ARGEMmy: an intermediate DSGE model calibrated/estimated for Argentina: two policy rules are often better than one

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[1] The opinions expressed in this paper are the author's and do not necessarily reflect those of the Central Bank of Argentina.

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ARGEMmy: an intermediate DSGE model calibrated/estimated for Argentina: two policy rules are often better than one[2]

1. Introduction

The purpose of this paper is to advance in the construction and calibration/estimation of an intermediate DSGE model with two policy rules for Argentina and explore to what extent two policy rules can be better than one. The BCRA's research department currently uses a very small and non-micro founded model with two policy rules which I designed a few years ago (MEP: Modelo Económico Pequeño (see Elosegui, Escudé, Garegnani and Sotes Paladino 2007)) as the backbone for a system of macro and monetary projections. During 2006-07 I constructed the much larger DSGE model ARGEM, mainly for research purposes. It seemed that there was need for an intermediate sized DSGE model that could be of help in bridging the gap between the two. ARGEMmy is the result of this new effort.[3] Hopefully, it will help in bringing the DSGE modeling strategy closer to the policy environment.

The new model has much of the fundamental structure of ARGEM: it includes banks as well as the ability to model a managed exchange rate regime by means of two simultaneous policy rules (which may be feedback rules or not): the usual policy rule for achieving an operational target for the nominal interest rate and an additional policy rule that reflects the Central Bank's intervention in the foreign exchange market. It also has some features that may be seen as an advance on ARGEM. In particular, instead of a feedback rule on international reserves, as in the current version of ARGEM, I now use a feedback rule on the rate of nominal currency depreciation that includes a long run target for international reserves (as a ratio to GDP). This seems closer to the way Central Banks that systematically intervene in the foreign exchange market actually interpret their intervention, caring for the level of the exchange rate in the short to medium run and the level of foreign exchange reserves in a longer run.

Making specific assumptions on monetary and exchange rate policy in Argentina is not easy. After two hyperinflationary experiences Argentina fixed its exchange rate to the U.S. dollar during the Convertibility period (April 1991-December 2001) with the hope of putting and end to its long inflationary history. However, since the dollar floated against other currencies (which represented 85% of Argentina's trade)

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[3] The features of ARGEM that are suppressed in order to simplify the model are: 1) investment, and hence the capital stock and its intensity of utilization, implying that what is called consumption in ARGEMmy should be interpreted as absorption (consumption plus investment), 2) the deposit rate, which is collapsed with the Central Bank bond rate under the assumption that they are perfect substitutes, 3) bank reserves in the Central Bank and Bank demand for foreign and domestic currency cash, 4) manufactured exports, which leaves only primary sector exports (commodities). As a consequence of 4) in (this version of) ARGEMmy there is no Phillips equations for manufactured exports. Nevertheless, there is still abundant nominal rigidity in ARGEMmy since it includes three Phillips equations (wages, domestic goods, and imported goods), all with Calvo style stickiness plus full indexation to the previous period's inflation for those who do not optimize currently. Also, imported goods prices are set in domestic (local) currency, generating a slow pass-through of both foreign prices and the exchange rate to domestic import prices.

and strongly appreciated against all currencies (from 1995 to 2001), so did the peso, generating loss of competitiveness, high unemployment and the expectation of a regime shift. After the demise of Convertibility and an interim period of turbulence, the nominal exchange rate once again tended to be stable against the dollar, albeit at around 3 pesos per dollar (instead of 1, as during Convertibility) until recently. There are now no institutional restrictions on changing the nominal exchange rate as there was during Convertibility, nor on influencing the domestic interest rate through monetary policy. The Central Bank regularly intervenes both in the money market and in the foreign exchange market, with higher frequency in the second.[4]

Due to the diversity of exchange rate regimes Argentina has had in the last few decades (and the fact that there is still the possibility of future changes in the regime), I built the model so that it can handle different regimes. In particular, there are two policy rules (one for the interest rate and another for the rate of nominal depreciation), which may or may not be feedback rules. When they are both feedback rules, they both respond to deviations of the year on year 'consumption' inflation rate from a target (that defines the nonstochastic steady state inflation) and deviations of GDP and the trade balance ratio (to GDP) from their nonstochastic steady state (NSS) values. This reflects a simultaneous concern for inflation, output, and current account stabilization. In ARGEM I used the multilateral real exchange rate (MRER) instead of the trade balance ratio. But they are quite interchangeable, since both are directly related to external balance objectives. I found it convenient here to use the trade balance ratio because it was easier to express its steady state value in terms of parameters that may be estimated instead of imposing a steady state value that would introduce an unnecessary restriction in the estimation process. But it may also be more natural to think in terms of an equilibrium long run trade balance ratio (that reflects the net foreign debt servicing in the steady state) in a policy rule or in a Central Bank loss function. Nevertheless, the model can be formulated using either variable, both of which are endogenous in the NSS.

In this paper I summarize preliminary results on the Bayesian estimation of a subset of the parameters in ARGEMmy using data from the post-Convertibility period. I found that a model with only a simple policy rule for the rate of nominal currency depreciation yields a better fit than one with two simple policy rules. Hence, I only report results from the latter. I use the estimated parameters to address the main objective of this paper: to explore to what extent a monetary and foreign exchange regime with two policy rules (i.e., a 'Managed Exchange Rate' (MER) regime) may be superior to the usual alternatives: a 'Floating Exchange Rate' (FER) regime and a 'Pegged Exchange Rate' (PER) regime. For this I place ARGEMmy within a linear-quadratic optimal control framework under commitment and perfect information, introducing an ad-hoc quadratic Central Bank intertemporal loss function. I obtain the optimal policy rules and minimum losses under different Central Bank preferences (or styles) and for the three alter-

[4] In an empirical paper, Garegnani and Escudé (2004) study the role of the U.S. MRER as a fundamental for Argentina's MRER. Escudé (2008) studies the simple nonlinear dynamics of the Argentinian economy during both the Convertibility and post-Convertibility periods within a deterministic model.

native policy regimes. The preliminary results I show here indicate that two policy rules are usually better than one. Indeed, in all the cases I actually computed, the MRER regime generated a lower loss. Hence, having a model that can reflect two policy rules is not only of greater generality than conventional models but at least for many Central Bank styles is the only way to represent a policy regime that gets the Central Bank closer to its objectives.

Although the model is constructed for a developing country economy, I believe that some of the central ideas are applicable to industrialized countries, even countries like the U.S. which even though it is the closest one can come to an example of a closed economy is nevertheless open, making exchange rate developments very important. In an empirical paper, S. Kim (2003) estimates a generalized structural VAR to jointly analyze the effects of foreign exchange intervention and interest rate setting using data for the U.S. for the post Bretton-Woods period. He correctly stresses the need for a unified empirical model for the analysis of two policies that obviously interact. His results show that there is plenty of such interaction and he suggests the need to model foreign exchange policy explicitly when addressing monetary policy and exchange rate developments. The idea behind the use of two policy rules in my modeling goes precisely in this direction. If such a unified framework is needed for the U.S. economy, it is of course even more important in considering developing economies in which foreign exchange market intervention is routinely practiced on a day to day basis.

The rest of the paper has the following structure. Section 2 presents ARGEMmy in detail. Section 3 arranges the log-linear approximation to the model equations for simple policy rules in a matrix form suitable for model solution. Section 4 addresses the baseline calibration. Section 5 shows results from a search for the ranges in which the individual simple policy rule coefficients maintain the saddlepath stability of the model. Section 6 contains preliminary Bayesian estimation of a subset of the model parameters, including the persistence coefficients and standard errors of the exogenous shock processes. Section 7 puts the set of non-policy log-linear equations in a matrix form suitable for optimal policy analysis, introduces the Central Bank loss function used, summarizes the theory for optimal policy under commitment and full information, and shows numerical results for optimal policy rules and resulting losses for the three policy regimes. Finally, section 8 concludes. I relegate much of the material to Appendices, including the complete set of non-linear and log-linear equations, the derivation of the recursive formulation of the three Phillips equations, a detailed initial calibration of all the model parameters and resulting steady state values of the endogenous variables, and a set of impulse responses for the simple policy rules model that was estimated.

2. The model

2.1. Households

Infinitely lived households are monopolistic competitors in the supply of differentiated labor. There is a domestic market for state-contingent securities that are held by households, insuring them against profit and wage idiosyncratic risks (see Woodford (2003)). This makes households essentially the same in equilibrium, and allows us to maintain the representative household fiction (i.e. dispense with the complexities that stem from household heterogeneity). Aside from these state-

contingent securities, they hold financial wealth in the form of domestic currency (M_t^0) and peso denominated one period nominal deposits issued by domestic commercial banks (D_t) that pay a nominal interest rate i_t. They consume a bundle of domestic and imported goods and are unable to insure their real incomes against the effect of domestic and foreign inflation and exchange rate developments. I assume that the Central Bank fully and credibly insures depositors, so the deposit rate is considered riskless.

2.1.1 The household optimization problem

The household holds cash M_t^0 because doing so it economizes on transactions costs. I assume that consumption transactions involve the use of real resources and that these transactions costs per unit of expenditure are a decreasing and convex function τ_M of the currency/consumption ratio ϖ_t:

$$\tau_M(\varpi_t) \qquad \tau'_M < 0, \tau''_M > 0, \tag{1}$$
$$\varpi_t \equiv \frac{M_t^0}{P_t^C C_t} = \frac{M_t^0/P_t}{p_t^C C_t},$$

where C_t is a consumption index, and P_t and P_t^C are the price indexes of domestic goods and of the the consumption bundle, respectively. For convenience, I have defined the relative price of consumption goods in terms of domestic goods:

$$p_t^C \equiv \frac{P_t^C}{P_t}.$$

All price indexes are in monetary units. The two basic price indexes in the SOE are those of domestically produced ('domestic') goods, P_t, and imported goods P_t^N. The consumption price index is a CES composite of these basic price indexes, as I detail below. The assumption in (1) is that when the currency/consumption ratio ϖ_t increases, transactions costs per unit of consumption decrease, but at a decreasing rate that reflects a diminishing marginal productivity of currency in the reduction of transactions costs.

I model nominal stickiness as in ARGEM (Escudé (2007)). In particular, households set wages under monopolistic competition with sticky nominal wages. Household $h \in [0,1]$ is the sole supplier of labor of type h, and makes the wage setting decision taking the aggregate wage index and labor supply as parametric. Every period, each household has a probability $1-\alpha_W$ of being able to set the optimum wage for its specific labor type. This probability is independent of when it last set the optimal wage. When it can't optimize, the household adjusts its wage rate by fully indexing to last period's overall rate of wage inflation. Hence, when it can set the optimal wage rate it must take into account that in any future period j there is a probability α_W^j that its wage will be the one it sets today plus full indexation. Hence, the household faces a wage survival constraint, according to which the wage rate it sets at t, $W_t(h)$, has a probability α_W^j of surviving (indexed) until period $t+j$:

$$W_{t+j}(h) = W_t(h)\frac{W_t}{W_{t-1}}\frac{W_{t+1}}{W_t}...\frac{W_{t+j-1}}{W_{t+j-2}} \tag{2}$$
$$\equiv W_t(h)\pi_t^W\pi_{t+1}^W...\pi_{t+j-1}^W \equiv W_t(h)\Psi_{t,j}^w,$$

where the rate of wage inflation is defined as $\pi_t^W \equiv W_t/W_{t-1}$, and the cumulative wage inflation between $t+j-2$ and t is $\Psi_{t,j}^w$, with $\Psi_{t,0}^w \equiv 1$. In deriving the first order condition for $W_t(h)$ below the following identity is used :

$$\frac{W_t(h)}{W_{t+j}}\Psi_{t,j}^w = \frac{W_t(h)}{W_t}\frac{\pi_t^W \pi_{t+1}^W ... \pi_{t+j-1}^W}{\pi_{t+1}^W ... \pi_{t+j-1}^W \pi_{t+j}^W} = \frac{W_t(h)}{W_t}\frac{\pi_t^W}{\pi_{t+j}^W}. \tag{3}$$

The household also faces the labor demand function for its particular type of labor as a constraint:

$$h_t(h) = h_t\left(\frac{W_t(h)}{W_t}\right)^{-\psi}, \tag{4}$$

where W_t is the aggregate wage index, defined as:

$$W_t = \left(\int_0^\infty W_t(h)^{1-\psi}dh\right)^{1/(1-\psi)}, \tag{5}$$

and where ψ is the elasticity of substitution between differentiated labor services[5]. When h sets the optimal wage, it must take into account that there is a probability α_W^j that at time $t+j$ its wage will be the $W_t(h)\Psi_{t,j}^w$, and that hence the labor demand it faces is:

$$h_{t+j}(h) = h_{t+j}\left(\frac{W_t(h)\Psi_{t,j}^w}{W_{t+j}}\right)^{-\psi}. \tag{6}$$

The household receives income from profits, wage, and interest, and spends on consumption, taxes, and transactions costs. Its real budget constraint in period t is:

$$\begin{aligned}\frac{M_t^0(h)}{P_t} + \frac{D_t(h)}{P_t} &= \frac{\Pi_t(h)}{P_t} + \frac{W_t(h)}{P_t}h_t(h) - \frac{T_t(h)}{P_t} + \frac{\Upsilon_t(h)}{P_t} \\ &+ \frac{M_{t-1}^0(h)}{P_t} + (1+i_{t-1})\frac{D_{t-1}(h)}{P_t} - \left[1+\tau_M\left(\frac{M_t^0(h)/P_t}{p_t^C C_t(h)}\right)\right]p_t^C C_t(h)\end{aligned} \tag{7}$$

where $\Pi_t(h)$ is nominal profits, $h_t(h)$ is hours of work, $T_t(h)$ is lump sum taxes net of transfers, and $\Upsilon_t(h)$ is the income obtained in t from holding state-contingent securities.

Household h maximizes an inter-temporal utility function which is additively separable in the consumption of private goods C_t and leisure:

$$E_t\sum_{j=0}^\infty \beta^j\left\{z_{t+j}^C \log\left[C_{t+j}(h) - \xi C_{t+j-1}(h)\right] + \left[\overline{h} - \eta z_{t+j}^H \frac{h_{t+j}(h)^{1+\chi}}{1+\chi}\right]\right\}, \tag{8}$$

where β is the intertemporal discount factor, $\overline{h}$ is the maximum labor time available (and hence the term in square brackets is "leisure"), η is a constant, χ is the inverse of the elasticity of labor supply with respect to the real wage, z_t^C and z_t^H are consumption demand and labor supply shocks that are common to all households. Consumption nests habit formation, where ξ is a positive parameter less than unity.

[5] I derive these equations from domestic intermediate firms' cost minimization below.

The household's inter-temporal solvency is guaranteed by its inability to incur in debt, which I assume does not bind in any finite time:

$$D_{t+T} \geq 0, \qquad \forall T \geq 0. \tag{9}$$

Household h chooses $C_{t+j}(h)$, $D_{t+j}(h)$, $M^{0,H}_{t+j}(h)$, (j=1,2,...) and $W_t(h)$, by maximizing (8) subject to its sequence of budget constraints (7), its combined labor demands and wage survival constraints (6), and its "no debt" constraints (9). Substituting for the labor demand constraints, the Lagrangian is hence:

$$\begin{aligned}
&E_t \sum_{j=0}^{\infty} \beta^j \{ z^C_{t+j} \log \left[C_{t+j}(h) - \xi C_{t+j-1}(h) \right] + \overline{h} \\
&- (\alpha_W)^j \frac{\eta z^H_{t+j}}{1+\chi} \left(h_{t+j} \left(\frac{W_t(h) \Psi^w_{t,j}}{W_{t+j}} \right)^{-\psi} \right)^{1+\chi} \\
&+ \lambda_{t+j}(h) \left\{ \frac{\Pi_{t+j}(h)}{P_{t+j}} - \frac{T_{t+j}(h)}{P_{t+j}} + (\alpha_W)^j \frac{W_t(h) \Psi^w_{t,j}}{P_{t+j}} h_{t+j} \left(\frac{W_t(h) \Psi^w_{t,j}}{W_{t+j}} \right)^{-\psi} \right. \\
&- \left[1 + \tau_M \left(\frac{M^0_{t+j}(h)/P_{t+j}}{p^C_{t+j} C_{t+j}(h)} \right) \right] p^C_{t+j} C_{t+j}(h) + \frac{M^0_{t+j-1}(h)}{P_{t+j}} \\
&\left. + (1 + i_{t+j-1}) \frac{D_{t+j-1}(h)}{P_{t+j}} - \frac{M^0_{t+j}(h)}{P_{t+j}} - \frac{D_{t+j}(h)}{P_{t+j}} + \frac{\Upsilon_{t+j}(h)}{P_{t+j}} \right\} \Bigg\} .
\end{aligned} \tag{10}$$

where $\beta^j \lambda_{t+j}(h)$ are the Lagrange multipliers, and can be interpreted as the marginal utility of real income.

Since (aside from their labor type) households only differ on whether they can choose the optimal wage, I eliminate the household index below, and use $\widetilde{W_t}$ to distinguish the newly optimal wage from the aggregate wage index W_t (which includes both optimal and indexed wages). The first order conditions for an optimum (including the transversality condition) are the following:

$$C_t : \qquad \frac{z^C_t}{C_t - \xi C_{t-1}} - \beta \xi E_t \left(\frac{z^C_{t+1}}{C_{t+1} - \xi C_t} \right) = \lambda_t \varphi_M \left(\frac{M^0_t / P_t}{p^C_t C_t} \right) p^C_t \tag{11}$$

$$D_t : \qquad \lambda_t = \beta \left(1 + i_t \right) E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \right) \tag{12}$$

$$M^0_t : \qquad \lambda_t \left[1 + \tau'_M \left(\frac{M^0_t / P_t}{p^C_t C_t} \right) \right] = \beta E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \right) \tag{13}$$

$$\begin{aligned}
W_t \ : \qquad & 0 = E_t \sum_{j=0}^{\infty} (\beta \alpha_W)^j \lambda_{t+j} h_{t+j} \frac{W_{t+j}}{P_{t+j}} \left(\pi^W_{t+j} \right)^{\psi_t} \\
& \times \left\{ \left(\frac{\widetilde{W_t}}{W_t} \frac{\pi^W_t}{\pi^W_{t+j}} \right) - \frac{\psi}{\psi - 1} \frac{\eta z^H_{t+j} \left(h_{t+j} \right)^{\chi}}{\lambda_{t+j} W_{t+j} / P_{t+j}} \left(\frac{\widetilde{W_t}}{W_t} \frac{\pi^W_t}{\pi^W_{t+j}} \right)^{-\psi \chi} \right\}
\end{aligned} \tag{14}$$

$$\lim_{t \to \infty} \beta^t D_t = 0. \tag{15}$$

In (12) and (13) the domestic goods inflation rate $\pi_{t+1} \equiv P_{t+1}/P_t$ has been defined, and in (11) the auxiliary function φ_M gives the total effect on expenditure (i.e., including transactions cost related expenditures) of a marginal increase in consumption. It is defined as:[6]

$$\varphi_M(\varpi_t) \equiv 1 + \tau_M(\varpi_t) - \varpi_t \tau'_M(\varpi_t), \tag{16}$$

which implies:

$$\varphi'_M(\varpi_t) = -\varpi_t \tau''_M(\varpi_t) < 0.$$

(11) shows that in equilibrium the utility gain from a marginal increase in consumption (left side of the equality), equals the foregone marginal utility of real income it generates, including that which is related to transactions costs (given by $\varphi_M(.)$). (12) states that the loss in utility from marginally increasing the holding of deposits equals the expected utility of the addition to real interest income it generates next period. And (13) states that the net loss of utility from marginally increasing the holding of cash after taking into account the reduction in transactions costs it generates, is equal to the expected marginal utility of having it available tomorrow with its purchasing power corrected for inflation.

Combining (12) and (13) yields:

$$-\tau'_M\left(\frac{M_t^0/P_t}{p_t^C C_t}\right) = 1 - \frac{1}{1+i_t}, \tag{17}$$

which shows that the optimum stock of currency as a fraction of expenditure in consumption is such that the reduction in transactions costs generated by a marginal increase in this ratio equals the opportunity cost of holding cash. Inverting $-\tau'_M$ gives the following demand function for cash as a vehicle for transactions (sometimes called 'liquidity preference' function):

$$M_t^0/P_t = \mathcal{L}(1+i_t)\, p_t^C C_t, \tag{18}$$

where $\mathcal{L}(.)$ is defined as:

$$\mathcal{L}(1+i_t) \equiv (-\tau'_M)^{-1}\left(1 - \frac{1}{1+i_t}\right),$$

and is strictly decreasing, since:

$$\mathcal{L}'(1+i_t) = \left[-\tau''_M(.)\,(1+i_t)^2\right]^{-1} < 0.$$

From here on I replace the first order condition (13) by (18) and use (18) to eliminate the household currency to consumption ratio wherever it appears through the use of the following auxiliary functions:

$$\widetilde{\varphi}_M(1+i_t) \equiv \varphi_M(\mathcal{L}(1+i_t)), \qquad \widetilde{\tau}_M(1+i_t) \equiv \tau_M(\mathcal{L}(1+i_t)). \tag{19}$$

In particular, (11) can be written as:

$$\frac{z_t^C}{C_t - \xi C_{t-1}} - \beta\xi E_t\left(\frac{z_{t+1}^C}{C_{t+1} - \xi C_t}\right) = \lambda_t \widetilde{\varphi}_M(1+i_t)\, p_t^C \tag{20}$$

[6] $\varphi_M(m/a)$ is the partial derivative of $[1+\tau_M(m/a)]\,a$ with respect to a.

In (14), since all households that can set their optimal wage in t make the same decision, the optimum wage rate is denoted $\widetilde{W}_t$. Hence, (5) and (2) imply the following law of motion for the aggregate wage rate (after taking into account that in the Calvo setup, because optimizers are randomly chosen from the population, their average wage rate in $t-1$ is equal to the average overall wage level (indexed by wage inflation) no matter when they optimized for the last time):

$$W_t^{1-\theta} = \alpha_W \left(W_{t-1}\pi_{t-1}^W\right)^{1-\theta} + (1-\alpha_W)\widetilde{W}_t^{1-\theta}. \tag{21}$$

Defining the real wage in terms of domestic goods and the relative wage between the optimizers and the general level:

$$w_t = \frac{W_t}{P_t}, \qquad \widetilde{w}_t = \frac{\widetilde{W}_t}{W_t},$$

the first order condition for W_t becomes:

$$\begin{aligned} 0 &= E_t \sum_{j=0}^{\infty} (\beta\alpha_W)^j \lambda_{t+j} h_{t+j} w_{t+j} \left(\pi_{t+j}^W\right)^{\psi} \\ &\left\{ \left(\frac{\widetilde{w}_t \pi_t^W}{\pi_{t+j}^W}\right) - \frac{\psi}{\psi-1} \frac{\eta z_{t+j}^H (h_{t+j})^{\chi}}{\lambda_{t+j} w_{t+j}} \left(\frac{\widetilde{w}_t \pi_t^W}{\pi_{t+j}^W}\right)^{-\psi\chi} \right\}. \end{aligned} \tag{22}$$

And dividing through (21) by $W_{t-1}^{1-\theta}$ and rearranging gives:

$$\widetilde{w}_t \pi_t^W = \left(\frac{\left(\pi_t^W\right)^{1-\theta} - \alpha_W \left(\pi_{t-1}^W\right)^{1-\theta}}{1-\alpha_W}\right)^{\frac{1}{1-\theta}}. \tag{23}$$

Hence, (22) becomes the non-linear Phillips equation that determines the dynamics of wage inflation:

$$\begin{aligned} 0 &= E_t \sum_{j=0}^{\infty} (\beta\alpha_W)^j \lambda_{t+j} h_{t+j} w_{t+j} \left(\pi_{t+j}^W\right)^{\psi-1} \\ &\left\{ \left(\frac{\left(\pi_t^W\right)^{1-\theta} - \alpha_W \left(\pi_{t-1}^W\right)^{1-\theta}}{1-\alpha_W}\right)^{\frac{1+\psi\chi}{1-\theta}} - \frac{\psi}{\psi-1} \frac{\eta z_{t+j}^H (h_{t+j})^{\chi} \left(\pi_{t+j}^W\right)^{1+\psi\chi}}{\lambda_{t+j} w_{t+j}} \right\}. \end{aligned} \tag{24}$$

In Appendix 2 I obtain a recursive three equation version of this equation which is actually used for simulation and estimation.

2.1.2. Domestic and imported consumption

So far I have ignored the open economy attributes of consumption as well as product differentiation. I now distinguish between domestic and imported consumption goods. The consumption index used in the household optimization problem is actually a constant elasticity of substitution (CES) aggregate consumption index of domestic and imported goods:

$$C_t = \left(a_D^{\frac{1}{\theta^C}} \left(C_t^D\right)^{\frac{\theta^C-1}{\theta^C}} + a_N^{\frac{1}{\theta^C}} \left(C_t^N\right)^{\frac{\theta^C-1}{\theta^C}}\right)^{\frac{\theta^C}{\theta^C-1}}, \qquad a_D + a_N = 1. \tag{25}$$

$\theta^C (> 0)$ is the elasticity of substitution between domestic and imported consumption goods. Also, C_t^D and C_t^N are themselves CES aggregates of the domestic and imported (respectively) varieties of goods available:

$$C_t^D = \left(\int_0^1 C_t^D(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \qquad \theta > 1 \tag{26}$$

$$C_t^N = \left(\int_0^1 C_t^N(i)^{\frac{\theta^N-1}{\theta^N}} di \right)^{\frac{\theta^N}{\theta^N-1}}, \qquad \theta^N > 1. \tag{27}$$

where θ and θ^N are the elasticities of substitution between varieties of domestic and imported goods in household expenditure, respectively. Total consumption expenditure is:

$$P_t^C C_t = P_t C_t^D + P_t^N C_t^N. \tag{28}$$

Then minimization of (28) subject to (25) for a given C_t, yields the following relations:

$$P_t = a_D^{\frac{1}{\theta^C}} P_t^C \left(\frac{C_t^D}{C_t} \right)^{-\frac{1}{\theta^C}} \tag{29}$$

$$P_t^N = a_N^{\frac{1}{\theta^C}} P_t^C \left(\frac{C_t^N}{C_t} \right)^{-\frac{1}{\theta^C}}. \tag{30}$$

Introducing these in (25) yields the consumption price index:

$$P_t^C = \left(a_D \left(P_t\right)^{1-\theta^C} + a_N \left(P_t^N\right)^{1-\theta^C} \right)^{\frac{1}{1-\theta^C}}. \tag{31}$$

Furthermore, it is readily seen that a_D and a_N in (25) are the shares of domestic and imported consumption in total consumption expenditures:

$$a_D = \frac{P_t C_t^D}{P_t^C C_t} = \frac{C_t^D}{p_t^C C_t}, \qquad a_N = 1 - a_D = \frac{P_t^N C_t^N}{P_t^C C_t} = \frac{p_t^N C_t^N}{p_t^C C_t}, \tag{32}$$

where

$$p_t^N \equiv \frac{P_t^N}{P_t}$$

is the relative domestic price of imports in terms of domestic goods, or internal terms of trade (ITT). I calibrate a_D below as to have home bias ($a_D > 0.5 > a_N$).

Conditions (29), and (30) are necessary for the optimal allocation of household expenditures across domestic and imported goods. Similarly, for the optimal allocation across varieties of domestic and imported goods within these classes, and using (26), (27), the following conditions hold:

$$P_t(i) = P_t \left(\frac{C_t^D(i)}{C_t^D} \right)^{-\frac{1}{\theta^C}}$$

$$P_t^N(i) = P_t^N \left(\frac{C_t^N(i)}{C_t^N} \right)^{-\frac{1}{\theta^C}}.$$

Finally, dividing (31) through by P_t yields a relation between the relative price of consumption goods in terms of domestic goods and the ITT:

$$p_t^C = \left[a_D + (1 - a_D) \left(p_t^N\right)^{1-\theta^C} \right]^{\frac{1}{1-\theta^C}}.$$

2.2. Domestic goods firms

2.2.1. Final domestic goods

There is perfect competition in the production (or bundling) of final domestic output Q_t, with the output of intermediate firms as inputs. A representative final domestic output firm uses the following CES technology:

$$Q_t = \left(\int_0^1 Q_t(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \qquad \theta > 1 \tag{33}$$

where θ is the elasticity of substitution between any two varieties of domestic goods and $Q_t(i)$ is the output of the intermediate domestic good i. The final domestic output representative firm solves the following problem each period:

$$\max_{Q_t(i)} P_t \left(\int_0^1 Q_t(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}} - \int_0^1 P_t(i) Q_t(i) di, \tag{34}$$

the solution of which is the demand for each type of domestic good as a fraction of aggregate domestic output that is itself an inverse function of the good's price relative to the aggregate domestic price index:

$$Q_t(i) = Q_t \left(\frac{P_t(i)}{P_t} \right)^{-\theta}. \tag{35}$$

Introducing (35) in (33) and simplifying, it is readily seen that the domestic goods price index is:

$$P_t = \left(\int_0^1 P_t(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}}. \tag{36}$$

Also, introducing (35) into the cost part of (34) yields:

$$\int_0^1 P_t(i) Q_t(i) di = P_t Q_t.$$

2.2.2. Intermediate domestic goods

A continuum of monopolistically competitive firms produce intermediate domestic goods using labor and imported inputs, with no entry or exit. They face perfectly competitive bundlers of import goods and labor types. The production function of firm i is:

$$Q_t(i) = \epsilon_t \left(z_t h_t(i) \right)^{b^D} N_t^D(i)^{1-b^D} \tag{37}$$

where ϵ_t and z_t are industry-wide productivity shocks (transitory and permanent, respectively), N_t^D is the consumption in production of intermediate imported inputs, and $h_t(i)$ is a CES index of all the labor types:

$$h_t(i) = \left(\int_0^1 h_t(h,i)^{\frac{\psi-1}{\psi}} dh \right)^{\frac{\psi}{\psi-1}}, \tag{38}$$

where $h_t(h,i)$ is the amount of labor type h used by the domestic firm i.

2.2.3. Marginal cost and input demands

I assume that a stochastic and possibly time-varying fraction ς_t of the cost bill is financed by the domestic banking system. Let i_t^L be the bank nominal loan rate. During period t the firm formulates its demand for bank loans taking into account its expected financing needs in period $t+1$. Its total variable cost in period t is:

$$\left(1+\varsigma_t i_{t-1}^L\right)\left[W_t h_t(i)+P_t^N N_t^D(i)\right]$$

To maximize profits, the firm must minimize costs. It takes as given the wages $W_t(h)$ set by the different households. Consider first the minimization of total labor cost:

$$\int_0^1 W_t(h)h_t(h,i)dh \tag{39}$$

subject to a constant aggregate index of labor types (38). I call the Lagrange multiplier W_t. It does not depend on i since the problem is the same for all firms. Then the minimization results in i's inverse demand function for labor type h:

$$W_t(h)=W_t\left(\frac{h_t(h,i)}{h_t(i)}\right)^{-\frac{1}{\psi}}. \tag{40}$$

Defining the aggregate demand (over all firms) for labor of type h:

$$h_t(h)=\int_0^1 h_t(h,i)di,$$

and the aggregate demand (over all firms) for the labor bundle (over all households):

$$h_t=\int_0^1 h_t(h)dh,$$

(40) implies the labor demand function (4) I used for the household problem. Furthermore, introducing (40) in (38) yields:

$$W_t=\left(\int_0^1 W_t(h)^{1-\psi}di\right)^{\frac{1}{1-\psi}},$$

confirming that the Lagrange multiplier is indeed the aggregate wage index as the notation implied. And introducing (40) in (39) yields a more convenient expression for the wage bill of firm i:

$$\int_0^1 W_t(h)h_t(h,i)dh=W_t h_t(i).$$

I now obtain factor and bank loan demands by solving the following cost minimization problem:

$$\min_{h_t(i),N_t^D(i)}\left\{\left(1+\varsigma_t i_{t-1}^L\right)\left[W_t h_t(i)+P_t^N N_t^D(i)\right]\right\}$$

subject to (37), where $Q_t(i)$ is given. The problem is the same for all firms, so I eliminate the firm index. The first order conditions are:

$$\left(1+\varsigma_t i_{t-1}^L\right) W_t h_t = b^D MC_t Q_t \tag{41}$$

$$\left(1+\varsigma_t i_{t-1}^L\right) P_t^N N_t^D = (1-b^D) MC_t Q_t, \tag{42}$$

where MC_t is the Lagrange multiplier (and has the obvious interpretation of marginal cost). Adding these equations term by term and dividing by P_t gives:

$$\left(1+\varsigma_t i_{t-1}^L\right)\left(w_t h_t + p_t^N N_t^D\right) = mc_t Q_t, \tag{43}$$

where I defined the real wage w_t and real marginal cost mc_t:

$$w_t \equiv \frac{W_t}{P_t}, \qquad mc_t \equiv \frac{MC_t}{P_t}.$$

Furthermore, introducing the first order conditions (41)-(42) in the production function (37) yields the following expression for the real marginal cost:

$$mc_t = \frac{1}{\kappa \epsilon_t}\left(1+\varsigma_t i_{t-1}^L\right)\left(\overline{w}_t\right)^{b^D}\left(p_t^N\right)^{1-b^D}, \tag{44}$$

where

$$\overline{w}_t \equiv \frac{W_t}{z_t P_t} \equiv \frac{w_t}{z_t}$$

is the efficiency wage and

$$\kappa \equiv \left(b^D\right)^{b^D}\left(1-b^D\right)^{1-b^D}.$$

Aggregate demand functions for h_t and N_t^D are obtained directly from (41)-(42) and (44):

$$h_t = \frac{1}{\kappa \epsilon_t} b^D \left(\frac{p_t^N}{\overline{w}_t}\right)^{1-b^D} Q_t / z_t \tag{45}$$

$$N_t^D = \frac{1}{\kappa \epsilon_t}(1-b^D)\left(\frac{\overline{w}_t}{p_t^N}\right)^{b^D} Q_t. \tag{46}$$

Also, dividing (41) by (42) term by term gives the relation:

$$w_t h_t = \frac{b^D}{1-b^D} p_t^N N_t^D. \tag{47}$$

Finally, the aggregate real demand for bank loans by firms in period t is:

$$\frac{L_t}{P_t} = \varsigma_t E_t\left(w_{t+1} h_{t+1} + p_{t+1}^N N_{t+1}^D\right) = \frac{\varsigma_t}{b^D} E_t\left(w_{t+1} h_{t+1}\right). \tag{48}$$

2.2.4. Sticky nominal price setting

Firms make pricing decisions taking the aggregate price and quantity indexes as parametric. Every period, each firm has a probability $1-\alpha_D$ of being able to set the optimum price for its specific type of good and whenever it can't optimize it adjusts its price by fully indexing to last period's overall rate of domestic inflation. Hence, when it can set its optimal price it must take into account that in any future period j there is a probability α_D^j that its price will be the one it sets today plus full indexation. Hence, the firm's price survival constraint states that the price it sets at t, $P_t(i)$ has a probability α_D^j of surviving (indexed) until period $t+j$:

$$P_{t+j}(i) = P_t(i)\pi_t\pi_{t+1}...\pi_{t+j-1} \equiv P_t(i)\Psi_{t,j}^p. \tag{49}$$

where $\Psi_{t,0}^p \equiv 1$. Below I make use of the following identity:

$$\frac{P_t(i)}{P_{t+j}}\Psi_{t,j}^p = \frac{P_t(i)}{P_t}\frac{\pi_t}{\pi_{t+j}}. \tag{50}$$

Hence, I can express the firm's pricing problem as:

$$\max_{P_t(i)} E_t \sum_{j=0}^{\infty} \alpha_D^j \Lambda_{t,t+j}^D \left\{ \frac{P_t(i)\Psi_{t,j}^p}{P_{t+j}} - mc_{t+j}(i) \right\} Q_{t+j}(i)$$

subject to

$$Q_{t+j}(i) = Q_{t+j}\left(\frac{P_t(i)\Psi_{t,j}^p}{P_{t+j}}\right)^{-\theta}.$$

$\Lambda_{t,t+j}^D$ is the pricing kernel used by domestic firms for discounting, which is equal to households' intertemporal marginal rate of substitution in the consumption of domestic goods between periods $t+j$ and t:

$$\Lambda_{t,t+j}^D \equiv \beta^j \frac{U_{C^D,t+j}}{U_{C^D,t}}.$$

Note that the marginal utility of consuming domestic goods may be obtained from the marginal utility of consuming the aggregate bundle of (domestic and imported) goods. Specifically:

$$U_{C^D,t} = U_{C,t}\frac{dC_t}{dC_t^D} = U_{C,t}a_D^{\frac{1}{\theta^C}}\left(\frac{C_t^D}{C_t}\right)^{-\frac{1}{\theta^C}} = U_{C,t}\frac{P_t}{P_t^C} = U_{C,t}\frac{1}{p_t^C},$$

where the second equality if obtained by differentiating (25) with respect to C_t^D, and the third comes from (29). Hence, using (20), the pricing kernel of domestic firms is:

$$\Lambda_{t,t+j}^D \equiv \beta^j \frac{U_{C^D,t+j}}{U_{C^D,t}} = \beta^j \frac{\lambda_{t+j}\widetilde{\varphi}_M(1+i_{t+j})}{\lambda_t\widetilde{\varphi}_M(1+i_t)} \equiv \beta^j \frac{\overline{\Lambda}_{t+j}^D}{\overline{\Lambda}_t^D}. \tag{51}$$

Hence, the firm's first order condition is the following:

$$0 = E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^D Q_{t+j}(\pi_{t+j})^{\theta} \left\{ \frac{\widetilde{P}_t}{P_t}\frac{\pi_t}{\pi_{t+j}} - \frac{\theta}{\theta-1} mc_{t+j} \right\}. \tag{52}$$

Since all optimizing firms make the same decision I call the optimum price $\widetilde{P}_t$ and drop the firm index. In the (modified) Calvo setup, because optimizers are randomly chosen from the population their average price in $t-1$ is equal to that period's overall price index (indexed by the previous period's inflation) no matter when they optimized for the last time. Hence, (36) implies the following law of motion for the aggregate domestic goods price index:

$$P_t^{1-\theta} = \alpha_D \left(P_{t-1}\pi_{t-1}\right)^{1-\theta} + (1-\alpha_D)\widetilde{P}_t^{1-\theta}. \tag{53}$$

Dividing through by $P_{t-1}^{1-\theta}$ and rearranging yields:

$$\widetilde{p}_t \pi_t = \left(\frac{\left(\pi_t\right)^{1-\theta} - \alpha_D \left(\pi_{t-1}\right)^{1-\theta}}{1-\alpha_D}\right)^{\frac{1}{1-\theta}}. \tag{54}$$

where I define the optimal to average domestic relative price:

$$\widetilde{p}_t = \frac{\widetilde{P}_t}{P_t}.$$

Hence, using (54) I can express (52) as the (non-linear) Phillips equation that determines the dynamics of domestic inflation:

$$0 = E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^D Q_{t+j} \left(\pi_{t+j}\right)^{\theta-1} \left\{ \left(\frac{\left(\pi_t\right)^{1-\theta} - \alpha_D \left(\pi_{t-1}\right)^{1-\theta}}{1-\alpha_D}\right)^{\frac{1}{1-\theta}} - \frac{\theta}{\theta-1} mc_{t+j}\pi_{t+j} \right\}.$$

2.3. Foreign trade firms

There are two types of foreign trade firms: competitive primary goods producing firms that export all their output, and monopolistically competitive importers with sticky local currency pricing.

