon_w\sigma_L)} (mrs_t - rw_t) + \beta E_t[\pi_{t+1}^w - \chi_w \pi_t] \\ i_t &= \rho i_{t-1} + \alpha(1 - \rho)\pi_t + \beta(1 - \rho)y_t + \partial\Delta e_t + z_t. \\ i_t &= i_t^* + E_t[\Delta e_{t+1}] + \zeta b_t^* \\ \frac{T}{Y} \tau_t + (1 - \chi) \frac{Y_{co}}{Y} (p_{co,t}^* - p_t^* + rer_t + y_{co,t}) &= \phi_b b_{t-1}^g + \phi_g \frac{G}{Y} (p_{H,t} - p_t + g_t) \end{aligned}$$

The above equations are successively those of production, Phillips curve for F-goods, Phillips curve for H-goods, Phillips curve for the nominal wage, equation of the monetary authority, interest rate parity, external debt, and finally the fiscal equation. We note that we present the main equations of the model (IS, Phillips, monetary, fiscal), but in the estimation we add all the other equations that we have demonstrated before, namely the demand function for domestic goods, the substitution function between H and F goods, the foreign consumption function, the domestic demand function for imported goods, the export volume equation, the export deflator equation, the real exchange rate dynamics equation, the nominal devaluation equation, the foreign inflation equation, the PIC inflation equation, the relative price dynamics equation for H-goods, the balance of payments equation the equation for the relative price dynamics of goods F, the investment equation, the market basket price equation, the real GDP equation, the Euler equation for household consumption, the equation for entrepreneurial consumption, the equation for the spread between the return on capital and the opportunity cost of funds lent, the spread equation, the return on capital equation, the investment dynamics equation, the labor supply equation, the labor demand equation, the capital evolution equation, the entrepreneurs' net worth equation, the real wage evolution equation, and finally the budget constraint equation.

The model represents domestic shocks and foreign shocks. For the former, we consider consumption, productivity, monetary policy, commodity production and real interest rate shocks. For the second shocks, an exogenous process is considered for the foreign interest rate,

foreign inflation, international commodity price, foreign demand, spread shock and fiscal policy shock.

By convention, foreign country parameters are quoted as "***". mrs is labor supply. rw is labor demand. mc is marginal cost. y_{co} is commodity production (part of GDP is linked to natural resources). In total, this model includes 43 log-linearized equations in the stationary state.

Results and interpretations of the model estimation

To evaluate the open economy model, we will estimate nine models: Model 1.1: Model without financial parameters and fixed exchange rate regime. Model 1.2: Model without financial parameters and flexible exchange rate. Model 1.3: Model without financial parameters and floating exchange rate. Model 2.1: Model with financial parameters and fixed exchange rate regime. 2.2: Model with financial parameters and managed exchange rate regime. 2.3: Model with financial parameters and floating exchange rate regime. 3.1: Model with friction, fiscal rule and fixed exchange rate regime. 3.2: Model with friction, fiscal rule and managed exchange rate regime. 3.3: Model with friction, fiscal rule and flexible exchange rate regime.

For the monetary rule, we will keep throughout the Bayesian estimation the dual targeting of inflation and output with interest rate smoothing. The variable that we will increase is the exchange rate. In the managed exchange rate regime, the exchange rate variable will be removed from the Phillips equation, while in the floating exchange rate regime; the exchange rate variable will appear neither in the Phillips equation nor in the interest rate equation.

Evaluation of models

The Moroccan economy is characterized by an incomplete pass-through. To model it, we assume that importers selling F products on the domestic market face nominal rigidities, allowing them to adjust their prices. The probability of firm survival is set at 0.9728, which implies an expected working life of 36 years for entrepreneurs. We refer to the results of the SVAR modeling that appear in my PhD thesis, as well as to the values commonly adopted in the literature for the calibration. The confidence interval is 5% - 95%.

Table 1 : Bayesian estimation results for the nine models

Parameters	Prior	Posterior								
		Model 1.1	Model 1.2	Model 1.3	Model 2.1	Model 2.2	Model 2.3	Model 3.1	Model 3.2	Model 3.3
β	0.995	0.9952	0.9954	0.9944	0.9949	0.9952	0.9948	0.9944	0.9939	0.9948
$\frac{Y_H}{Y}$	0.88	0.9927	0.9970	0.9926	0.9788	0.9808	0.9807	0.9998	0.9980	0.9826
$\frac{G}{Y}$	0.180	0.1155	0.1129	0.1337	0.1292	0.1333	0.1319	0.1903	0.1767	0.2054
σ_L	10.000	9.9863	10.0005	9.9867	9.9901	10.0023	10.0118	10.0014	10.0085	10.0013
$\frac{Y_{co}}{Y}$	0.120	0.0073	0.0030	0.0074	0.0212	0.0192	0.0193	0.0002	0.0020	0.0174
$\frac{T}{Y}$	0.12	-	-	-	-	-	-	0.1902	0.1759	0.1995
χ	0.500	-	-	-	-	-	-	0.5345	0.6069	0.6636

