Impulse responses to the "Normalization of Monetary policy on "Mediterranean region: DSGE and FAVAR analysis

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Abstract

The aim of this paper is to evaluate impulse responses for main macroeconomic variables of panel countries in Mena region due to a shock of normalization of monetary policy (Foreign interest rates). In this case, we simulate three scenarios using a DSGE model. The first one, it consists to a base model without macroprudential policy and characterized by a managed exchange regime. The second is defined by base model adding macroprudential policy and the last scenario is based to a float exchange regime. We build 38 equations for a quarterly data set of five countries in MENA region.

Results of simulating show that macroprudential policy seems to have positive effects to minimize contractions in Real GDP and investment. An interesting distinction between the two cases is the evolution of CPI inflation. In fact, the exchange rate depreciates less in the case of macroprudential policy which pushes down the imported component inflation.

Key words: **DSGE, Macroprudential policy, MENA region.**

Introduction

Unconventional monetary policy framework implemented by the advanced country central banks after the 2009 global crisis, play a major role in explaining capital flows to emerging markets . Globally abundant liquidity conditions and extremely low interest rates in advanced economies, coupled with improved growth outlook and higher interest rates in emerging markets attract substantial capital inflows towards the emerging world.

Between 2009 and the end of 2012, emerging markets received about $4^{1}/_{2}$ trillions dollars of gross capital inflows (FMI), representing one half of global capital flows. As consequence, bond and equity prices rallied and currencies strengthened. After the prolonged period of ultra-expansionary monetary policies in advanced economies that goes back to the global financial crisis, we are witnessing a reversed policy, a shift towards a normalization of monetary policy and somewhat more expansionary fiscal policy.

When such policy is reversed, these vulnerabilities that build up during accommodative monetary policies in major advanced economies can unwind suddenly. Then, previous episodes of market volatility can be created, as well as the "Taper Tantrum" episode in May and June of 2013. While, the mere expectations of the shift in the policy has been one important driver behind recent increases in bond yields in mature economies and the appreciation of the US dollar.

Emerging and developing economies are especially vulnerable to external shocks. Many channels explain such vulnerability. First all, these countries remain dependent from economic activity in industrialized countries (trade channel) and from international capital markets –including banking activity to finance their investment (the financial channel). Especially MENA countries, witnessed a high levels of dollars denominates debt and a net debtor position Vis à Vis the rest of the world.

In this context, it seems relevant to address the issue of how central banks in the Mediterranean Region should cope with the potential spillovers from these policy changes in advanced economies, taking into account the different monetary and exchange rate strategies that they follow.

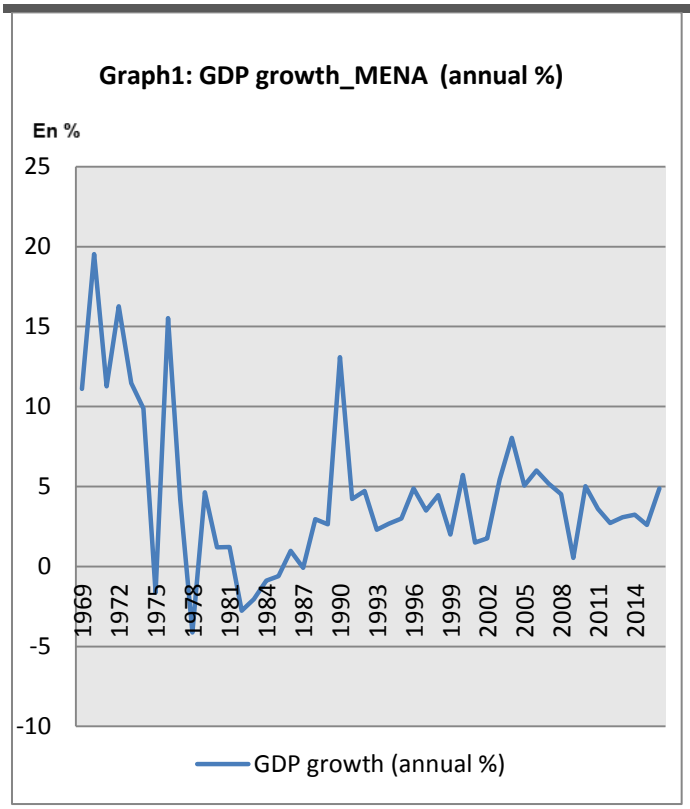
In fact, many countries in the South Mediterranean shore have, historically relied on stable exchange rates as the monetary policy, although some of them have moved or are moving towards more flexible exchange rate regimes and inflation targeting framework under the advice of international financial institutions.

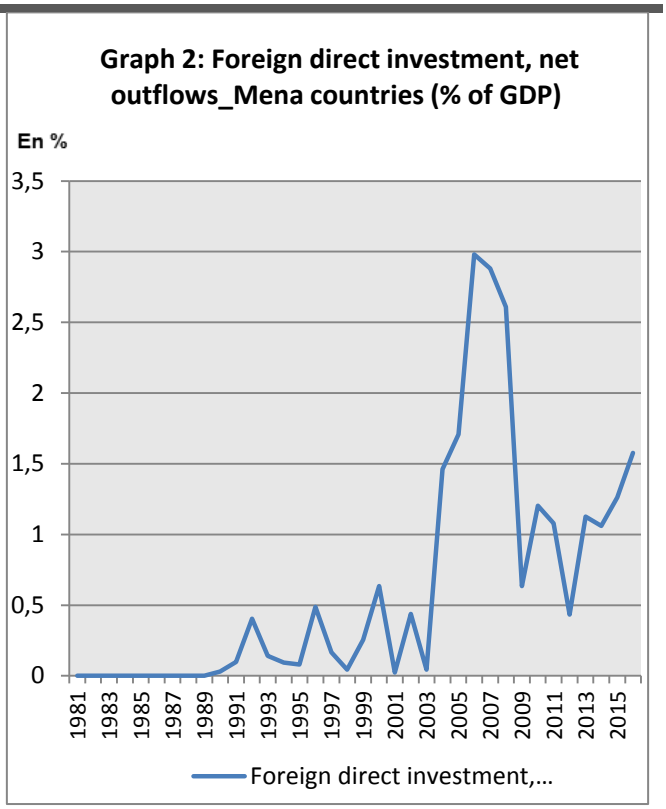
So, in the case of the countries with fixed exchange rates with depending on the openness of their capital accounts, have to accept the monetary policy stance of the reference country. But countries with more flexible exchange rate can disentangle their monetary conditions by allowing depreciation of the exchange rate this would have side effects on inflation (higher inflation rates).