2.3.1 Primary exports producing firms

Firms in the export sector use domestic goods and "land" (representing natural resources) to produce an export commodity. Land is assumed to be fixed in quantity, hence generating diminishing returns. I assume that the export good is a single homogenous primary good (a commodity). Firms in this sector sell their output in the international market at the foreign currency price P_t^{**X}. They are price takers in factor and product markets. The price of primary goods in terms of the domestic currency is merely the exogenous international price multiplied by the nominal exchange rate (vis a vis a trade-weighted basket of currencies): $S_t P_t^{**X}$. I also assume that there is a mean one i.i.d. "climate" shock z_t^A that can make the harvest greater or smaller than expected. In order to obtain a lagged response in a simple way I assume that in period t export firms sign contracts by which they commit to delivering their (as yet unknown due to the "climate" shock) $(t+4)$-period harvest (i.e., next year, same quarter) at known t-period unit prices and exchange rates. Hence, though in t their export revenues have predetermined prices and exchange rate they earn more or less than they expected according to the realization of the "climate" shock.

Let the production function employed by firms in the export sector be the following:

$$X_t = (z_{t-4})^{1-b^A} \left(Q_{t-4}^{DX}\right)^{b^A} z_t^A, \qquad b^A < 1, \tag{55}$$

where Q_t^{DX} is the amount of domestic goods used as input in the export sector, and z_t is the same permanent productivity shock we used for domestic sector firms. These firms maximize expected profit

$$E_t \Pi_{t+4}^X = S_t P_t^{**X} E_t X_{t+4} - P_t Q_t^{DX}$$

subject to (55). The first order condition yields the export sector's (factor) demand for domestic goods:

$$Q_t^{DX} = z_t \left(b^A e_t p_t^{**}\right)^{\frac{1}{1-b^A}} \tag{56}$$

or equivalently:

$$Q_t^{DX} = b^A e_t p_t^{**} E_t X_{t+4}, \tag{57}$$

where I defined the SOE's multilateral real exchange rate (MRER) and external terms of trade (XTT):

$$e_t \equiv \frac{S_t P_t^{**N}}{P_t}, \qquad p_t^{**} \equiv \frac{P_t^{**X}}{P_t^{**N}},$$

where P_t^{**N} is the price index of the foreign currency price of the SOE's imports. The XTT is exogenous as it is completely determined in the Rest of the World (RW). Also, inserting the factor demand function in the production function shows that optimal exports vary directly with the lagged product of the MRER and the XTT:

$$X_t = z_{t-4} \left(b^A e_{t-4} p_{t-4}^{**}\right)^{\frac{b^A}{1-b^A}} z_t^A. \tag{58}$$

According to my assumptions, the real value of exports in terms of domestic goods is:

$$\frac{S_{t-4} P_{t-4}^{**X} X_t}{P_t} = \frac{e_{t-4} p_{t-4}^{**} X_t}{\widetilde{\pi}_t} = z_{t-4} \frac{\left(b^A e_{t-4} p_{t-4}^{**}\right)^{\frac{1}{1-b^A}}}{\widetilde{\pi}_t b^A} z_t^A, \tag{59}$$

where I defined the year on year domestic inflation at t as:

$$\widetilde{\pi}_t = \pi_t \pi_{t-1} \pi_{t-2} \pi_{t-3}.$$

Henceforth, a tilde over an inflation or growth rate variable will have the same year on year meaning. (Note that the tilde in the auxiliary functions $\widetilde{\varphi}^M(.)$ and $\widetilde{\tau}^M(.)$ has an entirely different meaning.)

2.3.2. Imported goods firms

Final imported goods Perfectly competitive importing firms produce (or bundle) final imported goods using the output of monopolistically competitive intermediate imported goods producers. The representative firm in this sector uses the following CES technology:

$$N_t = \left(\int_0^1 N_t(i)^{\frac{\theta^N - 1}{\theta^N}} di\right)^{\frac{\theta^N}{\theta^N - 1}}, \qquad \theta^N > 1,$$

where θ^N is the elasticity of substitution between varieties of imported goods in consumption. Maximizing profits (as in (34) for final domestic output firms) gives the demand function that the intermediate importer of good i faces:

$$N_t(i) = N_t \left(\frac{P_t^N(i)}{P_t^N} \right)^{-\theta^N}. \tag{60}$$

The resulting (domestic currency) price index for imported goods is:

$$P_t^N = \left(\int_0^1 P_t^N(i)^{1-\theta^N} di \right)^{\frac{1}{1-\theta^N}}, \tag{61}$$

and the import cost bill is:

$$\int_0^1 P_t^N(i) N_t(i) di = P_t^N N_t.$$

Intermediate imported goods A continuum of monopolistically competitive firms generate intermediate imported goods. They buy a bundled final good abroad at the foreign price and turn it into differentiated goods to be sold in the domestic market in domestic currency. They purchase the bundled final good at the price $S_t P_t^{**N}$, where P_t^{**N} is the foreign currency price index of the imported bundle and S_t is the nominal exchange rate (pesos per unit of foreign currency). Notice that $S_t P_t^{**N}$ is thus the marginal cost for these firms. Their pricing (in the domestic currency) follows the same setup we used for firms producing domestic intermediate goods, with a probability $1 - \alpha_N$ of optimal price setting and full indexation when they can't optimize price. According to the price survival constraint, the price $P_t^N(i)$ the firm sets at t has a probability α_N^j of surviving (indexed) until $t + j$:

$$P_{t+j}^N(i) = P_t^N(i) \pi_t^N \pi_{t+1}^N ... \pi_{t+j-1}^N \equiv P_t^N(i) \Psi_{t,j}^N, \qquad \left(\Psi_{t,0}^N \equiv 1 \right). \tag{62}$$

When the firm optimizes it takes into account that there is a probability α_N^j that the demand for its good in $t + j$ will be:

$$N_{t+j}(i) = N_{t+j} \left(\frac{P_t^N(i) \Psi_{t,j}^N}{P_{t+j}^N} \right)^{-\theta^N}. \tag{63}$$

Hence, they solve:

$$\max_{P_t^N(i)} E_t \sum_{j=0}^{\infty} \alpha_N^j \Lambda_{t,t+j}^N N_{t+j}(i) \left\{ \frac{P_t^N(i) \Psi_{t,j}^N}{P_{t+j}^N} - \frac{S_{t+j} P_{t+j}^{**N}}{P_{t+j}^N} \right\}$$

subject to (63). $\Lambda_{t,t+j}^N$ is the pricing kernel used by importing firms for discounting. It is equal to households' intertemporal marginal rate of substitution in the consumption of imported goods between periods $t + j$ and t:

$$\Lambda_{t,t+j}^N \equiv \beta^j \frac{U_{C^N,t+j}}{U_{C^N,t}}.$$

The marginal utility of consuming imported goods may be obtained from the marginal utility of consuming the aggregate bundle of (domestic and imported) goods. Specifically:

$$U_{C^N,t} = U_{C,t}\frac{dC_t}{dC_t^N} = U_{C,t}a_N^{\frac{1}{\theta^C}}\left(\frac{C_t^N}{C_t}\right)^{-\frac{1}{\theta^C}} = U_{C,t}\frac{P_t^N}{P_t^C} = U_{C,t}\frac{p_t^N}{p_t^C},$$

where the second equality if obtained by differentiating (25) with respect to C_t^N, and the third uses (30). Hence, using (20) the pricing kernel of import sector firms is:

$$\Lambda_{t,t+j}^N \equiv \beta^j\frac{U_{C^N,t+j}}{U_{C^N,t}} = \beta^j\frac{\lambda_{t+j}\widetilde{\varphi}_M\left(1+i_{t+j}\right)p_{t+j}^N}{\lambda_t\widetilde{\varphi}_M\left(1+i_t\right)p_t^N} \equiv \beta^j\frac{\overline{\Lambda}_{t+j}^N}{\overline{\Lambda}_t^N}. \tag{64}$$

Hence, after eliminating the firm index, the first order condition for intermediate importing firms is:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha_N\right)^j\overline{\Lambda}_{t+j}^N N_{t+j}(\pi_{t+j}^N)^{\theta^N}\left\{\frac{\widetilde{P}_t^N}{P_t^N}\frac{\pi_t^N}{\pi_{t+j}^N} - \frac{\theta^N}{\theta^N-1}\frac{S_{t+j}P_{t+j}^{**N}}{P_{t+j}^N}\right\}.$$

Since all optimizing firms make the same decision, I call the optimal import price $\widetilde{P}_t^N$. Hence (61) and (62) imply the following law of motion for the aggregate domestic currency import price index:

$$\left(P_t^N\right)^{1-\theta^N} = \alpha_N\left(P_{t-1}^N\pi_{t-1}^N\right)^{1-\theta^N} + \left(1-\alpha_N\right)\left(\widetilde{P}_t^N\right)^{1-\theta^N}. \tag{65}$$

Using the definitions of e_t and p_t^N, I can express the preceding equations as:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha_N\right)^j\overline{\Lambda}_{t+j}^N N_{t+j}(\pi_{t+j}^N)^{\theta^N}\left\{\frac{\widetilde{p}_t^N\pi_t^N}{\pi_{t+j}^N} - \frac{\theta^N}{\theta^N-1}\frac{e_{t+j}}{p_{t+j}^N}\right\}$$

$$\left(\pi_t^N\right)^{1-\theta^N} = \alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N} + \left(1-\alpha_N\right)\left(\widetilde{p}_t^N\pi_t^N\right)^{1-\theta^N},$$

where

$$\widetilde{p}_t^N \equiv \frac{\widetilde{P}_t^N}{P_t^N}$$

is the relative price between optimized and overall imported goods. Eliminating $\widetilde{p}_t^N\pi_t^N$, yields the Phillips equation for imported goods inflation:

$$\begin{aligned} 0 &= E_t\sum_{j=0}^{\infty}\left(\beta\alpha_N\right)^j\overline{\Lambda}_{t+j}^N N_{t+j}(\pi_{t+j}^N)^{\theta^N-1} \\ &\times\left\{\left(\frac{\left(\pi_t^N\right)^{1-\theta^N} - \alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N}}{1-\alpha_N}\right)^{\frac{1}{1-\theta^N}} - \frac{\theta^N}{\theta^N-1}\frac{\pi_{t+j}^N e_{t+j}}{p_{t+j}^N}\right\}. \end{aligned}$$

Notice that

$$\frac{e_t}{p_t^N} = \frac{S_tP_t^{**N}}{P_t^N}$$

reflects the deviation (whenever it differs from 1) from the Law of one Price for imported goods.

2.4. Banks

I assume that there is a competitive banking industry, with no entry, exit, or mergers. Banks are owned by households, and are price takers in financial markets. They obtain funds in the international market B_t^{*B}, supply one period deposit facilities to households D_t, and use the proceeds to supply one period loans to firms L_t, lend (or borrow) in the interbank market, and purchase (or sell) Central Bank bonds B_t^{CB}. Any interbank loans cancel out and profits that arise from period t-1 operations are distributed to owners in period t, so the balance sheet constraint for the representative bank is:

$$L_t + B_t^{CB} = D_t + S_t B_t^{*B}. \tag{66}$$

I assume that deposits are perfect substitutes for Central Bank bonds (so they earn the same interest rate i_t) but households may not invest directly in these bonds (possibly because there is a minimum amount allowed for such investments which only the banks can achieve). I assume that interest on banks' foreign debt is paid out in the following period, just before profits are distributed to owners. Since banks' business is assumed to be in domestic currency, they face (uninsurable) exchange rate uncertainty. For every unit of foreign currency they repay they must expect to have pesos in the amount of

$$E_t \delta_{t+1}(1 + i_t^B),$$

where i_t^B is the nominal interest rate they are charged abroad and δ_{t+1} is the nominal rate of currency depreciation:

$$\delta_{t+1} = \frac{S_{t+1}}{S_t}.$$

I assume that banks must pay a (risk and/or liquidity) premium over the international riskless rate i_t^{**} for the funds they obtain abroad. Since I do not model the rest of the world, the premium (function) is exogenously given. It has an exogenous stochastic and time-varying component ϕ_t^{**B} (that can represent general liquidity conditions in the international market) as well as an endogenous (more risk-related) component $p_B(.)$ that is an increasing convex function of the GDP adjusted (individual) bank foreign debt. Individual banks thus fully internalize the fact that their individual foreign debt decision determines the foreign currency interest rate they face, which is:

$$1 + i_t^B = (1 + i_t^{**})\phi_t^{**B}\left[1 + p_B\left(\frac{S_t B_t^{*B}}{P_t Y_t}\right)\right], \tag{67}$$

where I assume $p_B' > 0$ and $p_B'' > 0$.

Banks have a real cost function that depends on the (previous period's) real loan creating activities of the bank. I assume this cost function is quadratic. Specifically, I assume the following real cost function:

$$C_{t+1}^B = \frac{1}{2} b^B \left(\frac{L_t}{z_t P_t}\right)^2 \qquad (b^B > 0)$$

The representative bank maximizes expected profit each period:

$$E_t\Pi^B_{t+1} = i^L_t L_t + i_t\left(B^{CB}_t - D_t\right) - E_t\delta_{t+1} i^B_t S_t B^{*B}_t - P_t\frac{1}{2}b^B\left(\frac{L_t}{z_t P_t}\right)^2$$

subject to its balance sheet constraint (66), and its supply of foreign funds constraint (67). The solution to this problem gives the supply of loans as a simple linear function of the loan margin $i^L_t - i_t$ (68) and the optimal amount of foreign funding in the form of a "risk-adjusted uncovered interest parity" relation (69):

$$\frac{L^S_t}{z_t P_t} = \frac{1}{b^B}\left(i^L_t - i_t\right) \tag{68}$$

$$i_t = E_t\delta_{t+1}\left\{(1+i^{**}_t)\phi^{**B}_t\left[1+\varphi_B\left(\frac{S_t B^{*B}_t}{P_t Y_t}\right)\right]-1\right\}, \tag{69}$$

where the following auxiliary function has been defined:

$$\varphi_B(a) \equiv p_B(a) + a p'_B(a) = p_B(a)\left[1+\varepsilon_B(a)\right], \tag{70}$$

where

$$\varepsilon_B(a) \equiv a\frac{p'_B(a)}{p_B(a)}$$

is the elasticity of the endogenous risk premium function.

Given L^S_t, D^S_t, and B^{*B}_t, the aggregate bank demand for Central Bank bonds is given by the aggregate bank balance sheet constraint:

$$B^{CB,D}_t = D^S_t + S_t B^{*B}_t - L^S_t. \tag{71}$$

2.5. The public sector

The public sector is made up of the Government and the Central Bank.

2.5.1. The Government

The Government issues foreign currency denominated bonds in the international markets and pays interest on these bonds, spends on goods, and collects taxes. I assume that fiscal policy consists of exogenous paths for nominal lump-sum tax collection (T_t) and real expenditures (G_t). The Government finances any resulting deficit by issuing foreign currency denominated bonds (B^{*G}_t). I assume that an integral component of fiscal policy is the (credible) commitment to achieve a long run target for the foreign debt to GDP ratio (γ^{GT}). To hold foreign currency denominated government bonds, foreign investors charge a risk premium over the risk-free foreign interest rate. As in the case of banks, the risk premium (function) is exogenously given and is assumed to have an exogenous stochastic component (an external financing shock) and an endogenous component. I assume that the latter is an increasing function of the public sector net foreign liability to GDP ratio. Hence the gross interest rate on the government's foreign debt is:

$$1+i^G_t = (1+i^{**}_t)\phi^{**G}_t\left[1+p_G\left(\frac{S_t\left(B^{*G}_t - R^{*CB}_t\right)}{P_t Y_t}\right)\right]. \tag{72}$$

where $p'_G > 0$, and R^{*CB}_t is the Central Bank's international reserves.

The Government flow budget constraint is:

$$S_t B^{*G}_t = P_t G_t - T_t + (1+i^G_{t-1})S_t B^{*G}_{t-1}. \tag{73}$$

2.5.2. The Central Bank

The Central Bank issues currency (M_t^0) and domestic currency bonds $\left(B_t^{CB}\right)$, and holds international reserves $\left(R_t^{*CB}\right)$ in the form of foreign currency denominated riskless bonds issued by the RW. I assume that Central Bank bonds are only held by domestic banks. The (flow) budget constraint of the Central Bank is:

$$\begin{aligned} M_t^0 + B_t^{CB} - S_t R_t^{*CB} &= M_{t-1}^0 + (1+i_{t-1})B_{t-1}^{CB} - (1+i_{t-1}^*)S_t R_{t-1}^{*CB} \\ &= \left[M_{t-1}^0 + B_{t-1}^{CB} - S_{t-1}R_{t-1}^{*CB}\right] - \left[i_{t-1}^* S_t R_{t-1}^{*CB} + (S_t - S_{t-1})\, R_{t-1}^{*CB} - i_{t-1}B_{t-1}^{CB}\right]. \end{aligned} \tag{74}$$

The second term in square brackets after the last equality is the Central Bank's quasi-fiscal surplus (QF_t). It includes interest earned and capital gains on international reserves minus the interest paid on its bonds. I assume that the Central Bank transfers its quasi-fiscal surplus (or deficit) to the Government every period. Hence, its net wealth is constant. Furthermore, assuming its net worth is zero, the Central Bank's balance sheet "constraint" is always preserved:

$$M_t^0 + B_t^{CB} - S_t R_t^{*CB} = M_{t-1}^0 + B_{t-1}^{CB} - S_{t-1}R_{t-1}^{*CB} = 0. \tag{75}$$

The Central Bank supplies whatever amount of cash is demanded by households, and can influence these supplies by changing R_t^{*CB} or B_t^{CB}, i.e. intervene in the foreign exchange market or in the interbank cum Central Bank bond market.

2.5.3. The consolidated public sector

Adding (73) and (74) term by term and using (75) gives the consolidated public sector budget constraint:

$$S_t B_t^{*G} = (1+i_{t-1}^G)S_t B_{t-1}^{*G} - (T_t - P_t G_t) - QF_t, \tag{76}$$

where QF_t is the Central Bank's quasi-surplus:

$$QF_t \equiv \left[i_{t-1}^{**} + (1 - S_{t-1}/S_t)\right] S_t R_{t-1}^{*CB} - i_{t-1}B_{t-1}^{CB} \tag{77}$$

The Government sells foreign currency bonds in international capital markets to the extent that the sum of its capital repayments and interest payments on these bonds exceeds the sum of the domestic currency value of the Central Bank's quasi-surplus and the Government's primary surplus ($T_t - P_t G_t$).

2.6. Market clearing equations, GDP, and the balance payments

In the labor market, the household supply of labor h_t equals domestic firms' demand (45):

$$h_t = \frac{b^D}{\kappa \epsilon_t}\left(\frac{p_t^N}{\overline{w}_t}\right)^{1-b^D}\frac{Q_t}{z_t}. \tag{78}$$

In the loan market, bank loan supply (68) equals loan demand by firms (48), yielding the following expression for the loan rate:

$$i_t^L = i_t + \frac{b^B \varsigma_t}{b^D z_t} E_t\left(w_{t+1}h_{t+1}\right) = i_t + \frac{b^B \varsigma_t}{b^D} E_t\left(\frac{z_{t+1}}{z_t}\overline{w}_{t+1}h_{t+1}\right). \tag{79}$$

In the domestic goods market, the output of domestic firms Q_t must satisfy final demand from households (including transactions cost related consumption of output) and the Government, as well as intermediate demand from the export and banking sectors:

$$Q_t = \left[a_D + \widetilde{\tau}_M \left(1 + i_t\right)\right] p_t^C C_t + G_t + z_t \left(b^A e_t p_t^{**}\right)^{\frac{1}{1-b^A}} + \frac{z_t}{2b^B} \left(i_t^L - i_t\right)^2. \tag{80}$$

Expenditure in total imports $p_t^N N_t$, is the sum of household and firm demand:

$$\begin{aligned} p_t^N N_t &= \left(1 - a_D\right) p_t^C C_t + p_t^N N_t^D \\ &= \left(1 - a_D\right) p_t^C C_t + \frac{1 - b^D}{b^D} w_t h_t, \end{aligned} \tag{81}$$

where the second equality uses (47).

GDP in terms of domestic goods is:

$$Y_t = p_t^C C_t + G_t + \frac{e_{t-4} p_{t-4}^{**}}{\widetilde{\pi}_t} X_t - p_t^N N_t, \tag{82}$$

where exports and imports are given by (59) and (81), respectively.

The balance of payments and trade balance equations are:

$$B_t^{*G} + B_t^{*B} - R_t^{*CB} = (1 + i_{t-1}^G) B_{t-1}^{*G} + \left(1 + i_{t-1}^B\right) B_{t-1}^{*B} - \left(1 + i_{t-1}^{**}\right) R_{t-1}^{*CB} - TB_t, \tag{83}$$

$$TB_t = P_{t-4}^{**X} X_t - P_t^{**N} N_t = P_t^{**N} \left(\frac{p_{t-4}^{**}}{\widetilde{\pi}_t^{**N}} X_t - N_t \right) \tag{84}$$

where I use the year on year import inflation at t:

$$\widetilde{\pi}_t^{**N} = \pi_t^{**N} \pi_{t-1}^{**N} \pi_{t-2}^{**N} \pi_{t-3}^{**N}.$$

2.7. Monetary Policy

The model allows for different monetary and exchange rate policy regimes. My baseline is what I call a 'Managed Exchange Rate' (MER) regime. In this regime, the Central Bank, through its regular interventions in the money and foreign exchange markets, aims for the achievement of two operational targets: one for the interbank interest rate i_t, and another for the rate of nominal depreciation against a trade-weighted basket of currencies δ_t. Using fairly general feedback rules, the Central Bank responds to deviations of the consumption year on year inflation rate ($\widetilde{\pi}_t^C$) from a target ($\widetilde{\pi}^T$), and to deviations of detrended GDP and the trade balance to GDP ratio (and possibly its lagged value) from the NSS levels of the respective variables[7]. Variables without a time subscript denote non-stochastic steady state

[7] With more microfoundation, instead of the deviations from the nonstochastic steady state levels one would like to use deviations from 'natural' levels that are based on private welfare. In a closed economy setting, Rotemberg and Woodford (1999) and Woodford (2003) show that the levels that correspond to a reference economy with no nominal rigidities (but subject to the same shocks as the model economy) have a solid microeconomic justification based on household welfare. However, De Paoli (2006) shows that in an open economy setting the same kind of calculations lead to more complex target levels where merely assuming no nominal rigidity is not enough. In this paper I use an ad-hoc loss function for the Central Bank instead of a microfounded one and completely sidestep the issue by assuming that both the simple policy rules and the Central Bank loss function (that leads to the optimal policy rules) respond to the deviations from the nonstochastic steady state.

values. I assume that the long run inflation target (which is also the steady state level of inflation) is positive: $\widetilde{\pi}_t^T > 1$. (In practice, I also assume it is constant). I introduce history dependence in the two feedback rules through the presence of the lagged operational target variable, as well as a long run target for international reserves in the case of foreign exchange market intervention. The simple feedback rules are the following:

$$1 + i_t = \Xi^{TR} (1 + i_{t-1})^{h_0} \left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}_t^T} \right)^{h_1} \left(\frac{Y_t/z_t}{(Y_t/z_t)^T} \right)^{h_2} \left(\frac{S_t TB_t / P_t Y_t}{\gamma^{TBT}} \right)^{h_3}, \tag{85}$$

where

$$\Xi^{TR} \equiv \left(\frac{\mu^{z**}\pi}{\beta} \right)^{1-h_0}, \qquad h_0 \geq 0, \quad h_1 \geq 0, \quad h_2 \geq 0, \quad h_1 h_2 \neq 0. \tag{86}$$

and

$$\delta_t = \Xi^{FXI} (\delta_{t-1})^{k_0} \left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}_t^T} \right)^{k_1} \left(\frac{Y_t/z_t}{(Y_t/z_t)^T} \right)^{k_2} \left(\frac{S_t TB_t / P_t Y_t}{\gamma^{TBT}} \right)^{k_3} \times \left(\frac{S_t R_t^{*CB} / (P_t Y_t)}{\gamma^{CBT}} \right)^{k_5} \exp(\varepsilon_t^\delta) \tag{87}$$

where

$$\Xi^{FXI} \equiv \left(\frac{\pi}{\pi^{**N}} \right)^{1-k_0}, \qquad k_5 \neq 0. \tag{88}$$

ε_t^δ is an i.i.d. nominal depreciation rate policy shock (without persistence). The multiplicative terms (Ξ^{TR}) and (Ξ^{FXI}) in the feedback rules are designed so as to obtain a non-stochastic steady state where the inflation target is achieved and the nominal rate of depreciation is consistent with it.[8] During the transition, the coefficients in these feedback rules indicate the direction and magnitude of Central Bank responses to deviations of each of these variables from their targets. They translate the Central Bank high frequency actions (hourly, daily or weekly) to the model's quarterly frequency. γ^{CBT} is a long run target for the Central Bank reserves to GDP ratio, and γ^{TBT} is a long run target for the trade balance to GDP ratio. The latter should be consistent with the country's long run foreign debt service (and, hence, with the fiscal assumptions which are explicit in the model).[9]

In order to be able to accommodate non-feedback policies, either one of the feedback rules (or both) can be replaced by a simple autorregresive rule: the interest rate feedback rule by an AR(1) on Central Bank bonds or, if there is a feedback rule for the rate of nominal depreciation, on Central Bank international reserves, and the nominal depreciation rate feedback rule by an AR rule on the same variable or on Central Bank international reserves. Such non-feedback rules imply policies more akin to an 'automatic pilot' type of monetary and/or exchange rate policy.

For optimal policies, in section 7 I explicitly model two 'extreme' policy regimes that result in models that are 'nested' with respect to the general model. In a

[8] Notice that I could just as well say that "the nominal rate of depreciation target is achieved and the inflation rate is consistent with it".

[9] I deal with the nonstochastic steady state at length in Appendix 5.

'Floating Exchange Rate' (FER) regime the Central Bank abstains from intervening in the foreign exchange market. Hence, the policy rule for the rate of nominal depreciation is eliminated and so is the Central Bank foreign exchange reserves variable (in real terms and made stationary) $r_t^{*CB} = R_t^{*CB} / \left(z_t P_t^{**N}\right)$, by replacing it with its NSS value r^{*CB} as a parameter. In a 'Pegged Exchange Rate' (PER) regime, the Central Bank abstains from intervening in the money market. Hence, the policy rule for the interest rate is eliminated and so is the Central Bank domestic currency bonds variable (in real terms and made stationary) $b_t^{CB} = B_t^{CB} / (z_t P_t)$, by replacing it with its NSS value b^{CB} as a parameter.

Although the paper specifically addresses the case of two CB policy rules, note that the model could be modified to reflect an institutional arrangement in which the CB is in charge of 'monetary' policy while the Government (Treasury) is in charge of the foreign exchange policy. This would require a few changes in the model (since the CB balance sheet would not be enough to reflect the restriction that involves short run debt, FX reserves, and CB cash liabilities) and the assumption of full coordination between the two agencies so that the loss function would correspond to the consolidated government (and not exclusively the CB).

2.8. Permanent productivity shocks

Growth is introduced in the model through the SOE's permanent productivity shock z_t and its relation with its equivalent in the RW: z_t^{**}. I assume that the RW's permanent productivity growth $\mu_t^{z**} \equiv z_t^{**}/z_{t-1}^{**}$ is governed by an exogenous process:

$$\mu_t^{z**} = \left(\mu_{t-1}^{z**}\right)^{\rho^{\mu^{z**}}} \left(\mu^{z**}\right)^{1-\rho^{\mu^{z**}}} \exp\left(\varepsilon_t^{\mu^{z**}}\right), \tag{89}$$

where $\varepsilon_t^{\mu^{z**}}$ is an i.i.d. technology shock. On the other hand, the SOE's permanent productivity growth $\mu_t^z \equiv z_t/z_{t-1}$ is assumed to be governed by the following stochastic process:

$$\mu_t^z = \left(\mu_{t-1}^z\right)^{\rho^{\mu^z}} \left(\mu_{t-1}^{z**}\right)^{1-\rho^{\mu^z}} \left(z_{t-1}^{\circ}\right)^{\alpha_{\mu^z}} \exp\left(\varepsilon_t^{\mu^z}\right), \tag{90}$$

where $\varepsilon_t^{\mu^z}$ is an i.i.d. technology shock and $z_t^{\circ} \equiv z_t^{**}/z_t$ is the ratio between the permanent productivity levels in the SOE and the RW. During the transition, the growth rate of the RW influences the growth rate of the SOE through the coefficient $1-\rho^{\mu^z}$, while the growth rate of the SOE has no influence on the rate of growth of the RW.[10] Also, the persistence coefficients may be different, and the disturbance terms may be correlated. Notice that the following identity holds:

$$\frac{\mu_t^{z**}}{\mu_t^z} = \frac{z_t^{**}/z_{t-1}^{**}}{z_t/z_{t-1}} = \frac{z_t^{\circ}}{z_{t-1}^{\circ}}. \tag{91}$$

I assume that in the non-stochastic SS the productivity levels and growth rates in the RW and the SOE are equal: $z^{\circ} = 1$ and $\mu^z = \mu^{z**}$. (89)-(91) are additional model equations.

[10] I am hence assuming that there is a cointegrating relation between the (logs of the) permanent technology shocks in the LRW and the SOE which includes a direct lagged influence of the LRW's rate of technological growth on that of the SOE but no reciprocal influence. This appears consistent with the intuitive notion of a SOE that is also less developed and hence its technological innovations have an insignificant influence on the LRW's innovations but absorbs a significant fraction of the LRW's innovations.

2.9. Functional forms for the auxiliary functions

The specific functional form I use for the transactions cost function is the following:

$$\tau_M(\varpi_t) \equiv a_M \varpi_t + \varpi_t^{-b_M} + c_M, \qquad a_M, b_M > 0. \tag{92}$$

There is a satiation level of the cash/consumption ratio after which the function becomes increasing in its argument. Obviously, only the decreasing portion of the function is relevant. There are three parameters for calibration: a_M, b_M, c_M. According to (18), the resulting liquidity preference function is:

$$\varpi_t = \frac{m_t^0}{p_t^C c_t} = \mathcal{L}(1+i_t) \equiv \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{1}{1+b_M}}. \tag{93}$$

Hence, the money market clearing equation and the transactions cost equation (two of the model equations), are:

$$m_t^0 = \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{1}{1+b_M}} p_t^C c_t \tag{94}$$

$$\widetilde{\tau}_t^M = a_M \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{1}{1+b_M}} + \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{-b_M}{1+b_M}} + c_M. \tag{95}$$

Also, the resulting auxiliary function for the total effect on expenditure of a marginal increase in consumption (16) is:

$$\varphi_M(\varpi_t) = 1 + c_M + (1+b_M)\,\varpi_t^{-b_M},$$

giving another of the model equations:

$$\widetilde{\varphi}_t^M = 1 + c_M + (1+b_M)\left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{-b_M}{1+b_M}}. \tag{96}$$

Note that (95) and (96) are used as model equations merely to make other equations simpler. From (94) I derive the elasticity of cash demand (as a fraction of consumption) with respect to the gross interest rate that is useful for calibration:

$$\varepsilon_t^{m^0} = \frac{\varpi_t^{1+b_M}}{(1+b_M)\,b_M\,(1+i_t)}. \tag{97}$$

For the bank risk premium I use the following functional form:

$$p_B\left(e_t b_t^{*B}/y_t\right) \equiv \frac{\alpha_1^B}{1 - \alpha_2^B e_t b_t^{*B}/y_t}, \qquad \alpha_1^B > 0, \alpha_2^B > 0. \tag{98}$$

Hence, in the risk-adjusted uncovered interest parity equation (70) $\varphi_B(.)$ is:

$$\varphi_B\left(e_t b_t^{*B}/y_t\right) = \frac{\alpha_1^B}{\left(1 - \alpha_2^B e_t b_t^{*B}/y_t\right)^2}, \tag{99}$$

and the elasticity of $p_B(.)$ is:

$$\varepsilon_B\left(e_t b_t^{*B}/y_t\right) \equiv \frac{1}{\frac{1}{\alpha_2^B\left(e_t b_t^{*B}/y_t\right)} - 1}. \tag{100}$$

The government risk premium has the same functional form as the one for banks:

$$p_G\left(e_t\left(b_t^{*G} - r_t^{*CB}\right)/y_t\right) \equiv \frac{\alpha_1^G}{1 - \alpha_2^G e_t\left(b_t^{*G} - r_t^{*CB}\right)/y_t}, \qquad \alpha_1^G > 0, \alpha_2^G > 0. \tag{101}$$

3. The loglinear approximation to ARGEMmy in matrix form

The model equations of the log-linear approximation to the equations of ARGEMmy (excluding the autoregressive processes for the disturbance variables Z_t) around the NSS can be expressed in matrix form as:

$$\begin{aligned} \begin{bmatrix} B_{11}^0 & B_{12}^0 \\ B_{21}^0 & B_{22}^0 \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} &= \begin{bmatrix} 0 & 0 \\ A_{21}^0 & A_{22}^0 \end{bmatrix} E_t \begin{bmatrix} X_{t+1} \\ Y_{t+1} \end{bmatrix} \\ + \begin{bmatrix} C_{11}^0 & C_{12}^0 \\ C_{21}^0 & C_{22}^0 \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} &+ \begin{bmatrix} J_{11}^0 & J_{12}^0 \\ J_{21}^0 & 0 \end{bmatrix} \begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix} + \begin{bmatrix} \varkappa_{t+1}^X \\ 0 \end{bmatrix}. \end{aligned} \tag{102}$$

The first block row in (102) includes all static equations and all dynamic equations that do not include forward-looking terms, and the second block row includes the remaining equations, i.e., those that include forward-looking terms. Vectors X_t and Y_t are formed by the loglinear deviations of the endogenous variables from their NSS values in such a way that matrices B_{11}^0 and B_{22}^0 are square. The first two of the equations in the first block row correspond to the simple feedback rules for the interest rate and the nominal rate of currency depreciation, respectively. $\varkappa_t^X$ includes the i.i.d. shocks that directly affect some of the equations without specific autorregressive dynamics (that would justify additional equations). In particular, it includes the shocks to the policy rules and the shock to the permanent productivity growth equation. More compactly, the system is:

$$B^0 d_t = A^0 E_t d_{t+1} + C^0 d_{t-1} + J^0 \widetilde{Z}_t - \varkappa_{t+1}^d, \tag{103}$$

where

$$\begin{aligned} d_t &= \begin{bmatrix} X_t \\ Y_t \end{bmatrix}, \quad \widetilde{Z}_t = \begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix}, \quad \varkappa_t^d = \begin{bmatrix} \varkappa_t^X \\ 0 \end{bmatrix} \quad A^0 = \begin{bmatrix} 0 & 0 \\ A_{21}^0 & A_{22}^0 \end{bmatrix}, \\ B^0 &= \begin{bmatrix} B_{11}^0 & B_{12}^0 \\ B_{21}^0 & B_{22}^0 \end{bmatrix}, \qquad C^0 = \begin{bmatrix} C_{11}^0 & C_{12}^0 \\ C_{21}^0 & C_{22}^0 \end{bmatrix}, \qquad J^0 = \begin{bmatrix} J_{11}^0 & J_{12}^0 \\ J_{21}^0 & 0 \end{bmatrix}. \end{aligned}$$

The system has been previously simplified to substitute out variables lagged by more than one quarter. For example, since I have a fourth lag for the RER (e), I defined new variables for the first, second, third and fourth lags ($\widehat{e}_{1t}$, $\widehat{e}_{2t}$, $\widehat{e}_{3t}$, $\widehat{e}_{4t}$, respectively), so that in each new equation only one lag is used. Almost exactly the same procedure was followed for the fourth lag of the ToT ($\widehat{p}^{**X}$). The only difference is that since this variable represents an exogenous disturbance that

follows an AR(1) process (and is hence in vector Z_t), in order to eliminate lags 2 to 4 I also defined a new endogenous variable $\widehat{p}_{0,t}^{**X}$ that is included in the vector of endogenous variables to obtain connectivity between the exogenous and endogenous ToT variables. Since the system includes year on year gross rates of domestic and consumption inflation ($\widehat{\widetilde{\pi}}_t^D$ and $\widehat{\widetilde{\pi}}_t^C$, respectively), permanent productivity growth ($\widehat{\widetilde{\mu}}_t^z$), and nominal rate of depreciation ($\widehat{\widetilde{\delta}}_t^M$), new variables were introduced in order to eliminate the lags 2 to 4.