ϕ_b	0.330	-	-	-	-	-	-	0.3217	0.3287	0.3115
ϕ_g	0.100	-	-	-	-	-	-	0.1014	0.1020	0.1005
ζ	0.001	0.0010	0.0010	0.0011	0.0010	0.0009	0.0010	0.0012	0.0012	0.0013
θ_H	0.750	0.6882	0.5979	0.5854	0.5169	0.5018	0.5305	0.4417	0.4602	0.4461
χ_H	0.500	0.4842	0.4909	0.4927	0.4853	0.4768	0.4848	0.4676	0.4664	0.4692
ε_L	6.000	0.0086	0.0034	0.0118	5.4086	3.9424	5.5554	5.0782	5.3368	5.6857
θ_F	0.660	0.7038	0.6969	0.6971	0.7024	0.7042	0.7043	0.6859	0.6826	0.6893
χ_F	0.500	0.5017	0.5012	0.5407	0.5155	0.5064	0.5089	0.5049	0.5028	0.4951
θ_w	0.813	0.6882	0.6892	0.7154	0.7300	0.6295	0.7122	0.7210	0.6940	0.7082
χ_w	1.000	1.0119	0.9931	0.9666	1.0101	1.0032	1.0074	1.0001	1.0021	1.0029
ρ_i	0.700	0.7007	0.8568	0.7251	0.7180	0.8006	0.7152	0.8256	0.7205	0.8334
ϕ_π	1.500	1.4780	1.4741	1.4789	1.5042	1.5226	1.5085	1.5072	1.4924	1.5118
ϕ_y	0.300	0.3332	0.2688	0.3351	0.3040	0.2867	0.2870	0.2821	0.2807	0.2838
∂	0.100	inf	0.0690	-	inf	0.0684	-	inf	0.0869	-
ρ_a	0.750	0.7788	0.7960	0.7890	0.9468	0.9456	0.9479	0.9301	0.9319	0.9194
ρ_g	0.750	0.7509	0.7888	0.7783	0.7673	0.7594	0.7646	0.7375	0.7241	0.7324
ρ_z	0.750	0.6344	0.6279	0.7415	0.5256	0.5075	0.5303	0.6573	0.6940	0.6492
ρ_{i*}	0.800	0.6551	0.6313	0.6356	0.6689	0.6847	0.6774	0.7827	0.8061	0.7694
$\rho_{\pi*}$	0.550	0.4807	0.4740	0.3966	0.4772	0.4582	0.5060	0.4519	0.5058	0.4774
ρ_{pco*}	0.900	0.9936	0.9935	0.9927	0.9932	0.9935	0.9935	0.9932	0.9936	0.9939
ρ_{yco}	0.900	0.9966	0.9964	0.9980	0.9955	0.9949	0.9956	0.9954	0.9952	0.9950
ρ_{y*}	0.700	0.9489	0.9454	0.9652	0.9670	0.9750	0.9754	0.8703	0.8658	0.8896
ρ_{sp}	0.700	-	-	-	0.4203	0.4366	0.4113	0.7008	0.7610	0.7014
ρ_{rer}	0.700	0.4452	0.4680	0.5575	0.4659	0.4241	0.4635	0.6036	0.6055	0.6724
σ_a	0.700	0.6994	0.6978	0.6469	0.8472	0.7013	0.8201	0.7037	0.7677	0.7022
σ_g	1.000	1.0037	0.9981	0.9899	1.0019	0.9992	0.9780	1.0005	1.0092	1.0005

σ_z	0.250	0.245 6	0.2470	0.205 5	0.220 4	0.2454	0.2002	0.2447	0.2170	0.2444
σ_{i*}	0.080	0.333 6	0.3812	0.326 5	0.362 7	0.3518	0.3546	0.3481	0.3501	0.3559
σ_{π^*}	0.130	0.137 6	0.1366	0.142 4	0.138 9	0.1415	0.1376	0.1367	0.1426	0.1377
σ_{pco^*}	0.900	1.080 0	1.0424	1.156 8	1.103 6	1.1117	1.0835	1.0997	1.0979	1.0708
σ_{yco}	0.400	0.959 4	0.9664	0.933 9	0.959 1	0.9675	0.9669	0.9555	0.9634	0.9570
σ_{y^*}	2.500	2.512 6	2.4760	2.474 8	2.494 3	2.4974	2.5070	2.4958	2.5016	2.5015
σ_{sp}	0.250	-	-	-	0.274 0	0.2707	0.2767	0.3062	0.3081	0.3029
σ_{rer}	1.000	0.977 6	1.0160	1.004 9	0.997 7	0.9959	0.9933	1.0003	1.0025	1.0035
$\frac{K}{N}$	2.000	1.969 5	2.0490	2.017 2	1.890 6	1.8673	1.8644	1.8516	1.8444	1.8754

After determining the calibration of the model, we need to validate the a priori and posterior distributions. From the figure in Appendix 1, we notice that the posterior distributions are slightly different from the a priori distributions, as well as the variances of the posteriors are lower than those of the priors, which means that our sample provides additional information to the model.

For the interpretation of the parameters of the Bayesian estimation, we have classified the main remarks into four categories. We will mainly focus on an economic interpretation of the parameters concerning the preconditions of inflation targeting.

Preferences of the monetary authority

From the parameter estimates, we notice a strong persistence of the nominal interest rate. It remains between 0.7 and 0.9.

The response of the interest rate to the change in inflation is stronger than the output weight in all models. This asserts the superiority of the inflation objective. The weight given to inflation is higher in models 2 and 3, which replicates the influence of the budget constraint on inflation. However, it should be noted that these values remain close to the values estimated in some emerging and developed economies¹.

The exchange rate coefficient in the policy rule remains lower than the inflation and output coefficients. It tends to increase when new parameters are introduced into the model, which means that the central bank wants to keep the exchange rate stable.