And likely swings in capital flow can have implications for financial stability, as emerging market economies have repeatedly experienced indeed, some of countries have been forced to tighter monetary conditions in a procyclical way to counter inflationary pressures, and have used their buffers of international reserves and implemented macroprudential and capital control measures in order to preserve financial stability. In any case, tighter dollar funding conditions, in particular, are challenging for emerging market economies with high levels of dollar denominated debt.

This is why it have been argued that the traditional "Trilemma" in international finance (in a financially integrated world it's impossible to have at the same time free capital mobility, fixed exchange rate and independent monetary policy), has been transformed into a "dilemma" by the existence of a so called "Global finance cycle" whereby in an independent monetary policy pursuing domestic policy objectives (controlling inflation and promoting growth).

In fact, rising interest rate by the FED have posed considerable challenges for emerging economies. Notably, countries with high borrowing needs, large dollar denominated debt and fragile macroeconomics conditions like as MENA countries. That's paper sample includes Egypt, Jordan , Morocco and Tunisia as the emerging market economies in the region, as they have undertaken comprehensive reform and liberalization programs since the 1990 (Small Open Economy DSGE Model). Graph 1 and Graph 2; show the evolution of GDP growth and capital outflows **(Graph 1 and Graph 2)**





The vast literature on capital flows, starting with the seminal work of Calvo, leiderman and Reinhart (93) puts forward expansionary monetary policies of advanced economies, especially the FED's policies as a major driver of capital flows to emerging markets. Follow-up studies by Fernandez-Arias (96), Taylor and Sarno(97) and Montiel, Reinhart(99) highlight the effect of US interest rates.

While empirical studies focus on the FED'S quantitative easing programs on capital flows after the global financial crisis, Ahmed and Zlate (2013) find that the US unconventional monetary policy affects the composition of capital inflows to emerging markets and leaves the volume unchanged.

World Bank (2014) reaches similar findings with the later, but the impact according to this study diminishes over time. Yet, a number of recent studies take a different perspective on the subject. They assert that spillover effects of US unconventional monetary policy on Emerging Markets capital flows depends on country specific countries.

Hence, some recent empirical studies assert that emerging countries with recent relatively stronger fundamentals, deeper financial markets, and tighter macroprudential policy stance suffered less during the tapper tantrum (Misha et al.(2013), Ahmed, Coubilay , Zlate(2015)).

For this reason, it has been argued that the traditional "trilemma" in international finance (i.e., in a financially integrated world it's impossible to have at the same time free capital mobility, fixed exchange rates and independent monetary policy) has been transformed into a "dilemma" by the existence of a so called "global financial cycle", whereby an independent monetary policy pursuing domestic policy objectives (controlling inflation and promoting growth) is possible if and only if the capital account is managed. In these conditions, sound fundamentals and the use of traditional macroeconomic (fiscal and monetary policies) may not be sufficient. Authorities may need also to resort to macro-prudential and capital flow management instrument to smooth financial cycles and capital flows.

This paper extends the spillover effects of normalization in these countries in a fully specified, small open economy DSGE model. Because the model economy is dynamic and involves endogenous variables, real, monetary and financial variables, we can examine the impulse responses of many variables due to an external shock.

The aim of our paper is dual; the first one object is to estimate parameters equations via heterogeneity panel data, in order to take into account for different specificities of countries. The second is to test the significance "Dilemma" called "Global financial cycle" in MENA region, via simulating impulse responses of macroeconomic variables of MENA Region. For this object, our empirical analysis is divided in two parts. The first one consists on simulating the **DSGE** model for a panel data to compare responses across three models:

i. **Baseline model**-defined by **flexible exchange rate**, without **macro prudential** - incorporating 38 equations.
ii. Baseline model + **macro prudential**.
iii. Baseline model +**managed float regime**.

1. Empirical strategy

In this section, we describe the empirical strategy used to evaluate **the potential effects of foreign interest rate shock** on MENA countries and the underlying transmission mechanisms. For this aim, we used **38 equations** in **DSGE model**, which parameters have obtained by historical regression of panel data (using **STATA software**). Impulse responses for pooled macroeconomic variables have obtained by running three models on **MATLAB .2017R.** These three models are defined as follow:

1. **Baseline model**-defined by **managed exchange rate**, without **macroprudential** - incorporating **38 equations**.
2. Baseline model + **macroprudential**.
3. Baseline model + **float regime**.

1. The model Economy

One of the major challenges facing the emerging market economies of the MENA region is to design economic policies that could help them to create a stable macroeconomic environment while achieving sustainable, long-term economic growth. Our model economy

The base model is defined by (37) equations:

B1.1: Aggregate demand for home goods

$$\frac{Y_H}{Y}Y_{H,t}=\left((1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})+(1-\alpha_I)\frac{I}{Y}\right)d_{H,t}+\frac{G}{Y}g_t+\frac{C_H^*}{Y}c_{H,t}^* \quad (1)$$

B1.2: Domestic and private demand for home goods

$$\left((1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})+(1-\alpha_I)\frac{I}{Y}\right)d_{H,t}=(1-\alpha_C)\frac{C}{Y}c_t+(1-\alpha_c)\frac{C^e}{Y}c_t^e-(1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})\eta_C(p_{H,t}-p_t)$$

$$+(1-\alpha_I)\frac{I}{Y}(inv_t-\eta_I(p_{I,t}-p_t)) \quad (2)$$

B1.3: Foreign demand for home goods

$$C_{H,t}^*=y_t^*-\eta^*(p_{H,t}-p_t-rer_t) \quad (3)$$

B1.4: Volume of imports

$$\frac{M}{Y}m_t = \alpha_C \frac{C}{Y}c_t + \alpha_C \frac{C^e}{Y}c_t^e - \alpha_C(\frac{C}{Y}+\frac{C^e}{Y})\eta_C(p_{F,t}-p_t)+\alpha_I \frac{I}{Y}(inv_t - \eta_I(p_{F,t}-p_{I,t})) \quad (4)$$

B1.5: Volume of exports

$$\frac{X}{Y}x_t = \frac{C_H^*}{Y}c_{H,T}^* + \frac{Y_{CO}}{Y}Y_{CO,t} \quad (5)$$