Hence, vectors X_t and Y_t are the following:

$$\begin{aligned} X_t \equiv [\ & \widehat{i}_t\ \widehat{\delta}_t^M\ \widehat{r}_t^{*CB}\ \widehat{tb}_t\ \widehat{n}_t\ \widehat{b}_t^{CB}\ \widehat{i}_t^G\ \widehat{b}_t^{*G}\ \widehat{i}_t^B\ \widehat{mc}_t\ \widehat{h}_t\ \widehat{q}_t\ \widehat{y}_t\ \widehat{p}_t^C\ \widehat{e}_t^C \\ & \widehat{m}_t^0\ \widehat{\widetilde{\varphi}}_t^M\ \widehat{\widetilde{\tau}}_t^M\ \widehat{\ell}_t\ \widehat{d}_t\ \widehat{\mu}_t^z\ \widehat{\pi}_t^W\ \widehat{\pi}_t\ \widehat{\pi}_t^N\ \widehat{z}_t^\circ\ \widehat{e}_t\ \widehat{\pi}_t^C\ \widehat{\widetilde{w}}_t\ \widehat{p}_t^N\ \widehat{x}_t\ \widehat{tbr}_t \\ & \widehat{\widetilde{\pi}}_t\ \widehat{\pi}_{1t}\ \widehat{\pi}_{2t}\ \widehat{\pi}_{3t}\ \widehat{\widetilde{\pi}}_t^C\ \widehat{\pi}_{1t}^C\ \widehat{\pi}_{2t}^C\ \widehat{\pi}_{3t}^C\ \widehat{\widetilde{\delta}}_t\ \widehat{\delta}_{1t}\ \widehat{\delta}_{2t}\ \widehat{\delta}_{3t}\ \widehat{\widetilde{\mu}}_t^z\ \widehat{\mu}_{1t}^z\ \widehat{\mu}_{2t}^z\ \widehat{\mu}_{3t}^z \\ & \widehat{e}_{1t}\ \widehat{e}_{2t}\ \widehat{e}_{3t}\ \widehat{e}_{4t}\ \widehat{p}_{0t}^{**X}\ \widehat{p}_{1t}^{**X}\ \widehat{p}_{2t}^{**X}\ \widehat{p}_{3t}^{**X}\ \widehat{p}_{4t}^{**X}\ ]', \end{aligned}$$

$$Y_t \equiv [\widehat{c}_t\ \widehat{\lambda}_t^\circ\ \widehat{b}_t^{*B}\ \widehat{i}_t^L\ \widehat{t}_t\ \widehat{r}_t\ \widehat{\Gamma}_t^W\ \widehat{\Psi}_t^W\ \widehat{\Gamma}_t^D\ \widehat{\Psi}_t^D\ \widehat{\Gamma}_t^N\ \widehat{\Psi}_t^N\ ]'.$$

X_t includes 31 main variables (the first 2 rows of X_t above) and 25 additional variables that may be considered auxiliary and related to lag reduction.[11] Vector Y_t includes the endogenous variables associated to the equations that include forward-looking terms. I thus have a total of 66 (=31+25+12) endogenous variables in the subsystem given by (102). Noting that none of the elements in the main diagonal of B^0 are zero (by construction), I found it convenient to normalize the equation coefficients by multiplying through by the matrix D^{00} formed by the inverses of those elements, transforming (103) to:

$$B^{00}d_t = A^{00}E_t d_{t+1} + C^{00}d_{t-1} + J^{00}\widetilde{Z}_t - D^{00}\varkappa_{t+1}^d, \tag{104}$$

where now B^{00} has ones on its main diagonal and:

$$A^{00} = D^{00}A^0, \qquad B^{00} = D^{00}B^0, \qquad C^{00} = D^{00}C^0, \qquad J^{00} = D^{00}J^0$$

The rest of the linear system is given by the autorregressive dynamics of the disturbances included in vector Z_t:

$$Z_t \equiv [\widehat{g}_t\ \widehat{z}_t^C\ \widehat{z}_t^H\ \widehat{\epsilon}_t\ \widehat{z}_t^A\ \widehat{\varsigma}_t\ \widehat{\pi}_t^{**N}\ \widehat{i}_t^{**}\ \widehat{\phi}_t^{**B}\ \widehat{\phi}_t^{**G}\ \widehat{\mu}_t^{z**}\ \widehat{p}_t^{**X}\ ]'.$$

which can be expressed as:

$$Z_t = MZ_{t-1} + \varkappa_t^Z$$

where all the eigenvalues of M are within the unit circle and $\varkappa_t^Z$ is an i.i.d. stochastic process. It is convenient to stack this matrix equation with the same equation lagged one period:

$$\begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix} = \begin{bmatrix} M & 0 \\ 0 & M \end{bmatrix} \begin{bmatrix} Z_{t-1} \\ Z_{t-2} \end{bmatrix} + \begin{bmatrix} \varkappa_t^Z \\ \varkappa_{t-1}^Z \end{bmatrix}.$$

[11] Note that these complications are unnecessary when using Dynare for solving the system. However, I found that Dynare is not yet in working form for obtaining optimal policy rules using a medium-size model such as ARGEMmy.

or

$$\widetilde{Z}_{t+1} = \widetilde{M}\widetilde{Z}_t + \widetilde{\varkappa}^Z_{t+1}, \tag{105}$$

where

$$\widetilde{M} = \begin{bmatrix} M & 0 \\ 0 & M \end{bmatrix}, \qquad \widetilde{\varkappa}^Z_t = \begin{bmatrix} \varkappa^Z_t \\ \varkappa^Z_{t-1} \end{bmatrix}.$$

Finally, note that the consumption dynamics equation, which is in the second block row of (102), includes a term $E_t z^C_{t+1}$. Using the AR(1) equation for the dynamics of z^C_t, that term has been replaced by $\rho^{z^C} z^C_t$. More generally, matrix J^0_{21} is the sum of two matrices:

$$J^0_{21} = J^{0*}_{21} + J^{0**}_{21} M,$$

one that includes the coefficients on current disturbances (say $J^{0*}_{21} Z_t$) and another that corresponds to coefficients on expected disturbances (say $J^{0**}_{21} E_t Z_{t+1} = J^{0**}_{21} M Z_t$).

Hence, the initial loglinear system is defined by (104) and (105). I now proceed to transform subsystem (104) by also substituting out all lagged variables, i.e., all the elements of X_{t-1} and Y_{t-1} that appear in the equations, and thus put the system in a form suitable for solving by applying the generalized Schur (or QZ) decomposition of a matrix pencil (as in Klein (2000)). Since only a subset of the variables in vectors X_t and Y_t actually appear lagged (in at least one equation) and my experience is that the null columns of matrix C tend to create problems in the computation of the solution (by making the Z_{11} submatrix singular), I define selector matrices S_X and S_Y that select only the elements of X_t and Y_t that actually appear lagged. Correspondingly, I define new, lower dimensional, vectors $\overline{X}_t = S_X X_{t-1}$ and $\overline{Y}_t = S_Y Y_{t-1}$ that contain all these lagged variables. I also define matrices

$$\overline{C}^{00}_{j1} = C^{00}_{j1} S'_X, \qquad \overline{C}^{00}_{j2} = C^{00}_{j2} S'_Y, \qquad j = 1, 2,$$

that have the same non-zero elements as matrices C^{00}_{ij} but leave out the columns of zeros. Notice that, by construction, $\overline{C}_{j1}\overline{X}_t = C_{j1} X_t$ and $\overline{C}_{j2}\overline{Y}_t = C_{j2} Y_t$ $(j = 1, 2)$. Hence, (104) becomes:

$$\begin{bmatrix} \overline{X}_{t+1} \\ \overline{Y}_{t+1} \end{bmatrix} = \begin{bmatrix} S_X & 0 \\ 0 & S_Y \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix}, \tag{106}$$

$$\begin{bmatrix} B^{00}_{11} & B^{00}_{12} \\ B^{00}_{21} & B^{00}_{22} \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ A^{00}_{21} & A^{00}_{22} \end{bmatrix} E_t \begin{bmatrix} X_{t+1} \\ Y_{t+1} \end{bmatrix} + \begin{bmatrix} \overline{C}^{00}_{11} & \overline{C}^{00}_{12} \\ \overline{C}^{00}_{21} & \overline{C}^{00}_{22} \end{bmatrix} \begin{bmatrix} \overline{X}_t \\ \overline{Y}_t \end{bmatrix}$$
$$+ \begin{bmatrix} J^{00}_{11} & J^{00}_{12} \\ J^{00}_{21} & 0 \end{bmatrix} \begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix} - \begin{bmatrix} D^{00}_{11} & 0 \\ 0 & D^{00}_{22} \end{bmatrix} \begin{bmatrix} \varkappa^X_{t+1} \\ 0 \end{bmatrix},$$

where $\overline{X}_t$ contains the 34 elements of X_{t-1} that appear in the system:

$$\begin{aligned} \overline{X}_t \equiv\ & [\widehat{i}_{t-1}\ \widehat{\delta}_{t-1}\ \widehat{r}^{*CB}_{t-1}\ \widehat{tb}_{t-1}\ \widehat{b}^{CB}_{t-1}\ \widehat{i}^G_{t-1}\ \widehat{b}^{*G}_{t-1}\ \widehat{i}^B_{t-1}\ \widehat{y}_{t-1}\ \widehat{p}^C_{t-1}\ \widehat{\mu}^z_{t-1}\ \widehat{\pi}^W_{t-1} \\ & \widehat{\pi}_{t-1}\ \widehat{\pi}^N_{t-1}\ \widehat{z}^\circ_{t-1}\ \widehat{e}_{t-1}\ \widehat{\pi}^C_{t-1}\ \widehat{\overline{w}}_{t-1}\ \widehat{p}^N_{t-1}\ \widehat{\pi}_{1,t-1}\ \widehat{\pi}_{2,t-1}\ \widehat{\pi}^C_{1,t-1}\ \widehat{\pi}^C_{2,t-1}\ \widehat{\delta}_{1,t-1} \\ & \widehat{\delta}_{2,t-1}\ \widehat{\mu}^z_{1,t-1}\ \widehat{\mu}^z_{2,t-1}\ \widehat{e}_{1,t-1}\ \widehat{e}_{2,t-1}\ \widehat{e}_{3,t-1}\ \widehat{p}^{**X}_{0,t-1}\ \widehat{p}^{**X}_{1,t-1}\ \widehat{p}^{**X}_{2,t-1}\ \widehat{p}^{**X}_{3,t-1}\ ]', \end{aligned}$$

and $\overline{Y}_t$ contains the 3 elements of Y_{t-1} that appear:

$$\overline{Y}_t \equiv [\ \widehat{c}_{t-1}\ \ \widehat{b}^{*B}_{t-1}\ \ \widehat{i}^{L}_{t-1}\ ]'.$$

System (106) can be written more compactly as:

$$\begin{aligned} k_{t+1} &= S d_t \\ A^{00} E_t d_{t+1} &= B^{00} d_t - \overline{C}^{00} k_t - J^{00} \widetilde{Z}_t + D^{00} \varkappa^d_{t+1}, \end{aligned} \tag{107}$$

where

$$\begin{aligned} k_t &= \begin{bmatrix} \overline{X}_t \\ \overline{Y}_t \end{bmatrix}, \qquad d_t = \begin{bmatrix} X_t \\ Y_t \end{bmatrix}, \qquad S = \begin{bmatrix} S_X & 0 \\ 0 & S_Y \end{bmatrix}, \\ A^{00} &= \begin{bmatrix} 0 & 0 \\ A^{00}_{21} & A^{00}_{22} \end{bmatrix}, \quad B^{00} = \begin{bmatrix} B^{00}_{11} & B^{00}_{12} \\ B^{00}_{21} & B^{00}_{22} \end{bmatrix}, \quad D^{00} = \begin{bmatrix} D^{00}_{11} & 0 \\ 0 & D^{00}_{22} \end{bmatrix} \\ \overline{C}^{00} &= \begin{bmatrix} \overline{C}^{00}_{11} & \overline{C}^{00}_{12} \\ \overline{C}^{00}_{21} & \overline{C}^{00}_{22} \end{bmatrix}, \qquad J^{00} = \begin{bmatrix} J^{00}_{11} & J^{00}_{12} \\ J^{00}_{21} & 0 \end{bmatrix}, \qquad \varkappa^d_t = \begin{bmatrix} \varkappa^X_t \\ 0 \end{bmatrix}. \end{aligned}$$

k_t and d_t are the vectors of predetermined and jump variables, respectively. I now stack (107) along with (105) as:

$$\begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & A^{00} \end{bmatrix} \begin{bmatrix} \widetilde{Z}_{t+1} \\ k_{t+1} \\ E_t d_{t+1} \end{bmatrix} = \begin{bmatrix} \widetilde{M} & 0 & 0 \\ 0 & 0 & S \\ -J^{00} & -\overline{C}^{00} & B^{00} \end{bmatrix} \begin{bmatrix} \widetilde{Z}_t \\ k_t \\ d_t \end{bmatrix} + \begin{bmatrix} \widetilde{\varkappa}^Z_{t+1} \\ 0 \\ D^{00} \varkappa^d_{t+1} \end{bmatrix},$$

or

$$A E_t \widehat{s}_{t+1} = B \widehat{s}_t + \widehat{\varkappa}_{t+1},$$

where:

$$\begin{aligned} \widehat{s}_t &= \begin{bmatrix} k^+_t \\ d_t \end{bmatrix} \equiv \begin{bmatrix} \widetilde{Z}_t \\ k_t \\ d_t \end{bmatrix}, \qquad A = \begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & A^{00} \end{bmatrix}, \\ B &= \begin{bmatrix} \widetilde{M} & 0 & 0 \\ 0 & 0 & S \\ -J^{00} & -\overline{C}^{00} & B^{00} \end{bmatrix}, \qquad \widehat{\varkappa}_t = \begin{bmatrix} \varkappa^{k^+}_t \\ D^{00} \varkappa^d_t \end{bmatrix}, \quad \varkappa^{k^+}_{t+1} = \begin{bmatrix} \widetilde{\varkappa}^Z_{t+1} \\ 0 \end{bmatrix}. \end{aligned}$$

Solving this system by means of the QZ decomposition and reinserting the innovations yields the time series representation of the DSGE model:

$$\begin{aligned} k^+_{t+1} &= G k^+_t + \varkappa^{k^+}_{t+1} \\ d_t &= K k^+_t, \end{aligned}$$

or, partitioning G and K conformably with k^+_t:

$$\begin{aligned} \widetilde{Z}_{t+1} &= G_{zz} \widetilde{Z}_t + G_{zk} k_t + \widetilde{\varkappa}^Z_{t+1} \\ k_{t+1} &= G_{kz} \widetilde{Z}_t + G_{kk} k_t + D^{00}_{11} \varkappa^k_{t+1} \\ d_t &= K_z \widetilde{Z}_t + K_k k_t. \end{aligned}$$

4. Baseline calibration, and dogmatic priors

Appendix 5 includes an analysis of the NSS and a detailed baseline calibration. The steps shown there (with some inessential changes) were implemented in a MATLAB m-file that interacts with the Dynare mod-file that contains the model and stochastic simulation or estimation instructions. A number of great ratios and structural parameters jointly determine the steady state values of the endogenous variables. Since I have different strengths of opinion for different great ratios and since substantial identification problems have to be surpassed by means of the imposition of 'dogmatic priors' for some of the parameters, I have divided them in two categories. For the first group I use dogmatic priors and impose them on the model. For the second group my priors are less strong and hence I allow them to vary endogenously with the parameter values that are either estimated or imposed. I also impose the steady state values of a small subset of the endogenous variables.

The steady state values for endogenous variables that were imposed were the trend adjusted GDP (at 10% above the 2005 level at constant 1993 prices: $y = 585.5$), the Government foreign debt interest rate ($1 + i^G = 1.07^{0.25}$), and the bank loan interest rate ($1 + i^L = 1.12^{0.25}$). I also imposed the Central Bank inflation target (which determines the domestic inflation rates: $\pi^T = 1.065^{0.25}$) and the steady state values of a few of the RW shock variables subject to autorregresive processes: the exogenous risk/liquidity premia for banks and the government ($\left(\phi^{**B}\right)^4 = \left(\phi^{**G}\right)^4 = 1.005$) and the external terms of trade shock ($p^* = 0.0047634357$).

The great ratios (to GDP) I imposed are: the Government's expenditure ratio ($g/y = 0.16$) and foreign debt ratio ($\gamma^{GT} = eb^{*G}/y = 0.2$), households' cash ratio ($m^0/y = 0.08$), the Central Bank's international reserves ratio ($\gamma^{CBT} = er^{*CB}/y = 0.13$), Banks' foreign debt ratio ($eb^{*B}/y = 0.0658$) and loan ratio ($\ell/y = 0.23$), and the economy's imports ratio ($p^N N/y = 0.22$). I also imposed households' transactions cost to consumption expenditures ratio ($\tau_M = \tau_M c/c = 0.001$).

The parameter values I imposed are the intertemporal discount rate ($\beta = 0.999$), the share of domestic goods in household expenditures (or home bias parameter $a_D = 0.8610526316$), the inverse of the elasticity of labor supply with respect to the real wage ($\chi = 0.7$), the elasticities of the endogenous risk premia for the government ($\varepsilon_G = 0.833397207$) and banks ($\varepsilon_B = 1.15745156$), the interest elasticity of cash demand by households ($\varepsilon_M = 0.85$), and the persistence parameters for the consumption shock ($\rho^{z^C} = 0.85$) and the Central Bank international reserves policy rule (whenever it was used: $\rho^{r^{*CB}} = 0.1$).

The estimated parameters are the coefficients in the policy rules, the elasticities of substitution (ES) between imported varieties (θ^N) and between labor varieties (ψ), the ES between domestic and imported goods in consumption (θ^C), the parameters in the production functions of the domestic (b^D) and export goods (b^A) sectors, the habit parameter (ξ), the Calvo probabilities of not setting the optimal price for domestic goods (α_D), imported goods (α_N) and wages (α_W), and the parameters related to the evolution of the rate of growth of productivity (α_{μ^z}, ρ^{μ^z}). The remaining persistence parameters were also estimated:

$$\rho^{z^H}, \quad \rho^{\epsilon}, \quad \rho^{\varsigma}, \quad \rho^{z^A}, \quad \rho^{p^*}, \quad \rho^{\pi^{*N}}, \quad \rho^{i^*}, \rho^{\phi^{*B}}, \quad \rho^{\phi^{*G}}, \quad \rho^{\mu^{z*}}, \quad \rho^{g},$$

along with the fourteen standard deviations of the exogenous shocks.

The values of the remaining parameters and great ratios are determined endogenously from the previous estimated or imposed values using steady state equations. The endogenous parameters are:

$$\theta, \quad \eta, \quad b^B, \quad \alpha_1^G, \quad \alpha_2^G, \quad \alpha_2^B, \quad \alpha_1^B, \quad a_M, \quad b_M, \quad c_M,$$

And the endogenous great ratios are:

$$\frac{q}{y}, \quad \frac{p^C c}{y}, \quad \frac{\overline{w}h}{y}, \quad \frac{etb}{y}, \quad \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}/b^A}{y}, \quad \varpi \equiv \frac{m^0}{p^C c}, \quad \frac{q^{DX}}{y}, \quad \frac{n^D}{n}, \quad \frac{b^{CB}}{y}, \quad \frac{d}{y}.$$

In particular, the Central Bank and Bank balance sheets therefore imply the Central Bank domestic bonds ratio ($b^{CB}/y = 0.05$), and Banks' deposit ratio ($d/y = 0.2142$), respectively.

5. Policy parameter stability ranges

For numerical solution of ARGEMmy using Dynare I wrote the model block using the nonlinear equations and let Dynare calculate the loglinear approximations. In this section I report individual policy parameter ranges that, starting from a baseline calibration of these parameters, guaranteed the Blanchard-Kahn stability conditions. For the remaining parameters I used calibrations which in section 6 constitute the prior mean of the estimated parameters. In order to satisfy the Blanchard-Kahn stability conditions it was necessary to introduce some forward-lookingness either in the policy rules or elsewhere. Although other variants involving Central Bank policy rules were available, the one I adopted was to assume that the tax collection process is a forward-looking AR(1) (i.e. with a persistence parameter greater than 1), as seen previously. This can be interpreted as representing a (lump sum) tax collection policy that is front loaded and geared to obtaining fiscal solvency. To avoid unnecessary complications, the persistence parameter in this equation was calibrated ($\rho^t = 1.6$) and the equation was not shocked.

All variants of the Central Bank policy rules satisfied the Blanchard-Kahn conditions for a baseline set of calibrated policy parameters. To get an idea of how much the coefficients could depart from the baseline level, I performed a sensitivity analysis for the nine policy rule coefficients. Starting from a baseline calibration for the coefficients in the two policy feedback rules I looked for the largest connected intervals (to one decimal in the vicinity of zero and to one digit otherwise) within which each of the coefficients could be moved individually (and leaving the rest at the baseline value) without altering the Blanchard-Kahn conditions for existence and determinacy of model solution. I didn't check for: 1) parameter values above 10, 2) negative values for the inertial parameters, or 3) negative values for the next two parameters in the interest rate feedback rule (inflation and GDP). The baseline values of the policy coefficients in the simple policy feedback rules were the following, where I repeat the policy rules for the reader's convenience:

Interest rate feedback rule:

h_0	h_1	h_2	h_3	h_4
0.5	1.5	1.2	−0.6	−0.4

$$1+i_t = \Xi^{TR}\left(1+i_{t-1}\right)^{h_0}\left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}_t^T}\right)^{h_1}\left(\frac{y_t}{y}\right)^{h_2}\left(\frac{e_t tb_t/y_t}{\gamma^{TBT}}\right)^{h_3}\left(\frac{e_{t-1}tb_{t-1}/y_{t-1}}{\gamma^{TBT}}\right)^{h_4}$$

Nominal depreciation feedback rule:

k_0	k_1	k_2	k_3	k_4	k_5
0.5	−1.5	−1.2	−1.5	−0.5	1.5

$$\delta_t = \Xi^{FXI}\left(\delta_{t-1}\right)^{k_0}\left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}_t^T}\right)^{k_1}\left(\frac{y_t}{y}\right)^{k_2}\left(\frac{e_t tb_t/y_t}{\gamma^{TBT}}\right)^{k_3}\left(\frac{e_{t-1}tb_{t-1}/y_{t-1}}{\gamma^{TBT}}\right)^{k_4}$$
$$\times\left(\frac{e_t r_t^{*CB}/y_t}{\gamma^{CBT}}\right)^{k_5}\exp(\varepsilon_t^{\delta})$$

Table 1 shows the stability results. Both of the inertial coefficient intervals of stability were quite wide around zero, both going into high superinertial levels. In the case of the interest rate rule, there were no upper bounds (up to 10) for the reactions to GDP, and the parameter on the contemporary trade balance to GDP ratio had to be negative. The 'Taylor Principle' did not hold, for the coefficient on inflation could go down to 0 without impairing stability. In the case of the second feedback rule, there were no upper or lower bounds for the response to inflation, GDP, or the contemporary trade balance to GDP ratio. The coefficient on the international reserves to GDP ratio k_5, only had to be outside of a small interval around zero. Because unity is included in the feasible intervals for h_0 and k_0, one or both of the simple policy rules can be implemented as the feedback response of the first difference (in the interest rate or the depreciation rate) to the various arguments on the r.h.s.

TABLE 1
Individual policy parameter stability ranges

Interest rate feedback rule:	
$h_0 \in$	$[0, 10]$
$h_1 \in$	$[0, 6]$
$h_2 \in$	$[0, 10]$
$h_3 \in$	$[-10, -0.5]$
$h_4 \in$	$[-0.5, 0.5]$
Nominal depreciation feedback rule:	
$k_0 \in$	$[0, 10]$
$k_1 \in$	$[-10, 10]$
$k_2 \in$	$[-10, 10]$
$k_3 \in$	$[-10, 10]$
$k_4 \in$	$[-10, 3]$
$k_5 \notin$	$[-0.1, 0.2]$

These approximate bounds proved to be useful for instructing Dynare to limit the search for the estimated parameters.

6. Bayesian estimation

In this section I show preliminary results on the Bayesian estimation of a subset of the model parameters. As is well known, unlike GMM estimation, Bayesian estimation is system-based. It fits the solution of the DSGE model to a vector of time series (An and Schorfheide (2007)). Also, like maximum likelihood estimation it is based on the likelihood function generated by the DSGE model, but through prior densities it also incorporates the additional information the researcher may have (e.g. his expert opinion on how the model is supposed to behave). However, the Bayesian estimation of DSGE models is plagued with pitfalls. Lack of identification of some of the parameters of interest is usual and is one of the most difficult issues to tackle (Canova (2007), Canova and Sala (2005), Iskrev (2007)). In countries like Argentina there are additional difficulties related to lack of trustworthy data series, structural breaks through frequent deep crises, changes of policy regimes, etc. Although life is not easy for applied researchers in less developed countries, Bayesian methods constitute an important venue for bridging some of the difficulties. However, the lack of identification of a significant subset of the parameters of interest when the model is relatively large makes it almost mandatory to resort to a mixed calibration/estimation strategy.

In this section I show results on the calibration/estimation of ARGEMmy using Dynare/MATLAB. Since they pertain to the post-Convertibility era I use only 22 observations between 2002:3 and 2007:4 for 10 observable variables. The first four are the quarter to quarter rates of growth of GDP, Private Absorption (i.e., Private Consumption plus Investment), Government current expenditures, and Imports. These series are from the national accounts measured in 1993 prices. The next three observable variables are the quarter to quarter rates of growth of Deposits (Bank deposits subject to reserve requirements), and Cash (Bills and Coins), and the Consumption MRER (in level). These are BCRA (Central Bank of Argentina) series. The last three are the quarter to quarter inflation rates for domestic and imported goods and for wages. For the domestic and imported prices I use the GDP and imports deflators from the national accounts, and I proxied wages by the remunerations reflected in the pension system (Gross average remunerations with accrued 13th annual remuneration -'aguinaldo') because it is much more representative than any existing wage series.

As soon as I increased the number of observable variables to more than just a few I began to have problems in the initial search for the posterior mode with any of the first five Dynare mode_compute options, including Sims' csminwel. The sixth option, which unfortunately has very scant documentation (see DynareWiki in the Dynare website), instead of using a standard optimization routine (Newton type), uses a Monte Carlo optimization algorithm. It looks for a point in the parameters space with high posterior density and a good covariance matrix to be used by the jumping distribution in the second Metropolis Hastings process. It uses a MH algorithm with a starting diagonal covariance matrix to repeatedly update the posterior covariance matrix, the posterior mean and the posterior mode estimates through Metropolis Hastings draws. The number of simulations and the number of times the process is repeated can be established through options specific to the 'mode_compute=6' option. Another advantage of this option is that it also tunes the scale factor for the jumping distribution used in the second (and usual)

Metropolis Hastings algorithm so that the acceptance ratio is around one third.

This option proved to be extremely helpful. However, even with this option increasing the number of observable series used and the number of parameters to be estimated was not an easy task. There were often warning signs indicating a poorly conditioned Hessian matrix or an insufficiently large support of the weighting density for the calculation of the Modified Harmonic Mean estimate (for the marginal density of the data conditional on the model). Such difficulties, probably related to lack of identification or poor identification of some of the parameters and possibly problems with some of my data, led me to reduce the number of parameters I had initially set out to estimate as well as the number of observable series I had initially included in my data file.

It is quite clear that the exchange rate remained a central concern for monetary policy in Argentina in the post-Convertibility period. Although the dollar exchange rate is the most visible, the monetary authorities pay attention to the Consumption MRER. A preliminary estimation compared the model where the Central Bank uses the two feedback rules to the model where it uses only the foreign exchange intervention feedback rule and an autorregresive equation for the domestic value of the Central Bank's international reserves. The second model systematically generated a significantly higher marginal data density conditional on the model. Hence, below I only show the results from the second model.

The estimation process was iterative. After making a preliminary exploration of the parameter space I decided on a set of prior means for the structural parameters and performed a second or third estimation after correcting part of the discrepancies between the prior and estimated posterior means of 1) the standard errors of the shocks, 2) the corresponding persistence parameters (when these existed and where estimated), and 3) the feedback rule parameters (the k_i). The fact that these parameters do not affect the model's NSS made this easier (than also correcting the priors for the main structural parameters). The assumptions on priors and some of the information produced on the posteriors and are in Table 2 below. And some of the voluminous additional Dynare output is shown in Appendix 6.

TABLE 2

ESTIMATION RESULTS

Log data density is 134.624146

Parameters

	prior mean	post. mean	confidence interval		prior	pstdev
k_0	0.20	-0.1657	-0.4853	0.0736	norm	2.000
k_1	-2.50	-1.6218	-2.9543	-0.6590	norm	4.500
k_2	-0.50	-0.3903	-0.6251	-0.0985	norm	2.000
k_3	-0.60	0.0026	-0.0002	0.0056	norm	1.000
k_4	-0.50	0.0018	-0.0013	0.0047	norm	1.000
k_5	0.15	0.0300	-0.1125	0.2004	norm	1.000
thetaN	1.30	1.1754	1.1477	1.2011	norm	3.000
thetaC	0.70	0.9895	0.8425	1.1286	norm	2.000
bD	0.89	0.8903	0.8774	0.9044	beta	0.050
bA	0.06	0.0729	0.0634	0.0792	beta	0.030
xi	0.85	0.8091	0.7979	0.8230	beta	0.040
psi	12.00	7.3116	4.6179	10.2944	norm	24.000
alphaD	0.70	0.6133	0.5889	0.6299	beta	0.100
alphaN	0.70	0.5889	0.5617	0.6270	beta	0.100
alphaW	0.70	0.5808	0.5559	0.6042	beta	0.100
alpha_z	0.01	0.0151	0.0119	0.0175	beta	0.015
rhoz	0.85	0.6733	0.6587	0.6863	beta	0.100
rhozH	0.60	0.5283	0.5150	0.5501	beta	0.100
rhoEpsilon	0.70	0.6563	0.6322	0.6820	beta	0.100
rhoVarsigma	0.55	0.5951	0.5680	0.6298	beta	0.100
rhozA	0.20	0.2270	0.1854	0.2579	beta	0.100
rhopStar	0.83	0.8169	0.8006	0.8318	beta	0.100
rhoPiStarN	0.65	0.5981	0.5833	0.6140	beta	0.100
rhoiStar	0.72	0.7275	0.7080	0.7489	beta	0.100
rhoPhiStarB	0.50	0.2790	0.2608	0.2904	beta	0.080
rhoPhiStarG	0.25	0.2733	0.2580	0.2881	beta	0.080
rhoMuzStar	0.50	0.5226	0.5025	0.5383	beta	0.090
rhog	0.80	0.8196	0.7992	0.8377	beta	0.060

Standard deviation of shocks

	prior mean	post. mean	confidence interval		prior	pstdev
eps_zC	0.250	0.1445	0.0975	0.1886	invg	Inf
eps_zH	0.600	0.6980	0.6448	0.7835	invg	0.2
eps_epsilon	0.200	0.3412	0.2179	0.4669	invg	Inf
eps_varsigma	0.040	0.0845	0.0109	0.1573	invg	Inf
eps_zA	0.080	0.0643	0.0185	0.1196	invg	Inf
eps_pStar	0.150	0.2416	0.1629	0.3189	invg	Inf
eps_piStarN	0.100	0.0925	0.0471	0.1391	invg	Inf
eps_iStar	0.400	0.3690	0.2974	0.4250	invg	0.2
eps_phiStarB	0.150	0.1763	0.1299	0.2211	invg	Inf
eps_phiStarG	0.050	0.0553	0.0112	0.1213	invg	Inf
eps_muzStar	0.100	0.0656	0.0378	0.0918	invg	Inf
eps_g	0.100	0.1267	0.0951	0.1575	invg	Inf
eps_varepsilonz	0.080	0.0818	0.0600	0.1032	invg	Inf
eps_varepsilondelta	0.100	0.0519	0.0244	0.0801	invg	Inf

7. Optimal Monetary and Exchange rate Policy under Commitment

7.1. The matrix system for a linear quadratic optimal control framework

For the study of optimal policy rules I leave out the two equations that represent the simple policy rules and express the rest of ARGEMmy (excluding the autoregressive processes for the disturbance variables Z_t) in the following matrix format:

$$\begin{bmatrix} B_{11}^{00} & B_{12}^{00} \\ B_{21}^{00} & B_{22}^{00} \end{bmatrix} \begin{bmatrix} V_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ A_{21}^{00} & A_{22}^{00} \end{bmatrix} E_t \begin{bmatrix} V_{t+1} \\ Y_{t+1} \end{bmatrix}$$
$$+ \begin{bmatrix} C_{11}^{00} & C_{12}^{00} \\ C_{21}^{00} & C_{22}^{00} \end{bmatrix} \begin{bmatrix} V_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ F_2^2 \end{bmatrix} E_t u_{t+1} - \begin{bmatrix} F_1^1 \\ F_2^1 \end{bmatrix} u_t$$
$$+ \begin{bmatrix} F_1^0 \\ F_2^0 \end{bmatrix} u_{t-1} + \begin{bmatrix} J_{11}^{00} & J_{12}^{00} \\ J_{21}^{00} & 0 \end{bmatrix} \begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix} - \begin{bmatrix} D_1^{00} & 0 \\ 0 & D_2^{00} \end{bmatrix} \begin{bmatrix} \varkappa_{t+1}^V \\ 0 \end{bmatrix}.$$

Although I use the same notation for the main matrices (A^0, B^0, C^0) as in (102) for simplicity, they are of smaller dimension since they leave out the first two rows and columns (the latter become matrices F^2, F^1, F^0). As before, the first block row includes all static equations and all dynamic equations that do not include forward-looking terms, and the second block row includes the remaining equations, i.e., those that include forward-looking terms. Vector V_t is the lower part of vector X_t used in section 3:

$$X_t = \begin{bmatrix} u_t \\ V_t \end{bmatrix},$$

where u_t is the vector of policy instruments. As in section 3, I normalized the equation coefficients so that the main diagonal of B^{00} is made up of ones. More compactly, the system is:

$$B^{00}d_t = A^{00}E_t d_{t+1} + C^{00}d_{t-1} + F^2 E_t u_{t+1} - F^1 u_t + F^0 u_{t-1} + J^{00}\widetilde{Z}_t - D^{00}\varkappa^d_{t+1}, \quad (108)$$

where

$$\begin{aligned}
d_t &= \begin{bmatrix} V_t \\ Y_t \end{bmatrix}, \quad \widetilde{Z}_t = \begin{bmatrix} Z_t \\ Z_{t-1} \end{bmatrix}, \quad \varkappa^d_t = \begin{bmatrix} \varkappa^V_t \\ 0 \end{bmatrix} \quad A^{00} = \begin{bmatrix} 0 & 0 \\ A^{00}_{21} & A^{00}_{22} \end{bmatrix}, \\
B^{00} &= \begin{bmatrix} B^{00}_{11} & B^{00}_{12} \\ B^{00}_{21} & B^{00}_{22} \end{bmatrix}, \quad C^{00} = \begin{bmatrix} C^{00}_{11} & C^{00}_{12} \\ C^{00}_{21} & C^{00}_{22} \end{bmatrix}, \quad D^{00} = \begin{bmatrix} D^{00}_1 & 0 \\ 0 & D^{00}_2 \end{bmatrix}, \\
J^0 &= \begin{bmatrix} J^{00}_{11} & J^{00}_{12} \\ J^{00}_{21} & 0 \end{bmatrix} = \begin{bmatrix} J^{00}_1 \\ J^{00}_2 \end{bmatrix}, \; F^0 = \begin{bmatrix} F^0_1 \\ F^0_2 \end{bmatrix}, \; F^1 = \begin{bmatrix} F^1_1 \\ F^1_2 \end{bmatrix}, \; F^2 = \begin{bmatrix} 0 \\ F^2_2 \end{bmatrix}.
\end{aligned}$$

I now eliminate the null columns of matrix C^{00} for exactly the same reasons as in section 3. Define selector matrices S^*_V and S^*_Y that select only the elements of V_t and Y_t that appear lagged in the reduced system. Correspondingly, define new, lower dimensional, vectors $\overline{V}_t = S^*_V V_{t-1}$ and $\overline{Y}_t = S^*_Y Y_{t-1}$ that eliminate all lagged variables and define matrices $\overline{C}^*_{ji}$ that have the same non-zero elements as matrices C_{ij} but leave out the columns of zeros:

$$\begin{bmatrix} \overline{C}^*_{11} & \overline{C}^*_{12} \\ \overline{C}^*_{21} & \overline{C}^*_{22} \end{bmatrix} = \begin{bmatrix} C^{00}_{11} & C^{00}_{12} \\ C^{00}_{21} & C^{00}_{22} \end{bmatrix} \begin{bmatrix} S^{*\prime}_V & 0 \\ 0 & S^{*\prime}_Y \end{bmatrix}.$$