¹ For more details, see Moriyama, K., & Arbatli, E. C. (2011). Estimating a small open-economy model for Egypt: Spillovers, inflation dynamics, and implications for monetary policy.

These results imply that the preferences of the monetary authority are first to keep price stability, then output stability, then exchange rate stability.²

Credibility of the monetary authority

The weight of the determination of future inflation is more or less 0.6 in all models. This means that the forward-looking behavior of economic agents is strong. These positive forward-looking expectations indicate the credibility of the central bank, and therefore its effectiveness.

The expectations of economic agents differ according to the nature of the goods. When it comes to imported goods, economic agents' expectations reach their highest value (0.6665) in model 3.3, compared to 0.6604 in 2.3. While for local goods, credibility is high in model 3.2. (0.6790), against 0.6711 in 2.3.

This is an important result in favor of the adoption of inflation targeting in Morocco. Indeed, inflation targeting is not the optimal monetary policy regime for curbing inflation, but it is effective in anchoring inflation expectations around the target and maintaining stable inflation.

Financial parameters

Financial frictions are taken into account in the models through the introduction of the spread and the evolution of the contractors' net worth.

The estimation of the capital parameter on the net worth of entrepreneurs indicates that almost 50% of the capital expenditures of entrepreneurs are financed by debt.

The price rigidity and indexation parameters are higher when financial parameters are introduced, suggesting that the impact of the financial friction is significant. It results in feedback between the financial and real sectors.

Persistence of shocks and their standard deviations

The estimates show a high degree of persistence in the shocks to commodity demand, external commodity prices, external demand, the spread, and the external interest rate. These shocks reach their highest value in the model including financial frictions and the fiscal rule. After these shocks, we find those of domestic demand and supply. The interest rate shock is the least significant.

The standard deviation of the risk of international openness is high. This implies that the restrictions on capital mobility are quite high.

Impulse response

The aim of this paragraph is to find out the impact of financial and non-financial shocks on macroeconomic variables, the role of the financial friction in the transmission of non-financial shocks, and the confrontation between the three rules (financial, fiscal and exchange rate).

² To confirm these results, we ran another simulation of the models, giving the same weight (2) to the objectives. We found that the order of preference changes only in model 3.3, where the inflation and output coefficients are successively 2.0001 and 2.0007.

The impulse responses are used to describe the adequacy of the model by checking the sign and amplitude of the shocks. The results of the impulse responses are presented in Appendix 2, while those of the variance decomposition are presented in Appendix 3.

Role of the Financial Accelerator

The role of the financial sector is discussed through the external interest rate shock. The question is the impact of the exchange rate depreciation on the macroeconomy through the foreign currency debt channel. We generate the impact of the i^* shock and monetary policy in the three models.

A rise in the foreign interest rate leads to a depreciation of the exchange rate, which puts upward pressure on inflation. To reduce inflationary pressures, the central bank raises the interest rate to restore the value of the dirham. Investment responses to external shocks have been dampened in the model containing financial frictions.

However, the effects of monetary policy were amplified by the multiplier effect of the financial friction in both models. Indeed, for a given spread the higher real interest rate requires a higher real return on capital. But this is only possible if investment today decreases in order to increase the marginal product of capital tomorrow, i.e. there should be a reduction in the capital stock. The increase in the real interest rate, under Fisher, affects the net worth of entrepreneurs (cost of debt), the financing gap of investment, consumption, employment and asset prices.

The monetary policy shock confirms, therefore, that interest rate decisions in monetary control considerably influence the choice of financing and investment.

The presence of the financial friction is also important, as it acts as a friction of demand shocks and a retarder of supply shocks [16].

We note that the response of investment to the technology shock weakens when financial frictions and the fiscal rule are introduced into the model. We also notice that the financial data mitigate the Fisher deflation effect since the marginal cost of debt, as well as asset prices, do not react strongly to the productivity shock, thus protecting the firm's net worth.

IMPACT OF THE FINANCIAL SHOCK

An unfavorable shock to the spread (the financial situation of entrepreneurs) worsens the balance sheet of entrepreneurs and thus reduces the demand for capital, which leads to a persistent reduction in investment, production and employment. Weak domestic demand leads to a reduction in inflation and interest rates. Fluctuations in the real exchange rate and the terms of trade are the main vehicles for the propagation of the shock on the economy. The response of the variables is more persistent when the tax rule is included in the model.

CHOICE OF EXCHANGE RATE REGIME IN FRICTIONLESS/ FRICTIONAL MODELS

The sign of the reactions of the macroeconomic variables is the same in all models. The only difference is in the amplitude of the shocks.

Indeed, a positive shock to the domestic interest rate leads to an instantaneous fall in inflation, an economic slowdown and a depreciation of the exchange rate. While a foreign interest rate shock leads to a depreciation of the exchange rate, higher inflation and interest.

From the graphs, we see that the response of the interest rate to the external shock changes in magnitude when the frictions and the exchange rate regime are modified. The weak response of the internal interest rate implies that the exchange rate plays its role as an absorber of external shocks.

We also note that in the models with and without friction, the response of macroeconomic variables to shocks to the internal interest rate is modest under a floating exchange rate regime. This response is weak under the managed exchange rate regime in the models with a fiscal rule. After the introduction of the financial data, the depreciation of the exchange rate is not as strong as in the model without financial frictions. As the depreciation is less important, the negative effect on the net worth is more moderate.

COMPARISON BETWEEN MODELS AND DETERMINATION OF THE OPTIMAL MODEL

According to the impulse response results, the model with the tax rule allows the central bank to better anchor agents' expectations.