B1.6: Export deflator

$$\frac{X}{y}(p_{X,t}-p_t) = \frac{C_H^*}{Y}(p_{H,t}-p_t)+\frac{Y_{co}}{Y}(p_{CO,t}^*-p_t^*+rer_t) \quad (6)$$

B1.7: Definition of the real exchange rate

$$\text{rer}_t = rer_{t-1}+\Delta e_t+\pi_t^*-\pi_t \quad (7)$$

B1.8: Definition of the price of Home goods

$$(p_{H,t}-p_t) = (p_{H,t-1}-p_{t-1})+\pi_{H,t}-\pi_t \quad (8)$$

B1.9: Uncovered interest rate parity condition

$$i_t = i_t^* + E_t[\Delta e_{t+1}] + \varsigma\, b_t^* \quad (9)$$

B1.10: Balance of payment

$$\frac{B^*}{Y}(rer_t+b_t^*) = \frac{B^*}{Y}(i_{t-1}^* + (1+\varsigma)b_{t-1}^* + rer_t - \pi_t^*)+\frac{M}{Y}(rer_t+m_t)$$
$$+\chi\frac{Y_{co}}{Y}(p_{CO,t}^*-p_t^*+rer_t+Y_{CO,t})-\frac{X}{Y}(p_{X,t}-p_t-x_t) \quad (10)$$

B1.11 Imperfect exchange rate pass-through

$$\pi_{F,t} = \frac{\beta}{1+\beta\chi_F}E_t[\pi_{F,t+1}]+\frac{\chi_F}{1+\beta\chi_F}\pi_{F,t-1}+\frac{(1-\theta_F)(1-\beta\theta_F)}{\theta_F(1+\beta\chi_F)}(rer_t-(p_{F,t}-p_t)) \quad (11)$$

B1.12 Dynamic definition of the price of foreign goods

$$(\mathrm{p}_{F,t}-p_t) = (p_{F,t-1}-p_{t-1})+\pi_{F,t}-\pi_t \quad (12)$$

B1.13 investment goods deflator

$$(p_{I,t} - p_t) = (1-\alpha_I)(p_{H,t} - p_t) + \alpha_I (p_{F,t} - p_t) \qquad (13)$$

B1.14 consumption goods deflator

$$0=(1-\alpha_C)(p_{H,t} - p_t) + \alpha_I (p_{F,t} - p_t) \qquad (14)$$

B1.15 GDP definition

$$y_t = \frac{Y_H}{Y} y_{H,t} + \frac{Y_{co}}{Y} y_{co,t}, \quad \text{with } \frac{Y_H}{Y} + \frac{Y_{CO}}{Y} = 1 \qquad (15)$$

B1.16 Modified. Euler equation of consumption

$$c_t = -\sigma \frac{(1-h)}{1+h}(i_t - E_t\pi_{t+1}) + \frac{1}{1+h} E_t c_{t+1} + \frac{h}{1+h} c_{t-1} \qquad (16)$$

B1.17 consumption of entrepreneurs

$$c_t^e = \eta_t \qquad (17)$$

B1.18 dynamic of external debt

$$D_t = (1+i^*_t) D_{t-1} + E_t\left[\Delta e_{t+1}\right] + z_t \qquad (18)$$

B1.20 real return to capital

$$rr_t^k = (1-\varepsilon)(mc_t + y_t - k_{t-1}) + \varepsilon q_t - q_{t-1} \qquad (20)$$

$$\varepsilon = \frac{(1-\delta)}{R^k}$$

B1.21 investment adjust cost

$$q_t - (p_{I,t} - p_t) = \zeta_{INV}(inv_t - inv_{t-1}) - \beta\zeta_{INV} E_t\left[inv_{t+1} - inv_t\right] \qquad (21)$$

B1.22 Aggregate supply of home goods

$$y_{H,t} = a_t + \alpha k_{t-1} + (1-\alpha) l_t \qquad (22)$$

B1.23 Definition of the marginal rate of substitution b/w labor and consumption

$$mrs_t = \sigma_L l_t + \frac{1}{\sigma}\frac{1}{(1-h)}c_t - \frac{1}{\sigma}\frac{h}{(1-h)}c_{t-1} \qquad (23)$$

B1.24 Demand for labor

$$rw_t = mc_t + y_t - l_t \qquad (24)$$

B1.25 Philips curve

$$\pi_{H,t} = \frac{\beta}{1+\beta\chi_H}E_t\left[\pi_{H,t+1}\right] + \frac{\beta}{1+\beta\chi_H}\pi_{H,t-1} + \frac{(1-\theta_H)(1-\beta\theta_H)}{\theta_H(1+\beta\chi_H)}(mc_t - (p_{H,t} - p_t)) \qquad (25)$$

B1.26 Capital evolution

$$k_t = \zeta_{INV} + (1-\delta)k_{t-1} \qquad (26)$$

B1.27 Monetary policy rule

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t + \phi_y y_t + \phi_{\Delta_e}\Delta e_t) + z_t \qquad (27)$$

B1.28 Phillips curve for wages

$$\pi_t^w = \chi_w \pi_{t-1} + \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\varepsilon_w\sigma_L)}(mrs_t - rw_t) + \beta E_t\left[\pi_{t+1}{}^w - \chi_w\pi_t\right] \qquad (28)$$

B1.29 Definition of infaltion wages

$$\pi_t^w = rw_t - rw_{t-1} + \pi_t \qquad (29)$$

B1.30 Government expenditure evolution

$$g_t = \rho_g g_{t-1} + \varepsilon_{g,t} \qquad (30)$$

B1.31 Productivity evolution

$$a_t = \rho_a a_{t-1} + \varepsilon_{a,t} \qquad (31)$$

B1.32 New monetary deviation evolution

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t} \qquad (32)$$

B1.33 Foreign interest rate evolution

$$i_t^* = \rho_{i^*} i_{t-1}^* + \varepsilon_{i^*,t} \qquad (33)$$

B1.34 Foreign inflation evolution

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_{\pi^*,t} \qquad (34)$$

B1.35 commodity price evolution (in real foreign terms)

$$(p_{co,t}^* - p_t^*) = \rho_{pco^*} (p_{co,t-1}^* - p_{t-1}^*) + \varepsilon_{pco^*,t} \qquad (35)$$

B1.36 commodity production evolution

$$y_{co,t} = \rho_{yco} y_{co,t-1} + \varepsilon_{co,t} \qquad (36)$$

B1.37 foreign demand

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_{y^*,t} \qquad (37)$$

2 Model calibration and solution

Table 1 presents the parameters, steady –state values, and shock processes used to calibrate the model.