As it turns out, $\overline{Y}_t$ has the same three elements as before after eliminating the simple policy rules, and hence $S^*_Y = S_Y$, but S^*_V now selects only 30 of the 54 variables in V_t (because $\widehat{tb}_{t-1}$ and $\widehat{y}_{t-1}$ only appeared in the simple policy rules and nowhere else in the original system). I also define the vector of lagged instrument variables $\overline{u}_t = u_{t-1}$. Hence, I have the following matrix system:

$$\begin{bmatrix} \overline{u}_{t+1} \\ \overline{V}_{t+1} \\ \overline{Y}_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ S^*_V & 0 \\ 0 & S_Y \end{bmatrix} \begin{bmatrix} V_t \\ Y_t \end{bmatrix} + \begin{bmatrix} I_{2\times 2} \\ 0 \\ 0 \end{bmatrix} u_t,$$

$$\begin{bmatrix} 0 & 0 \\ A^{00}_{21} & A^{00}_{22} \end{bmatrix} E_t \begin{bmatrix} V_{t+1} \\ Y_{t+1} \end{bmatrix} = \begin{bmatrix} B^{00}_{11} & B^{00}_{12} \\ B^{00}_{21} & B^{00}_{22} \end{bmatrix} \begin{bmatrix} V_t \\ Y_t \end{bmatrix}$$
$$- \begin{bmatrix} F^0_1 & \overline{C}^*_{11} & \overline{C}^*_{12} \\ F^0_2 & \overline{C}^*_{21} & \overline{C}^*_{22} \end{bmatrix} \begin{bmatrix} \overline{u}_t \\ \overline{V}_t \\ \overline{Y}_t \end{bmatrix} + \begin{bmatrix} F^1_1 \\ F^1_2 \end{bmatrix} u_t - \begin{bmatrix} 0 \\ F^2_2 \end{bmatrix} E_t u_{t+1}$$
$$- \begin{bmatrix} J^{00}_1 \\ J^{00}_2 \end{bmatrix} \widetilde{Z}_t + \begin{bmatrix} D^{00}_1 & 0 \\ 0 & D^{00}_2 \end{bmatrix} \begin{bmatrix} \varkappa^V_{t+1} \\ 0 \end{bmatrix}.$$

These equations can be expressed as:

$$\begin{aligned} \overline{k}_{t+1} &= S^* \widetilde{d}_t + I^0 u_t \\ A^{00} E_t \widetilde{d}_{t+1} &= B^{00} \widetilde{d}_t - \overline{C}^* \overline{k}_t + F^1 u_t - F^2 E_t u_{t+1} - J^{00} \widetilde{Z}_t + D^{00} \varkappa^d_{t+1}, \end{aligned} \tag{109}$$

where

$$\begin{aligned} \overline{k}_t &= \begin{bmatrix} \overline{u}_t \\ \overline{V}_t \\ \overline{Y}_t \end{bmatrix}, \qquad \widetilde{d}_t = \begin{bmatrix} V_t \\ Y_t \end{bmatrix}, \qquad I^0 = \begin{bmatrix} I_{2\times 2} \\ 0_{30\times 2} \\ 0_{3\times 2} \end{bmatrix}, \\ \overline{C}^* &= \begin{bmatrix} F^0_1 & \overline{C}^*_{11} & \overline{C}^*_{12} \\ F^0_2 & \overline{C}^*_{21} & \overline{C}^*_{22} \end{bmatrix}, \qquad S^* = \begin{bmatrix} 0_{2\times 54} & 0_{2\times 12} \\ S^*_V & 0_{30\times 12} \\ 0_{3\times 54} & S_Y \end{bmatrix}. \end{aligned}$$

As before, the exogenous stochastic processes are given by (105). Stacking these with the first equation in (109) yields the constraints the policymaker faces:

$$\begin{aligned} \widetilde{k}_{t+1} &= \widehat{M} \widetilde{k}_t + \widehat{S} \widetilde{d}_t + \widehat{I} u_t + \varkappa^*_{t+1} \\ A^{00} E_t \widetilde{d}_{t+1} &= B^{00} \widetilde{d}_t - \widehat{C} \widetilde{k}_t + F^1 u_t - F^2 E_t u_{t+1} + D^{00} \varkappa^d_{t+1} \end{aligned} \tag{110}$$

where

$$\begin{aligned} \widetilde{k}_t &= \begin{bmatrix} \widetilde{Z}_t \\ \overline{k}_t \end{bmatrix}, \qquad \widehat{I} = \begin{bmatrix} 0_{24\times 2} \\ I^0 \end{bmatrix}, \qquad \widehat{C} = \begin{bmatrix} J^{00} & \overline{C}^* \end{bmatrix} \\ \widehat{M} &= \begin{bmatrix} \widetilde{M} & 0_{24\times 35} \\ 0_{35\times 24} & 0_{35\times 35} \end{bmatrix}, \qquad \widehat{S} = \begin{bmatrix} 0_{24\times 66} \\ S^* \end{bmatrix}, \qquad \varkappa^*_t = \begin{bmatrix} \widetilde{\varkappa}_t \\ 0_{35\times 1} \end{bmatrix}. \end{aligned}$$

Below I also use an even more compact expression:

$$\widetilde{A} E_t s_{t+1} = \widetilde{B} s_t + \widehat{\varkappa}^*_{t+1}, \tag{111}$$

where

$$\begin{aligned} s_t &= \begin{bmatrix} \widetilde{k}_t \\ \widetilde{d}_t \\ u_t \end{bmatrix}, \qquad \widehat{\varkappa}^*_t = \begin{bmatrix} \varkappa^*_t \\ D^{00} \varkappa^d_t \end{bmatrix} \\ \widetilde{A} &= \begin{bmatrix} I_{59\times 59} & 0 & 0 \\ 0 & A^{00} & F^2 \end{bmatrix}, \qquad \widetilde{B} = \begin{bmatrix} \widehat{M} & \widehat{S} & \widehat{I} \\ -\widehat{C} & B^{00} & F^1 \end{bmatrix}. \end{aligned} \tag{112}$$

7.2. Linear quadratic optimal control under full information and commitment

I assume that the Central Bank and the private sector have full information. The Central Bank minimizes an intertemporal loss function at time $t = 0$:

$$\mathcal{L}_0 = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} L_t, \tag{113}$$

where (twice) the period loss function is

$$\begin{aligned} L_t &= \omega_\pi \left(\widehat{\widetilde{\pi}}_t^C\right)^2 + \omega_y \left(\widehat{y}_t\right)^2 + \omega_{tb} \left(\widehat{tbr}_t\right)^2 + \omega_i \left(\widehat{i}_t\right)^2 + \omega_\delta \left(\widehat{\delta}_t\right)^2 \\ &\quad + \omega_{\Delta i} \left(\Delta \widehat{i}_t\right)^2 + \omega_{\Delta i} \left(\Delta \widehat{\delta}_t\right)^2 + \omega_{\Delta e} \left(\Delta \widehat{e}_t\right)^2, \end{aligned}$$

subject to constraints (110) and initial conditions for the predetermined variables ($k_0 = k^\circ$). This period loss function is quite general, and can include costs for deviations of year on year consumption inflation, GDP, and the trade balance (to GDP) ratio from their non-stochastic steady state values, costs for deviations of each of the two operational targets from their non-stochastic steady state values, and also costs for changes in the operational targets and/or the RER. The cost for interest rate deviations from the steady state can reflect a desire to stay away from the zero lower bound. The cost for deviations of the rate of nominal depreciation is included basically for the analysis of its effects. And the cost for changes in the RER can reflect a desire to maintain an undervalued currency (as some LDCs apparently do) to help domestic firms compete against foreign firms (in international markets as well as in the domestic market) or, quite the contrary, a desire to maintain an overvalued currency (as some LDCs used to do during the runup to elections in order to gain votes by allowing the population to live beyond its means).

The vector of target variables is

$$\tau_t = \left[\begin{array}{cccccccc} \widehat{i}_{t-1} & \widehat{\delta}_{t-1} & \widehat{e}_{t-1} & \widehat{y}_t & \widehat{e}_t & \widehat{\widetilde{\pi}}_t^C & \widehat{tbr}_t & \widehat{i}_t & \widehat{\delta}_t \end{array} \right]'. \tag{114}$$

It includes all the variables that (in this paper) the Central Bank can potentially be interested in including in its period loss function. It can be expressed in terms of the endogenous variables as:

$$\tau_t = \left[\begin{array}{cccc} 0_{3\times 24} & S_T^k & 0_{3\times 66} & 0_{3\times 2} \\ 0_{4\times 24} & 0_{4\times 35} & S_T^d & 0_{4\times 2} \\ 0_{2\times 24} & 0_{2\times 35} & 0_{2\times 66} & I_{2\times 2} \end{array} \right] \left[\begin{array}{c} \widetilde{Z}_t \\ \overline{k}_t \\ \widetilde{d}_t \\ u_t \end{array} \right] \equiv T s_t. \tag{115}$$

S_T^k is a selector matrix that selects the first ($\widehat{i}_{t-1}$), second ($\widehat{\delta}_{t-1}$) and fourteenth ($\widehat{e}_{t-1}$) elements of $\overline{k}_t$ and S_T^d is the selector matrix that selects the 11th ($\widehat{y}_t$), 24th ($\widehat{e}_t$), 29th ($\widehat{\widetilde{\pi}}_t^C$) and 34th ($\widehat{tbr}_t$) elements of $\widetilde{d}_t$.

L_t can be expressed in matrix form as:

$$L_t = \tau_t' \Omega^0 \tau_t,$$

where

$$\Omega^0 = \begin{bmatrix} \omega_{\Delta i} & 0 & 0 & 0 & 0 & 0 & 0 & -\omega_{\Delta i} & 0 \\ 0 & \omega_{\Delta\delta} & 0 & 0 & 0 & 0 & 0 & 0 & -\omega_{\Delta\delta} \\ 0 & 0 & \omega_{\Delta e} & 0 & -\omega_{\Delta e} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \omega_y & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\omega_{\Delta e} & 0 & \omega_e + \omega_{\Delta e} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \omega_{tb} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \omega_\pi & 0 & 0 \\ -\omega_{\Delta i} & 0 & 0 & 0 & 0 & 0 & 0 & \omega_i + \omega_{\Delta i} & 0 \\ 0 & -\omega_{\Delta\delta} & 0 & 0 & 0 & 0 & 0 & 0 & \omega_\delta + \omega_{\Delta\delta} \end{bmatrix}.$$

In terms of the complete set of endogenous variables, (twice) the period loss function is:

$$L_t = \tau_t' \Omega^0 \tau_t = s_t' T' \Omega^0 T s_t \equiv s_t' \Omega s_t, \tag{116}$$

where Ω can be partitioned conformably to s_t in (112)

$$\Omega = \begin{bmatrix} \Omega_{kk} & \Omega_{kd} & \Omega_{ku} \\ \Omega_{dk} & \Omega_{dd} & \Omega_{du} \\ \Omega_{uk} & \Omega_{ud} & \Omega_{uu} \end{bmatrix}. \tag{117}$$

Hence, the Central Bank's problem is to choose a sequence of optimal controls $\{u_t\}_{t=0,1...}$ that minimizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} s_t' \Omega s_t,$$

subject to (111) for all t and initial the conditions $\widetilde{k}_0 = k^\circ$. I assume that the Central Bank and the private sector always have the same information set. Since the commitment solution is certainty equivalent, one can think of the Central Bank's policy problem as deterministic. Hence, the Lagrangian function can be expressed as:

$$E_0 \left\{ \sum_{t=0}^{\infty} \left[\beta^t \frac{1}{2} s_t' \Omega s_t + \beta^t \lambda_{t+1}' \left(\widetilde{B} s_t - \widetilde{A} s_{t+1} \right) \right] - \beta^{-1} \lambda_0^{k\prime} \left(\widetilde{k}_0 - k^\circ \right) \right\}, \tag{118}$$

where the vector of Lagrange multipliers is $\mu_{t+1} \equiv \beta^t \lambda_{t+1}$, where

$$\lambda_{t+1} = \begin{bmatrix} \lambda_{t+1}^k \\ \lambda_t^d \end{bmatrix}.$$

Following Svensson and Woodford (2003), the dating of the multipliers reflects the fact that the constraints for the predetermined variables depend on information at $t+1$ whereas the constraints for the jump variables, being in expectations, depend on the information available in period t. Now note that if we define a fictitious vector of multipliers for period -1 which is equal to 0:

$$\lambda_{-1}^d = 0, \tag{119}$$

the following equality holds (for any arbitrary d°, u°):

$$\lambda_0' \widetilde{A}\left(s_0 - s^\circ\right) = \left[\begin{array}{cc} \lambda_0^{k\prime} & \lambda_{-1}^{d\prime} \end{array}\right] \left[\begin{array}{ccc} I & 0 & 0 \\ 0 & A^0 & F^2 \end{array}\right] \left[\begin{array}{c} \widetilde{k}_0 - k^\circ \\ \widetilde{d}_0 - d^\circ \\ u_0 - u^\circ \end{array}\right] = \lambda_0^{k\prime}\left(\widetilde{k}_0 - k^\circ\right).$$

Hence, I can use a more symmetric notation writing (118) as:

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[\frac{1}{2}s_t'\Omega s_t + \lambda_{t+1}'\left(\widetilde{B}s_t - \widetilde{A}s_{t+1}\right)\right] - \beta^{-1}\lambda_0'\widetilde{A}\left(s_0 - s^\circ\right)\right\}. \tag{120}$$

The first order conditions for λ_t and s_t for $t = 0, 1, ...,$ are:

$$\widetilde{A}s_{t+1} = \widetilde{B}s_t \tag{121}$$

$$\widetilde{B}'\lambda_{t+1} = \beta^{-1}\widetilde{A}'\lambda_t - \Omega s_t. \tag{122}$$

(Note that the introduction of λ_{-1}^d (=0) makes the second of these equations adopt a recursive form. Without it, that equation would have a different form for $t = 0$:

$$\begin{aligned} \widetilde{B}'\lambda_{t+1} &= -\Omega s_t, && \text{if } t = 0 \\ \widetilde{B}'\lambda_{t+1} &= \beta^{-1}\widetilde{A}'\lambda_t - \Omega s_t, && \text{if } t > 0. \end{aligned}$$

I could, equivalently, leave the Lagrangian as in (118) and introduce λ_{-1}^d (=0) at this stage to make these first order conditions recursive.) The fact that, under commitment, the Central Bank behaves differently in the first period (when it optimizes) from all the subsequent periods (when it follows the initial optimization) should be interpreted as the Central Bank exploiting the private sector's expectations only in the initial period. The fact that the Central Bank has an incentive to exploit the private sector's expectations each period (not just the initial one) implies that the commitment policy is time inconsistent (Kydland and Prescott (1977)). Nevertheless, there is no a priori reason for not assuming that the Central Bank may behave in a time inconsistent way. The main reason for using this assumption in this paper, however, is simply that the commitment policy solution is simpler to derive than, say, the time consistent discretionary policy in which the Central Bank optimizes each period.

Stacking (121)-(122) and reintroducing the stochastic shocks, gives:

$$\left[\begin{array}{cc} \widetilde{A} & 0 \\ 0 & \widetilde{B}' \end{array}\right] E_t\left[\begin{array}{c} s_{t+1} \\ \lambda_{t+1} \end{array}\right] = \left[\begin{array}{cc} \widetilde{B} & 0 \\ -\Omega & \beta^{-1}\widetilde{A}' \end{array}\right]\left[\begin{array}{c} s_t \\ \lambda_t \end{array}\right] + \left[\begin{array}{c} \widehat{\varkappa}_{t+1}^* \\ 0 \end{array}\right],$$

and using (117) and the definitions of $\widetilde{A}$ and $\widetilde{B}$ in (112) this becomes:

$$\begin{bmatrix} I & 0 & 0 & 0 & 0 \\ 0 & A^{00} & F^2 & 0 & 0 \\ 0 & 0 & 0 & \widehat{M}' & -\widehat{C}' \\ 0 & 0 & 0 & \widehat{S}' & B^{00\prime} \\ 0 & 0 & 0 & \widehat{I}' & F^{1\prime} \end{bmatrix} \begin{bmatrix} \widetilde{k}_{t+1} \\ E_t\widetilde{d}_{t+1} \\ E_t u_{t+1} \\ E_t\lambda^k_{t+1} \\ \lambda^d_t \end{bmatrix}$$

$$= \begin{bmatrix} \widehat{M} & \widehat{S} & \widehat{I} & 0 & 0 \\ -\widehat{C} & B^{00} & F^1 & 0 & 0 \\ -\Omega_{kk} & -\Omega_{kd} & -\Omega_{ku} & \beta^{-1}I & 0 \\ -\Omega_{dk} & -\Omega_{dd} & -\Omega_{du} & 0 & \beta^{-1}A^{00\prime} \\ -\Omega_{uk} & -\Omega_{ud} & -\Omega_u & 0 & \beta^{-1}F^{2\prime} \end{bmatrix} \begin{bmatrix} \widetilde{k}_t \\ \widetilde{d}_t \\ u_t \\ \lambda^k_t \\ \lambda^d_{t-1} \end{bmatrix} + \begin{bmatrix} \varkappa^*_{t+1} \\ D^{00}\varkappa^d_{t+1} \\ 0 \\ 0 \\ 0 \end{bmatrix}.$$

Under commitment, the Lagrange multipliers that correspond to the non-predetermined variables λ^d_t are predetermined (Currie and Levine (1993), Backus and Driffil (1986)) and their optimal values reflect the policy's history-dependence. In order to apply the generalized Schur decomposition, I change the order of the vectors so that the those with predetermined variables are first. For this I can simply interchange the second and fifth (matrix) columns in the square matrices above, obtaining:

$$\begin{bmatrix} I & 0 & 0 & 0 & 0 \\ 0 & 0 & F^2 & 0 & A^{00} \\ 0 & -\widehat{C}' & 0 & \widehat{M}' & 0 \\ 0 & B^{00\prime} & 0 & \widehat{S}' & 0 \\ 0 & F^{1\prime} & 0 & \widehat{I}' & 0 \end{bmatrix} \begin{bmatrix} \widetilde{k}_{t+1} \\ \lambda^d_t \\ E_t u_{t+1} \\ E_t\lambda^k_{t+1} \\ E_t\widetilde{d}_{t+1} \end{bmatrix}$$

$$= \begin{bmatrix} \widehat{M} & 0 & \widehat{I} & 0 & \widehat{S} \\ -\widehat{C} & 0 & F^1 & 0 & B^{00} \\ -\Omega_{kk} & 0 & -\Omega_{ku} & \beta^{-1}I & -\Omega_{kd} \\ -\Omega_{dk} & \beta^{-1}A^{00\prime} & -\Omega_{du} & 0 & -\Omega_{dd} \\ -\Omega_{uk} & \beta^{-1}F^{2\prime} & -\Omega_u & 0 & -\Omega_{ud} \end{bmatrix} \begin{bmatrix} \widetilde{k}_t \\ \lambda^d_{t-1} \\ u_t \\ \lambda^k_t \\ \widetilde{d}_t \end{bmatrix} + \begin{bmatrix} \varkappa^*_{t+1} \\ D^{00}\varkappa^d_{t+1} \\ 0 \\ 0 \\ 0 \end{bmatrix}.$$

or, with obvious notation for the matrices:

$$A^{opt}W_{t+1} = B^{opt}W_t + \varkappa^{opt}_{t+1}. \tag{123}$$

$$W_t = \begin{bmatrix} \widetilde{k}_t \\ \lambda^d_{t-1} \\ u_t \\ \lambda^k_t \\ \widetilde{d}_t \end{bmatrix} = \begin{bmatrix} \widehat{k}_t \\ \widehat{d}_t \end{bmatrix}, \qquad \varkappa^{opt}_t = \begin{bmatrix} \varkappa^*_t \\ D^{00}\varkappa^d_t \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\widehat{k}_t = \begin{bmatrix} \widetilde{k}_t \\ \lambda^d_{t-1} \end{bmatrix}, \qquad \widehat{d}_t = \begin{bmatrix} u_t \\ \lambda^k_t \\ \widetilde{d}_t \end{bmatrix}.$$

Note that there are initial conditions for the predetermined variables $k_0 = k^\circ$ and $\lambda^d_{-1} = 0$. Applying the QZ decomposition and reintroducing the innovations (where those on the Lagrange multipliers are null -see Backus and Driffill (1986)), gives the following results:

$$\begin{aligned} \widehat{k}_{t+1} &= G^{opt}\widehat{k}_t + \begin{bmatrix} \varkappa^*_{t+1} \\ 0 \end{bmatrix} \\ \widehat{d}_t &= K^{opt}\widehat{k}_t + \begin{bmatrix} 0 \\ 0 \\ D^{00}\varkappa^d_{t+1} \end{bmatrix}, \end{aligned} \tag{124}$$

which can be expanded to:

$$\widetilde{k}_{t+1} = G^{opt}_{kk}\widetilde{k}_t + G^{opt}_{kl}\lambda^d_{t-1} + \varkappa^*_{t+1} \tag{125}$$

$$\lambda^d_t = G^{opt}_{lk}\widetilde{k}_t + G^{opt}_{ll}\lambda^d_{t-1}; \tag{126}$$

$$u_t = K^{opt}_{uk}\widetilde{k}_t + K^{opt}_{ul}\lambda^d_{t-1} \tag{127}$$

$$\lambda^k_t = K^{opt}_{kk}\widetilde{k}_t + K^{opt}_{kl}\lambda^d_{t-1} \tag{128}$$

$$\widetilde{d}_t = K^{opt}_{dk}\widetilde{k}_t + K^{opt}_{dl}\lambda^d_{t-1} + D^0\varkappa^d_{t+1}. \tag{129}$$

(127) gives the optimal policy under commitment in terms of the (endogenous and exogenous) state variables. And (126) gives the law of motion for the predetermined Lagrange multipliers. In $t = 0$, when the Central Bank optimizes and commits, it sets its instruments according to $u_0 = K^{opt}_{uk}\widetilde{k}_0$, since $\lambda^d_{-1} = 0$. In $t = 1$, however, it must stick to its commitment by taking (126) into account for the value of the predetermined multipliers:

$$u_1 = K^{opt}_{uk}\widetilde{k}_1 + K^{opt}_{ul}G^{opt}_{lk}\widetilde{k}_0$$

More generally, using (126) and $\lambda^d_{-1} = 0$, I can eliminate λ^d_{t-1} from (127) and derive the optimal policy at t as an integral feedback from the model predetermined variables and their past history since the time of commitment:

$$u_t = K^{opt}_{uk}\widetilde{k}_t + K^{opt}_{ul}\sum_{j=0}^{t-1}\left(G^{opt}_{ll}\right)^j\left(G^{opt}_{lk}\widetilde{k}_{t-1-j}\right).$$

This formulation emphasizes the history dependence created by the commitment in $t = 0$ to follow (127) forever. The matrices

$$K^{opt}_{uk},\quad K^{opt}_{ul}G^{opt}_{lk},\quad K^{opt}_{ul}G^{opt}_{ll}G^{opt}_{lk},\quad K^{opt}_{ul}\left(G^{opt}_{ll}\right)^2 G^{opt}_{lk}, ... \tag{130}$$

give the responses of the instruments to current predetermined variables, to lagged values of the predetermined variables, to the twice lagged values of the predetermined variables, etc., as new periods of time elapse starting from the commitment date. Also, note that since

$$\widetilde{k}_t = \begin{bmatrix} \widetilde{Z}_t \\ \overline{k}_t \end{bmatrix} = \begin{bmatrix} \widetilde{Z}_t \\ \overline{u}_t \\ \overline{V}_t \\ \overline{Y}_t \end{bmatrix} = \begin{bmatrix} Z_t \\ Z_{t-1} \\ u_{t-1} \\ S^*_V V_{t-1} \\ S^*_Y Y_{t-1} \end{bmatrix},$$

the Central Bank is responding to current and lagged values of the exogenous disturbances, to lagged values of the control variables, and to lagged values of the subset of the rest of the endogenous variables that appear lagged in the model equations.

Using (127) and (129) I can express the model's endogenous variables in terms of the control system (123) predetermined variables:

$$s_t = \begin{bmatrix} \widetilde{k}_t \\ \widetilde{d}_t \\ u_t \end{bmatrix} = \begin{bmatrix} I_{59\times 59} & 0_{59\times 66} \\ K_{dk}^{opt} & K_{dl}^{opt} \\ K_{uk}^{opt} & K_{ul}^{opt} \end{bmatrix} \begin{bmatrix} \widetilde{k}_t \\ \lambda_{t-1}^{d} \end{bmatrix} \equiv \overline{K}\widehat{k}_t,$$

and hence express the period loss function in terms of the latter variables:

$$L_t = \tau_t'\Omega^0\tau_t = s_t'\Omega s_t = \widehat{k}_t'\overline{K}'\Omega\overline{K}\widehat{k}_t \equiv \widehat{k}_t'\Omega^K\widehat{k}_t.$$

Hence, the Central Bank loss (113) is:

$$\mathcal{L}_0 = E_0\sum_{t=0}^{\infty}\beta^t\frac{1}{2}\widehat{k}_t'\Omega^K\widehat{k}_t.$$

Using the law of iterated expectations, I write this loss function recursively:

$$\begin{aligned} \mathcal{L}_t &= E_t\sum_{\tau=t}^{\infty}\beta^\tau\frac{1}{2}\widehat{k}_\tau'\Omega^K\widehat{k}_\tau = \widehat{k}_0'\Omega^K\widehat{k}_0 + \beta E_t\left(E_{t+1}\sum_{\tau=t}^{\infty}\beta^\tau\frac{1}{2}\widehat{k}_{\tau+1}'\Omega^K\widehat{k}_{\tau+1}\right) \quad (131) \\ &= \widehat{k}_0'\Omega^K\widehat{k}_0 + \beta E_t\mathcal{L}_{t+1}. \end{aligned}$$

and (using the usual guess and verify procedure) guess that the loss function has the form

$$\mathcal{L}_t = \widehat{k}_t'V\widehat{k}_t + v, \quad (132)$$

where V and v are a matrix and a vector to be determined. Using (124) and (132) in (131), gives:

$$\begin{aligned} \widehat{k}_t'V\widehat{k}_t + v &= \widehat{k}_t\Omega^K\widehat{k}_t + \beta E_t\left(\widehat{k}_{t+1}'V\widehat{k}_{t+1} + v\right) \\ &= \widehat{k}_t\Omega^K\widehat{k}_t + \beta E_t\left(\left(\widehat{k}_t'G^{opt\prime} + \begin{bmatrix} \varkappa_{t+1}^{*\prime} & 0 \end{bmatrix}\right)V\left(G^{opt}\widehat{k}_t + \begin{bmatrix} \varkappa_{t+1}^{*} \\ 0 \end{bmatrix}\right)\right) + \beta v \\ &= \widehat{k}_t\left(\Omega^K + \beta G^{opt\prime}VG^{opt}\right)\widehat{k}_t + E_t\varkappa_{t+1}^{*\prime}V_{kk}\varkappa_{t+1}^{*} + \beta v, \end{aligned}$$

where I partitioned V conformably to the two components of $\widehat{k}_t$. Hence, the following equalities must be true:

$$\begin{aligned} V &= \Omega^K + \beta G^{opt\prime}VG^{opt}, \quad (133) \\ v &= \frac{\beta}{1-\beta}E_t\varkappa_{t+1}^{*\prime}V_{kk}\varkappa_{t+1}^{*} = \frac{\beta}{1-\beta}trace\left(V_{kk}\Sigma\right), \end{aligned}$$

where Σ is the conditional covariance matrix of the shocks to the exogenous autorregressive processes $\varkappa_{t+1}^{*}$:

$$\Sigma \equiv E_t\varkappa_{t+1}^{*}\varkappa_{t+1}^{*\prime} = \begin{bmatrix} E_t\widetilde{\varkappa}_{t+1}\widetilde{\varkappa}_{t+1}' & 0_{24\times 35} \\ 0_{35\times 24} & 0_{35\times 35} \end{bmatrix} \equiv \begin{bmatrix} \widetilde{\Sigma} & 0 \\ 0 & 0 \end{bmatrix}. \quad (134)$$

Therefore, the Central Bank loss as of period $t = 0$ is:

$$\begin{aligned}
\mathcal{L}_0 &= \widehat{k}_0' V \widehat{k}_0 + \frac{\beta}{1-\beta} trace\left(V_{kk}\Sigma\right) \\
&= \widetilde{k}_0' V_{kk} \widetilde{k}_0 + \frac{\beta}{1-\beta} trace\left(V_{kk}\Sigma\right) \\
&= trace\left(V_{kk}\left(\widetilde{k}_0 \widetilde{k}_0' + \frac{\beta}{1-\beta}\Sigma\right)\right),
\end{aligned}$$

where the second equality uses (119).

Hence, under commitment the Central Bank's expected loss is composed of two terms. The first is related to the initial conditions for the disturbance variables $\widetilde{Z}_0$ and the non-disturbance variables $\overline{k}_0$, and the second is related to the stochastic shocks. In the numerical exercises below I calculate both. First, I assume that the initial conditions are the NSS. Since the variables are in log-deviations from these values, the first loss component is zero, and the loss reduces to the second component:

$$\mathcal{L}_0 = \frac{\beta}{1-\beta} trace\left(V_{zz}\widetilde{\Sigma}\right),$$

where V_{zz} is the upper left block of V_{kk}. This is called Loss0 in the tables below. For the loss when at the time of commitment the economy is not in the NSS (Loss1 in the tables below), I construct a stylized stagflationary scenario where most of the disturbance state variables and all of the non-disturbance variables are either 1% above or 1% below the NSS (Loss1 in the tables below). The exact pattern is the following:

g_t	z_t^C	z_t^H	ϵ_t	z_t^A	ς_t	π_t^{**N}	i_t^{**}	ϕ_t^{**B}	ϕ_t^{**G}	μ_t^{z**}	p_t^{**X}
+	0	0	−	−	0	0	+	+	+	0	−

g_{t-1}	z_{t-1}^C	z_{t-1}^H	ϵ_{t-1}	z_{t-1}^A	ς_{t-1}	π_{t-1}^{**N}	i_{t-1}^{**}	ϕ_{t-1}^{**B}	ϕ_{t-1}^{**G}	μ_{t-1}^{z**}	p_{t-1}^{**X}
+	0	0	−	−	0	0	+	+	+	0	−

i_{t-1}	δ_{t-1}	r_{t-1}^{*CB}	b_{t-1}^{CB}	i_{t-1}^G	b_{t-1}^{*G}	i_{t-1}^B	p_{t-1}^C	μ_{t-1}^z	π_{t-1}^W	π_{t-1}	π_{t-1}^N
+	+	−	−	+	+	−	+	−	+	+	+
z_{t-1}°	e_{t-1}	π_{t-1}^C	$\overline{w}_{t-1}$	p_{t-1}^N	$\pi_{1,t-1}$	$\pi_{2,t-1}$	$\pi_{1,t-1}^C$	$\pi_{2,t-1}^C$	$\delta_{1,t-1}$	$\delta_{2,t-1}$	$\mu_{1,t-1}^z$
+	−	+	−	+	+	+	+	+	+	+	−
$\mu_{2,t-1}^z$	$e_{1,t-1}$	$e_{2,t-1}$	$e_{3,t-1}$	$p_{0,t-1}^{**X}$	$p_{1,t-1}^{**X}$	$p_{2,t-1}^{**X}$	$p_{3,t-1}^{**X}$	c_{t-1}	b_{t-1}^{*B}	i_{t-1}^L	
−	−	−	−	−	−	−	−		−	−	−

In the FER and PER regimes, of course, r_{t-1}^{*CB} and b_{t-1}^{CB} respectively, disappear.

The matrix V is obtained simply iterating on the Lyapunov equation (133) starting with $V = I$ on the r.h.s. Convergence is guaranteed by the fact that matrix G^{opt} has all its eigenvalues inside the unit disk.

In the next subsection optimal policy rules and CB losses are also calculated for two 'extreme' cases of ARGEMmy: those that correspond to a floating exchange

rate (FER) regime and to a pegged exchange rate (PER) regime (see section 2.7 above). These are particular cases of ARGEMmy. In the first, the vector u_t reduces to $\widehat{i}_t$ (and, since there is no CB intervention in the FX market, r_t^{*CB} is transformed into a parameter that is kept at the same steady state value as in the general model). In the second the vector u_t reduces to $\widehat{\delta}_t$ (and, since there is no CB intervention in the money market, b_t^{CB} is transformed into a parameter that is kept at the same steady state value as in the general model). Since there is a change in the ordering of the target variables (according to what subvectors they belong to), care must be taken to make the corresponding changes in matrices Ω^0 and T.

7.3. Numerical results on optimal policy rules and losses

For the numerical exercises in this section I used the parameter values estimated in section 6, except for the case of the Government foreign debt interest elasticity which I increased to $\varepsilon^G = 1$ (from 0.8334) in order to amplify the neighborhood around the parameters that are modified in the exercises (including the weights in the loss function) that satisfy the Blanchard-Kahn conditions for the MER regime. This has the sole effect of changing the values of the parameters α_1^G and α_2^G.

Tables 3 below show the two measures of losses corresponding to the optimal controls for the MER (interest rate and rate of nominal depreciation), FER (interest rate), and PER regimes (rate of nominal depreciation), for various sets of weights ω_j in the CB's loss function (or CB styles for brevity). For each CB style, the loss that is lowest is in bold and the second lowest loss is in italics. Tables 3.A and 3B show CB styles in which the CB is neutral between the three gaps ($\omega_\pi = \omega_y = \omega_{tb} = 1$) and styles in which it is more averse ($\omega_j = 2$) to one of the gaps. In each of these cases the CB may or may not have an aversion to changing the interest rate or the rate of nominal depreciation. Table 3.C considers CB styles in which the CB is much more averse ($\omega_j = 5$) to one of the three gaps. Table 3.D adresses the special cases of styles in which the CB has a preference for not changing the MRER or for maintaining i or δ away from their NSS values. Table 3.E takes CB style D (in which the CB has some aversion to changing both the interest rate and the rate of nominal depreciation) and considers changes in some of the model parameters: the coefficients for nominal rigidity ($\alpha_W, \alpha_D, \alpha_N$), the interest elasticities of the bank risk premium (ε_B) and cash demand (ε_M), and the elasticities of substitution between imported goods (θ^N) and between labor types (ψ).

It is noteworthy that in all the cases shown (indeed, in all the cases I computed and are not shown), the MER achieves a substantially lower loss for both measures of loss. This includes cases in which the CB has no misgivings about changing its instrument(s) and cases in which it does, cases in which the CB is more (and substantially more) averse to a particular gap, cases in which there is lower nominal rigidity for wages, domestic goods prices and/or imported goods prices, and cases in which there are lower elasticities of substitution for imported goods or labor types. Which regime has the second lowest loss depends on its style and the type of loss. The PER regime almost always achieves the second lowest Loss0. However, in general the FER regime dominates the PER regime in the case of Loss1 (i.e., total loss). One must bear in mind that Loss1 is heavily dependent on the stagflationary initial situation assumed for this exercise. A different initial

condition could reverse the ordering. Of course, it is possible that a CB style and especially an initial situation can be constructed in which the MER does not dominate. But the styles and initial scenario considered here were not constructed with the intention of favoring the MER regime.

TABLE 3.A

Losses for alternative CB styles and policy regimes

Weights on loss function for different Central Bank styles

	BASELINE				INFLATION AWARE			
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
$\omega_{\Delta i}$	0	0.5	0	0.5	0	0.5	0	0.5
$\omega_{\Delta \delta}$	0	0	0.5	0.5	0	0	0.5	0.5
$\omega_{\Delta e}$	0	0	0	0	0	0	0	0
ω_y	1	1	1	1	1	1	1	1
ω_e	0	0	0	0	0	0	0	0
ω_{tb}	1	1	1	1	1	1	1	1
ω_π	1	1	1	1	2	2	2	2
ω_i	0	0	0	0	0	0	0	0
ω_δ	0	0	0	0	0	0	0	0
Loss0 (thousands)								
MER (2 policy rules)								
	10.37	**80.71**	**48.35**	**74.45**	**12.61**	**85.16**	**50.54**	**76.53**
FER (Float)								
	5122.2	5122.3	5129.4	5129.5	5160.0	5160.1	5163.9	5164.0
PER (Peg)								
	5017.2	*5017.3*	*5020.7*	*5020.8*	*5030.9*	*5031.0*	*5034.3*	*5034.5*
Loss1 (thousands)								
MER (2 policy rules)								
	220.37	**2261.1**	**1596.3**	**2217.0**	**271.41**	**2377.4**	**1667.8**	**2281.7**
FER (Float)								
	51032	*51032*	*51116*	*51116*	*51455*	*51455*	*51606*	*51606*
PER (Peg)								
	100510	100510	100680	100680	100810	100810	101070	101070

It is somewhat surprising that the total absence of nominal rigidity or the reduction in nominal rigidity for two of the three Phillips equations (cases $D1$-$D4$) substantially increases the losses for the MER regime.[12] In contrast, the elimination or reduction of nominal rigidity increases Loss0 and diminishes Loss1 for the FER regime and (almost always) diminishes both losses for the PER regime.

A reduction in the interest elasticity of banks' risk premium function (case $D5$) reduces both losses for all three regimes, and a reduction in the interest elasticity of households' cash demand function (case $D6$) slightly increases both losses for the MER and PER regimes while it slightly diminishes both losses for the FER regime. An increase in the elasticity of substitution for imported goods (case $D7$) reduces

[12] Although I was able to reduce all three parameters to zero, reducing only two of them led to problems with the Blanchard-Kahn coditions in the MER regime, so I avoided reductions to zero in the case of partial reductions.

Loss0 and very substantially reduces Loss1for all three regimes. Finally, an increase in the elasticity of substitution for labor types (case $D8$) reduces both losses for the MER regime and slightly increases them for the FER and PER regimes.