The Bayesian estimation of the frictionless model with a fixed exchange rate regime shows that the transmission of the exchange rate channel is greater than that of the interest rate channel. Thus, the participation of the exchange rate in the stabilization of inflation and output is non-negligible, hence the presence of the exchange rate target in the monetary rule.

However, the impulse responses of the rule estimation with a managed and flexible exchange rate regime show the capacity of the exchange rate to absorb external shocks.

Taking into account the fiscal rule and financial stability through asset volatility and financial frictions allows for a better conduct of monetary policy. Indeed, in the models with frictions, the effects of the domestic shock tend to multiply, which has improved the transmission of monetary policy, and has reduced the effect of the exchange rate depreciation on the net worth of entrepreneurs. Impulse responses in these models are more hump-shaped, delaying the maximum effect of the shock.

The effect of a financial shock on macroeconomic variables is more pronounced in the model that incorporates the fiscal rule, and becomes more pronounced when the exchange rate regime is flexible.

Thus, the inclusion of financial frictions in its analytical framework will allow the central bank to ensure macroeconomic stability, but it does not alter the benefits of the managed and floating exchange rate as a medium-term shock absorber.

In addition to the impulse functions and Bayesian estimation, the comparison between models can be made from the log densities of the alternative models. The larger the value of the density, the stronger the Bayes factor [17].

Table 2 :Comparison between models using log density

Model	Log density
Frictionless and fixed exchange	-1309.717618
Frictionless and flexible change	-1322.157914
Frictionless and floating change	-1363.687677
With friction and fixed exchange	-1308.580094
With friction and flexible change	-1304.683871
With friction and floating exchange	-1295.913910
With friction, tax rule and fixed exchange	-1336.962077
With friction, tax rule and flexible exchange	-1346.548132
With friction, tax rule and floating exchange rate	-1347.660708

From this table, we can clearly see that the introduction of financial frictions leads to an improvement in the marginal probability. Thus, the foreign currency debt and the financial friction improve the overall fit of the model.

The comparison of the nine models provides clear evidence of the superiority of the model with financial frictions and a floating exchange rate regime with a Bayes factor of 111.58.

Simulation results indicate that there are two models that allow the monetary authority to achieve the inflation and output target, as well as reduce excessive exchange rate fluctuations: model 2.3 and 3.3. Indeed, both models represent good impulse response results. However, the model with the fiscal rule provides better credibility and copes with financial shocks, while the model that excludes this rule represents a greater amount of information than the other models.

CONCLUSION

To study the external shocks hitting the Moroccan economy, we estimate in this paper a New Keynesian Small Open Economy DSGE model. The standard neo-Keynesian model has been extended to a richer model characterized by financial frictions, imperfect exchange rate pass-through, unemployment, fiscal rule and new shocks.

This model has been divided into nine sub-models. A model without frictions, a model with financial frictions and a model with fiscal rule. In each sub-model, we tested the three exchange rate regimes: fixed, flexible and floating.

The results of the Bayesian estimation allowed us to understand the preferences of the monetary authority, its credibility, the importance of financial frictions and the choice of the exchange rate regime, as well as the persistence of structural shocks. The measurement of the weight of future inflation shows that economic agents can better anticipate inflation in a model that incorporates the fiscal rule.

We have shown that the inclusion of financial frictions and external debt plays an important role in the DSGE model for three main reasons: 1. An adverse financial shock could lead to a recession. 2. The presence of financial frictions amplifies and propagates the effects of monetary policy shocks on investment, output, and employment, but mitigates the effects of technology-related shocks. 3. Financial integration dampens the responses of investment and output to external shocks.