Because availability of the main data series, is limited across different groups in the MENA countries. We used heterogeneous unbalanced panel data to estimate parameters of equations. Indeed, the risk aversion parameter σ is equal to 2.61, which is the estimate from a panel study by Ostry and Reinhart (1992).

Indeed, we need to be sure about the consistency of the coefficients to be used in the model. The steady –state parameters estimated in the MENA countries in our sample are presented in the table 1:

Table 1: Calibration and parameters of the model:

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
β	0.895	G/Y	0.11	χ	0.5	ρ_a	0.95
σ	2.61	ζ_{INV}	20	α_C	0.33	ρ_g	0.95
h	0.0	R^k	$(\frac{1}{\beta}+0.02)^{\frac{1}{4}}$	α_I	0.50	ρ_z	0.00
σ_l	1	$Def.rate$	0.0075	η_c	0.50	ρ_{i^*}	0.97
α	0.35	Y_{CO}/Y	0.21	η_i	0.50	ρ_{π^*}	0.55
δ	0.02	$(X-M)/Y$	0.05	η^*	0.50	ρ_{pco^*}	0.97
ζ	0.001	θ_H	0.75	χ_H	0.50	θ_w	0.8125
χ_w	1.00	ε_L	6.0	θ_F	0.875	χ_F	1.0
ρ_i	0.0	ϕ_π	1.50	ϕ_y	0.125	ϕ_{Δ_e}	0.0
ρ_{yco}	0.95	ρ_{y^*}	0.85	σ_a	0.7%	σ_g	1.5%
σ_z	0.25%	σ_{π^*}	0.125%	σ_{pco^*}	13.0%	σ_{yco}	1.0%

3. Impulse responses due to a shock to foreign interest rate

3.1 Comparison base model versus with macro prudential policy in MENA countries

For the one step, we simulate the impulse responses of model variables to a one percent increase in foreign interest rate and we compare these reactions VS the model with macro prudential policy.

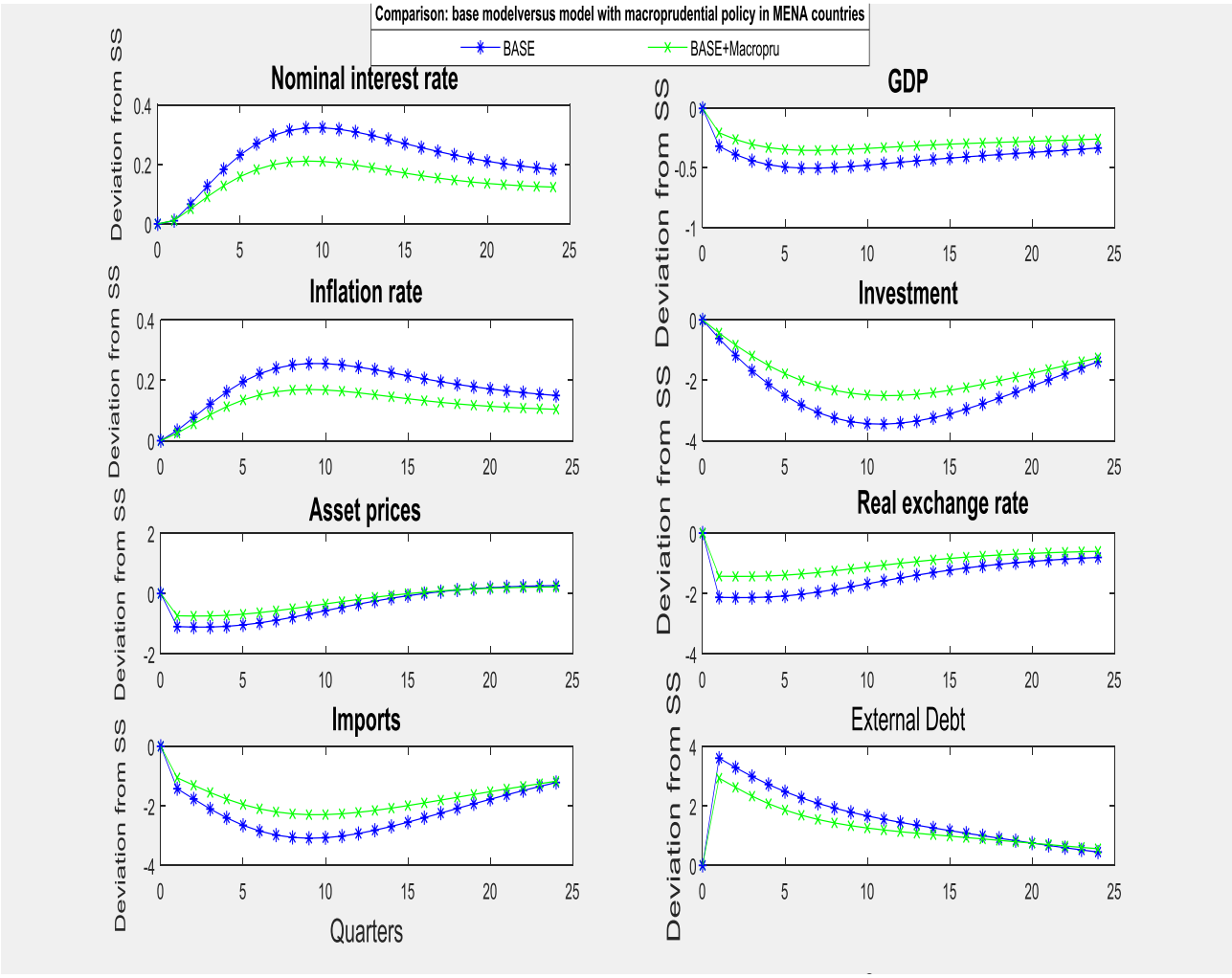
We present the impulse responses of model variables ta a 1 percent increase foreign interest rate in figure (1).

To take into account for macroprudential policy, we introduce a capital flow taxes in equation of Uncovered interest parity:

$$i_t = i_t^* + E_t\left[\Delta e_{t+1}\right] + \varsigma\, b_t^* + \underbrace{\zeta_{\Delta b^*}(b_t^* - b_{t-1}^*)}_{taxes} \quad (9')'$$

Simulation of the DSGE program of two models (i) and (ii) are presented in these graphs as follows:

Figure 1: Comparison base model versus with macro prudential policy in MENA countries



Matlab codes are used by dynare to estimate the rest of coefficients consistent with assumptions .