TABLE 3.B

Losses for alternative CB styles and policy regimes

Weights on loss function for different Central Bank styles

	OUTPUT AWARE				TRADE BALANCE AWARE			
	I	*J*	*K*	*L*	*M*	*N*	*O*	*P*
$\omega_{\Delta i}$	0	0.5	0	0.5	0	0.5	0	0.5
$\omega_{\Delta\delta}$	0	0	0.5	0.5	0	0	0.5	0.5
$\omega_{\Delta e}$	0	0	0	0	0	0	0	0
ω_y	2	2	2	2	1	1	1	1
ω_e	0	0	0	0	0	0	0	0
ω_{tb}	1	1	1	1	2	2	2	2
ω_π	1	1	1	1	1	1	1	1
ω_i	0	0	0	0	0	0	0	0
ω_δ	0	0	0	0	0	0	0	0
Loss0 (thousands)								
MER (2 policy rules)								
	27.35	**85.36**	**49.24**	**76.19**	**10.38**	**62.81**	**48.18**	**65.09**
FER (Float)								
	5123.7	5123.8	5130.7	5130.9	10104	10104	10130	10130
PER (Peg)								
	5017.8	*5017.9*	*5021.2*	*5021.4*	*9981.1*	*9981.3*	*9988.5*	*9988.6*
Loss1 (thousands)								
MER (2 policy rules)								
	579.42	**2364.0**	**1616.8**	**2258.2**	**220.42**	**1834.0**	**1591.9**	**1955.2**
FER (Float)								
	51048	*51048*	*51133*	*51133*	*100460*	*100460*	*100540*	*100540*
PER (Peg)								
	100520	100520	100690	100690	199800	199800	199900	199900

Tables 4, 5 and 6 show the matrices K_{uk}^{opt} and K_{ul}^{opt} corresponding to the initial period after optimization and various CB styles (cases A-P). Each one of these tables considers a specific policy regime. For each regime, it was verified that any proportional change in the weights has no effect on the coefficients in K_{uk}^{opt} and compensating proportional changes in the coefficients in K_{ul}^{opt}. Note that although λ_{t-1}^{d} is of dimension 66 (in all three regimes), only the last 12 elements of this vector (corresponding to the equations with expectational terms) are nonzero (and hence are the only ones reported). Each column corresponds to the CB style that appear in the upper part of the column and are defined as in Tables 3. The first column(s) represents a baseline case in which the weights ω_y , ω_{tb} , ω_π are unity and the rest are zero.

TABLE 3.C

Losses for alternative CB styles and policy regimes

Weights on loss function for different Central Bank styles

	More extreme preferences						
	D	*Q*	*R*	*S*	*T*	*U*	*V*
$\omega_{\Delta i}$	0.5	0.5	0.5	0.5	0.5	0.5	0.5
$\omega_{\Delta \delta}$	0.5	0.5	0.5	0.5	0.5	0.5	0.5
$\omega_{\Delta e}$	0	0	0	0	0	0	0
ω_y	1	1	5	1	1	10	1
ω_e	0	0	0	0	0	0	0
ω_{tb}	1	1	1	5	1	1	10
ω_π	1	5	1	1	10	1	1
ω_i	0	0	0	0	0	0	0
ω_δ	0	0	0	0	0	0	0
Loss0 (thousands)							
MER (2 policy rules)							
	74.45	**82.79**	**80.86**	**57.48**	**92.42**	**87.35**	**54.37**
FER (Float)							
	5129.5	5200.9	5134.6	*24672*	5236.2	5140.4	*47913*
PER (Peg)							
	5020.8	*5055.8*	*5023.0*	24767	*5083.6*	*5025.4*	49124
Loss1 (thousands)							
MER (2 policy rules)							
	2217.0	**2469.4**	**2366.6**	**1729.9**	**2757.1**	**2512.7**	**1633.5**
FER (Float)							
	51116	*52049*	*51184*	*243370*	*52382*	*51260*	*469900*
PER (Peg)							
	100680	101520	100730	494270	101980	100790	977950

Note that when there is no preference for instrument inertia some of the coefficients can be quite high. However, these coefficients become much smaller when there is a preference for instrument inertia. In the MER regime $\omega_{\Delta i} = 0.5$ is sufficient to generate an autorregressive coefficient for the interest rate of 0.5 and $\omega_{\Delta\delta} = 0.5$ is sufficient to generate an autorregressive coefficient for the rate of nominal depreciation of 0.3. In the FER and PER regimes, however, a much higher $\omega_{\Delta i}$ or $\omega_{\Delta\delta}$ is required to achieve such levels of autorregressiveness. For example, in the FER regime $\omega_{\Delta i} = 1000$ generates an AR coefficient of only 0.1 for the interest rate, and in the PER regime $\omega_{\Delta\delta} = 20$ generates an AR coefficient of 0.35 for the rate of nominal depreciation.[13] This implies that the MER regime is more naturally inclined to generate inertia in the use of the controls (as long as there is some aversion to changing them) than the 'corner' regimes. Also, when in the MER regime there is some aversion to changing both controls, while the autorregressive coefficient for the interest rate is in the 0.35-0.4 range, the one corresponding to the rate of nominal depreciation becomes highly negative (around -2.5).

[13] These results do not appear in the tables because these were constructed so as to be able to compare regimes and such high omegas generate instability in the MER regime.

TABLE 3.D

Losses for alternative CB styles and policy regimes

Weights on loss function for different Central Bank styles

Resistence to change in e and non-NSS values for i and δ

	D	W	X	Y	Z	YY	ZZ
$\omega_{\Delta i}$	0.5	0.5	0.5	0.5	0.5	0.5	0.5
$\omega_{\Delta \delta}$	0.5	0.5	0.5	0.5	0.5	0.5	0.5
$\omega_{\Delta e}$	0	1	5	0	0	0	0
ω_y	1	1	1	1	1	1	1
ω_e	0	0	0	0	0	0	0
ω_{tb}	1	1	1	1	1	1	1
ω_π	1	1	1	1	1	1	1
ω_i	0	0	0	1	5	0	0
ω_δ	0	0	0	0	0	1	5
Loss0 (thousands)							
MER (2 policy rules)							
	74.45	**87.92**	**96.31**	**125.70**	**176.59**	**81.69**	**88.43**
FER (Float)							
	5129.5	5140.9	5171.3	5130.3	5133.5	5136.0	5153.5
PER (Peg)							
	5020.8	*5026.3*	*5043.6*	*5021.7*	*5025.1*	*5023.6*	*5031.9*
Loss1 (thousands)							
MER (2 policy rules)							
	2217.0	**2576.4**	**2811.4**	**3397.3**	**4369.0**	**2418.6**	**2606.7**
FER (Float)							
	51116	*51212*	*51531*	*51119*	*51132*	*51204*	*51480*
PER (Peg)							
	100680	100800	101210	100690	100710	100790	101110

8. Conclusion

This paper constructs an intermediate DSGE model with a banking system and a Central Bank that uses two policy rules, calibrates/estimates it for the Argentinian economy using Dynare, and uses it to analyze optimal policies under commitment. The model is a simplification of the larger DSGE model ARGEM (see Escudé (20007)). However, ARGEMmy (as I call the simpler model) has most of the fundamental structure of ARGEM, including 1) banks that are at the center of the financial aspects of the model and generate the model's uncovered interest parity equation, 2) endogenous risk premiums for banks and the government when being financed abroad, 3) a full-fledged fiscal sector (with a minimal tax structure), 4) growth introduced through a permanent productivity shock that is cointegrated with its equivalent for the rest of the world, 5) the ability to model a policy regime which uses two simultaneous policy rules which may or may not involve feedback: one for the interest rate and another for the rate of nominal depreciation. Results from a preliminary estimation of a subset of the model's parameters are shown and then used for the analysis of optimal monetary and exchange rate policies. The log-linear model is put in a matrix form suitable for a linear-quadratic optimal control framework under the assumption of commitment and full information. The optimal policy rules and related CB loss are derived for the 'managed exchange

rate' (MER) regime and for two 'corner' regimes: a 'floating exchange rate' (FER) regime and a 'pegged exchange rate' (PER) regime. Sensitivities of the CB loss are studied for various CB styles (preferences) and other model parameters that measure nominal rigidities, elasticities of substitution, and interest elasticities for the bank risk premium and for cash demand. For all the cases computed, the MER regime achieves a substantially lower CB loss than either of the the two 'corner' regimes.

TABLE 3.E

Losses for alternative parameter values in CB style D

	D	$D1$	$D2$	$D3$	$D4$	$D5$	$D6$	$D7$	$D8$
α_W	0.5808	0	0.5808	0.1	0.1	0.5808	0.5808	0.5808	0.5808
α_D	0.6133	0	0.2	0.6133	0.2	0.6133	0.6133	0.6133	0.6133
α_N	0.5889	0	0.1	0.1	0.5889	0.5889	0.5889	0.5889	0.5889
ε_B	1.1575	1.1575	1.1575	1.1575	1.1575	0.9	1.1575	1.1575	1.1575
ε_M	0.85	0.85	0.85	0.85	0.85	0.85	0.7	0.85	0.85
θ^N	1.1754	1.1754	1.1754	1.1754	1.1754	1.1754	1.1754	1.3	1.1754
ψ	7.3116	7.3116	7.3116	7.3116	7.3116	7.3116	7.3116	7.3116	9.0
Loss0 (thousands)									
MER (2 policy rules)									
	74.45	**188.01**	**179.47**	**187.14**	**178.29**	**53.06**	**74.46**	**61.89**	**72.28**
FER (Float)									
	5129.5	5160.5	5176.0	5132.8	5046.2	4944.0	5126.4	4984.8	5134.5
PER (Peg)									
	5020.8	*5009.2*	*5025.3*	*5000.8*	*4978.0*	*4830.9*	*50232*	*4925.2*	*5023.8*
Loss1 (thousands)									
MER (2 policy rules)									
	2217.0	**4242.5**	**4241.4**	**4316.6**	**4262.0**	**1747.1**	**2217.4**	**1062.7**	**2162.9**
FER (Float)									
	51116	*50720*	*51000*	*50595*	*4967.1*	*49206*	*51085*	*25813*	*51164*
PER (Peg)									
	100680	99622	100110	99683	98991	96721	100690	48028	100750

Optimal Policy Rules for a MER regime

TABLE 4.1A

Optimal Policy Rules

	A		B		C		D	
Coefficients on non-disturbance state variables					$\overline{u}_t$, $\overline{V}_t$, $\overline{Y}_t$			
$\hat{i}_{t-1}$	-0.0036	0.0014	0.5098	-0.176	-0.0001	0	0.4089	-0.0227
$\hat{\delta}^{M}_{t-1}$	-0.9441	-6.6518	-1.3004	-5.2117	-12.9423	0.3364	-3.0817	-2.0873
$\hat{r}^{*CB}_{t-1}$	2.4517	-0.9557	0.0298	-0.0452	0.0454	-0.0265	0.0156	-0.0156
$\hat{b}^{CB}_{t-1}$	-0.0001	0	0	0	0	0	0	0
$\hat{i}^{G}_{t-1}$	-3.7949	1.4793	-0.0461	0.0699	-0.0703	0.0409	-0.0242	0.0242
$\hat{b}^{*G}_{t-1}$	-3.7949	1.4793	-0.0461	0.0699	-0.0703	0.0409	-0.0242	0.0242
$\hat{i}^{B}_{t-1}$	-1.2474	0.4863	-0.0152	0.023	-0.0231	0.0135	-0.008	0.008
$\hat{p}^{C}_{t-1}$	12.4366	0.0607	0.2919	0.5539	1.4784	0.4337	0.3851	0.2901
$\hat{\mu}^{z}_{t-1}$	2.1446	8.1183	2.8784	3.4041	14.6635	0.4619	4.2279	1.0882
$\hat{\pi}^{W}_{t-1}$	-4.3468	2.0206	-0.0371	-0.0342	-0.4836	-0.0965	-0.0358	-0.0414
$\hat{\pi}^{D}_{t-1}$	-7.6711	8.8121	1.637	5.6468	13.8732	-0.1634	3.6589	2.3532
$\hat{\pi}^{N}_{t-1}$	-0.198	-2.5135	-0.9701	-0.8396	-2.9287	-0.1189	-1.3971	-0.1497
$\hat{z}^{\circ}_{t-1}$	1.8452	-0.6645	0.0709	-0.0245	0.1388	0.0003	0.0672	-0.0098
$\hat{e}_{t-1}$	1.14	5.6754	0.905	4.9854	12.7265	-0.2909	2.6363	2.1521
$\hat{\pi}^{C}_{t-1}$	-12.0442	-0.3051	-0.1793	-0.3616	-1.0477	-0.3103	-0.2409	-0.185
$\widehat{w}_{t-1}$	-3.6239	2.7997	0.8557	0.214	3.3303	-0.109	1.2473	-0.2006
$\hat{p}^{N}_{t-1}$	-1.2539	-4.6715	-2.5495	-0.443	-11.2417	0.0954	-3.6866	0.688
$\hat{\pi}^{D}_{1,t-1}$	-6.2423	6.6717	2.9209	1.4474	3.4686	-0.1414	4.4591	-0.4571
$\hat{\pi}^{D}_{2,t-1}$	4.2137	8.9129	6.3053	-1.0723	33.7782	-0.3367	8.8148	-2.7738
$\hat{\pi}^{C}_{1,t-1}$	-13.4383	-0.5235	-0.0778	-0.188	-0.5604	-0.1686	-0.1121	-0.0927
$\hat{\pi}^{C}_{2,t-1}$	-2.9559	-0.3741	-0.0135	-0.0602	-0.1383	-0.0506	-0.0261	-0.0279
$\hat{\delta}^{M}_{1,t-1}$	6.2622	-6.5582	-2.9256	-1.4402	-3.4664	0.1476	-4.463	0.4609
$\hat{\delta}^{M}_{2,t-1}$	-4.264	-8.8629	-6.3122	1.0769	-33.8074	0.3396	-8.8229	2.7777
$\hat{\mu}^{z}_{1,t-1}$	-6.2423	6.6717	2.9209	1.4474	3.4686	-0.1414	4.4591	-0.4571
$\hat{\mu}^{z}_{2,t-1}$	4.2137	8.9129	6.3053	-1.0723	33.7782	-0.3367	8.8148	-2.7738
$\hat{e}_{1,t-1}$	-7.6235	-0.1394	1.7515	-4.0684	-10.3742	-0.1649	1.5123	-2.9453
$\hat{e}_{2,t-1}$	11.2782	2.4174	3.6505	-2.7177	32.6929	-0.2107	4.6981	-2.4989
$\hat{e}_{3,t-1}$	-4.545	-9.6137	-6.8011	1.1566	-36.4343	0.3632	-9.5079	2.9919
$\hat{p}^{**X}_{0,t-1}$	1.8616	0.3696	-5.4797	10.7555	-0.4463	-0.1255	-3.5815	6.6866
$\hat{p}^{**X}_{1,t-1}$	-7.6235	-0.1394	1.7515	-4.0684	-10.3742	-0.1649	1.5123	-2.9453
$\hat{p}^{**X}_{2,t-1}$	11.2782	2.4174	3.6505	-2.7177	32.6929	-0.2107	4.6981	-2.4989
$\hat{p}^{**X}_{3,t-1}$	-4.545	-9.6137	-6.8011	1.1566	-36.4343	0.3632	-9.5079	2.9919
$\hat{c}_{t-1}$	1.2171	2.8893	2.8506	0.4119	11.9742	-0.1662	4.0169	-0.7222
$\hat{b}^{*B}_{t-1}$	-1.2474	0.4863	-0.0152	0.023	-0.0231	0.0135	-0.008	0.008
$\hat{i}^{L}_{t-1}$	-0.6854	0.1622	0.0274	0.0345	0.0635	-0.0141	0.0486	0.0064

TABLE 4.1B

Optimal Policy Rules

	A		B		C		D	
Coefficients on disturbance variables $\widetilde{Z}_t$								
$\widehat{g}_t$	0.5257	-0.3924	0.1389	-0.0236	0.5322	-0.0359	0.1821	-0.0514
$\widehat{z}_t^C$	0.5071	-0.0832	0.2696	0.1965	0.668	0.0253	0.3563	0.0558
$\widehat{z}_t^H$	-0.4184	0.1522	-0.0448	-0.0348	-0.1664	-0.0101	-0.0624	-0.0095
$\widehat{\epsilon}_t$	4.2584	-3.6613	-1.2389	-0.1797	-5.2913	0.1519	-1.8115	0.3739
$\widehat{z}_t^A$	-2.1807	-8.4078	-5.4995	0.399	-27.3989	0.2829	-7.7851	2.1664
$\widehat{\varsigma}_t$	-0.0358	0.0088	-0.0004	0	-0.0044	-0.0011	-0.0003	-0.0001
$\widehat{\pi}_t^{**N}$	3.3759	1.5295	3.6661	-3.2152	5.4002	0.0126	3.388	-2.5576
$\widehat{i}_t^{**}$	-16.5854	6.465	-0.2015	0.3055	-0.3071	0.179	-0.1057	0.1059
$\widehat{\phi}_t^{**B}$	-1.1346	0.4423	-0.0138	0.0209	-0.021	0.0122	-0.0072	0.0072
$\widehat{\phi}_t^{**G}$	-5.1775	2.0182	-0.0629	0.0954	-0.0959	0.0559	-0.033	0.033
$\widehat{\mu}_t^{z**}$	3.8109	-1.4816	0.07	-0.0282	0.1298	-0.029	0.0609	0.0031
$\widehat{p}_t^{**X}$	0.5184	-0.2805	3.783	-6.7956	0.0725	-0.0115	2.1391	-4.0192
$\widehat{i}_{t-1}^{**}$	8.8831	-3.4626	0.1079	-0.1636	0.1645	-0.0959	0.0566	-0.0567
$\widehat{\mu}_{t-1}^{z**}$	0.5604	0.9251	0.81	-0.24	1.6612	0.306	0.8257	-0.2435
Coefficients on LMs corresponding to equations with expectational terms								
λ_{t-1}^c	-0.7868	0.9884	-0.0211	0.0633	0.0155	0.0436	-0.0038	0.0248
$\lambda_{t-1}^{\lambda^0}$	98.9923	-40.4211	1.1717	-2.052	1.5667	-1.2282	0.5509	-0.7437
$\lambda_{t-1}^{b^{*B}}$	22.697	-20.588	0.4225	-1.2083	-0.352	-0.8137	0.0546	-0.4397
$\lambda_{t-1}^{i^L}$	-0.0193	0.0142	-0.0003	0.0008	-0.0001	0.0005	-0.0001	0.0003
λ_{t-1}^t	27.2273	-11.2455	0.3096	-0.5963	0.3804	-0.3595	0.1328	-0.2217
λ_{t-1}^r	-3.3148	-0.0323	-0.0207	-0.0392	-0.1331	-0.0364	-0.0273	-0.02
$\lambda_{t-1}^{\Gamma^W}$	5.9737	-5.8089	0.2098	-0.2147	0.293	-0.1397	0.1349	-0.0615
$\lambda_{t-1}^{\Psi^W}$	-1.7399	9.5285	-0.0638	0.8599	0.7985	0.6125	0.1446	0.3727
$\lambda_{t-1}^{\Gamma^D}$	10.9352	-11.6702	0.2884	-0.6743	0.013	-0.4579	0.0968	-0.2542
$\lambda_{t-1}^{\Psi^D}$	16.1871	-11.6189	0.3211	-0.6122	0.2239	-0.4003	0.14	-0.2226
$\lambda_{t-1}^{\Gamma^N}$	9.6918	-11.1071	0.2697	-0.6496	-0.0118	-0.4424	0.0861	-0.2463
$\lambda_{t-1}^{\Psi^N}$	10.6502	-7.4211	0.2232	-0.3698	0.2352	-0.2383	0.1136	-0.1332

TABLE 4.2A

Optimal Policy Rules

Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$	E		F		G		H	
$\hat{i}_{t-1}$	-0.0043	0.002	0.4933	-0.1928	-0.0001	-0.0001	0.3862	-0.0376
$\hat{\delta}^{M}_{t-1}$	-0.3332	-6.6724	-1.2896	-5.2368	12.5202	0.3299	-3.1447	-2.1791
$\hat{r}^{*CB}_{t-1}$	2.9054	-1.3263	0.0597	-0.0853	0.0846	-0.0535	0.0306	-0.0311
$\hat{b}^{CB}_{t-1}$	-0.0001	0	0	0	0	0	0	0
$\hat{i}^{G}_{t-1}$	-4.4973	2.0529	-0.0924	0.1321	-0.131	0.0828	-0.0473	0.0482
$\hat{b}^{*G}_{t-1}$	-4.4973	2.0529	-0.0924	0.1321	-0.131	0.0828	-0.0473	0.0482
$\hat{i}^{B}_{t-1}$	-1.4783	0.6748	-0.0304	0.0434	-0.0431	0.0272	-0.0156	0.0158
$\hat{p}^{C}_{t-1}$	12.7723	0.7612	0.4029	0.7814	2.0425	0.5919	0.5519	0.4166
$\hat{\mu}^{z}_{t-1}$	2.1321	7.6201	2.9593	3.6309	14.3973	0.4875	4.4127	1.2707
$\hat{\pi}^{W}_{t-1}$	-3.7203	1.5662	-0.1168	-0.1358	-0.6628	-0.1365	-0.134	-0.1021
$\hat{\pi}^{D}_{t-1}$	-8.2601	8.2726	1.5473	5.5637	12.888	-0.2917	3.6178	2.3847
$\hat{\pi}^{N}_{t-1}$	-0.1495	-2.5289	-1.0066	-0.9621	-2.8609	-0.1384	-1.4786	-0.2333
$\hat{z}^{\circ}_{t-1}$	2.1804	-0.9365	0.0946	-0.0499	0.1682	-0.019	0.0816	-0.0183
$\hat{e}_{t-1}$	0.4948	5.7038	0.8782	4.9562	12.1869	-0.3308	2.6448	2.194
$\hat{\pi}^{C}_{t-1}$	-12.6724	-0.971	-0.2537	-0.5313	-1.5162	-0.448	-0.3567	-0.2763
$\widehat{w}_{t-1}$	-3.4414	2.4739	0.8191	0.2217	2.9778	-0.1695	1.2232	-0.1921
$\hat{p}^{N}_{t-1}$	-0.9529	-4.7092	-2.6414	-0.7471	-10.774	0.1351	-3.8602	0.5085
$\hat{\pi}^{D}_{1,t-1}$	-6.1496	6.6541	3.0464	1.8617	2.8012	-0.2081	4.7152	-0.1868
$\hat{\pi}^{D}_{2,t-1}$	2.9363	8.9776	6.5149	-0.3822	32.4802	-0.4962	9.1833	-2.3974
$\hat{\pi}^{C}_{1,t-1}$	-15.6954	-1.0888	-0.1089	-0.2886	-0.8491	-0.2565	-0.1693	-0.144
$\hat{\pi}^{C}_{2,t-1}$	-3.4435	-0.6163	-0.0147	-0.0964	-0.2068	-0.0803	-0.0381	-0.045
$\hat{\delta}^{M}_{1,t-1}$	6.1612	-6.5729	-3.0516	-1.8558	-2.8004	0.2137	-4.7196	0.19
$\hat{\delta}^{M}_{2,t-1}$	-2.9677	-8.9439	-6.5221	0.3858	-32.5088	0.499	-9.1919	2.4009
$\hat{\mu}^{z}_{1,t-1}$	-6.1496	6.6541	3.0464	1.8617	2.8012	-0.2081	4.7152	-0.1868
$\hat{\mu}^{z}_{2,t-1}$	2.9363	8.9776	6.5149	-0.3822	32.4802	-0.4962	9.1833	-2.3974
$\hat{e}_{1,t-1}$	-6.9031	-0.1354	1.8993	-3.6469	10.5611	-0.2171	1.7374	-2.7386
$\hat{e}_{2,t-1}$	9.8003	2.5062	3.7412	-2.4203	32.0127	-0.3108	4.8195	-2.3844
$\hat{e}_{3,t-1}$	-3.1671	-9.6835	-7.0272	0.4122	-35.0342	0.5353	-9.9054	2.5859
$\hat{p}^{**X}_{0,t-1}$	1.8033	0.4316	-5.703	9.9934	-0.523	-0.1326	-3.884	6.401
$\hat{p}^{**X}_{1,t-1}$	-6.9031	-0.1354	1.8993	-3.6469	-10.5611	-0.2171	1.7374	-2.7386
$\hat{p}^{**X}_{2,t-1}$	9.8003	2.5062	3.7412	-2.4203	32.0127	-0.3108	4.8195	-2.3844
$\hat{p}^{**X}_{3,t-1}$	-3.1671	-9.6835	-7.0272	0.4122	-35.0342	0.5353	-9.9054	2.5859
$\hat{c}_{t-1}$	0.1939	3.5636	2.9445	0.7442	11.4768	-0.1994	4.2008	-0.527
$\hat{b}^{*B}_{t-1}$	-1.4783	0.6748	-0.0304	0.0434	-0.0431	0.0272	-0.0156	0.0158
$\hat{i}^{L}_{t-1}$	-0.6865	0.1204	0.0211	0.0259	0.0239	-0.023	0.0414	0.0026

TABLE 4.2B

Optimal Policy Rules

	E		F		G		H	
Coefficients on disturbance variables $\tilde{Z}_t$								
$\hat{g}_t$	0.3725	-0.2463	0.1468	-0.0051	0.5211	-0.0355	0.1936	-0.0413
$\hat{z}_t^C$	0.1229	0.1633	0.2774	0.2331	0.6574	0.0356	0.3772	0.0793
$\hat{z}_t^H$	-0.3345	0.1019	-0.0532	-0.0476	-0.1749	-0.0128	-0.0739	-0.0178
$\hat{\epsilon}_t$	4.0717	-3.2591	-1.2115	-0.2259	-4.8188	0.2311	-1.8059	0.3436
$\hat{z}_t^A$	-1.1812	-8.453	-5.6849	-0.215	-26.2535	0.4188	-8.1202	1.8213
$\hat{\varsigma}_t$	-0.0333	0.006	-0.001	-0.0009	-0.0063	-0.0016	-0.001	-0.0006
$\hat{\pi}_t^{**N}$	4.4104	0.4533	3.815	-2.9294	5.4199	-0.0233	3.5895	-2.4096
$\hat{i}_t^{**}$	-19.6552	8.9721	-0.4037	0.5772	-0.5724	0.3619	-0.2068	0.2107
$\hat{\phi}_t^{**B}$	-1.3446	0.6138	-0.0276	0.0395	-0.0392	0.0248	-0.0141	0.0144
$\hat{\phi}_t^{**G}$	-6.1357	2.8008	-0.126	0.1802	-0.1787	0.113	-0.0646	0.0658
$\hat{\mu}_t^{z**}$	4.474	-2.0264	0.1157	-0.0891	0.1848	-0.0707	0.0841	-0.02
$\hat{p}_t^{**X}$	0.349	-0.3041	3.9151	-6.3354	0.2656	0.0251	2.2956	-3.8666
$\hat{i}_{t-1}^{**}$	10.5273	-4.8054	0.2162	-0.3091	0.3066	-0.1939	0.1108	-0.1128
$\hat{\mu}_{t-1}^{z**}$	0.962	0.6689	0.8518	-0.1599	1.7306	0.3206	0.897	-0.1899
Coefficients on LMs corresponding to equations with expectational terms								
λ_{t-1}^{c}	-0.4803	0.709	-0.0236	0.0567	0.0044	0.0399	-0.0063	0.0227
$\lambda_{t-1}^{\lambda^0}$	59.1055	-28.2628	1.2123	-1.9051	1.559	-1.2084	0.578	-0.7152
$\lambda_{t-1}^{b^{*B}}$	13.5413	-14.694	0.4629	-1.0989	-0.1869	-0.7571	0.0904	-0.4096
$\lambda_{t-1}^{i^L}$	-0.0116	0.0101	-0.0004	0.0007	-0.0002	0.0005	-0.0001	0.0003
λ_{t-1}^{t}	16.2804	-7.8683	0.327	-0.5458	0.3979	-0.347	0.1476	-0.2082
λ_{t-1}^{r}	-1.9389	-0.0637	-0.0153	-0.0293	-0.1014	-0.027	-0.0208	-0.0152
$\lambda_{t-1}^{\Gamma^W}$	3.3122	-4.0884	0.1964	-0.2266	0.2287	-0.1575	0.115	-0.0753
$\lambda_{t-1}^{\Psi^W}$	-1.5727	6.9819	-0.1334	0.7172	0.4872	0.5139	0.0659	0.3118
$\lambda_{t-1}^{\Gamma^D}$	6.5113	-8.3261	0.3065	-0.6188	0.0828	-0.4324	0.1116	-0.2408
$\lambda_{t-1}^{\Psi^D}$	9.5833	-8.2251	0.3307	-0.5724	0.2435	-0.3896	0.1446	-0.2168
$\lambda_{t-1}^{\Gamma^N}$	5.7698	-7.9316	0.2884	-0.5942	0.0607	-0.4162	0.102	-0.2322
$\lambda_{t-1}^{\Psi^N}$	6.2527	-5.2372	0.226	-0.3502	0.2276	-0.2373	0.1126	-0.1323

TABLE 4.3A

Optimal Policy Rules

Coefficients on non-disturbance state variables	I		J		K $\overline{u}_t, \overline{V}_t, \overline{Y}_t$		L	
$\hat{i}_{t-1}$	-0.0029	0.0009	0.5084	-0.1719	-0.0001	0	0.4079	-0.0242
$\hat{\delta}^{M}_{t-1}$	-1.7817	-6.6112	-1.2965	-5.2415	-13.1588	0.134	-3.0978	-2.1578
$\hat{r}^{*CB}_{t-1}$	1.963	-0.6374	0.0295	-0.0429	0.0465	-0.0257	0.0158	-0.0153
$\hat{b}^{CB}_{t-1}$	-0.0001	0	0	0	0	0	0	0
$\hat{i}^{G}_{t-1}$	-3.0385	0.9867	-0.0457	0.0664	-0.072	0.0398	-0.0244	0.0237
$\hat{b}^{*G}_{t-1}$	-3.0385	0.9867	-0.0457	0.0664	-0.072	0.0398	-0.0244	0.0237
$\hat{i}^{B}_{t-1}$	-0.9988	0.3243	-0.015	0.0218	-0.0237	0.0131	-0.008	0.0078
$\hat{p}^{C}_{t-1}$	11.8154	-0.5062	0.2952	0.5069	1.4279	0.3935	0.3784	0.2756
$\hat{\mu}^{z}_{t-1}$	2.2895	8.5432	2.8352	3.6566	14.9317	0.7286	4.2582	1.238
$\hat{\pi}^{W}_{t-1}$	-5.0814	2.4218	-0.0479	0.0984	-0.3849	0	-0.0135	0.0183
$\hat{\pi}^{D}_{t-1}$	-6.6498	9.2263	1.6198	5.7785	14.1784	0.1187	3.6873	2.4692
$\hat{\pi}^{N}_{t-1}$	-0.297	-2.4964	-0.9572	-0.9239	-3.0055	-0.1913	-1.4085	-0.1998
$\hat{z}^{\circ}_{t-1}$	1.483	-0.431	0.0701	-0.0219	0.1392	0.0011	0.0671	-0.009
$\hat{e}_{t-1}$	2.0188	5.6284	0.9066	4.9732	12.8967	-0.13	2.6449	2.1956
$\hat{\pi}^{C}_{t-1}$	-11.0793	0.2205	-0.1816	-0.3316	-1.014	-0.2834	-0.2369	-0.1761
$\widehat{w}_{t-1}$	-3.7307	3.0665	0.8398	0.3575	3.4445	-0.0053	1.2686	-0.1312
$\hat{p}^{N}_{t-1}$	-1.7144	-4.6292	-2.5184	-0.6527	-11.367	-0.0284	-3.7121	0.5806
$\hat{\pi}^{D}_{1,t-1}$	-6.1565	6.6757	2.8791	1.7407	3.6521	0.04	4.5003	-0.2894
$\hat{\pi}^{D}_{2,t-1}$	5.9781	8.8187	6.2371	-0.5883	34.0061	-0.1134	8.8712	-2.5515
$\hat{\pi}^{C}_{1,t-1}$	-10.9998	-0.0892	-0.0791	-0.1732	-0.5439	-0.1552	-0.1103	-0.0884
$\hat{\pi}^{C}_{2,t-1}$	-2.4291	-0.1808	-0.0139	-0.0557	-0.1337	-0.0469	-0.0257	-0.0267
$\hat{\delta}^{M}_{1,t-1}$	6.1926	-6.5336	-2.8856	-1.7265	-3.6455	-0.0285	-4.5041	0.2962
$\hat{\delta}^{M}_{2,t-1}$	-6.0544	-8.7531	-6.245	0.5958	-34.0348	0.1183	-8.8796	2.5566
$\hat{\mu}^{z}_{1,t-1}$	-6.1565	6.6757	2.8791	1.7407	3.6521	0.04	4.5003	-0.2894
$\hat{\mu}^{z}_{2,t-1}$	5.9781	8.8187	6.2371	-0.5883	34.0061	-0.1134	8.8712	-2.5515
$\hat{e}_{1,t-1}$	-8.4032	-0.1302	1.7127	-3.7954	-10.3995	-0.1791	1.54	-2.8398
$\hat{e}_{2,t-1}$	13.0888	2.3115	3.6221	-2.5122	32.7409	-0.1655	4.7146	-2.44
$\hat{e}_{3,t-1}$	-6.4482	-9.5121	-6.7276	0.6346	-36.6801	0.1223	-9.5688	2.7521
$\hat{p}^{**X}_{0,t-1}$	1.8637	0.3209	-5.3982	10.1904	-0.4521	-0.1226	-3.6234	6.5256
$\hat{p}^{**X}_{1,t-1}$	-8.4032	-0.1302	1.7127	-3.7954	-10.3995	-0.1791	1.54	-2.8398
$\hat{p}^{**X}_{2,t-1}$	13.0888	2.3115	3.6221	-2.5122	32.7409	-0.1655	4.7146	-2.44
$\hat{p}^{**X}_{3,t-1}$	-6.4482	-9.5121	-6.7276	0.6346	-36.6801	0.1223	-9.5688	2.7521
$\hat{c}_{t-1}$	2.5205	2.2648	2.8501	0.4816	12.0274	-0.1378	4.0359	-0.6745
$\hat{b}^{*B}_{t-1}$	-0.9988	0.3243	-0.015	0.0218	-0.0237	0.0131	-0.008	0.0078
$\hat{i}^{L}_{t-1}$	-0.6683	0.196	0.0265	0.0419	0.0714	-0.007	0.0496	0.0101

TABLE 4.3B

Optimal Policy Rules

Coefficients on disturbance variables	I		J $\widetilde{Z}_t$		K		L	
$\widehat{g}_t$	0.7074	-0.5258	0.1451	-0.0522	0.516	-0.0571	0.1808	-0.0634
$\widehat{z}_t^C$	1.0066	-0.3146	0.277	0.162	0.6644	0.0072	0.3551	0.0437
$\widehat{z}_t^H$	-0.5264	0.1991	-0.046	-0.0216	-0.1593	-0.0016	-0.0603	-0.004
$\widehat{\epsilon}_t$	4.3623	-3.9979	-1.2142	-0.3697	-5.4247	0.0224	-1.8363	0.283
$\widehat{z}_t^A$	-3.6004	-8.336	-5.4384	-0.0336	-27.6179	0.0684	-7.8372	1.96
$\widehat{\varsigma}_t$	-0.0381	0.0112	-0.0004	0.0005	-0.0039	-0.0007	-0.0002	0.0001
$\widehat{\pi}_t^{**N}$	2.3972	2.4318	3.6137	-2.8536	5.5587	0.1504	3.4231	-2.4154
$\widehat{i}_t^{**}$	-13.2796	4.3122	-0.1999	0.2903	-0.3149	0.1739	-0.1068	0.1038
$\widehat{\phi}_t^{**B}$	-0.9085	0.295	-0.0137	0.0199	-0.0215	0.0119	-0.0073	0.0071
$\widehat{\phi}_t^{**G}$	-4.1455	1.3461	-0.0624	0.0906	-0.0983	0.0543	-0.0333	0.0324
$\widehat{\mu}_t^{z**}$	3.1007	-1.015	0.0699	-0.0308	0.1281	-0.0312	0.0599	0.001
$\widehat{p}_t^{**X}$	0.757	-0.2677	3.734	-6.4645	0.0938	-0.0037	2.1591	-3.9354
$\widehat{i}_{t-1}^{**}$	7.1125	-2.3096	0.1071	-0.1555	0.1686	-0.0931	0.0572	-0.0556
$\widehat{\mu}_{t-1}^{z**}$	0.0582	1.1578	0.794	-0.1546	1.6891	0.3452	0.8325	-0.2056
Coefficients on LMs corresponding to equations with expectational terms							λ_{t-1}^d	
λ_{t-1}^c	-0.6028	0.6274	-0.0205	0.0594	0.0129	0.0414	-0.004	0.024
$\lambda_{t-1}^{\lambda^0}$	78.511	-26.6926	1.154	-1.9365	1.6146	-1.1822	0.5556	-0.7236
$\lambda_{t-1}^{b^{*B}}$	17.9143	-13.2432	0.4128	-1.1393	-0.3104	-0.7769	0.0582	-0.4272
$\lambda_{t-1}^{i^L}$	-0.0152	0.0091	-0.0003	0.0008	-0.0001	0.0005	-0.0001	0.0003
λ_{t-1}^t	21.5362	-7.4129	0.3047	-0.5625	0.3954	-0.3454	0.1344	-0.2156
λ_{t-1}^r	-2.7075	0.0379	-0.0209	-0.036	-0.1293	-0.0334	-0.0269	-0.019
$\lambda_{t-1}^{\Gamma^W}$	5.1994	-3.8177	0.2074	-0.2051	0.2945	-0.1374	0.1342	-0.061
$\lambda_{t-1}^{\Psi^W}$	-0.3647	5.8155	-0.0573	0.8012	0.7522	0.5737	0.1391	0.3583
$\lambda_{t-1}^{\Gamma^D}$	8.686	-7.4802	0.2825	-0.6344	0.0367	-0.4368	0.0987	-0.2466
$\lambda_{t-1}^{\Psi^D}$	12.9758	-7.5402	0.3156	-0.5773	0.2416	-0.3839	0.1413	-0.2165
$\lambda_{t-1}^{\Gamma^N}$	7.697	-7.1091	0.264	-0.611	0.0113	-0.4218	0.0881	-0.2388
$\lambda_{t-1}^{\Psi^N}$	8.6369	-4.8356	0.2197	-0.349	0.2446	-0.2294	0.1142	-0.1297