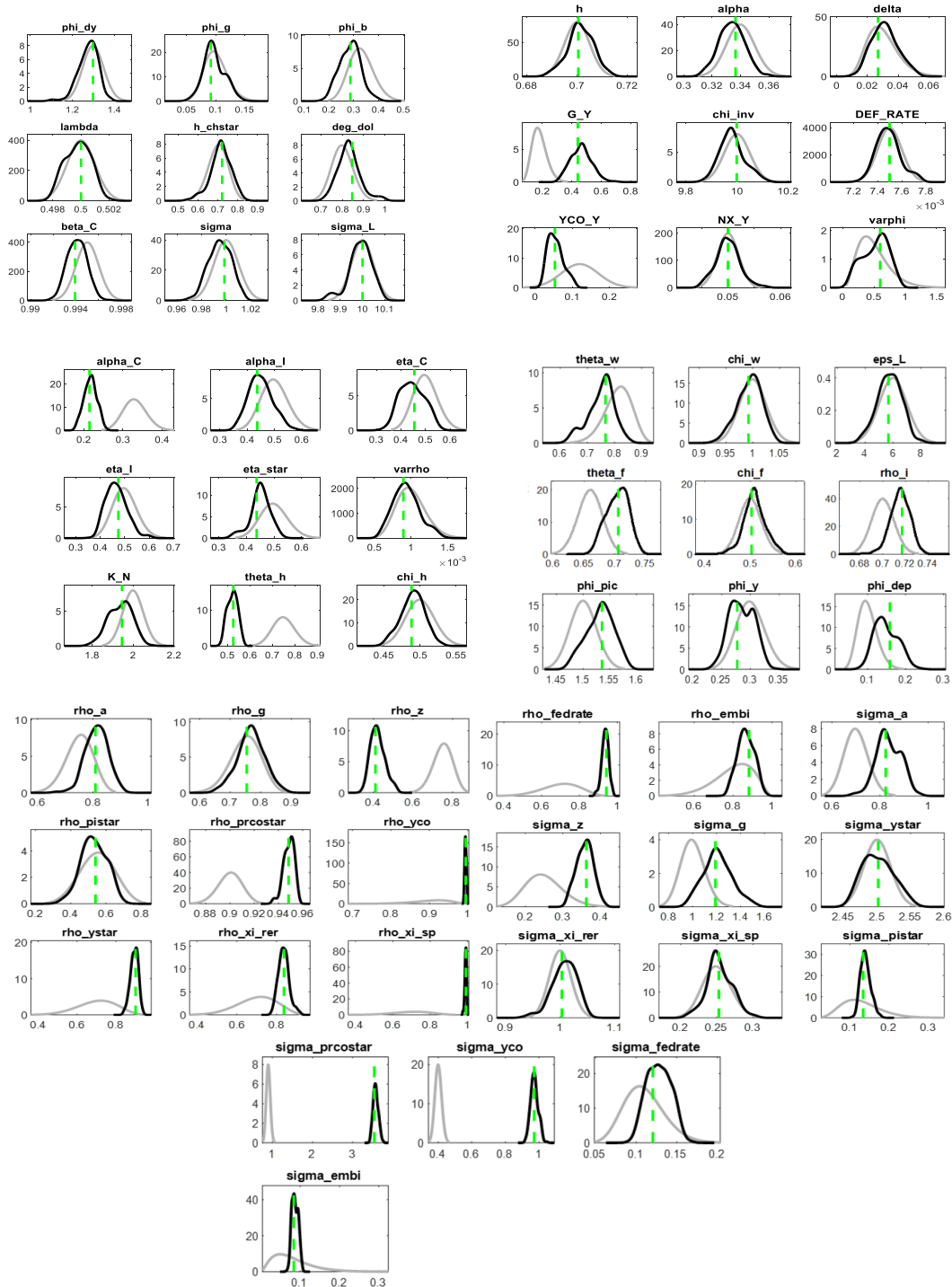
The estimation of the three exchange rate regimes for each model indicates that, in the case of a managed and floating exchange rate regime, the response of macroeconomic variables to an internal shock is weak. In the case of an external shock, the response of the nominal rate is weak, and the exchange rate plays its role as shock absorber.

The log density function as a criterion for evaluating the models confirms the results of the impulse responses and the variance decomposition. It gives preference to the estimated model with financial frictions and a floating exchange rate regime.

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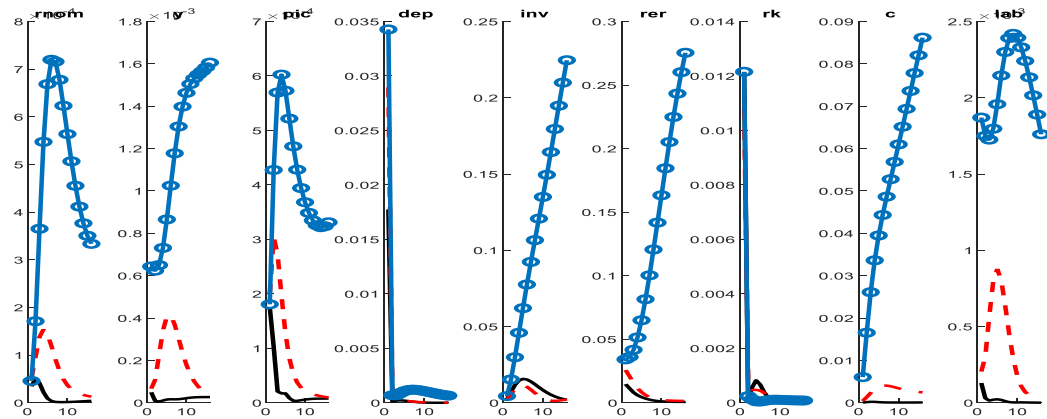
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APPENDIX 1: DISTRIBUTION OF PARAMETERS FOR THE NK MODEL FOR AN OPEN ECONOMY



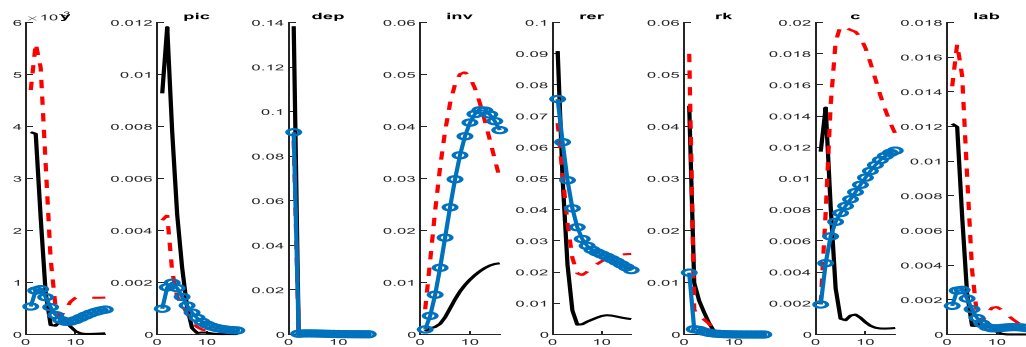
APPENDIX 2: IMPULSE RESPONSES OF THE NK MODEL FOR AN OPEN ECONOMY ROLE OF THE FINANCIAL ACCELERATOR

i* shock



Note : Black: model without friction. Red: model with friction. Blue: model with tax rule.