- The increase in the foreign interest rate for a given domestic interest rate –since this depends on the Monetary Policy rule-initially leads to an increase of External Debt from the equation and depreciation of nominal exchange rate:

$$D_t = (1+i^*_t)D_{t-1} + E_t\left[\Delta e_{t+1}\right] + z_t \quad (3)$$

- The real exchange rate depreciation puts upward pressures on inflation (since pass through is allowed) and through it on the nominal interest rate through the monetary policy ;

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t) + \varepsilon_t \quad (4)$$

- Lower investment is consistent with a reduction in asset prices which leads a contraction in Real GDP.
- At the same time, the lower demand for investment goods and the lower consumption, in addition to lower price of capital, reduces the real rental rate of capital today :

$$rr_t^k = (1-\varepsilon)(mc_t + y_t - k_{t-1}) + \varepsilon q_t - q_{t-1} \qquad (5)$$

$$\varepsilon = \frac{(1-\delta)}{R^k}$$

- Lower investment today is consistent with a reduction in asset prices.
- Total GDP is also affected by the contraction in net worth through lower investment and consumption.

This figure (1) show that contraction of GDP could be worse, in an economy with a high level of external debt. This effect is magnified when the economy not pursue a macro prudential policy. Also, a macro prudential policy seems to have positive effects and help to minimize contractions in an economy facing an excessive debt.

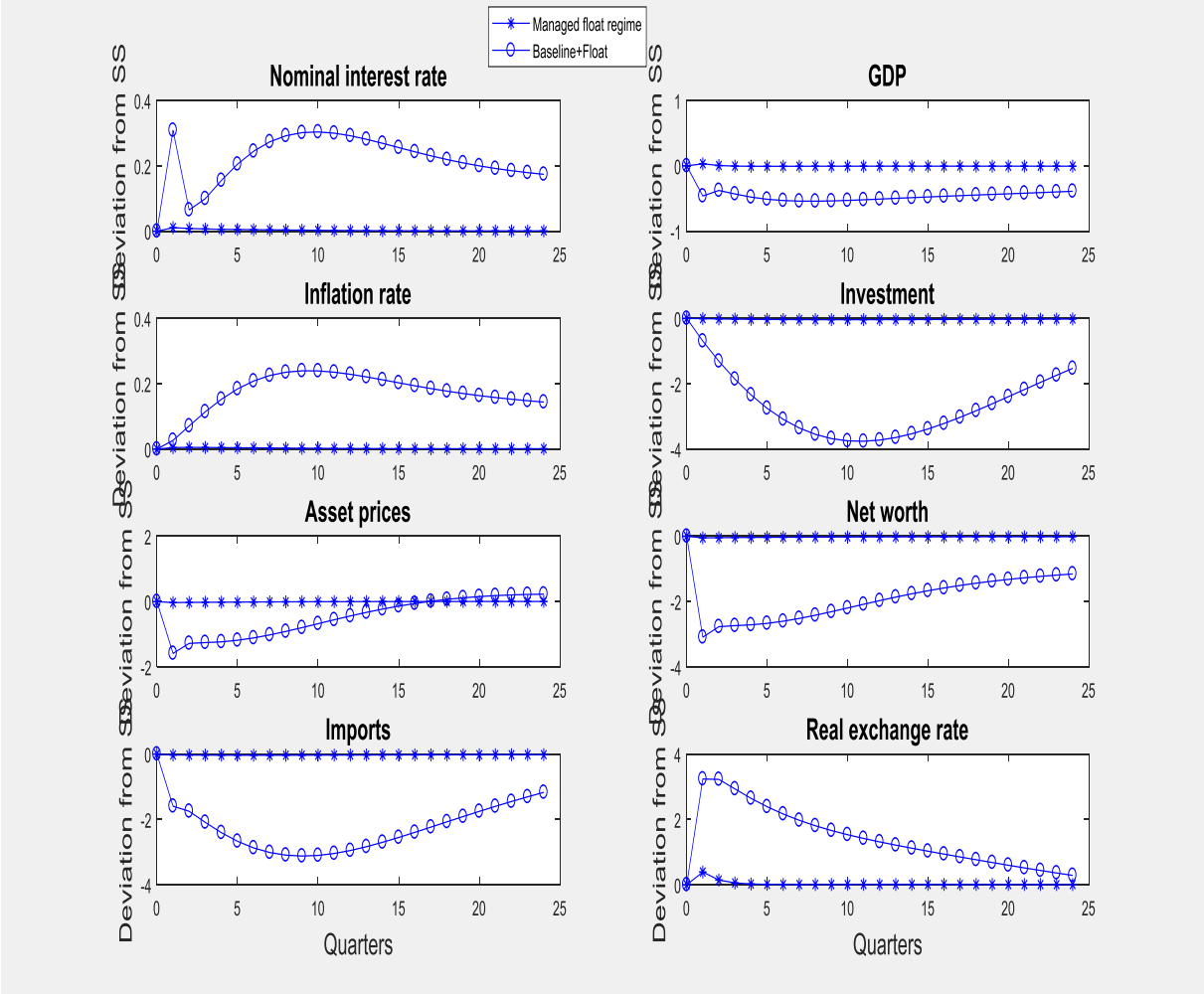
When, we simulate a base model with macro prudential policy by considering taxes on the capital flows by including the new parameter in the base model and modify the Interest Rate Parity condition. The ***Graph3*** shows that **macroprudential policy seems to have positive effects to minimize contractions in Real GDP and investment.** An interesting distinction between the two cases is the evolution of CPI inflation. In fact, although the exchange rate depreciates less in the case of macroprudential policy which pushes down the imported component inflation.

3.2 Comparison Exchange Regime flexibility vs managed float:

We compare responses across models (base; w/o flexible regime), to the same increase of one standard deviation in the foreign interest rate shock "y_e_nomstar" and we modify the calibration $\emptyset_{\Delta_e}$ from 0 to 0.1:

- $\emptyset_{\Delta_e}$ =0; no intervention.
- $\emptyset_{\Delta_e} \rightarrow \infty$: Fixed Exchange rate.
- $\emptyset_{\Delta_e} \neq 0$: Systematic non sterilized Foreign exchange intervention.

Figure 2: Comparison Exchange regime (ER) flexibility Vs Managed float in MENA countries



This figure shows that because dollarization of external debt, the jump in the interest rate with flexibility ER is associated with a more exchange rate depreciation relative to the baseline case with flexibility regime.