TABLE 4.4A

Optimal Policy Rules

	M		N		O		P	
Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$								
$\hat{i}_{t-1}$	-0.0036	0.0014	0.4527	-0.0923	0	0	0.3777	-0.0004
$\hat{\delta}^{M}_{t-1}$	-0.9475	-6.6534	-1.9634	-5.0621	-13.029	0.3371	-3.6437	-2.5514
$\hat{r}^{*CB}_{t-1}$	2.4527	-0.9565	0.021	-0.0315	0.0333	-0.0264	0.0121	-0.0126
$\hat{b}^{CB}_{t-1}$	-0.0001	0	0	0	0	0	0	0
$\hat{i}^{G}_{t-1}$	-3.7965	1.4805	-0.0325	0.0487	-0.0515	0.0408	-0.0188	0.0195
$\hat{b}^{*G}_{t-1}$	-3.7965	1.4805	-0.0325	0.0487	-0.0515	0.0408	-0.0188	0.0195
$\hat{i}^{B}_{t-1}$	-1.248	0.4867	-0.0107	0.016	-0.0169	0.0134	-0.0062	0.0064
$\hat{p}^{C}_{t-1}$	12.4328	0.0606	0.3691	0.4315	1.4236	0.4342	0.4142	0.2616
$\hat{\mu}^{z}_{t-1}$	2.1496	8.1193	3.8904	2.5712	14.7403	0.4612	5.095	1.0197
$\hat{\pi}^{W}_{t-1}$	-4.3446	2.0202	-0.0433	-0.0234	-0.4557	-0.0968	-0.0422	-0.0337
$\hat{\pi}^{D}_{t-1}$	-7.6645	8.8138	2.3929	5.3709	14.0219	-0.1648	4.2879	2.7774
$\hat{\pi}^{N}_{t-1}$	-0.1983	-2.5139	-1.2136	-0.4755	-2.9496	-0.1188	-1.5202	-0.0557
$\hat{z}^{\circ}_{t-1}$	1.846	-0.6651	0.0722	-0.0295	0.1301	0.0004	0.0694	-0.0151
$\hat{e}_{t-1}$	1.1435	5.6769	1.4943	5.0079	12.8158	-0.2916	3.1992	2.6729
$\hat{\pi}^{C}_{t-1}$	-12.0415	-0.3046	-0.2298	-0.2813	-1.0024	-0.3107	-0.2591	-0.1669
$\widehat{w}_{t-1}$	-3.6218	2.7999	1.0921	-0.0855	3.3797	-0.1095	1.4277	-0.2982
$\hat{p}^{N}_{t-1}$	-1.2551	-4.6726	-3.2507	0.452	-11.3156	0.0961	-4.2334	0.9973
$\hat{\pi}^{D}_{1,t-1}$	-6.2431	6.6724	3.3438	0.0861	3.5649	-0.1423	4.2889	-0.938
$\hat{\pi}^{D}_{2,t-1}$	4.2183	8.916	8.2155	-3.1102	33.9651	-0.3384	10.6632	-3.5979
$\hat{\pi}^{C}_{1,t-1}$	-13.4341	-0.5225	-0.1044	-0.1453	-0.5265	-0.1688	-0.1212	-0.0833
$\hat{\pi}^{C}_{2,t-1}$	-2.955	-0.3735	-0.0225	-0.0456	-0.1309	-0.0507	-0.0291	-0.0248
$\hat{\delta}^{M}_{1,t-1}$	6.2631	-6.559	-3.3474	-0.0801	-3.5621	0.1485	-4.292	0.9418
$\hat{\delta}^{M}_{2,t-1}$	-4.2686	-8.8661	-8.2233	3.1156	-33.994	0.3412	-10.6727	3.6023
$\hat{\mu}^{z}_{1,t-1}$	-6.2431	6.6724	3.3438	0.0861	3.5649	-0.1423	4.2889	-0.938
$\hat{\mu}^{z}_{2,t-1}$	4.2183	8.916	8.2155	-3.1102	33.9651	-0.3384	10.6632	-3.5979
$\hat{e}_{1,t-1}$	-7.6282	-0.1402	1.491	-5.372	-10.368	-0.1651	0.6981	-3.9334
$\hat{e}_{2,t-1}$	11.284	2.4201	5.2547	-3.4477	32.7906	-0.2115	6.8755	-2.869
$\hat{e}_{3,t-1}$	-4.55	-9.6171	-8.8615	3.3548	-36.6359	0.365	-11.5017	3.8808
$\hat{p}^{**X}_{0,t-1}$	1.8628	0.3689	-6.4985	13.1381	-0.4402	-0.1255	-4.4423	8.7442
$\hat{p}^{**X}_{1,t-1}$	-7.6282	-0.1402	1.491	-5.372	-10.368	-0.1651	0.6981	-3.9334
$\hat{p}^{**X}_{2,t-1}$	11.284	2.4201	5.2547	-3.4477	32.7906	-0.2115	6.8755	-2.869
$\hat{p}^{**X}_{3,t-1}$	-4.55	-9.6171	-8.8615	3.3548	-36.6359	0.365	-11.5017	3.8808
$\hat{c}_{t-1}$	1.2163	2.8914	3.5867	-0.5158	12.0432	-0.1668	4.6033	-1.0487
$\hat{b}^{*B}_{t-1}$	-1.248	0.4867	-0.0107	0.016	-0.0169	0.0134	-0.0062	0.0064
$\hat{i}^{L}_{t-1}$	-0.6852	0.1623	0.0348	0.0246	0.0681	-0.0142	0.0521	0.0056

TABLE 4.4B

Optimal Policy Rules

	M		N		O		P	
Coefficients on disturbance variables $\widetilde{Z}_t$								
$\widehat{g}_t$	0.5252	-0.3922	0.1658	-0.0552	0.5314	-0.0359	-0.0685	-0.0048
$\widehat{z}_t^C$	0.5062	-0.0827	0.3212	0.1193	0.6685	0.0254	-2.0939	0.5227
$\widehat{z}_t^H$	-0.4182	0.1522	-0.0554	-0.0192	-0.1647	-0.0101	-9.2201	2.8833
$\widehat{\epsilon}_t$	4.2557	-3.6617	-1.5909	0.2557	-5.3581	0.1525	-0.0003	0
$\widehat{z}_t^A$	-2.1843	-8.4105	-7.0921	2.242	-27.5649	0.2844	3.9944	-3.4675
$\widehat{\varsigma}_t$	-0.0358	0.0088	-0.0004	0.0001	-0.0042	-0.0011	-0.0821	0.085
$\widehat{\pi}_t^{**N}$	3.3796	1.5284	4.4404	-4.598	5.404	0.0126	-0.0056	0.0058
$\widehat{i}_t^{**}$	-16.5924	6.4704	-0.1422	0.2128	-0.2252	0.1784	-0.0256	0.0265
$\widehat{\phi}_t^{**B}$	-1.1351	0.4426	-0.0097	0.0146	-0.0154	0.0122	0.0548	0.0103
$\widehat{\phi}_t^{**G}$	-5.1796	2.0198	-0.0444	0.0664	-0.0703	0.0557	3.0228	-5.3102
$\widehat{\mu}_t^{z**}$	3.8124	-1.4827	0.057	-0.0072	0.1117	-0.0289	0.044	-0.0455
$\widehat{p}_t^{**X}$	0.5189	-0.2796	4.6792	-8.2527	0.058	-0.0113	0.9349	-0.434
$\widehat{i}_{t-1}^{**}$	8.8868	-3.4655	0.0761	-0.114	0.1206	-0.0955	0.0016	-0.0065
$\widehat{\mu}_{t-1}^{z**}$	0.5613	0.9248	0.974	-0.5648	1.66	0.306	0.0195	0.0635
Coefficients on LMs corresponding to equations with expectational terms								
λ_{t-1}^c	-0.7858	0.9881	-0.0098	0.0456	0.0235	0.0436	0.0006	0.0208
$\lambda_{t-1}^{\lambda^0}$	98.9263	-40.4135	0.7807	-1.4431	1.0658	-1.2236	0.3943	-0.6063
$\lambda_{t-1}^{b^{*B}}$	22.7053	-20.5428	0.2216	-0.8585	-0.3593	-0.8136	0.001	-0.3728
$\lambda_{t-1}^{i^L}$	-0.0193	0.0141	-0.0002	0.0006	0.0001	0.0005	-0.0001	0.0003
λ_{t-1}^t	27.2147	-11.2453	0.1978	-0.4218	0.243	-0.3582	0.0881	-0.1822
λ_{t-1}^r	-3.3136	-0.0322	-0.026	-0.0306	-0.1242	-0.0364	-0.0291	-0.0181
$\lambda_{t-1}^{\Gamma^W}$	5.9676	-5.8076	0.165	-0.1451	0.235	-0.1391	0.1174	-0.0464
$\lambda_{t-1}^{\Psi^W}$	-1.7318	9.5259	0.0794	0.635	0.851	0.612	0.1998	0.3219
$\lambda_{t-1}^{\Gamma^D}$	10.9228	-11.6676	0.1649	-0.4813	-0.0891	-0.4569	0.0488	-0.2113
$\lambda_{t-1}^{\Psi^D}$	16.1728	-11.6165	0.2061	-0.4328	0.1076	-0.3992	0.0948	-0.1826
$\lambda_{t-1}^{\Gamma^N}$	9.6803	-11.1046	0.1511	-0.4643	-0.1075	-0.4415	0.04	-0.205
$\lambda_{t-1}^{\Psi^N}$	10.639	-7.4238	0.1507	-0.2606	0.1434	-0.2374	0.0825	-0.1079

Optimal Policy Rules for a FER regime

TABLE 5.1A

Optimal Policy Rules - FER

	A	B	C	D	E	F	G	H
Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$								
$\hat{i}_{t-1}$	-0.0094	-0.0093	-0.0094	-0.0093	-0.0094	-0.0093	-0.0094	-0.0094
$\hat{\delta}^{M}_{t-1}$	-0.2566	-0.2566	-0.2347	-0.2347	-0.2593	-0.2593	-0.245	-0.245
$\hat{b}^{CB}_{t-1}$	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
$\hat{i}^{G}_{t-1}$	-0.008	-0.008	-0.0055	-0.0055	0.0067	0.0067	0.0068	0.0068
$\hat{b}^{*G}_{t-1}$	-0.008	-0.008	-0.0055	-0.0055	0.0067	0.0067	0.0068	0.0068
$\hat{i}^{B}_{t-1}$	0.0097	0.0097	0.0106	0.0106	0.0146	0.0146	0.0147	0.0147
$\hat{p}^{C}_{t-1}$	0.008	0.008	0.0067	0.0067	0.0084	0.0084	0.0074	0.0074
$\hat{\mu}^{z}_{t-1}$	0.2829	0.2828	0.2545	0.2544	0.2865	0.2865	0.267	0.267
$\hat{\pi}^{W}_{t-1}$	0.0483	0.0483	0.0445	0.0445	0.0488	0.0488	0.046	0.046
$\hat{\pi}^{D}_{t-1}$	0.3095	0.3094	0.281	0.2809	0.3133	0.3133	0.294	0.294
$\hat{\pi}^{N}_{t-1}$	-0.1008	-0.1008	-0.0872	-0.0872	-0.1037	-0.1037	-0.0934	-0.0934
$\hat{z}^{\circ}_{t-1}$	0.0131	0.0131	0.0109	0.0109	0.005	0.005	0.0044	0.0044
$\hat{e}_{t-1}$	0.2382	0.2382	0.2232	0.2232	0.2397	0.2396	0.2305	0.2305
$\hat{\pi}^{C}_{t-1}$	-0.0044	-0.0044	-0.0037	-0.0037	-0.0046	-0.0046	-0.0041	-0.0041
$\widehat{\overline{w}}_{t-1}$	0.0748	0.0747	0.0624	0.0624	0.0774	0.0774	0.0681	0.0681
$\hat{p}^{N}_{t-1}$	-0.1284	-0.1284	-0.1	-0.1	-0.135	-0.135	-0.1134	-0.1134
$\hat{\pi}^{D}_{1,t-1}$	0.2854	0.2854	0.2286	0.2286	0.2953	0.2953	0.2505	0.2504
$\hat{\pi}^{D}_{2,t-1}$	0.1451	0.1451	0.0926	0.0926	0.1603	0.1603	0.1207	0.1207
$\hat{\pi}^{C}_{1,t-1}$	-0.0019	-0.0019	-0.0016	-0.0016	-0.0021	-0.0021	-0.0018	-0.0018
$\hat{\pi}^{C}_{2,t-1}$	-0.0005	-0.0005	-0.0004	-0.0004	-0.0006	-0.0006	-0.0005	-0.0005
$\hat{\delta}^{M}_{1,t-1}$	-0.285	-0.2849	-0.2281	-0.2281	-0.2949	-0.2948	-0.25	-0.25
$\hat{\delta}^{M}_{2,t-1}$	-0.1446	-0.1446	-0.092	-0.092	-0.1598	-0.1598	-0.1201	-0.1201
$\hat{\mu}^{z}_{1,t-1}$	0.2854	0.2854	0.2286	0.2286	0.2953	0.2953	0.2505	0.2504
$\hat{\mu}^{z}_{2,t-1}$	0.1451	0.1451	0.0926	0.0926	0.1603	0.1603	0.1207	0.1207
$\hat{e}_{1,t-1}$	0.0306	0.0305	-0.0089	-0.0089	0.0384	0.0384	0.0042	0.0042
$\hat{e}_{2,t-1}$	-0.1513	-0.1513	-0.1467	-0.1467	-0.1456	-0.1456	-0.14	-0.1399
$\hat{e}_{3,t-1}$	-0.1566	-0.1565	-0.0999	-0.0999	-0.173	-0.1729	-0.1302	-0.1302
$\hat{p}^{**X}_{0,t-1}$	0.0736	0.0736	0.1004	0.1004	0.0573	0.0574	0.0813	0.0813
$\hat{p}^{**X}_{1,t-1}$	0.0306	0.0305	-0.0089	-0.0089	0.0384	0.0384	0.0042	0.0042
$\hat{p}^{**X}_{2,t-1}$	-0.1513	-0.1513	-0.1467	-0.1467	-0.1456	-0.1456	-0.14	-0.1399
$\hat{p}^{**X}_{3,t-1}$	-0.1566	-0.1565	-0.0999	-0.0999	-0.173	-0.1729	-0.1302	-0.1302
$\hat{c}_{t-1}$	0.1492	0.1492	0.1174	0.1174	0.1573	0.1573	0.133	0.133
$\hat{b}^{*B}_{t-1}$	0.0097	0.0097	0.0106	0.0106	0.0146	0.0146	0.0147	0.0147
	0.0042	0.0042	0.0036	0.0036	0.0043	0.0043	0.0038	0.0038

TABLE 5.1B

Optimal Policy Rules - FER

	A	B	C	D	E	F	G	H
Coefficients on disturbance variables $\widetilde{Z}_t$								
$\widehat{g}_t$	0.0461	0.0461	0.0456	0.0456	0.047	0.047	0.0465	0.0465
$\widehat{z}_t^C$	0.0326	0.0326	0.0289	0.0289	0.0338	0.0338	0.0309	0.0309
$\widehat{z}_t^H$	0.002	0.002	0.0022	0.0022	0.0019	0.0019	0.002	0.002
$\widehat{\epsilon}_t$	-0.088	-0.088	-0.0718	-0.0718	-0.0916	-0.0916	-0.0794	-0.0794
$\widehat{z}_t^A$	-0.1748	-0.1748	-0.1229	-0.1229	-0.1886	-0.1886	-0.1492	-0.1492
$\widehat{\varsigma}_t$	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
$\widehat{\pi}_t^{**N}$	0.2011	0.201	0.1677	0.1677	0.1883	0.1882	0.1649	0.1649
$\widehat{i}_t^{**}$	0.9037	0.9036	0.9217	0.9217	0.9723	0.9722	0.9773	0.9773
$\widehat{\phi}_t^{**B}$	0.988	0.9879	0.992	0.9919	0.994	0.9939	0.9962	0.9962
$\widehat{\phi}_t^{**G}$	-0.011	-0.011	-0.0075	-0.0075	0.0092	0.0092	0.0093	0.0093
$\widehat{\mu}_t^{z**}$	0.023	0.023	0.0193	0.0193	0.0061	0.0061	0.0054	0.0054
$\widehat{p}_t^{**X}$	-0.0232	-0.0232	-0.0322	-0.0322	-0.0137	-0.0137	-0.0216	-0.0216
$\widehat{i}_{t-1}^{**}$	0.0188	0.0188	0.0129	0.0129	-0.0157	-0.0157	-0.016	-0.016
$\widehat{\mu}_{t-1}^{z**}$	0.0453	0.0453	0.037	0.037	0.0447	0.0447	0.0386	0.0386
Coefficients on LMs corresponding to equations with expectational terms λ_{t-1}^{i}								
λ_{t-1}^{c}	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001
$\lambda_{t-1}^{\lambda^0}$	-0.0057	-0.0057	-0.0048	-0.0048	-0.003	-0.003	-0.0026	-0.0026
$\lambda_{t-1}^{b^{*B}}$	-0.0051	-0.0051	-0.004	-0.004	-0.0032	-0.0032	-0.0026	-0.0026
$\lambda_{t-1}^{i^L}$	0	0	0	0	0	0	0	0
λ_{t-1}^{t}	-0.0029	-0.0029	-0.0024	-0.0024	-0.0015	-0.0015	-0.0013	-0.0013
λ_{t-1}^{r}	-0.0004	-0.0004	-0.0004	-0.0004	-0.0002	-0.0002	-0.0002	-0.0002
$\lambda_{t-1}^{\Gamma^W}$	0.0014	0.0014	0.0012	0.0012	0.0008	0.0008	0.0007	0.0007
$\lambda_{t-1}^{\Psi^W}$	0.0068	0.0068	0.0057	0.0057	0.0036	0.0036	0.0031	0.0031
$\lambda_{t-1}^{\Gamma^D}$	-0.0017	-0.0017	-0.0014	-0.0014	-0.0009	-0.0009	-0.0008	-0.0008
$\lambda_{t-1}^{\Psi^D}$	-0.001	-0.001	-0.0008	-0.0008	-0.0005	-0.0005	-0.0004	-0.0004
$\lambda_{t-1}^{\Gamma^N}$	-0.0018	-0.0018	-0.0015	-0.0015	-0.0009	-0.0009	-0.0008	-0.0008
$\lambda_{t-1}^{\Psi^N}$	-0.0002	-0.0002	-0.0002	-0.0002	0	0	-0.0001	-0.0001

TABLE 5.2A

Optimal Policy Rules - FER

	I	J	K	L	M	N	O	P
Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$								
$\hat{i}_{t-1}$	-0.0094	-0.0093	-0.0094	-0.0094	-0.0093	-0.0093	-0.0094	-0.0093
$\hat{\delta}^{M}_{t-1}$	-0.2565	-0.2565	-0.2349	-0.2349	-0.252	-0.252	-0.2327	-0.2327
$\hat{b}^{CB}_{t-1}$	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
$\hat{i}^{G}_{t-1}$	-0.0075	-0.0075	-0.0051	-0.0051	-0.035	-0.035	-0.0285	-0.0285
$\hat{b}^{*G}_{t-1}$	-0.0075	-0.0075	-0.0051	-0.0051	-0.035	-0.035	-0.0285	-0.0285
$\hat{i}^{B}_{t-1}$	0.0099	0.0099	0.0108	0.0108	0.0008	0.0008	0.003	0.003
$\hat{p}^{C}_{t-1}$	0.0079	0.0079	0.0066	0.0066	0.0075	0.0075	0.0063	0.0063
$\hat{\mu}^{z}_{t-1}$	0.2835	0.2834	0.2553	0.2552	0.2757	0.2757	0.2487	0.2487
$\hat{\pi}^{W}_{t-1}$	0.049	0.049	0.0452	0.0452	0.0468	0.0468	0.0435	0.0435
$\hat{\pi}^{D}_{t-1}$	0.3095	0.3095	0.2813	0.2813	0.3023	0.3023	0.2772	0.2772
$\hat{\pi}^{N}_{t-1}$	-0.1009	-0.1009	-0.0874	-0.0874	-0.0956	-0.0955	-0.0835	-0.0835
$\hat{z}^{\circ}_{t-1}$	0.0127	0.0127	0.0107	0.0107	0.0279	0.0279	0.0236	0.0236
$\hat{e}_{t-1}$	0.238	0.238	0.2232	0.2232	0.2358	0.2358	0.2226	0.2226
$\hat{\pi}^{C}_{t-1}$	-0.0043	-0.0043	-0.0036	-0.0036	-0.0041	-0.0041	-0.0035	-0.0035
$\hat{\overline{w}}_{t-1}$	0.075	0.075	0.0628	0.0628	0.0697	0.0697	0.0586	0.0586
$\hat{p}^{N}_{t-1}$	-0.1285	-0.1285	-0.1004	-0.1004	-0.1163	-0.1162	-0.0906	-0.0906
$\hat{\pi}^{D}_{1,t-1}$	0.2856	0.2855	0.2292	0.2292	0.2675	0.2675	0.2185	0.2185
$\hat{\pi}^{D}_{2,t-1}$	0.1455	0.1455	0.0934	0.0934	0.1175	0.1174	0.0682	0.0682
$\hat{\pi}^{C}_{1,t-1}$	-0.0019	-0.0019	-0.0016	-0.0016	-0.0018	-0.0018	-0.0015	-0.0015
$\hat{\pi}^{C}_{2,t-1}$	-0.0005	-0.0005	-0.0004	-0.0004	-0.0005	-0.0005	-0.0004	-0.0004
$\hat{\delta}^{M}_{1,t-1}$	-0.2851	-0.2851	-0.2287	-0.2287	-0.2671	-0.267	-0.218	-0.218
$\hat{\delta}^{M}_{2,t-1}$	-0.145	-0.1449	-0.0928	-0.0928	-0.1169	-0.1169	-0.0676	-0.0676
$\hat{\mu}^{z}_{1,t-1}$	0.2856	0.2855	0.2292	0.2292	0.2675	0.2675	0.2185	0.2185
$\hat{\mu}^{z}_{2,t-1}$	0.1455	0.1455	0.0934	0.0934	0.1175	0.1174	0.0682	0.0682
$\hat{e}_{1,t-1}$	0.0308	0.0308	-0.0085	-0.0085	0.0163	0.0162	-0.0173	-0.0174
$\hat{e}_{2,t-1}$	-0.1511	-0.151	-0.1465	-0.1464	-0.1619	-0.1618	-0.1622	-0.1621
$\hat{e}_{3,t-1}$	-0.157	-0.1569	-0.1008	-0.1007	-0.1267	-0.1267	-0.0735	-0.0735
$\hat{p}^{**X}_{0,t-1}$	0.073	0.0731	0.0998	0.0998	0.1032	0.1032	0.1301	0.1301
$\hat{p}^{**X}_{1,t-1}$	0.0308	0.0308	-0.0085	-0.0085	0.0163	0.0162	-0.0173	-0.0174
$\hat{p}^{**X}_{2,t-1}$	-0.1511	-0.151	-0.1465	-0.1464	-0.1619	-0.1618	-0.1622	-0.1621
$\hat{p}^{**X}_{3,t-1}$	-0.157	-0.1569	-0.1008	-0.1007	-0.1267	-0.1267	-0.0735	-0.0735
$\hat{c}_{t-1}$	0.1484	0.1484	0.117	0.1169	0.1355	0.1355	0.1067	0.1067
$\hat{b}^{*B}_{t-1}$	0.0099	0.0099	0.0108	0.0108	0.0008	0.0008	0.003	0.003
$\hat{i}^{L}_{t-1}$	0.0042	0.0042	0.0036	0.0036	0.004	0.004	0.0034	0.0034

TABLE 5.2B

Optimal Policy Rules - FER

	I	J	K	L	M	N	O	P
Coefficients on disturbance variables $\widetilde{Z}_t$								
$\widehat{g}_t$	0.046	0.046	0.0454	0.0454	0.0447	0.0446	0.0443	0.0443
$\widehat{z}_t^C$	0.0321	0.0321	0.0285	0.0285	0.0309	0.0309	0.0276	0.0276
$\widehat{z}_t^H$	0.0021	0.0021	0.0022	0.0022	0.002	0.002	0.0022	0.0022
$\widehat{\epsilon}_t$	-0.0885	-0.0885	-0.0724	-0.0724	-0.0811	-0.0811	-0.0665	-0.0665
$\widehat{z}_t^A$	-0.1752	-0.1751	-0.1237	-0.1237	-0.1498	-0.1498	-0.1019	-0.1019
$\widehat{\varsigma}_t$	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
$\widehat{\pi}_t^{**N}$	0.2004	0.2004	0.1674	0.1674	0.2247	0.2246	0.1866	0.1866
$\widehat{i}_t^{**}$	0.9063	0.9063	0.9238	0.9238	0.778	0.7779	0.814	0.814
$\widehat{\phi}_t^{**B}$	0.9883	0.9882	0.9922	0.9921	0.977	0.9769	0.9825	0.9824
$\widehat{\phi}_t^{**G}$	-0.0103	-0.0103	-0.0069	-0.0069	-0.0477	-0.0477	-0.0389	-0.0389
$\widehat{\mu}_t^{z**}$	0.0222	0.0222	0.0187	0.0187	0.0539	0.0539	0.0458	0.0458
$\widehat{p}_t^{**X}$	-0.023	-0.023	-0.0319	-0.0319	-0.0404	-0.0404	-0.0512	-0.0512
$\widehat{i}_{t-1}^{**}$	0.0176	0.0176	0.0119	0.0119	0.0819	0.0819	0.0668	0.0668
$\widehat{\mu}_{t-1}^{z**}$	0.0455	0.0455	0.0372	0.0372	0.0463	0.0463	0.0378	0.0378
Coefficients on LMs corresponding to equations with expectational terms λ_{t-1}^d								
λ_{t-1}^c	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
$\lambda_{t-1}^{\lambda^0}$	-0.0056	-0.0056	-0.0047	-0.0047	-0.0053	-0.0053	-0.0045	-0.0045
$\lambda_{t-1}^{b^{*B}}$	-0.0051	-0.0051	-0.0039	-0.0039	-0.0043	-0.0043	-0.0035	-0.0035
$\lambda_{t-1}^{i^L}$	0	0	0	0	0	0	0	0
λ_{t-1}^t	-0.0028	-0.0028	-0.0024	-0.0024	-0.0027	-0.0027	-0.0023	-0.0023
λ_{t-1}^r	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
$\lambda_{t-1}^{\Gamma^W}$	0.0014	0.0014	0.0012	0.0012	0.0013	0.0013	0.0011	0.0011
$\lambda_{t-1}^{\Psi^W}$	0.0067	0.0067	0.0056	0.0056	0.0064	0.0064	0.0054	0.0054
$\lambda_{t-1}^{\Gamma^D}$	-0.0016	-0.0016	-0.0014	-0.0014	-0.0016	-0.0016	-0.0013	-0.0013
$\lambda_{t-1}^{\Psi^D}$	-0.001	-0.001	-0.0008	-0.0008	-0.0009	-0.0009	-0.0008	-0.0008
$\lambda_{t-1}^{\Gamma^N}$	-0.0018	-0.0018	-0.0015	-0.0015	-0.0017	-0.0017	-0.0014	-0.0014
$\lambda_{t-1}^{\Psi^N}$	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003

Optimal Policy Rules for a PER regime

TABLE 6.1A

Optimal Policy Rules - PER

	A	B	C	D	E	F	G	H
Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$								
$\widehat{\delta}^{M}_{t-1}$	-6.1555	-6.1552	-4.5373	-4.5373	-6.2324	-6.2321	-4.8788	-4.8788
$\widehat{i}_{t-1}$	0.008	0.0072	0.0059	0.0056	0.0079	0.0072	0.0063	0.0059
$\widehat{r}^{*CB}_{t-1}$	0.116	0.116	0.1266	0.1266	-0.0575	-0.0575	-0.0197	-0.0197
$\widehat{i}^{G}_{t-1}$	-0.1478	-0.1478	-0.1723	-0.1723	0.1195	0.1194	0.0548	0.0548
$\widehat{b}^{*G}_{t-1}$	-0.1478	-0.1478	-0.1723	-0.1723	0.1195	0.1194	0.0548	0.0548
$\widehat{i}^{B}_{t-1}$	-0.0593	-0.0593	-0.0646	-0.0646	0.029	0.029	0.0098	0.0098
$\widehat{p}^{C}_{t-1}$	0.2782	0.2782	0.223	0.223	0.2906	0.2906	0.2459	0.2459
$\widehat{\mu}^{z}_{t-1}$	6.3572	6.3566	4.5168	4.5168	6.5257	6.5252	4.9793	4.9793
$\widehat{\pi}^{W}_{t-1}$	0.7549	0.7549	0.5978	0.5978	0.7696	0.7696	0.646	0.646
$\widehat{\pi}^{D}_{t-1}$	7.5315	7.5311	5.6146	5.6146	7.654	7.6536	6.0513	6.0513
$\widehat{\pi}^{N}_{t-1}$	-2.1233	-2.1231	-1.5264	-1.5264	-2.2205	-2.2203	-1.7344	-1.7344
$\widehat{z}^{\circ}_{t-1}$	0.2035	0.2035	0.188	0.188	0.0578	0.0579	0.0706	0.0706
$\widehat{e}_{t-1}$	5.3419	5.3416	3.9619	3.9619	5.3759	5.3756	4.2042	4.2042
$\widehat{\pi}^{C}_{t-1}$	-0.1529	-0.1529	-0.1225	-0.1225	-0.1602	-0.1602	-0.1355	-0.1355
$\widehat{\overline{w}}_{t-1}$	1.8282	1.828	1.2309	1.2309	1.9219	1.9217	1.4237	1.4237
$\widehat{p}^{N}_{t-1}$	-3.6704	-3.6699	-2.2409	-2.2409	-3.907	-3.9066	-2.6981	-2.6981
$\widehat{\pi}^{D}_{1,t-1}$	6.3162	6.3158	4.5022	4.5022	6.663	6.6627	5.2441	5.2441
$\widehat{\pi}^{D}_{2,t-1}$	6.4138	6.4124	3.1549	3.1549	6.961	6.9598	4.1143	4.1142
$\widehat{\pi}^{C}_{1,t-1}$	-0.067	-0.067	-0.0537	-0.0537	-0.0707	-0.0707	-0.0598	-0.0598
$\widehat{\pi}^{C}_{2,t-1}$	-0.0186	-0.0186	-0.0147	-0.0147	-0.0201	-0.0201	-0.0167	-0.0167
$\widehat{\delta}^{M}_{1,t-1}$	-6.3212	-6.3207	-4.5056	-4.5056	-6.6687	-6.6684	-5.2486	-5.2486
$\widehat{\delta}^{M}_{2,t-1}$	-6.4192	-6.4178	-3.1575	-3.1574	-6.9671	-6.9659	-4.1178	-4.1178
$\widehat{\mu}^{z}_{1,t-1}$	6.3162	6.3158	4.5022	4.5022	6.663	6.6627	5.2441	5.2441
$\widehat{\mu}^{z}_{2,t-1}$	6.4138	6.4124	3.1549	3.1549	6.961	6.9598	4.1143	4.1142
$\widehat{e}_{1,t-1}$	0.1781	0.178	-0.1	-0.1	0.4701	0.4702	0.3533	0.3533
$\widehat{e}_{2,t-1}$	0.1052	0.1042	-1.4532	-1.4532	0.3214	0.3204	-1.2187	-1.2187
$\widehat{e}_{3,t-1}$	-6.9181	-6.9166	-3.403	-3.4029	-7.5083	-7.5071	-4.4378	-4.4377
$\widehat{p}^{**X}_{0,t-1}$	2.3106	2.3116	2.8823	2.8824	1.7162	1.7169	2.2262	2.2263
$\widehat{p}^{**X}_{1,t-1}$	0.1781	0.178	-0.1	-0.1	0.4701	0.4702	0.3533	0.3533
$\widehat{p}^{**X}_{2,t-1}$	0.1052	0.1042	-1.4532	-1.4532	0.3214	0.3204	-1.2187	-1.2187
$\widehat{p}^{**X}_{3,t-1}$	-6.9181	-6.9166	-3.403	-3.4029	-7.5083	-7.5071	-4.4378	-4.4377
$\widehat{c}_{t-1}$	4.3067	4.3061	2.7065	2.7065	4.5914	4.5909	3.2378	3.2378
$\widehat{b}^{*B}_{t-1}$	-0.0593	-0.0593	-0.0646	-0.0646	0.029	0.029	0.0098	0.0098
	0.1114	0.1113	0.0823	0.0823	0.1151	0.1151	0.0915	0.0915

TABLE 6.1B

Optimal Policy Rules - PER

	A	B	C	D	E	F	G	H
Coefficients on disturbance variables $\widetilde{Z}_t$								
$\widehat{g}_t$	0.0426	0.0426	0.0008	0.0008	0.0639	0.0639	0.0248	0.0248
$\widehat{z}_t^C$	0.6377	0.6376	0.474	0.474	0.6753	0.6753	0.5409	0.5409
$\widehat{z}_t^H$	-0.0052	-0.0052	0.0025	0.0025	-0.0081	-0.0081	-0.0011	-0.0011
$\widehat{\epsilon}_t$	-2.2714	-2.2712	-1.4613	-1.4613	-2.3986	-2.3984	-1.7172	-1.7172
$\widehat{z}_t^A$	-6.3643	-6.3631	-3.4409	-3.4408	-6.8572	-6.8562	-4.3352	-4.3351
$\widehat{\varsigma}_t$	0.0037	0.0037	0.0029	0.0029	0.0037	0.0037	0.0032	0.0032
$\widehat{\pi}_t^{**N}$	2.7855	2.7849	1.6011	1.6011	2.737	2.7365	1.8141	1.8141
$\widehat{i}_t^{**}$	-1.7014	-1.7005	-1.5586	-1.5582	-0.482	-0.4812	-0.5774	-0.577
$\widehat{\phi}_t^{**B}$	-0.4521	-0.4511	-0.3292	-0.329	-0.3552	-0.3542	-0.272	-0.2717
$\widehat{\phi}_t^{**G}$	-0.2016	-0.2016	-0.235	-0.235	0.163	0.163	0.0747	0.0747
$\widehat{\mu}_t^{z**}$	0.3268	0.3268	0.3255	0.3255	0.0187	0.0188	0.0706	0.0706
$\widehat{p}_t^{**X}$	-1.5318	-1.5325	-1.788	-1.788	-1.1659	-1.1664	-1.4151	-1.4151
$\widehat{i}_{t-1}^{**}$	0.3459	0.3459	0.4032	0.4032	-0.2796	-0.2796	-0.1282	-0.1282
$\widehat{\mu}_{t-1}^{z**}$	1.0287	1.0285	0.7057	0.7057	1.058	1.0579	0.7993	0.7993
Coefficients on LMs corresponding to equations with expectational terms λ_{t-1}^d								
λ_{t-1}^c	0.0081	0.0081	0.0065	0.0065	0.0042	0.0042	0.0036	0.0036
$\lambda_{t-1}^{\lambda^0}$	-0.2071	-0.2071	-0.1656	-0.1656	-0.1084	-0.1084	-0.0915	-0.0915
$\lambda_{t-1}^{b^{*B}}$	-0.2078	-0.2078	-0.1459	-0.1459	-0.1407	-0.1407	-0.1004	-0.1004
$\lambda_{t-1}^{i^L}$	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0	0
λ_{t-1}^t	-0.1011	-0.1011	-0.081	-0.081	-0.0527	-0.0527	-0.0445	-0.0445
λ_{t-1}^r	-0.0154	-0.0154	-0.0124	-0.0124	-0.0081	-0.0081	-0.0068	-0.0068
$\lambda_{t-1}^{\Gamma^W}$	0.0488	0.0488	0.0391	0.0391	0.0255	0.0255	0.0216	0.0216
$\lambda_{t-1}^{\Psi^W}$	0.2389	0.2389	0.1914	0.1914	0.1249	0.1249	0.1056	0.1056
$\lambda_{t-1}^{\Gamma^D}$	-0.0607	-0.0607	-0.0486	-0.0486	-0.0317	-0.0317	-0.0268	-0.0268
$\lambda_{t-1}^{\Psi^D}$	-0.0363	-0.0363	-0.0291	-0.0291	-0.0189	-0.0189	-0.016	-0.016
$\lambda_{t-1}^{\Gamma^N}$	-0.0646	-0.0646	-0.0518	-0.0518	-0.0336	-0.0336	-0.0284	-0.0284
$\lambda_{t-1}^{\Psi^N}$	-0.0088	-0.0088	-0.0089	-0.0089	-0.001	-0.001	-0.0025	-0.0025