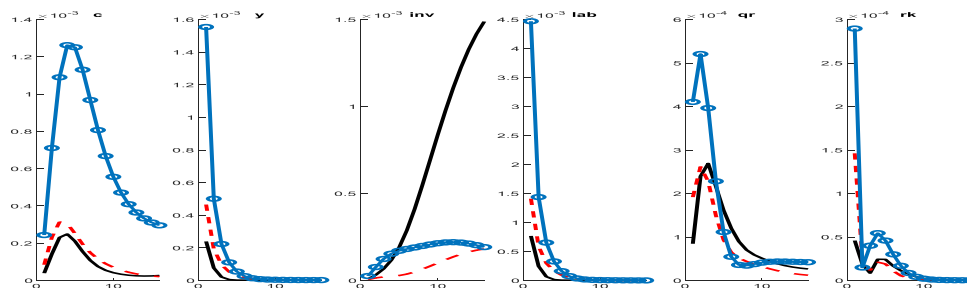
Currency shock



Note : Black: model without friction. Red: model with friction. Blue: model with fiscal rule.

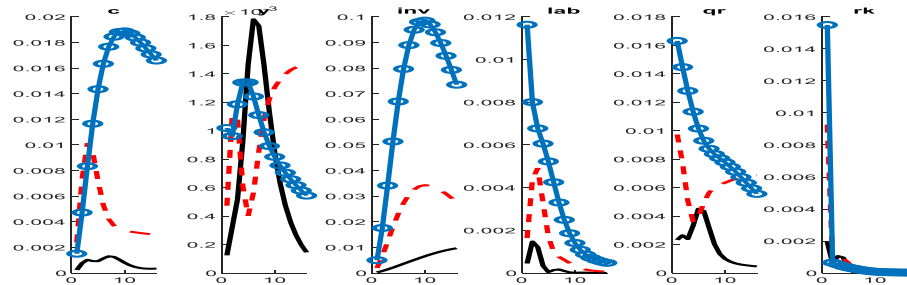
Supply shock and demand shock

Supply shock



Note : Black: model without friction. Red: model with friction. Blue: model with fiscal rule.

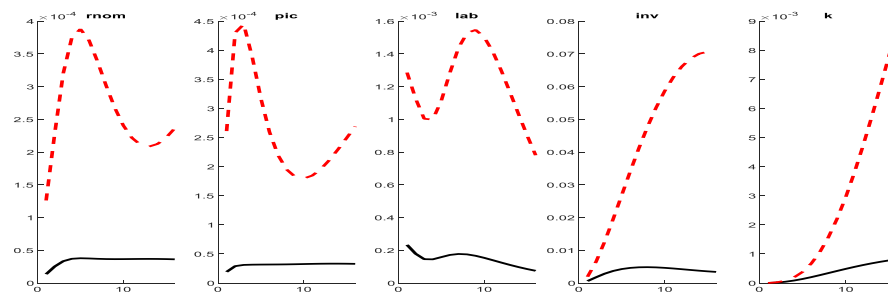
Demand shock



Note : Black: model without friction. Red: model with friction. Blue: model with fiscal rule

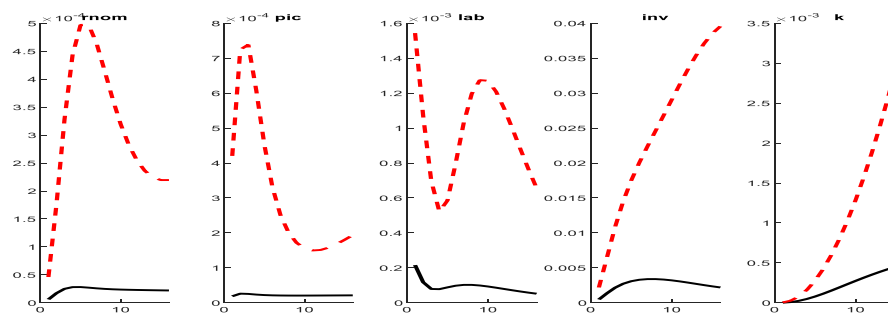
Impact of the financial shock

Models with fixed exchange rate regime



Note: Black: model with friction. Red: model with fiscal rule.