Since there is more depreciation, the adverse effect on the net worth, investment and economic activity is also more muted. Although, in the case of managed float exchange regime, the exchange rate depreciates less and the adverse effects on real activity are neutralized. One explanation of these results due to the manner of the determination of exchange rate in the case of managed exchange regime. In fact this regime takes into account of the many factors which are able to impact its level of price, in object to blur them to keep stability of exchange regime. For this reason, real effects are neutralized by these corrections applied directly to exchange rate.

Conclusion

This paper investigated the effects of monetary policies in advanced economies on real activity, inflation and real exchange rate in emerging countries, especially in MENA countries. Four countries are examined: Egypt, Jordan, Morocco and Tunisia via estimating a panel DSGE model, we attempted to compare the response of some selected variables to external shocks (foreign interest rates) and to evaluate three alternative policies:

1. **Base model**-defined by **managed exchange rate**, without **macroprudential** - incorporating **38 equations**.
2. Base model + **macroprudential policy**.
3. Base model + **float regime**.

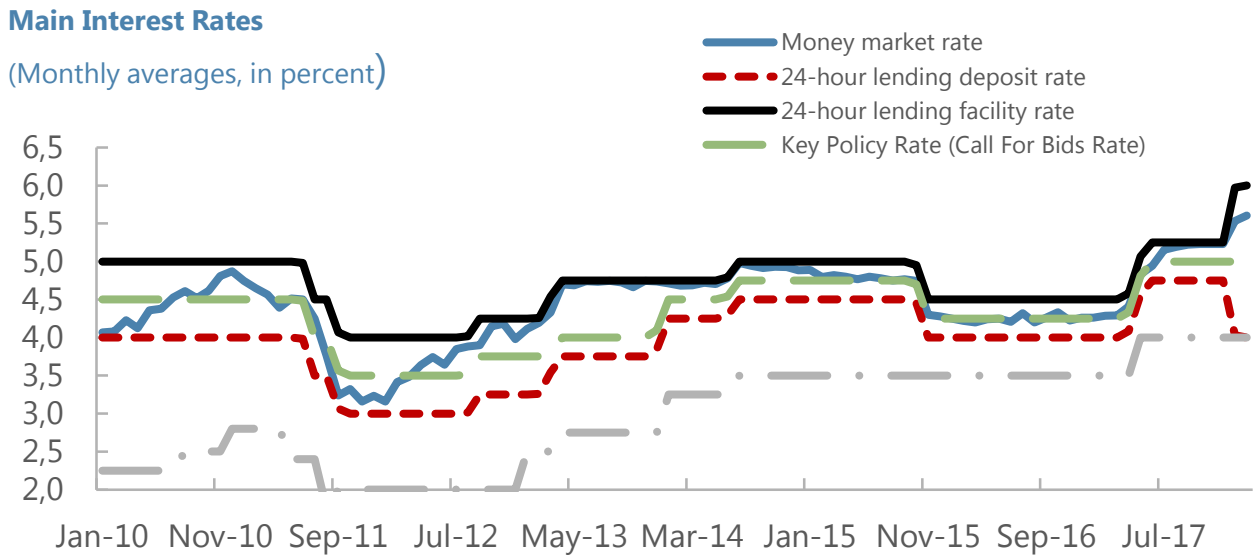
The results obtained, show a statistically significant effects of monetary tightening in advanced economy. The impulse responses functions obtained show that the foreign monetary policy shock leads in all cases leads to depreciation of real exchange rate, but with less dynamics and magnitude, if we used a macroprudential policy.

Additionaly , contraction of GDP could be worse in an economy without macroprudential tools . This effect is magnified when the economy has a high levels of dollars denominates debt and a net debtor position Vis à Vis the rest of the world.

However, simulated impulse responses in the case of managed Exchange Regime are generally implausible to interpret, which is related to moderated effect by the interventions of the Central banks.

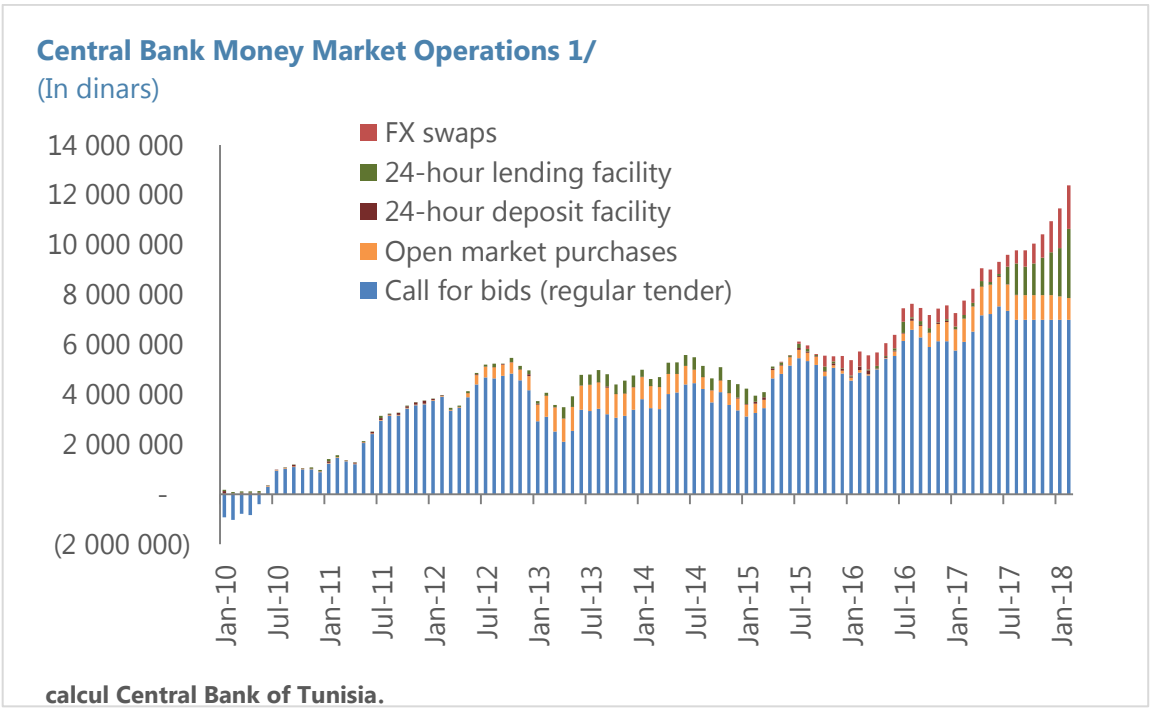
ANNEXE 1: EVOLUTION OF MAIN INTEREST RATES AND MARKET OPERATIONS IN CENTRAL BANK OF TUNISIA