TABLE 6.2A

Optimal Policy Rules - PER

	I	J	K	L	M	N	O	P
Coefficients on non-disturbance state variables $\overline{u}_t, \overline{V}_t, \overline{Y}_t$								
$\hat{\delta}^{M}_{t-1}$	-6.1499	-6.1496	-4.5423	-4.5423	-6.0214	-6.0212	-4.7041	-4.7041
$\hat{i}_{t-1}$	0.0079	0.0071	0.0058	0.0055	0.0082	0.0078	0.0063	0.0061
$\hat{r}^{*CB}_{t-1}$	0.1097	0.1096	0.1216	0.1216	0.4354	0.4354	0.3864	0.3864
$\hat{i}^{G}_{t-1}$	-0.1383	-0.1383	-0.1646	-0.1646	-0.6394	-0.6394	-0.5712	-0.5712
$\hat{b}^{*G}_{t-1}$	-0.1383	-0.1383	-0.1646	-0.1646	-0.6394	-0.6394	-0.5712	-0.5712
$\hat{i}^{B}_{t-1}$	-0.0561	-0.056	-0.0621	-0.062	-0.2218	-0.2218	-0.1968	-0.1968
$\hat{p}^{C}_{t-1}$	0.2737	0.2737	0.2197	0.2197	0.2614	0.2614	0.2141	0.2141
$\hat{\mu}^{z}_{t-1}$	6.3782	6.3776	4.5446	4.5446	6.0322	6.0318	4.478	4.478
$\hat{\pi}^{W}_{t-1}$	0.7797	0.7797	0.6189	0.6189	0.7057	0.7057	0.5717	0.5717
$\hat{\pi}^{D}_{t-1}$	7.5331	7.5327	5.6274	5.6274	7.3074	7.3071	5.7393	5.7393
$\hat{\pi}^{N}_{t-1}$	-2.125	-2.1248	-1.5321	-1.5321	-1.9459	-1.9458	-1.4387	-1.4387
$\hat{z}^{\circ}_{t-1}$	0.196	0.196	0.1822	0.1821	0.4738	0.4738	0.4094	0.4094
$\hat{e}_{t-1}$	5.3341	5.3338	3.963	3.963	5.2873	5.2871	4.1795	4.1795
$\hat{\pi}^{C}_{t-1}$	-0.1504	-0.1504	-0.1208	-0.1208	-0.1434	-0.1434	-0.1175	-0.1175
$\widehat{\overline{w}}_{t-1}$	1.8384	1.8382	1.243	1.243	1.6494	1.6493	1.1455	1.1455
$\hat{p}^{N}_{t-1}$	-3.6761	-3.6756	-2.2544	-2.2543	-3.2371	-3.2367	-2.0355	-2.0355
$\hat{\pi}^{D}_{1,t-1}$	6.3222	6.3218	4.5221	4.5221	5.683	5.6826	4.1194	4.1193
$\hat{\pi}^{D}_{2,t-1}$	6.4276	6.4262	3.1835	3.1835	5.4104	5.4096	2.6954	2.6954
$\hat{\pi}^{C}_{1,t-1}$	-0.0659	-0.0659	-0.0529	-0.0529	-0.0626	-0.0626	-0.0513	-0.0513
$\hat{\pi}^{C}_{2,t-1}$	-0.0183	-0.0183	-0.0145	-0.0145	-0.0171	-0.0171	-0.014	-0.014
$\hat{\delta}^{M}_{1,t-1}$	-6.3261	-6.3256	-4.5247	-4.5246	-5.6877	-5.6873	-4.1227	-4.1227
$\hat{\delta}^{M}_{2,t-1}$	-6.4325	-6.4312	-3.1857	-3.1857	-5.4151	-5.4143	-2.6977	-2.6976
$\hat{\mu}^{z}_{1,t-1}$	6.3222	6.3218	4.5221	4.5221	5.683	5.6826	4.1194	4.1193
$\hat{\mu}^{z}_{2,t-1}$	6.4276	6.4262	3.1835	3.1835	5.4104	5.4096	2.6954	2.6954
$\hat{e}_{1,t-1}$	0.1887	0.1885	-0.0848	-0.0848	-0.3599	-0.3601	-0.6837	-0.6837
$\hat{e}_{2,t-1}$	0.1136	0.1127	-1.4438	-1.4439	-0.294	-0.2945	-1.536	-1.536
$\hat{e}_{3,t-1}$	-6.933	-6.9315	-3.4338	-3.4338	-5.8359	-5.835	-2.9073	-2.9073
$\hat{p}^{**X}_{0,t-1}$	2.2906	2.2916	2.8607	2.8607	3.4039	3.4046	4.0242	4.0242
$\hat{p}^{**X}_{1,t-1}$	0.1887	0.1885	-0.0848	-0.0848	-0.3599	-0.3601	-0.6837	-0.6837
$\hat{p}^{**X}_{2,t-1}$	0.1136	0.1127	-1.4438	-1.4439	-0.294	-0.2945	-1.536	-1.536
$\hat{p}^{**X}_{3,t-1}$	-6.933	-6.9315	-3.4338	-3.4338	-5.8359	-5.835	-2.9073	-2.9073
$\hat{c}_{t-1}$	4.2769	4.2764	2.6927	2.6927	3.8198	3.8194	2.4736	2.4736
$\hat{b}^{*B}_{t-1}$	-0.0561	-0.056	-0.0621	-0.062	-0.2218	-0.2218	-0.1968	-0.1968
	0.1118	0.1118	0.0828	0.0828	0.1041	0.1041	0.0795	0.0795

TABLE 6.2B

Optimal Policy Rules - PER

	I	J	K	L	M	N	O	P
Coefficients on disturbance variables $\tilde{Z}_t$								
$\hat{g}_t$	0.0366	0.0366	-0.0038	-0.0037	0.0099	0.0099	-0.0212	-0.0212
$\hat{z}_t^C$	0.621	0.6209	0.4619	0.4619	0.5854	0.5854	0.4466	0.4466
$\hat{z}_t^H$	-0.0015	-0.0015	0.0055	0.0055	-0.0036	-0.0036	0.003	0.003
$\hat{\epsilon}_t$	-2.2871	-2.2869	-1.479	-1.479	-2.0267	-2.0265	-1.3453	-1.3453
$\hat{z}_t^A$	-6.376	-6.3748	-3.467	-3.4669	-5.4611	-5.4604	-3.0168	-3.0168
$\hat{\varsigma}_t$	0.0037	0.0037	0.003	0.003	0.0035	0.0035	0.0028	0.0028
$\hat{\pi}_t^{**N}$	2.7735	2.7729	1.6003	1.6003	2.8843	2.8838	1.6825	1.6825
$\hat{i}_t^{**}$	-1.6469	-1.646	-1.5166	-1.5163	-3.9556	-3.955	-3.412	-3.4117
$\hat{\phi}_t^{**B}$	-0.4458	-0.4448	-0.325	-0.3248	-0.6329	-0.6325	-0.4895	-0.4894
$\hat{\phi}_t^{**G}$	-0.1887	-0.1887	-0.2246	-0.2246	-0.8724	-0.8723	-0.7793	-0.7793
$\hat{\mu}_t^{z**}$	0.3103	0.3103	0.3125	0.3125	0.8985	0.8985	0.7928	0.7928
$\hat{p}_t^{**X}$	-1.5238	-1.5245	-1.779	-1.7791	-2.2011	-2.2016	-2.5176	-2.5177
$\hat{i}_{t-1}^{**}$	0.3237	0.3238	0.3854	0.3854	1.4968	1.4967	1.3371	1.3371
$\hat{\mu}_{t-1}^{z**}$	1.035	1.0348	0.7131	0.7131	0.9699	0.9698	0.6689	0.6689
Coefficients on LMs corresponding to equations with expectational terms λ_{t-1}^d								
λ_{t-1}^c	0.008	0.008	0.0064	0.0064	0.0076	0.0076	0.0062	0.0062
$\lambda_{t-1}^{\lambda^0}$	-0.2037	-0.2037	-0.1633	-0.1633	-0.1943	-0.1943	-0.159	-0.159
$\lambda_{t-1}^{b^{*B}}$	-0.2054	-0.2054	-0.1445	-0.1444	-0.1656	-0.1656	-0.1267	-0.1267
$\lambda_{t-1}^{i^L}$	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
λ_{t-1}^t	-0.0995	-0.0995	-0.0799	-0.0799	-0.0952	-0.0952	-0.078	-0.078
λ_{t-1}^r	-0.0152	-0.0152	-0.0122	-0.0122	-0.0145	-0.0145	-0.0119	-0.0119
$\lambda_{t-1}^{\Gamma^W}$	0.048	0.048	0.0385	0.0385	0.0458	0.0458	0.0375	0.0375
$\lambda_{t-1}^{\Psi^W}$	0.235	0.235	0.1886	0.1886	0.2244	0.2244	0.1838	0.1838
$\lambda_{t-1}^{\Gamma^D}$	-0.0597	-0.0597	-0.0479	-0.0479	-0.0571	-0.0571	-0.0468	-0.0468
$\lambda_{t-1}^{\Psi^D}$	-0.0357	-0.0357	-0.0286	-0.0286	-0.0342	-0.0342	-0.028	-0.028
$\lambda_{t-1}^{\Gamma^N}$	-0.0635	-0.0635	-0.051	-0.051	-0.0608	-0.0608	-0.0498	-0.0498
$\lambda_{t-1}^{\Psi^N}$	-0.0085	-0.0085	-0.0087	-0.0087	-0.0116	-0.0116	-0.0103	-0.0103

Appendix 1. The non-linear system

The main non-linear equations in non-stationary format

In this Appendix I put together the non-linear equations that conform the model and their stationary transformation. To save space, I first leave out the policy equations, identities and auxiliary variables, and include them when I list the equations with the variables in stationary form.

Balance of Payments:

$$\begin{aligned}\frac{B_t^{*G}}{P_t^{**N}} + \frac{B_t^{*B}}{P_t^{**N}} - \frac{R_t^{*CB}}{P_t^{**N}} &= (1+i_{t-1}^G)\frac{1}{\pi_t^{**N}}\frac{B_{t-1}^{*G}}{P_{t-1}^{**N}} + \left(1+i_{t-1}^B\right)\frac{1}{\pi_t^{**N}}\frac{B_{t-1}^{*B}}{P_{t-1}^{**N}} \\ &\quad - \left(1+i_{t-1}^{**}\right)\frac{1}{\pi_t^{**N}}\frac{R_{t-1}^{*CB}}{P_{t-1}^{**N}} - \frac{TB_t}{P_t^{**N}}\end{aligned}$$

Trade Balance:

$$\frac{TB_t}{P_t^{**N}} = \frac{p_{t-4}^{**}}{(e_t/e_{t-4})\left(\widetilde{\pi}_t/\widetilde{\delta}_t\right)}X_t - N_t$$

Imports:

$$N_t p_t^N = (1-a_D)\, p_t^C C_t + \frac{1-b^D}{b^D} w_t h_t$$

Central Bank balance:

$$\frac{B_t^{CB}}{P_t} = e_t \frac{R_t^{*CB}}{P_t^{**N}} - \frac{M_t^0}{P_t}$$

Government foreign debt interest rate:

$$1+i_t^G = (1+i_t^{**})\phi_t^{**G}\left[1+\frac{\alpha_1^G}{1-\alpha_2^G\left(\left(B_t^{*G}-R_t^{*CB}\right)e_t/\left(Y_t P_t^{**N}\right)\right)}\right].$$

Fiscal:

$$e_t\frac{B_t^{*G}}{P_t^{**N}} = (1+i_{t-1}^G)\frac{e_t}{\pi_t^{**N}}\frac{B_{t-1}^{*G}}{P_{t-1}^{**N}} - \left(\frac{T_t}{P_t} - G_t\right) - \left(1+i_{t-1}^{**} - \frac{1}{\delta_t}\right)\frac{e_t}{\pi_t^{**N}}\frac{R_{t-1}^{*CB}}{P_{t-1}^{**N}} + i_{t-1}\frac{B_{t-1}^{CB}}{\pi_t P_{t-1}}$$

Bank foreign debt interest rate:

$$1+i_t^B = (1+i_t^{**})\phi^{**B}\left(1+\frac{\alpha_1^B}{1-\alpha_2^B\left(e_t B_t^{*B}/Y_t P_t^{**N}\right)}\right)$$

Real marginal cost:

$$mc_t = \frac{1}{\kappa\epsilon_t}\left(1+\varsigma_t i_{t-1}^L\right)\left(\overline{w}_t\right)^{b^D}\left(p_t^N\right)^{1-b^D}$$

Labor market clearing:

$$h_t = \frac{b^D}{\kappa}\left(\frac{p_t^N}{\overline{w}_t}\right)^{1-b^D}\frac{Q_t}{z_t\epsilon_t}$$

Domestic goods market clearing:

$$Q_t = \left[a_D + \widetilde{\tau}_t^M\right] p_t^C C_t + G_t + z_t\left(b^A e_t p_t^{**}\right)^{\frac{1}{1-b^A}} + \frac{z_t}{2b^B}\left(i_t^L - i_t\right)^2$$

Real GDP:

$$Y_t = p_t^C C_t + G_t + \frac{e_{t-4} p_{t-4}^{**}}{\widetilde{\pi}_t} X_t - p_t^N N_t$$

Consumption relative price:

$$p_t^C = \left[a_D + (1 - a_D) \left(p_t^N \right)^{1-\theta^C} \right]^{\frac{1}{1-\theta^C}}$$

Consumption MRER:

$$e_t^C = \frac{e_t}{p_t^C}.$$

Money market clearing:

$$\frac{M_t^0}{P_t} = \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{1}{1+b_M}} p_t^C C_t$$

Transaction costs related marginal consumption expenditure multiplier:

$$\widetilde{\varphi}_t^M = 1 + c_M + (1 + b_M) \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{-b_M}{1+b_M}}.$$

Transaction costs related consumption expenditure markup:

$$\widetilde{\tau}_t^M = a_M \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{1}{1+b_M}} + \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{-b_M}{1+b_M}} + c_M.$$

Loans:

$$\frac{L_t}{P_t} = z_t \frac{1}{b^B} \left(i_t^L - i_t \right)$$

Deposits:

$$\frac{D_t}{P_t} = \frac{B_t^{CB}}{P_t} + \frac{L_t}{P_t} - \frac{S_t}{P_t} B_t^{*B}.$$

Productivity Growth:

$$\mu_t^z = \left(\mu_{t-1}^z \right)^{\rho^{\mu^z}} \left(\mu_{t-1}^{z**} \right)^{1-\rho^{\mu^z}} \left(z_{t-1}^{\circ} \right)^{\alpha_{\mu^z}} \exp\left(\varepsilon_t^{\mu^z} \right),$$

Exports:

$$X_t = z_{t-4} \left(b^A e_{t-4} p_{t-4}^{**} \right)^{\frac{b^A}{1-b^A}} z_t^A.$$

Trade Balance ratio:

$$tbr_t = \frac{e_t TB_t}{Y_t}$$

Dynamics of Consumption:

$$\frac{z_t^C}{C_t - \xi C_{t-1}} - \beta \xi E_t \left(\frac{z_{t+1}^C}{C_{t+1} - \xi C_t} \right) = \lambda_t \widetilde{\varphi}_t^M p_t^C$$

Marginal utility of real income:

$$\lambda_t = \beta\left(1+i_t\right)E_t\left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right)$$

Risk-adjusted uncovered interest parity:

$$i_t = E_t\delta_{t+1}\left\{\left(1+i_t^{**}\right)\phi_t^{**B}\left[1+\frac{\alpha_1^B}{\left(1-\alpha_2^B\left(e_tB_t^{*B}/Y_tP_t^{**N}\right)\right)^2}\right]-1\right\}$$

Loan market clearing:

$$i_t^L = i_t + \frac{b^B\varsigma_t}{b^D z_t}E_t\left(w_{t+1}h_{t+1}\right)$$

Government tax collection policy:

$$\frac{T_t}{P_t} = (E_t\frac{T_{t+1}}{P_{t+1}})^{\rho^t}t^{1-\rho^t}$$

Real interest rate:

$$r_t = \frac{1+i_t}{E_t\pi_{t+1}}$$

Wage inflation Phillips equation:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha_W\right)^j\lambda_{t+j}h_{t+j}w_{t+j}\left(\pi_{t+j}^W\right)^{\psi_t-1}$$
$$\left\{\left(\frac{\left(\pi_t^W\right)^{1-\theta}-\alpha_W\left(\pi_{t-1}^W\right)^{1-\theta}}{1-\alpha_W}\right)^{\frac{1+\psi\chi}{1-\theta}}-\frac{\psi}{\psi-1}\frac{\eta z_{t+j}^H\left(h_{t+j}\right)^{\chi}}{\lambda_{t+j}w_{t+j}}\left(\pi_{t+j}^W\right)^{1+\psi_t\chi}\right\}.$$

Domestic inflation Phillips equation:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha\right)^j\overline{\Lambda}_{t+j}^D Q_{t+j}\left(\pi_{t+j}\right)^{\theta-1}\left\{\left(\frac{\left(\pi_t\right)^{1-\theta}-\alpha_D\left(\pi_{t-1}\right)^{1-\theta}}{1-\alpha_D}\right)^{\frac{1}{1-\theta}}-\frac{\theta}{\theta-1}mc_{t+j}\pi_{t+j}\right\}.$$

Imported inflation Phillips equation:

$$\begin{aligned}0 &= E_t\sum_{j=0}^{\infty}\left(\beta\alpha_N\right)^j\overline{\Lambda}_{t+j}^N N_{t+j}(\pi_{t+j}^N)^{\theta^N-1}\\ &\times\left\{\left(\frac{\left(\pi_t^N\right)^{1-\theta^N}-\alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N}}{1-\alpha_N}\right)^{\frac{1}{1-\theta^N}}-\frac{\theta^N}{\theta^N-1}\frac{e_{t+j}}{p_{t+j}^N}\pi_{t+j}^N\right\}.\end{aligned}$$

The non-linear equations in stationary format

Now I rewrite the model equations in terms of stationary variables. For this, I deflate the real variables by the permanent productivity shock z_t, and add a superscript $^\circ$ to the Lagrange multiplier to denote that it is inflated by the same factor. Hence I define the following stationary variables:

$$
\begin{aligned}
m_t^0 &= \frac{M_t^0}{z_t P_t}, \qquad d_t = \frac{D_t}{z_t P_t}, \qquad \ell_t = \frac{L_t}{z_t P_t}, \qquad b_t^{CB} = \frac{B_t^{CB}}{z_t P_t}, \qquad t_t = \frac{T_t}{z_t P_t}, \\
g_t &= \frac{G_t}{z_t}, \qquad r_t^{*CB} = \frac{R_t^{*CB}}{z_t P_t^{**N}}, \qquad b_t^{*B} = \frac{B_t^{*B}}{z_t P_t^{**N}}, \qquad tb_t = \frac{TB_t}{z_t P_t^{**N}}, \\
b_t^{CB} &= \frac{B_t^{CB}}{z_t P_t}, \qquad b_t^{*G} = \frac{B_t^{*G}}{z_t P_t^{**N}} \qquad c_t = \frac{C_t}{z_t}, \qquad q_t = \frac{Q_t}{z_t}, \qquad y_t = \frac{Y_t}{z_t}, \\
q_t^{DX} &= \frac{Q_t^{DX}}{z_t}, \qquad \lambda_t^{\circ} = \lambda_t z_t, \qquad \overline{\Lambda}_t^{D\circ} = \overline{\Lambda}_t^{D} z_t, \qquad \overline{\Lambda}_t^{N\circ} = \overline{\Lambda}_t^{N} z_t \qquad x_t = \frac{X_t}{z_t}, \\
n_t &= \frac{N_t}{z_t}, \qquad z_t^{\circ} = \frac{z_t^{**}}{z_t}, \qquad \mu_t^z \equiv \frac{z_t}{z_{t-1}}, .
\end{aligned}
$$

The transformed equations are the following:

Interest rate feedback rule:

$$
1 + i_t = \left(\frac{\mu^{z**}\pi}{\beta}\right)^{1-h_0} (1 + i_{t-1})^{h_0} \left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}^T}\right)^{h_1} \left(\frac{y_t}{y}\right)^{h_2} \left(\frac{tbr_t}{\gamma^{TBT}}\right)^{h_3} \left(\frac{tbr_{t-1}}{\gamma^{TBT}}\right)^{h_4}
$$

(or, alternatively) AR Central Bank bond policy:

$$
b_t^{CB} = \left(b_{t-1}^{CB}\right)^{\rho^\delta} \left(b^{CB}\right)^{1-\rho^\delta} \exp(\varepsilon_t^{b^{CB}})
$$

(or, alternatively) AR Central Bank international reserves policy:

$$
e_t r_t^{CB} = \left(e_{t-1} r_{t-1}^{CB}\right)^{\rho^{r^{CB}}} (y_t)^{1-\rho^{r^{CB}}} \exp(\varepsilon_t^{r^{CB}})
$$

Nominal depreciation feedback rule:

$$
\begin{aligned}
\delta_t = \left(\frac{\pi}{\pi^{**N}}\right)^{1-k_0} (\delta_{t-1})^{k_0} \left(\frac{\widetilde{\pi}_t^C}{\widetilde{\pi}^T}\right)^{k_1} \left(\frac{y_t}{y}\right)^{k_2} \left(\frac{tbr_t}{\gamma^{TBT}}\right)^{k_3} \left(\frac{tbr_{t-1}}{\gamma^{TBT}}\right)^{k_4} \\
\times \left(\frac{e_t r_t^{*CB}/y_t}{\gamma^{CBT}}\right)^{k_5} \exp(\varepsilon_t^{\delta}).
\end{aligned}
$$

(or, alternatively) Nominal depreciation rule:

$$
\delta_t = (\delta_{t-1})^{\rho^\delta} \left(\delta^T\right)^{1-\rho^\delta} \exp(\varepsilon_t^{\delta})
$$

(or, alternatively, and if not used above) AR Central Bank international reserves policy:

$$
e_t r_t^{CB} = \left(e_{t-1} r_{t-1}^{CB}\right)^{\rho^{r^{CB}}} (y_t)^{1-\rho^{r^{CB}}} \exp(\varepsilon_t^{r^{CB}})
$$

Balance of Payments:

$$
b_t^{*G} + b_t^{*B} - r_t^{*CB} = \left(1 + i_{t-1}^G\right) \frac{b_{t-1}^{*G}}{\mu_t^z \pi_t^{**N}} + \left(1 + i_{t-1}^B\right) \frac{b_{t-1}^{*B}}{\mu_t^z \pi_t^{**N}} - \left(1 + i_{t-1}^{**}\right) \frac{r_{t-1}^{*CB}}{\mu_t^z \pi_t^{**N}} - tb_t
$$

Trade Balance:

$$tb_t = \frac{p_{4t}^{**}}{(e_t/e_{4,t})\left(\widetilde{\pi}_t/\widetilde{\delta}_t\right)} x_t - n_t$$

Imports:

$$n_t p_t^N = (1-a_D)\, p_t^C c_t + \frac{1-b^D}{b^D} \overline{w}_t h_t$$

Central Bank balance:

$$b_t^{CB} = e_t r_t^{*CB} - m_t^0$$

Government foreign debt interest rate:

$$1 + i_t^G = (1+i_t^{**})\phi_t^{**G}\left[1 + \frac{\alpha_1^G}{1-\alpha_2^G e_t\left(b_t^{*G} - r_t^{*CB}\right)/y_t}\right].$$

Fiscal:

$$e_t b_t^{*G} = (1+i_{t-1}^G)\frac{e_t b_{t-1}^{*G}}{\mu_t^z \pi_t^{**N}} - (t_t - g_t) - \left(1 + i_{t-1}^{**} - \frac{1}{\delta_t}\right)\frac{e_t r_{t-1}^{*CB}}{\mu_t^z \pi_t^{**N}} + i_{t-1}\frac{b_{t-1}^{CB}}{\mu_t^z \pi_t}$$

Bank foreign debt interest rate:

$$1 + i_t^B = (1+i_t^{**})\phi^{**B}\left(1 + \frac{\alpha_1^B}{1-\alpha_2^B e_t b_t^{*B}/y_t}\right)$$

Real marginal cost:

$$mc_t = \frac{1}{\kappa\epsilon_t}\left(1+\varsigma_t i_{t-1}^L\right)\left(\overline{w}_t\right)^{b^D}\left(p_t^N\right)^{1-b^D}$$

Labor market clearing:

$$h_t = \frac{b^D}{\kappa}\left(\frac{p_t^N}{\overline{w}_t}\right)^{1-b^D}\frac{q_t}{\epsilon_t}$$

Domestic goods market clearing:

$$q_t = \left[a_D + \widetilde{\tau}_t^M\right] p_t^C c_t + g_t + \left(b^A e_t p_t^{**}\right)^{\frac{1}{1-b^A}} + \frac{1}{2b^B}\left(i_t^L - i_t\right)^2$$

Real GDP:

$$y_t = p_t^C c_t + g_t + \frac{e_{4t} p_{4t}^{**}}{\widetilde{\pi}_t} x_t - p_t^N n_t$$

Consumption relative price:

$$p_t^C = \left[a_D + (1-a_D)\left(p_t^N\right)^{1-\theta^C}\right]^{\frac{1}{1-\theta^C}}$$

Consumption MRER:

$$e_t^C = \frac{e_t}{p_t^C}.$$

Money market clearing:

$$m_t^0 = \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{1}{1+b_M}} p_t^C c_t$$

Transaction costs related marginal consumption expenditure multiplier:

$$\widetilde{\varphi}_t^M = 1 + c_M + (1 + b_M) \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{-b_M}{1+b_M}}.$$

Transaction costs related consumption expenditure markup:

$$\widetilde{\tau}_t^M = a_M \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{1}{1+b_M}} + \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}} \right]^{\frac{-b_M}{1+b_M}} + c_M.$$

Loans:

$$\ell_t = \frac{1}{b^B} \left(i_t^L - i_t \right)$$

Deposits:

$$d_t = b_t^{CB} + \ell_t - e_t b_t^{*B}.$$

Productivity Growth:

$$\mu_t^z = \left(\mu_{t-1}^z \right)^{\rho^{\mu^z}} \left(\mu_{t-1}^{z**} \right)^{1-\rho^{\mu^z}} \left(z_{t-1}^{\circ} \right)^{\alpha_{\mu^z}} \exp\left(\varepsilon_t^{\mu^z} \right),$$

Identities:

$$\begin{aligned} \frac{z_t^{\circ}}{z_{t-1}^{\circ}} &= \frac{\mu_t^{z**}}{\mu_t^z}, & \frac{e_t}{e_{t-1}} &= \frac{\delta_t \pi_t^{**N}}{\pi_t}, & \frac{\pi_t^C}{\pi_t} &= \frac{p_t^C}{p_{t-1}^C}, \\ \frac{\overline{w}_t}{\overline{w}_{t-1}} &= \frac{\pi_t^W}{\mu_t^z \pi_t}, & \frac{p_t^N}{p_{t-1}^N} &= \frac{\pi_t^N}{\pi_t} \end{aligned}$$

Exports:

$$x_t = \frac{z_t^A}{\widetilde{\mu}_t^z} \left(b^A e_{4t} p_{4t}^{**} \right)^{\frac{b^A}{1-b^A}}.$$

Trade Balance ratio:

$$tbr_t = \frac{e_t tb_t}{y_t}$$

Auxiliary:

$$\widetilde{\pi}_t = \pi_t \pi_{t-1} \pi_{1,t-1} \pi_{2,t-1}, \quad \pi_{1,t} = \pi_{t-1}, \quad \pi_{2,t} = \pi_{1,t-1}, \quad \pi_{3,t} = \pi_{2,t-1}$$

$$\widetilde{\pi}_t^C = \pi_t^C \pi_{t-1}^C \pi_{1,t-1}^C \pi_{2,t-1}^C, \quad \pi_{1,t}^C = \pi_{t-1}^C, \quad \pi_{2,t}^C = \pi_{1,t-1}^C, \quad \pi_{3,t}^C = \pi_{2,t-1}^C$$

$$\widetilde{\delta}_t = \delta_t \delta_{t-1} \delta_{1,t-1} \delta_{2,t-1}, \quad \delta_{1,t} = \delta_{t-1}, \quad \delta_{2,t} = \delta_{1,t-1}, \quad \delta_{3,t} = \delta_{2,t-1}$$

$$\widetilde{\mu}_t^z = \mu_t^z \mu_{t-1}^z \mu_{1,t-1}^z \mu_{2,t-1}^z, \quad \mu_{1,t}^z = \mu_{t-1}^z, \quad \mu_{2,t}^z = \mu_{1,t-1}^z, \quad \mu_{3,t}^z = \mu_{2,t-1}^z$$

$$e_{1,t} = e_{t-1}, \quad e_{2,t} = e_{1,t-1}, \quad e_{3,t} = e_{2,t-1}, \quad e_{4,t} = e_{3,t-1}$$

$$p_{0,t}^{**} = p_t^{**}, \quad p_{1,t}^{**} = p_{t-1}^{**}, \quad p_{2,t}^{**} = p_{1,t-1}^{**}, \quad p_{3,t}^{**} = p_{2,t-1}^{**}, \quad p_{4,t}^{**} = p_{3,t-1}^{**}$$

Dynamics of Consumption:

$$\mu_t^z \left(\frac{z_t^C}{c_t \mu_t^z - \xi c_{t-1}} \right) - \beta \xi E_t \left(\frac{z_{t+1}^C}{c_{t+1} \mu_{t+1}^z - \xi c_t} \right) = \lambda_t^{\circ} \widetilde{\varphi}_t^M p_t^C$$

Marginal utility of real income:

$$\lambda_t^{\circ} = \beta\left(1+i_t\right) E_t\left(\frac{\lambda_{t+1}^{\circ}}{\mu_{t+1}^{z}\pi_{t+1}}\right)$$

Risk-adjusted uncovered interest parity:

$$i_t = E_t\delta_{t+1}\left\{\left(1+i_t^{**}\right)\phi^{**B}\left[1+\frac{\alpha_1^B}{\left(1-\alpha_2^B e_t b_t^{*B}/y_t\right)^2}\right]-1\right\}$$

Loan market clearing:

$$i_t^L = i_t + \frac{b^B\varsigma_t}{b^D}E_t\left(\mu_{t+1}^{z}\overline{w}_{t+1}h_{t+1}\right)$$

Government tax collection policy:

$$t_t = \left(E_t t_{t+1}\right)^{\rho^t} t^{1-\rho^t}$$

Real interest rate:

$$r_t = \frac{1+i_t}{E_t\pi_{t+1}}$$

Wage inflation Phillips equation:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha_W\right)^j\lambda_{t+j}^{\circ}h_{t+j}\overline{w}_{t+j}\left(\pi_{t+j}^W\right)^{\psi-1}$$
$$\left\{\left(\frac{\left(\pi_t^W\right)^{1-\theta}-\alpha_W\left(\pi_{t-1}^W\right)^{1-\theta}}{1-\alpha_W}\right)^{\frac{1+\psi\chi}{1-\theta}}-\frac{\psi}{\psi-1}\frac{\eta z_{t+j}^H\left(h_{t+j}\right)^{\chi}}{\lambda_{t+j}^{\circ}\overline{w}_{t+j}}\left(\pi_{t+j}^W\right)^{1+\psi\chi}\right\}.$$

Domestic inflation Phillips equation:

$$0 = E_t\sum_{j=0}^{\infty}\left(\beta\alpha\right)^j\overline{\Lambda}_{t+j}^{D\circ}q_{t+j}\left(\pi_{t+j}\right)^{\theta-1}\left\{\left(\frac{\left(\pi_t\right)^{1-\theta}-\alpha_D\left(\pi_{t-1}\right)^{1-\theta}}{1-\alpha_D}\right)^{\frac{1}{1-\theta}}-\frac{\theta}{\theta-1}mc_{t+j}\pi_{t+j}\right\}. \tag{136}$$

Imported inflation Phillips equation:

$$\begin{aligned} 0 &= E_t\sum_{j=0}^{\infty}\left(\beta\alpha_N\right)^j\overline{\Lambda}_{t+j}^{N\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N-1} \\ &\times\left\{\left(\frac{\left(\pi_t^N\right)^{1-\theta^N}-\alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N}}{1-\alpha_N}\right)^{\frac{1}{1-\theta^N}}-\frac{\theta^N}{\theta^N-1}\frac{e_{t+j}}{p_{t+j}^N}\pi_{t+j}^N\right\}. \end{aligned}$$

Appendix 2: The recursive versions of the Phillips equations

In order to implement practically the nonlinear Phillips equations it is necessary to get rid of the infinite summations. In this Appendix I reformulate them recursively.

Domestic inflation

First, rewrite (136) as:

$$\left(\frac{(\pi_t)^{1-\theta} - \alpha_D (\pi_{t-1})^{1-\theta}}{1-\alpha_D}\right)^{\frac{1}{1-\theta}} \Gamma_t^D = \Psi_t^D. \tag{137}$$

where

$$\begin{aligned}
\Gamma_t^D &= E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{D\circ} q_{t+j} (\pi_{t+j})^{\theta-1}, \\
\Psi_t^D &= \frac{\theta}{\theta-1} E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{\circ} q_{t+j} (\pi_{t+j})^{\theta} mc_{t+j}.
\end{aligned}$$

Second, note that the infinite sums involved in the definitions of Γ_t^D and Ψ_t^D can be written recursively:

$$\begin{aligned}
& E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{D\circ} q_{t+j} (\pi_{t+j})^{\theta-1} \\
= \; & \overline{\Lambda}_t^{D\circ} q_t (\pi_t)^{\theta-1} + E_t \sum_{j=1}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{D\circ} q_{t+j} (\pi_{t+j})^{\theta-1} \\
= \; & \overline{\Lambda}_t^{D\circ} q_t (\pi_t)^{\theta-1} + \beta\alpha E_{t+1} \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+1+j}^{D\circ} q_{t+1+j} (\pi_{t+1+j})^{\theta-1},
\end{aligned}$$

$$\begin{aligned}
& \frac{\theta}{\theta-1} E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{D\circ} q_{t+j} (\pi_{t+j})^{\theta} mc_{t+j} \\
= \; & \frac{\theta}{\theta-1} \overline{\Lambda}_t^{D\circ} q_t (\pi_t)^{\theta} mc_t + \frac{\theta}{\theta-1} E_t \sum_{j=1}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+j}^{D\circ} q_{t+j} (\pi_{t+j})^{\theta} mc_{t+j} \\
= \; & \frac{\theta}{\theta-1} \overline{\Lambda}_t^{D\circ} q_t (\pi_t)^{\theta} mc_t + \frac{\theta}{\theta-1} \beta\alpha E_{t+1} \sum_{j=0}^{\infty} (\beta\alpha)^j \overline{\Lambda}_{t+1+j}^{D\circ} q_{t+1+j} (\pi_{t+1+j})^{\theta} mc_{t+1+j}
\end{aligned}$$

i.e.,

$$\begin{aligned}
\Gamma_t^D &= \overline{\Lambda}_t^{\circ} q_t (\pi_t)^{\theta-1} + \beta\alpha \Gamma_{t+1}^D \\
\Psi_t^D &= \frac{\theta}{\theta-1} \overline{\Lambda}_t^{\circ} q_t (\pi_t)^{\theta} + \beta\alpha \Psi_{t+1}^D.
\end{aligned}$$

Third, using the definition of $\overline{\Lambda}_{t+j}$ (51):

$$\overline{\Lambda}_t^{D\circ} = \overline{\Lambda}_t^D z_t = \lambda_t \widetilde{\varphi}_M (1+i_t) z_t = \lambda_t^{\circ} \widetilde{\varphi}_t^M,$$

I can now rewrite the definitions of Γ_t^D and Ψ_t^D as well as their recursive formulations in terms of the system's variables:

$$\begin{aligned}
\Gamma_t^D &= E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \lambda_{t+j}^{\circ} \widetilde{\varphi}_{t+j}^M q_{t+j} (\pi_{t+j})^{\theta-1}, \\
\Psi_t^D &= \frac{\theta}{\theta-1} E_t \sum_{j=0}^{\infty} (\beta\alpha)^j \lambda_{t+j}^{\circ} \widetilde{\varphi}_{t+j}^M q_{t+j} (\pi_{t+j})^{\theta} mc_{t+j}.
\end{aligned}$$

$$\Gamma_t^D = \lambda_t^\circ \widetilde{\varphi}_t^M q_t \left(\pi_t\right)^{\theta-1} + \beta\alpha E_t \Gamma_{t+1}^D. \tag{138}$$

$$\Psi_t^D = \frac{\theta}{\theta-1} \lambda_t^\circ \widetilde{\varphi}_t^M q_t \left(\pi_t\right)^{\theta} mc_t + \beta\alpha E_t \Psi_{t+1}^D. \tag{139}$$

Finally, note that (137) can be written as:

$$\pi_t = \left[\alpha_D \left(\pi_{t-1}\right)^{1-\theta} + \left(1-\alpha_D\right)\left(\frac{\Psi_t^D}{\Gamma_t^D}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{140}$$

The last 3 equations conform the recursive formulation of the Phillips equation that I use for the non-linear system. The last equation is grouped with the static equations and the first two with the dynamic equations.