Models with floating exchange rate regime

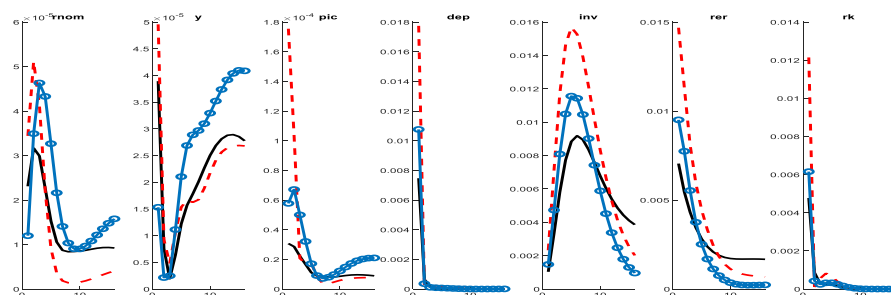


Note: Black: model with friction. Red: model with fiscal rule

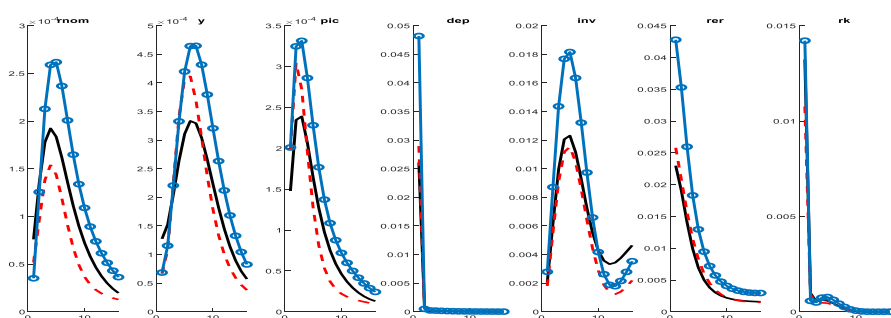
Choice of Exchange Rate Regime

i shock*

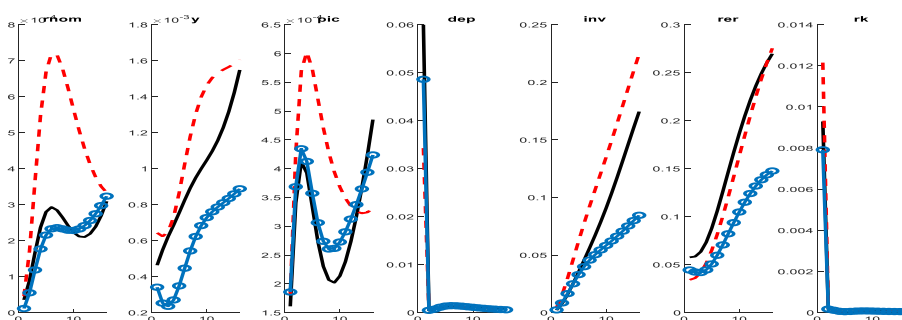
Models without financial frictions



Models with financial frictions



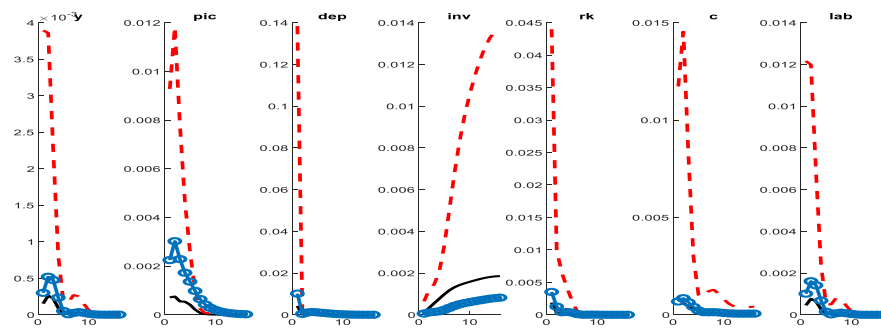
Models with tax rule



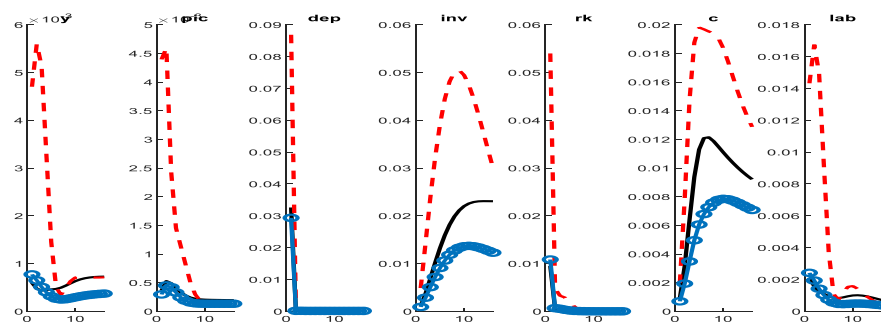
Note: Black: fixed exchange rate regime. Red: managed exchange rate regime. Blue: floating exchange rate regime

Currency shock

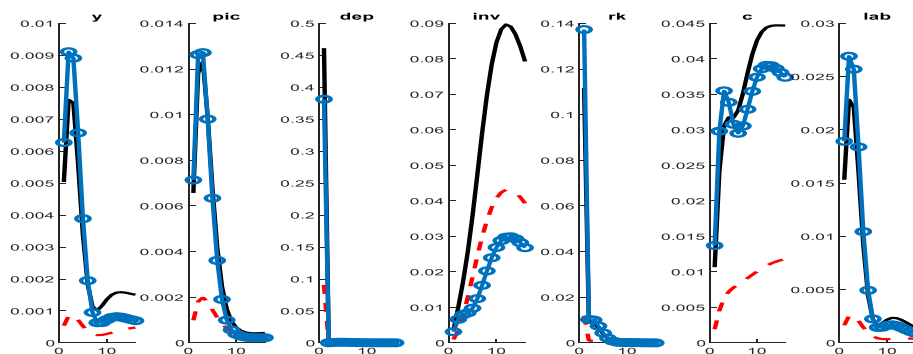
Models without financial frictions



Models with financial frictions



Models with tax rule

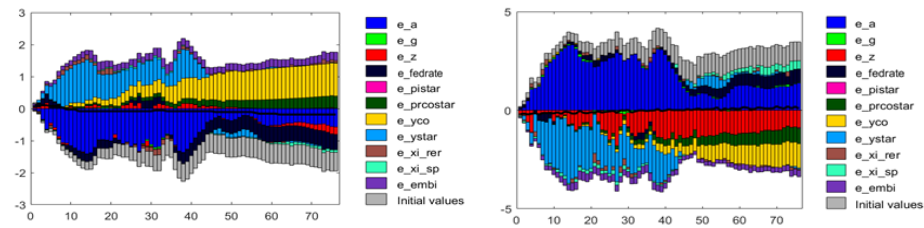


Note: Black: fixed exchange rate regime. Red: managed exchange rate regime. Blue: floating exchange rate regime