Graph5. Evolution of main interests rates in Tunisia



Sources: Tunisian authorities

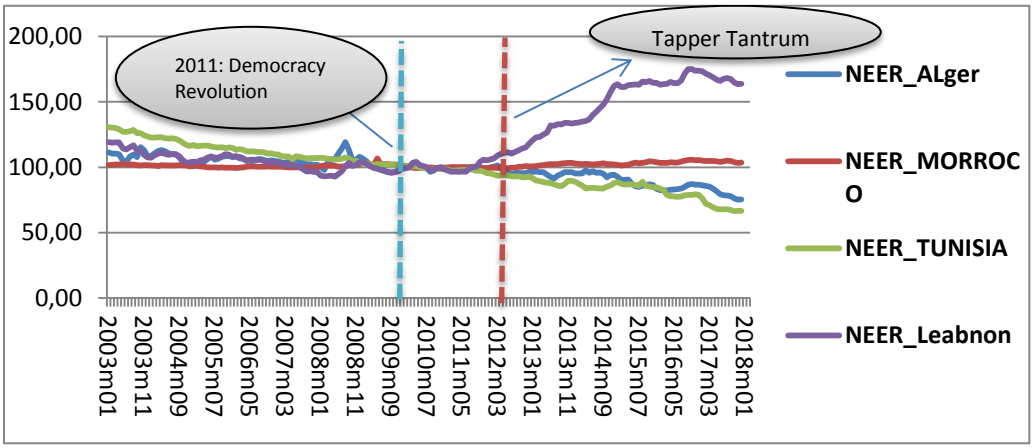
Graph 6: Central Bank market operations in Central Bank of Tunisia



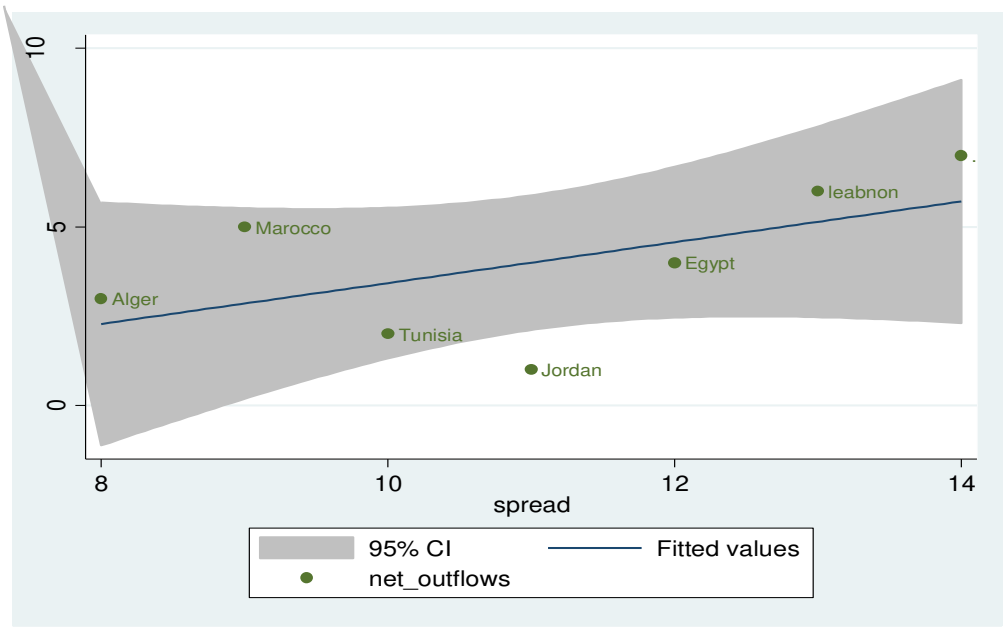
calcul Central Bank of Tunisia.

ANNEXE 2: DYNAMIC EVOLUTION OF NOMINAL EFFECTIVE EXCHANGE RATE IN TUNISIA AND CORRELATION BETWEEN OUTFLOWS NET FOREIGN INVESTMENT AND SPREAD INTERST RATES IN PANEL DATA

Graph 7 :Dynamic evolution of Nominal Effective Exchange rate in Tunisia



Graph8: Correlation between outflows net foreign investment and spread interest rates (1994-2008) in MENA countries



Annexe1:

The base model is defined by (37) equations:

B1.1: Aggregate demand for home goods

$$\frac{Y_H}{Y}Y_{H,t}=\left((1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})+(1-\alpha_I)\frac{I}{Y}\right)d_{H,t}+\frac{G}{Y}g_t+\frac{C_H^*}{Y}c_{H,t}^* \quad (1)$$

B1.2: Domestic and private demand for home goods

$$\left((1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})+(1-\alpha_I)\frac{I}{Y}\right)d_{H,t}=(1-\alpha_C)\frac{C}{Y}c_t+(1-\alpha_c)\frac{C^e}{Y}c_t^e-(1-\alpha_C)(\frac{C}{Y}+\frac{C^e}{Y})\eta_C(p_{H,t}-p_t)$$

$$+(1-\alpha_I)\frac{I}{Y}(inv_t-\eta_I(p_{I,t}-p_t)) \quad (2)$$

B1.3: Foreign demand for home goods

$$C_{H,t}^*=y_t^*-\eta^*(p_{H,t}-p_t-rer_t) \quad (3)$$

B1.4: Volume of imports

$$\frac{M}{Y}m_t=\alpha_C\frac{C}{Y}c_t+\alpha_C\frac{C^e}{Y}c_t^e-\alpha_C(\frac{C}{Y}+\frac{C^e}{Y})\eta_C(p_{F,t}-p_t)+\alpha_I\frac{I}{Y}(inv_t-\eta_I(p_{F,t}-p_{I,t})) \quad (4)$$

B1.5: Volume of exports

$$\frac{X}{Y}x_t=\frac{C_H^*}{Y}c_{H,T}^*+\frac{Y_{CO}}{Y}Y_{CO,t} \quad (5)$$

B1.6: Export deflator

$$\frac{X}{y}(p_{X,t}-p_t)=\frac{C_H^*}{Y}(p_{H,t}-p_t)+\frac{Y_{co}}{Y}(p_{CO,t}^*-p_t^*+rer_t) \quad (6)$$