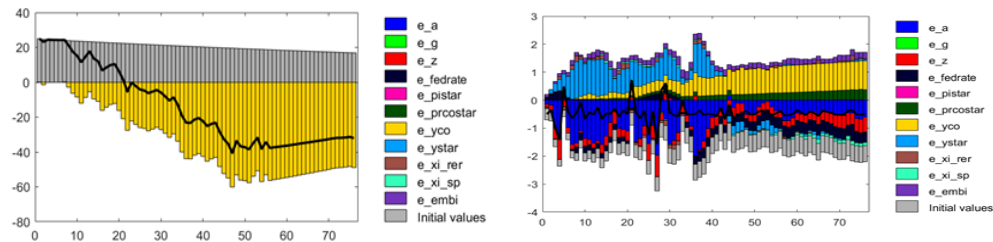
APPENDIX 3: VARIANCE DECOMPOSITION

Model with friction and flexible exchange

Interest rate Production

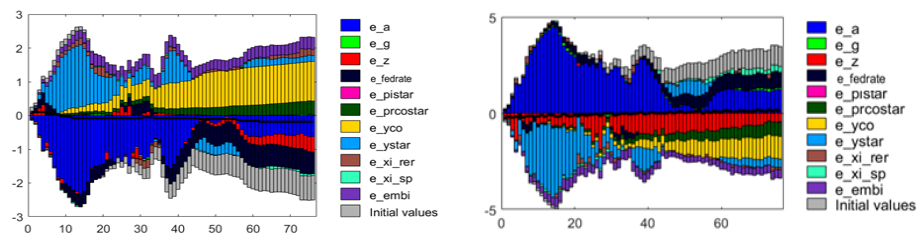


Commodity production Inflation

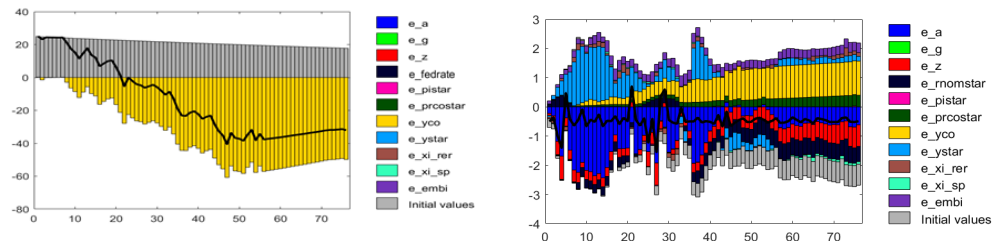


Model with friction and floating exchange

Interest rate Production

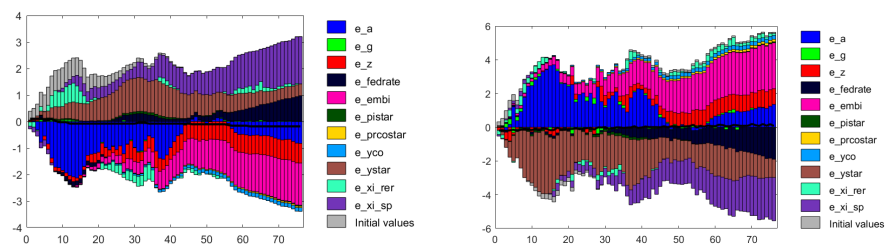


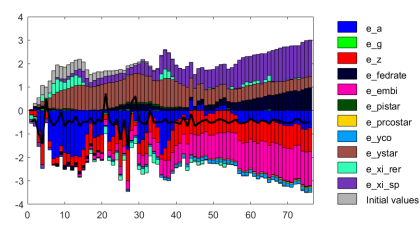
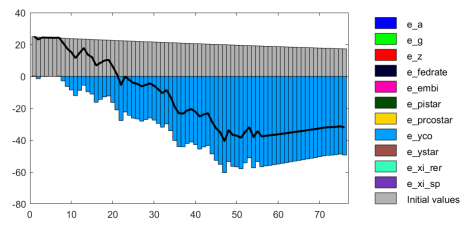
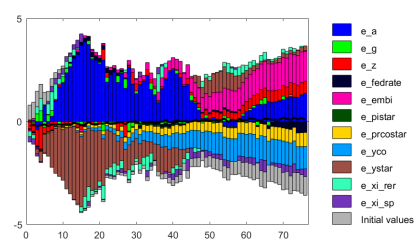
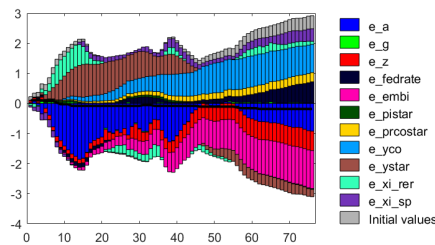
Commodity production Inflation



Model with friction, fiscal rule and flexible exchange

Interest rate Production



Commodity production Inflation**Model with friction, tax rule and floating exchange
Interest rate Production****Commodity production Inflation**