B1.7: Definition of the real exchange rate

$$\mathrm{rer}_t=rer_{t-1}+\Delta e_t+\pi_t^*-\pi_t \quad (7)$$

B1.8: Definition of the price of Home goods

$$(p_{H,t}-p_t)=(p_{H,t-1}-p_{t-1})+\pi_{H,t}-\pi_t \quad (8)$$

B1.9: **Uncovered interest rate parity condition**

$$i_t = i_t^* + E_t\left[\Delta e_{t+1}\right] + \varsigma\, b_t^* + \zeta_{\Delta b^*}(b_t^* - b_{t-1}^*) \quad (9')'$$

B1.10: Balance of payment

$$\frac{B^*}{Y}(rer_t + b_t^*) = \frac{B^*}{Y}(i_{t-1}^* + (1+\varsigma)b_{t-1}^* + rer_t - \pi_t^*) + \frac{M}{Y}(rer_t + m_t)$$
$$+\chi\frac{Y_{co}}{Y}(p_{CO,t}^* - p_t^* + rer_t + Y_{CO,t}) - \frac{X}{Y}(p_{X,t} - p_t - x_t) \qquad (10)$$

B1.11 Imperfect exchange rate pass-through

$$\pi_{F,t} = \frac{\beta}{1+\beta\chi_F}E_t\left[\pi_{F,t+1}\right] + \frac{\chi_F}{1+\beta\chi_F}\pi_{F,t-1} + \frac{(1-\theta_F)(1-\beta\theta_F)}{\theta_F(1+\beta\chi_F)}(rer_t - (p_{F,t} - p_t)) \quad (11)$$

B1.12 Dynamic definition of the price of foreign goods

$$(\mathrm{p}_{F,t} - p_t) = (p_{F,t-1} - p_{t-1}) + \pi_{F,t} - \pi_t \qquad (12)$$

B1.13 investment goods deflator

$$(p_{I,t} - p_t) = (1-\alpha_I)(p_{H,t} - p_t) + \alpha_I(p_{F,t} - p_t) \qquad (13)$$

B1.14 consumption goods deflator

$$0 = (1-\alpha_C)(p_{H,t} - p_t) + \alpha_I(p_{F,t} - p_t) \qquad (14)$$

B1.15 GDP definition

$$\mathrm{y}_t = \frac{Y_H}{Y}y_{H,t} + \frac{Y_{co}}{Y}y_{co,t}, \quad \text{with } \frac{Y_H}{Y} + \frac{Y_{CO}}{Y} = 1 \qquad (15)$$

B1.16 Modified. Euler equation of consumption

$$c_t = -\sigma\frac{(1-h)}{1+h}(i_t - E_t\pi_{t+1}) + \frac{1}{1+h}E_t c_{t+1} + \frac{h}{1+h}c_{t-1} \qquad (16)$$

B1.17 consumption of entrepreneurs

$$c_t^e = \eta_t \qquad (17)$$

B1.18 dynamic of external debt

$$D_t = (1+i^*_t)D_{t-1} + E_t\left[\Delta e_{t+1}\right] + z_t \qquad (18)$$

B1.20 real return to capital

$$rr_t^k = (1-\varepsilon)(mc_t + y_t - k_{t-1}) + \varepsilon q_t - q_{t-1} \qquad (20)$$
$$\varepsilon = \frac{(1-\delta)}{R^k}$$

B1.21 investment adjust cost

$$q_t - (p_{I,t} - p_t) = \zeta_{INV}(inv_t - inv_{t-1}) - \beta\zeta_{INV}E_t\left[inv_{t+1} - inv_t\right] \qquad (21)$$

B1.22 Aggregate supply of home goods

$$y_{H,t} = a_t + \alpha k_{t-1} + (1-\alpha)l_t \qquad (22)$$

B1.23 Definition of the marginal rate of substitution b/w labor and consumption

$$mrs_t = \sigma_L l_t + \frac{1}{\sigma}\frac{1}{(1-h)}c_t - \frac{1}{\sigma}\frac{h}{(1-h)}c_{t-1} \qquad (23)$$

B1.24 Demand for labor

$$rw_t = mc_t + y_t - l_t \qquad (24)$$

B1.25 Philips curve

$$\pi_{H,t} = \frac{\beta}{1+\beta\chi_H}E_t\left[\pi_{H,t+1}\right] + \frac{\beta}{1+\beta\chi_H}\pi_{H,t-1} + \frac{(1-\theta_H)(1-\beta\theta_H)}{\theta_H(1+\beta\chi_H)}(mc_t - (p_{H,t} - p_t)) \qquad (25)$$

B1.26 Capital evolution

$$k_t = \zeta_{INV} + (1-\delta)k_{t-1} \qquad (26)$$

B1.27 Monetary policy rule

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t + \phi_y y_t + \phi_{\Delta_e}\Delta e_t) + z_t \qquad (27)$$

B1.28 Phillips curve for wages

$$\pi_t^w = \chi_w \pi_{t-1} + \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\varepsilon_w\sigma_L)}(mrs_t - rw_t) + \beta E_t\left[\pi_{t+1}{}^w - \chi_w \pi_t\right] \quad (28)$$

B1.29 Definition of infaltion wages

$$\pi_t^w = rw_t - rw_{t-1} + \pi_t \quad (29)$$

B1.30 Government expenditure evolution

$$g_t = \rho_g g_{t-1} + \varepsilon_{g,t} \quad (30)$$

B1.31 Productivity evolution

$$a_t = \rho_a a_{t-1} + \varepsilon_{a,t} \quad (31)$$

B1.32 New monetary deviation evolution

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t} \quad (32)$$

B1.33 Foreign interest rate evolution

$$i_t^* = \rho_{i^*} i_{t-1}^* + \varepsilon_{i^*,t} \quad (33)$$

B1.34 Foreign inflation evolution

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_{\pi^*,t} \quad (34)$$

B1.35 commodity price evolution (in real foreign terms)

$$(p_{co,t}^* - p_t^*) = \rho_{pco^*}(p_{co,t-1}^* - p_{t-1}^*) + \varepsilon_{pco^*,t} \quad (35)$$

B1.36 commodity production evolution

$$y_{co,t} = \rho_{yco} y_{co,t-1} + \varepsilon_{co,t} \quad (36)$$

B1.37 foreign demand

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_{y^*,t} \quad (37)$$

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