Wage inflation

In the case of wage inflation, write:

$$0 = E_t \sum_{j=0}^{\infty} \left(\beta\alpha_W\right)^j \lambda_{t+j}^\circ h_{t+j} \overline{w}_{t+j} \left(\pi_{t+j}^W\right)^{\psi_t - 1}$$
$$\left\{ \left(\frac{\left(\pi_t^W\right)^{1-\theta} - \alpha_W \left(\pi_{t-1}^W\right)^{1-\theta}}{1-\alpha_W} \right)^{\frac{1+\psi_t\chi}{1-\theta}} - \frac{\psi}{\psi-1} \frac{\eta z_{t+j}^H \left(h_{t+j}\right)^\chi}{\lambda_{t+j}^\circ \overline{w}_{t+j}} \left(\pi_{t+j}^W\right)^{1+\psi_t\chi} \right\}.$$

in the form:

$$\left(\frac{\left(\pi_t^W\right)^{1-\psi} - \alpha_W \left(\pi_{t-1}^W\right)^{1-\psi}}{1-\alpha_W} \right)^{\frac{1+\psi\chi}{1-\psi}} \Gamma_t^W = \Psi_t^W. \tag{141}$$

where

$$\begin{aligned}
\Gamma_t^W &= E_t \sum_{j=0}^{\infty} \left(\beta\alpha_W\right)^j \lambda_{t+j}^\circ h_{t+j} \overline{w}_{t+j} \left(\pi_{t+j}^W\right)^{\psi-1}, \\
\Psi_t^W &= \frac{\psi}{\psi-1} E_t \sum_{j=0}^{\infty} \left(\beta\alpha_W\right)^j \lambda_{t+j}^\circ h_{t+j} \overline{w}_{t+j} \left(\pi_{t+j}^W\right)^{\psi-1} \frac{\eta z_{t+j}^H \left(h_{t+j}\right)^\chi}{\lambda_{t+j}^\circ \overline{w}_{t+j}} \left(\pi_{t+j}^W\right)^{1+\psi\chi} \\
&= \frac{\psi}{\psi-1} E_t \sum_{j=0}^{\infty} \left(\beta\alpha_W\right)^j \eta z_{t+j}^H \left(h_{t+j}\right)^{1+\chi} \left(\pi_{t+j}^W\right)^{\psi(1+\chi)}.
\end{aligned}$$

Second, the recursive versions of the infinite sums involved in the definitions of Γ_t and Ψ_t are:

$$\begin{aligned}
& E_t \sum_{j=0}^{\infty} \left(\beta\alpha_W\right)^j \lambda_{t+j}^\circ h_{t+j} \overline{w}_{t+j} \left(\pi_{t+j}^W\right)^{\psi-1} \\
= \; & \lambda_t^\circ h_t \overline{w}_t \left(\pi_t^W\right)^{\psi-1} + E_t \sum_{j=1}^{\infty} \left(\beta\alpha\right)^j \lambda_{t+j}^\circ h_{t+j} \overline{w}_{t+j} \left(\pi_{t+j}^W\right)^{\psi-1} \\
= \; & \lambda_t^\circ h_t \overline{w}_t \left(\pi_t^W\right)^{\psi-1} + \beta\alpha E_{t+1} \sum_{j=0}^{\infty} \left(\beta\alpha\right)^j \lambda_{t+1+j}^\circ h_{t+1+j} \overline{w}_{t+1+j} \left(\pi_{t+1+j}^W\right)^{\psi-1},
\end{aligned}$$

$$\frac{\psi}{\psi-1}E_t\sum_{j=0}^{\infty}(\beta\alpha_W)^j\,\eta z_{t+j}^H\,(h_{t+j})^{1+\chi}\left(\pi_{t+j}^W\right)^{\psi(1+\chi)}$$

$$= \frac{\psi}{\psi-1}\eta z_t^H\,(h_t)^{1+\chi}\left(\pi_t^W\right)^{\psi(1+\chi)}+\frac{\psi}{\psi-1}E_t\sum_{j=1}^{\infty}(\beta\alpha_W)^j\,\eta z_{t+j}^H\,(h_{t+j})^{1+\chi}\left(\pi_{t+j}^W\right)^{\psi(1+\chi)}$$

$$= \frac{\psi}{\psi-1}\eta z_t^H\,(h_t)^{1+\chi}\left(\pi_t^W\right)^{\psi(1+\chi)}+\beta\alpha_W\frac{\psi}{\psi-1}E_{t+1}\sum_{j=0}^{\infty}(\beta\alpha_W)^j\,\eta z_{t+1+j}^H\,(h_{t+1+j})^{1+\chi}\left(\pi_{t+1+j}^W\right)^{\psi(1+\chi)}$$

i.e.,

$$\begin{aligned}\Gamma_t^W &= \lambda_t^\circ h_t\overline{w}_t\left(\pi_t^W\right)^{\psi-1}+\beta\alpha_W E_t\Gamma_{t+1}^W\\ \Psi_t^W &= \frac{\psi}{\psi-1}\eta z_t^H\,(h_t)^{1+\chi}\left(\pi_t^W\right)^{\psi(1+\chi)}+\beta\alpha_W E_t\Psi_{t+1}^W.\end{aligned}$$

Finally, (141) can be written as:

$$\pi_t^W=\left[\alpha_W\left(\pi_{t-1}^W\right)^{1-\psi}+(1-\alpha_W)\left(\frac{\Psi_t^W}{\Gamma_t^W}\right)^{\frac{1-\psi}{1+\psi\chi}}\right]^{\frac{1}{1-\psi}}.$$

Imported goods inflation

In the case of imported goods inflation:

$$\begin{aligned}0 &= E_t\sum_{j=0}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+j}^{N\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N-1}\\ &\quad\times\left\{\left(\frac{\left(\pi_t^N\right)^{1-\theta^N}-\alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N}}{1-\alpha_N}\right)^{\frac{1}{1-\theta^N}}-\frac{\theta^N}{\theta^N-1}\frac{e_{t+j}}{p_{t+j}^N}\pi_{t+j}^N\right\}\end{aligned}$$

becomes

$$\left(\frac{\left(\pi_t^N\right)^{1-\theta^N}-\alpha_N\left(\pi_{t-1}^N\right)^{1-\theta^N}}{1-\alpha_N}\right)^{\frac{1}{1-\theta^N}}\Gamma_t^N=\Psi_t^N. \tag{142}$$

where

$$\begin{aligned}\Gamma_t^N &= E_t\sum_{j=0}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+j}^{N\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N-1}\\ \Psi_t^N &= \frac{\theta^N}{\theta^N-1}E_t\sum_{j=0}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+j}^{N\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N}\frac{e_{t+j}}{p_{t+j}^N}\end{aligned}$$

The recursions are:

$$E_t\sum_{j=0}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+j}^{\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N-1}$$

$$= \overline{\Lambda}_t^{N\circ}n_t(\pi_t^N)^{\theta^N-1}+E_t\sum_{j=1}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+j}^{N\circ}n_{t+j}(\pi_{t+j}^N)^{\theta^N-1}$$

$$= \overline{\Lambda}_t^{N\circ}n_t(\pi_t^N)^{\theta^N-1}+\beta\alpha_N E_{t+1}\sum_{j=0}^{\infty}(\beta\alpha_N)^j\,\overline{\Lambda}_{t+1+j}^{N\circ}n_{t+1+j}(\pi_{t+1+j}^N)^{\theta^N-1},$$

$$
\begin{aligned}
& \frac{\theta^N}{\theta^N-1} E_t \sum_{j=0}^{\infty} (\beta\alpha_N)^j \, \overline{\Lambda}_{t+j}^{N\circ} n_{t+j} (\pi_{t+j}^N)^{\theta^N} \frac{e_{t+j}}{p_{t+j}^N} \\
= & \frac{\theta^N}{\theta^N-1} \overline{\Lambda}_t^{N\circ} n_t (\pi_t^N)^{\theta^N} \frac{e_t}{p_t^N} + \frac{\theta^N}{\theta^N-1} E_t \sum_{j=1}^{\infty} (\beta\alpha_N)^j \, \overline{\Lambda}_{t+j}^{N\circ} n_{t+j} (\pi_{t+j}^N)^{\theta^N} \frac{e_{t+j}}{p_{t+j}^N} \\
= & \frac{\theta^N}{\theta^N-1} \overline{\Lambda}_t^{\circ} n_t (\pi_t^N)^{\theta^N} \frac{e_t}{p_t^N} + \beta\alpha_N \frac{\theta^N}{\theta^N-1} E_{t+1} \sum_{j=0}^{\infty} (\beta\alpha_N)^j \, \overline{\Lambda}_{t+1+j}^{\circ} n_{t+1+j} (\pi_{t+1+j}^N)^{\theta^N} \frac{e_{t+1+j}}{p_{t+1+j}^N}
\end{aligned}
$$

i.e.,

$$
\begin{aligned}
\Gamma_t^N &= \overline{\Lambda}_t^{N\circ} n_t (\pi_t^N)^{\theta^N-1} + \beta\alpha_N \Gamma_{t+1}^N \\
\Psi_t^N &= \frac{\theta^N}{\theta^N-1} \overline{\Lambda}_t^{N\circ} n_t (\pi_t^N)^{\theta^N} \frac{e_t}{p_t^N} + \beta\alpha_N \Psi_{t+1}^N .
\end{aligned}
$$

Third, using the definition of $\overline{\Lambda}_{t+j}$ (64):

$$
\overline{\Lambda}_t^{N\circ} = \overline{\Lambda}_t^N z_t = \lambda_t \widetilde{\varphi}_M (1+i_t) \, p_t^N z_t = \lambda_t^{\circ} \widetilde{\varphi}_t^M p_t^N ,
$$

I rewrite the definitions of Γ_t^N and Ψ_t^N as well as their recursive formulations in terms of the system's variables:

$$
\begin{aligned}
\Gamma_t^N &= \lambda_t^{\circ} \widetilde{\varphi}_t^M p_t^N n_t (\pi_t^N)^{\theta^N-1} + \beta\alpha_N E_t \Gamma_{t+1}^N \\
\Psi_t^N &= \frac{\theta^N}{\theta^N-1} \lambda_t^{\circ} \widetilde{\varphi}_t^M p_t^N n_t (\pi_t^N)^{\theta^N} \frac{e_t}{p_t^N} + \beta\alpha_N E_t \Psi_{t+1}^N .
\end{aligned}
$$

Finally, (142) can be written as:

$$
\pi_t^N = \left[\alpha_N \left(\pi_{t-1}^N\right)^{1-\theta^N} + (1-\alpha_N) \left(\frac{\Psi_t^N}{\Gamma_t^N} \right)^{1-\theta^N} \right]^{\frac{1}{1-\theta^N}} . \tag{143}
$$

Appendix 3. The log-linear system of equations

In this Appendix I list the log-linear approximation of the system equations. The complete set of nonlinear equations are in Appendix 1.

Interest rate feedback rule:

$$
\widehat{i}_t = h_0 \widehat{i}_{t-1} + h_1 \widehat{\widetilde{\pi}}_t^C + h_2 \widehat{y}_t + h_3 \widehat{tbr}_t + h_4 \widehat{tbr}_{t-1} .
$$

(or, alternatively) AR Central Bank bond policy:

$$
\widehat{b}_t^{CB} = \rho^{\delta} \widehat{b}_{t-1}^{CB} + \left(1-\rho^{\delta}\right) \widehat{b}^{CB} + \varepsilon_t^{b^{CB}}
$$

(or, alternatively) AR Central Bank international reserves policy:

$$
\widehat{e}_t + \widehat{r}_t^{*CB} = \rho^{r^{CB}} \left(\widehat{e}_{t-1} + \widehat{r}_{t-1}^{*CB} \right) + \left(1-\rho^{r^{CB}}\right) \widehat{y}_t + \varepsilon_t^{r^{CB}}
$$

Nominal depreciation feedback rule:

$$
\widehat{\delta}_t = k_0 \widehat{\delta}_{t-1} + k_1 \widehat{\widetilde{\pi}}_t^C + k_2 \widehat{y}_t + k_3 \widehat{tbr}_t + k_4 \widehat{tbr}_{t-1} + k_5 \left(\widehat{e}_t + \widehat{r}_t^{*CB} - \widehat{y}_t \right) + \varepsilon_t^{\delta}
$$

(or, alternatively) AR Nominal depreciation rule:

$$\widehat{\delta}_t = \rho^{\delta}\widehat{\delta}_{t-1} + \left(1-\rho^{\delta}\right)\delta^T + \varepsilon_t^{\delta}$$

(or, alternatively, and if not used above) AR Central Bank international reserves policy:

$$\widehat{e}_t + \widehat{r}_t^{*CB} = \rho^{r^{CB}}\left(\widehat{e}_{t-1} + \widehat{r}_{t-1}^{*CB}\right) + \left(1-\rho^{r^{CB}}\right)\widehat{y}_t + \varepsilon_t^{r^{CB}}$$

Balance of Payments:

$$\begin{aligned}\gamma_1^{BP}\widehat{r}_t^{*CB} + \gamma_2^{BP}\left(\widehat{i}_{t-1}^{G} + \widehat{b}_{t-1}^{*G}\right) + \gamma_3^{BP}\left(\widehat{i}_{t-1}^{B} + \widehat{b}_{t-1}^{*B}\right)\\ = \gamma_4^{BP}\widehat{tb}_t + \gamma_5^{BP}\widehat{b}_t^{*G} + \gamma_6^{BP}\widehat{b}_t^{*B} + \gamma_7^{BP}\left(\widehat{i}_{t-1}^{**} + \widehat{r}_{t-1}^{*CB}\right) - \gamma_8^{BP}\left(\widehat{\mu}_t^{z} + \widehat{\pi}_t^{**N}\right)\end{aligned}$$

Trade balance:

$$\widehat{tb}_t = \left(\gamma^{TB}+1\right)\left(\widehat{x}_t + \widehat{p}_{4t}^{**} - \widehat{e}_t + \widehat{e}_{t-1} - \widehat{\widetilde{\pi}}_t + \widehat{\widetilde{\delta}}_t\right) - \gamma^{TB}\widehat{n}_t \tag{144}$$

Imports:

$$\widehat{n}_t + \widehat{p}_t^{N} = \gamma^{N}\left(\widehat{c}_t + \widehat{p}_t^{C}\right) + \left(1-\gamma^{N}\right)\left(\widehat{h} + \widehat{\overline{w}}_t\right)$$

Central Bank balance:

$$a^{CB}\widehat{b}_t^{CB} + \left(1-a^{CB}\right)\widehat{m}_t^{0} = \widehat{r}_t^{*CB} + \widehat{e}_t$$

Government foreign debt interest rate:

$$\widehat{i}_t^{G} = \widehat{i}_t^{**} + \widehat{\phi}_t^{**G} + a^{G}\left(\widehat{e}_t + \left(b^{G}+1\right)\widehat{b}_t^{*G} - b^{G}\widehat{r}_t^{*CB} - \widehat{y}_t\right)$$

Fiscal:

$$\begin{aligned}\gamma_1^{F}\left(\widehat{b}_t^{*G} + \widehat{e}\right) + \gamma_2^{F}\left[\left(a_1^{F}+1\right)\widehat{i}_{t-1}^{**} + a_1^{F}\widehat{\delta}_t^{**} + \widehat{r}_{t-1}^{*CB} + \widehat{e}_t\right] + \gamma_3^{F}\widehat{t}_t\\ = \gamma_4^{F}\left(\widehat{i}_{t-1}^{G} + \widehat{b}_{t-1}^{*G} + \widehat{e}\right) + \gamma_5^{F}\left(\widehat{i}_{t-1} + \widehat{b}_{t-1}^{CB} - \widehat{\mu}_t^{z} - \widehat{\pi}\right) + \gamma_6^{F}\widehat{g}_t - \gamma_7^{F}\left(\widehat{\mu}_t^{z} + \widehat{\pi}_t^{**N}\right)\end{aligned}$$

Bank foreign debt interest rate:

$$\widehat{i}_t^{B} = \widehat{i}_t^{**} + \widehat{\phi}_t^{**B} + a^{B}\left(\widehat{e}_t + \widehat{b}_t^{*B} - \widehat{y}_t\right) \tag{145}$$

Real marginal cost:

$$\widehat{mc}_t = b^{D}\widehat{\overline{w}}_t + \left(1-b^{D}\right)\widehat{p}_t^{N} + \gamma_1^{MC}\widehat{i}_{t-1}^{L} + \gamma_2^{MC}\widehat{\varsigma}_t - \widehat{\epsilon}_t \tag{146}$$

Labor market clearing:

$$\widehat{h}_t = \left(1-b^{D}\right)\left(\widehat{p}_t^{N} - \widehat{\overline{w}}_t\right) + \widehat{q}_t - \widehat{\epsilon}_t \tag{147}$$

Domestic goods market clearing:

$$\begin{aligned}\widehat{q}_t \;=\; & \gamma_1^{Q}\left(\widehat{c}_t + \widehat{p}_t^{C} + b^{Q}\widehat{\widetilde{\tau}}_t^{M}\right) + \gamma_2^{Q}\frac{1}{1-b^{A}}\left(\widehat{e}_t + \widehat{p}_t^{**}\right) \\ & + \gamma_3^{Q}\left(\widehat{i}_t^{L} - \widehat{i}_t\right) + \gamma_4^{Q}\widehat{g}_t\end{aligned} \tag{148}$$

Real GDP:

$$a_1^Y \widehat{y}_t + \left(1 - a_1^Y\right)\left(\widehat{p}_t^N + \widehat{n}_t\right) = a_2^Y\left(\widehat{c}_t + \widehat{p}_t^C\right) + a_3^Y \widehat{g}_t + \left(1 - a_2^Y - a_3^Y\right)\left(\widehat{x}_t + \widehat{p}_{4t}^{**} + \widehat{e}_{4t} - \widehat{\widetilde{\pi}}_t\right) \tag{149}$$

Consumption relative price:

$$\widehat{p}_t^C = a_{PC}\widehat{p}_t^N \tag{150}$$

Consumption MRER:

$$\widehat{e}_t^C = \widehat{e}_t - \widehat{p}_t^C$$

Money market clearing:

$$\widehat{m}_t^0 = \widehat{c}_t + \widehat{p}_t^C - \alpha^M \widehat{i}_t$$

Transaction costs related marginal consumption expenditure multiplier:

$$\widehat{\widetilde{\varphi}}_t^M = \alpha^\varphi \widehat{i}_t$$

Transaction costs related consumption expenditure markup:

$$\widehat{\widetilde{\tau}}_t^M = \alpha^\tau \widehat{i}_t$$

Loans:

$$\widehat{\ell}_t = \left(1 + \gamma^L\right) i_t^L - \gamma^L i_t$$

Deposits:

$$\gamma_1^D \widehat{d}_t + \gamma_2^D \widehat{e}_t + \left(1 - \gamma_1^D - \gamma_2^D\right) b_t^{*B} = \gamma_3^D \widehat{b}_t^{CB} + \left(1 - \gamma_3^D\right)\widehat{\ell}_t$$

Productivity growth:

$$\widehat{\mu}_t^z = \rho^{\mu^z}\widehat{\mu}_{t-1}^z + \left(1 - \rho^{\mu^z}\right)\widehat{\mu}_{t-1}^{z**} + \alpha_{\mu^z}\widehat{z}_{t-1}^\circ + \varepsilon_t^{\mu^z} \tag{151}$$

Domestic inflation Phillips equation (static part):

$$\widehat{\pi}_t - \alpha_D \widehat{\pi}_{t-1} = (1 - \alpha_D)\left(\widehat{\Psi}_t^D - \widehat{\Gamma}_t^D\right)$$

Wage inflation Phillips equation (static part):

$$\pi_t^W - \alpha_W \pi_{t-1}^W = (1 - \alpha_W)\left(\widehat{\Psi}_t^W - \widehat{\Gamma}_t^W\right)$$

Imported goods inflation Phillips equation (static part):

$$\pi_t^N - \alpha_N \pi_{t-1}^N = (1 - \alpha_N)\left(\widehat{\Psi}_t^N - \widehat{\Gamma}_t^N\right)$$

Identities:

$$\widehat{z}_t^\circ = \widehat{z}_{t-1}^\circ + \widehat{\mu}_t^{z**} - \widehat{\mu}_t^z \tag{152}$$

$$\widehat{e}_t = \widehat{e}_{t-1} + \widehat{\delta}_t - \widehat{\pi}_t + \widehat{\pi}_t^{**N} \tag{153}$$

$$\widehat{\pi}_t^C = \widehat{\pi}_t + \widehat{p}_t^C - \widehat{p}_{t-1}^C$$

$$\widehat{\overline{w}}_t = \widehat{\overline{w}}_{t-1} + \widehat{\pi}_t^W - \widehat{\pi}_t - \widehat{\mu}_t^z$$
$$\widehat{p}_t^N = \widehat{p}_{t-1}^N + \widehat{\pi}_t^N - \widehat{\pi}_t \tag{154}$$

Exports:

$$\widehat{x}_t = \frac{b^A}{1-b^A}\left(\widehat{e}_{t-4} + \widehat{p}_{t-4}^{**}\right) - \widehat{\widetilde{\mu}}_t^z + \widehat{z}_t^A.$$

Trade Balance ratio:

$$\widehat{tbr}_t = \widehat{e}_t + \widehat{tb}_t - \widehat{y}_t$$

Auxiliary:

$$\widehat{\widetilde{\pi}}_t = \widehat{\pi}_t + \widehat{\pi}_{t-1} + \widehat{\pi}_{1,t-1} + \widehat{\pi}_{2,t-1}, \qquad \widehat{\pi}_{1,t} = \widehat{\pi}_{t-1}, \quad \widehat{\pi}_{2,t} = \widehat{\pi}_{1-1}, \quad \widehat{\pi}_{3,t} = \widehat{\pi}_{2,t-1}$$

$$\widehat{\widetilde{\pi}}_t^C = \widehat{\pi}_t^C + \widehat{\pi}_{t-1}^C + \widehat{\pi}_{1,t-1}^C + \widehat{\pi}_{2,t-1}^C, \qquad \widehat{\pi}_{1,t}^C = \widehat{\pi}_{t-1}^C, \quad \widehat{\pi}_{2,t}^C = \widehat{\pi}_{1,t-1}^C, \quad \widehat{\pi}_{3,t}^C = \widehat{\pi}_{2,t-1}^C$$

$$\widehat{\widetilde{\delta}}_t = \widehat{\delta}_t + \widehat{\delta}_{t-1} + \widehat{\delta}_{1,t-1} + \widehat{\delta}_{2,t-1}, \qquad \widehat{\delta}_{1,t} = \widehat{\delta}_{t-1}, \quad \widehat{\delta}_{2,t} = \widehat{\delta}_{1-1}, \quad \widehat{\delta}_{3,t} = \widehat{\delta}_{2,t-1}$$

$$\widehat{\widetilde{\mu}}_t^z = \widehat{\mu}_t^z + \widehat{\mu}_{t-1}^z + \widehat{\mu}_{1,t-1}^z + \widehat{\mu}_{2,t-1}^z, \qquad \widehat{\mu}_{1,t}^z = \widehat{\mu}_{t-1}^z, \quad \widehat{\mu}_{2,t}^z = \widehat{\mu}_{1,t-1}^z, \quad \widehat{\mu}_{3,t}^z = \widehat{\mu}_{2,t-1}^z$$

$$\widehat{e}_{1t} = \widehat{e}_{t-1}, \quad \widehat{e}_{2,t} = \widehat{e}_{1,t-1}, \quad \widehat{e}_{3,t} = \widehat{e}_{2,t-1}, \quad \widehat{e}_{4,t} = \widehat{e}_{3,t-1}.$$

$$\widehat{p}_{0,t}^{**} = \widehat{p}_t^{**}, \quad \widehat{p}_{1,t}^{**} = \widehat{p}_{0,t-1}^{**}, \quad \widehat{p}_{2,t}^{**} = \widehat{p}_{1,t-1}^{**}, \quad \widehat{p}_{3,t}^{**} = \widehat{p}_{2,t-1}^{**}, \quad \widehat{p}_{4,t}^{**} = \widehat{p}_{3,t-1}^{**}.$$

Dynamics of Consumption:

$$(1+a_C)\left\{\widehat{\mu}_t^z + \widehat{z}_t^C - \left[(1+\alpha_C)\left(\widehat{c}_t + \widehat{\mu}_t^z\right) - \alpha_C \widehat{c}_{t-1}\right]\right\} \tag{155}$$
$$-a_C\left\{E_t\widehat{z}_{t+1}^C - \left[(1+\alpha_C)E_t\left(\widehat{c}_{t+1} + \widehat{\mu}_{t+1}^z\right) - \alpha_C\widehat{c}_t\right]\right\} = \widehat{\lambda}_t^\circ + \widehat{\widetilde{\varphi}}_t^M + \widehat{p}_t^C$$

Marginal utility of real income:

$$\widehat{\lambda}_t^\circ = E_t\left(\widehat{\lambda}_{t+1}^\circ - \widehat{\pi}_{t+1} - \widehat{\mu}_{t+1}^z\right) + \widehat{i}_t$$

Risk-adjusted uncovered interest parity:

$$\widehat{i}_t = \gamma_1^B E_t\widehat{\delta}_{t+1} + \gamma_2^B\left[\widehat{i}_t^{**} + \widehat{\phi}_t^{**B} + \overline{a}^{RP}\left(\widehat{e}_t + \widehat{b}_t^{*B} - \widehat{y}_t\right)\right] \tag{156}$$

Loan market clearing:

$$\widehat{i}_t^L = \gamma^L\widehat{i}_t + \left(1-\gamma^L\right)\left[E_t\left(\widehat{\mu}_{t+1}^z + \widehat{\overline{w}}_{t+1} + \widehat{h}_{t+1}\right) + \widehat{\varsigma}_t\right]. \tag{157}$$

Government tax collection policy:

$$\widehat{t}_t = \rho^t E_t\widehat{t}_{t+1}, \qquad \left(\rho^t > 1\right)$$

Real interest rate:

$$\widehat{r}_t = \widehat{i}_t - E_t\widehat{\pi}_{t+1}$$

Domestic inflation Phillips equation (dynamic part):

$$\widehat{\Gamma}_t^D = \gamma^D\left[\widehat{\lambda}_t^\circ + \widehat{\widetilde{\varphi}}_t^M + \widehat{q}_t + (\theta-1)\widehat{\pi}_t\right] + \left(1-\gamma^D\right)E_t\widehat{\Gamma}_{t+1}^D.$$

$$\widehat{\Psi}_t^D = \varsigma^D \left[\widehat{\lambda}_t^\circ + \widehat{\widetilde{\varphi}}_t^M + \widehat{q}_t + \theta\widehat{\pi}_t + \widehat{mc}_t\right] + \left(1-\varsigma^D\right) E_t\widehat{\Psi}_{t+1}^D.$$

Wage inflation Phillips equation (dynamic part):

$$\begin{aligned}
\widehat{\Gamma}_t^W &= \gamma^W \left[\widehat{\lambda}_t^\circ + \widehat{h}_t + \widehat{\overline{w}}_t + (\psi-1)\,\widehat{\pi}_t^W\right] + \left(1-\gamma^W\right) E_t\widehat{\Gamma}_{t+1}^W \\
\widehat{\Psi}_t^W &= \varsigma^W \left[\widehat{z}_t^H + (1+\chi)\,\widehat{h}_t + \psi\,(1+\chi)\,\widehat{\pi}_t^W\right] + \left(1-\varsigma^W\right) E_t\widehat{\Psi}_{t+1}^W.
\end{aligned}$$

Imported goods inflation Phillips equation (dynamic part):

$$\begin{aligned}
\widehat{\Gamma}_t^N &= \gamma^N \left[\widehat{\lambda}_t^\circ + \widehat{\widetilde{\varphi}}_t^M + \widehat{p}_t^N + \widehat{n}_t + \left(\theta^N - 1\right)\widehat{\pi}_t^N)\right] + \left(1-\gamma^N\right) E_t\widehat{\Gamma}_{t+1}^N \\
\widehat{\Psi}_t^N &= \varsigma^N \left[\widehat{\lambda}_t^\circ + \widehat{\widetilde{\varphi}}_t^M + \widehat{p}_t^N + \widehat{n}_t + \theta^N\widehat{\pi}_t^N + \left(\widehat{e}_t - \widehat{p}_t^N\right)\right] + \left(1-\varsigma^N\right) E_t\widehat{\Psi}_{t+1}^N.
\end{aligned}$$

Note that the static and dynamic parts of the log-linear Phillips equations can be collapsed to the usual reduced form equations:

Wage inflation Phillips equation:

$$\widehat{\pi}_t^W - \widehat{\pi}_{t-1}^W = \beta E_t\left(\widehat{\pi}_{t+1}^W - \widehat{\pi}_t^W\right) + \frac{(1-\alpha_W)(1-\beta\alpha_W)}{\alpha_W(1+\psi\chi)}\left(\chi\widehat{h}_t + \widehat{z}_t^H - \widehat{\lambda}_t^\circ - \widehat{\overline{w}}_t\right) \quad (158)$$

Domestic inflation Phillips equation:

$$\widehat{\pi}_t - \widehat{\pi}_{t-1} = \beta\left(E_t\widehat{\pi}_{t+1} - \widehat{\pi}_t\right) + \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}\widehat{mc}_t \quad (159)$$

Imported goods inflation Phillips equation:

$$\widehat{\pi}_t^N - \widehat{\pi}_{t-1}^N = \beta\left(E_t\widehat{\pi}_{t+1}^N - \widehat{\pi}_t^N\right) + \frac{(1-\alpha_N)(1-\alpha_N\beta)}{\alpha_N}\left(\widehat{e}_t - \widehat{p}_t^N\right) \quad (160)$$

However, for future second order approximations it is useful to have the recursive Phillips equations, so I maintain them throughout.

Appendix 4. Model parameters and great ratios

The non-policy benchmark parameters and great ratios of the model are in Table A1 below. Parameters followed by (**) are those that are estimated. All values followed by (*) are imposed. The remaining steady state values of endogenous variables or great ratios and values for parameters are derived from imposed or estimated values.

Table A1

Steady state values of variables, great ratios and parameters

REST OF THE WORLD		
Risk-free interest rate	i^{**}	$1.06^{0.25} - 1$
Inflation (*)	π^{**}, π^{**N}	$1.023^{0.25}$
Productivity growth (*)	μ^{z**}	$1.033^{0.25}$
HOUSEHOLDS		
Intertemporal discount factor (*)	β	0.999
Inverse of labor supply elasticity (*)	χ	0.7
Share of domestic goods in consumption (*)	a_D	0.8610526316
Habit persistence (**)	ξ	0.8091
Labor parameter in utility	η	$4.06163527 \times 10^{-6}$
Probability of not optimizing wages (**)	α_W	0.5808
DOMESTIC SECTOR FIRMS		
Fraction of factors bill that is bank financed	ς	0.30537629
Production function parameter (**)	b^D	0.8903
Probability of not optimizing prices (**)	α_D	0.6133
PRIMARY SECTOR FIRMS		
Production function parameter (**)	b^A	0.0729
IMPORT SECTOR FIRMS		
Probability of not optimizing prices (**)	α_N	0.5889
EXOGENOUS GREAT RATIOS		
Government expenditures/GDP (*)	G/Y	0.16
Imports/GDP (*)	$p^N N/Y$	0.22
Cash/GDP (*)	m^0/Y	0.08
Loan/GDP (*)	ℓ/y	0.23
Central Bank bonds/GDP	b^{CB}/y	0.05
Bank Foreign debt/GDP (*)	eb^{*B}/y	0.0658
BANKS		
Foreign debt interest rate	i^B	0.020430244
Loan rate (*)	i^L	$1.12^{0.25} - 1$
Cost function parameter	b^B	$2.6471135748 \times 10^{-5}$
Foreign debt exogenous risk premium (*)	ϕ^{**B}	1.005
Foreign debt endogenous risk premium elasticity (*)	ε_B	1.15745156
Foreign debt endogenous risk premium parameter	α_1^B	0.00189918626
Foreign debt endogenous risk premium parameter	α_2^B	8.15334608955
MONEY DEMAND		
Transactions cost function interest elasticity (*)	ε_M	0.85
Transactions cost function parameter	a_M	1.04572957542459
Transactions cost function parameter	b_M	0.07222273891212
Transactions cost function parameter	c_M	−0.70487661051072
Money/consumption ratio	ϖ	0.08091690836698

Table 1 (continued)

POLICY		
Target inflation rate (*)	π^T	$1.065^{0.25}$
Target International Reserves/GDP (*)	γ^{CBT}	0.13
Target Gov. Debt/GDP (*)	γ^{GT}	0.20
OTHER RATES		
Central Bank bond interest rate	i	0.025172608
Nominal depreciation rate	δ	$1.041055718^{0.25}$
LEVEL		
GDP (*)	y	585.5
ELASTICITIES OF SUBSTITUTION		
ES for labor types (**)	ψ	7.3116
ES for domestic goods	θ	1.902214507
ES for imported goods (**)	θ^N	1.1754
ES between domestic and imported goods (**)	θ^C	0.9895
PRODUCTIVITY GROWTH		
Coef. on relative productivity level (**)	α_Z	0.0151
Persistence (**)	ρ^z	0.6733
GOVERNMENT		
Foreign debt exogenous risk premium (*)	ϕ^{**G}	1.005
Foreign debt endogenous risk premium elasticity (*)	ε_G	0.833397207
Foreign debt endogenous risk premium parameter	α_1^G	$6.006093674 \times 10^{-4}$
Foreign debt endogenous risk premium parameter	α_2^G	6.49377796598
PRODUCTIVITY GROWTH		
Coef. on relative productivity level (**)	α_Z	0.0151
Persistence (**)	ρ^{μ^z}	0.6733

Appendix 5. Analysis of the steady state and reference calibration of the parameters

The equations with all variables at their steady state levels

Underlying any consistent dynamic model is a static theory of how the macroeconomy functions in the 'long run'. In this appendix I consider this underlying theory implicit in ARGEMmy. For this, I first replace the stationary variables in the nonlinear equations by their non-stochastic steady state values (which I denote by the same variables without any time index). For simplicity, I normalize the consumption shock, the labor shock, the transitory technology shock, and the harvest shock to unity in the steady state: $z^C = z^H = \epsilon = z^A = 1$. I have assumed in section 2.8 that the technology levels and growth rates are the same in the SOE as in the RW ($z^\circ = 1$ and $\mu^z = \mu^{z**}$) so there is no need to now consider the new equations introduced there. The remaining model equations with the variables at their SS values are the following:

Interest rate feedback rule:

$$1 + i = \frac{\mu^{z**}\pi}{\beta}\left(\frac{\pi^C}{\pi^T}\right)^{\frac{4h_1}{1-h_0}} \tag{161}$$

(or, alternatively) AR Central Bank bond policy:

$$b^{CB} = b^{CB} \tag{162}$$

(or, alternatively) AR Central Bank international reserves policy:

$$\frac{er^{CB}}{y} = \gamma^{TBT}$$

Nominal depreciation feedback rule:

$$\delta = \left(\frac{\pi}{\pi^{**N}}\right)\left(\frac{\pi^{C}}{\pi^{T}}\right)^{\frac{4k_1}{1-k_0}}\left(\frac{er^{*CB}/y}{\gamma^{CBT}}\right)^{\frac{k_5}{1-k_0}}. \tag{163}$$

(or, alternatively) Nominal depreciation rule:

$$\delta = \delta^{T}$$

(or, alternatively if not used above) AR Central Bank international reserves policy:

$$\frac{er^{CB}}{y} = \gamma^{TBT}$$

Balance of Payments:

$$\frac{eb^{*G}}{y}\left[\frac{1+i^{G}}{\mu^{z**}\pi^{**N}}-1\right]+\frac{eb^{*B}}{y}\left[\frac{1+i^{B}}{\mu^{z**}\pi^{**N}}-1\right]-\frac{er^{*CB}}{y}\left[\frac{1+i^{**}}{\mu^{z**}\pi^{**N}}-1\right]=\frac{e}{y}tb \tag{164}$$

Trade Balance:

$$tb = \frac{p^{**}}{\left(\pi^{**N}\right)^{4}}x - n \tag{165}$$

Trade Balance ratio:

$$tbr = \frac{e}{y}tb$$

Exports:

$$x = \frac{z^{A}}{\left(\mu^{z}\right)^{4}}\left(b^{A}ep^{**}\right)^{\frac{b^{A}}{1-b^{A}}}. \tag{166}$$

Imports:

$$np^{N} = \left(1-a_{D}\right)p^{C}c + \frac{1-b^{D}}{b^{D}}\overline{w}h \tag{167}$$

Central Bank balance:

$$b^{CB} = er^{*CB} - m^{0}$$

Government foreign debt interest rate:

$$1+i^{G} = (1+i^{**})\phi^{**G}\left[1+\frac{\alpha_1^{G}}{1-\alpha_2^{G}e\left(b^{*G}-r^{*CB}\right)/y}\right] \tag{168}$$

Fiscal:

$$(t-g) = \left(\frac{1+i^{G}}{\mu^{z**}\pi^{**N}}-1\right)eb^{*G} - \left(\frac{1+i^{**}-1/\delta}{\mu^{z**}\pi^{**N}}\right)er^{*CB} + \frac{i}{\mu^{z**}\pi}b^{CB} \tag{169}$$

Bank foreign debt interest rate:

$$1+i^{B} = (1+i^{**})\phi^{**B}\left[1+\frac{\alpha_1^{B}}{1-\alpha_2^{B}eb^{*B}/y}\right] \tag{170}$$

Real marginal cost:

$$mc = \frac{1}{\kappa}\left(1+\varsigma i^L\right)\overline{w}^{b^D}\left(p^N\right)^{1-b^D} \tag{171}$$

Labor market clearing:

$$h = \frac{b^D}{\kappa}\left(\frac{p^N}{\overline{w}}\right)^{1-b^D} q. \tag{172}$$

Domestic goods market clearing:

$$q = \left[a_D + \widetilde{\tau}_M\right] p^C c + g + \left(b^A e p^{**}\right)^{\frac{1}{1-b^A}} + \frac{1}{2b^B}\left(i^L - i\right)^2 \tag{173}$$

Real GDP:

$$y = p^C c + g + \frac{ep^{**}}{\pi^4} x - p^N n \tag{174}$$

Consumption relative price:

$$p_t^C = \left[a_D + \left(1-a_D\right)\left(p_t^N\right)^{1-\theta^C}\right]^{\frac{1}{1-\theta^C}} \tag{175}$$

Consumption MRER:

$$e^C = \frac{e}{p^C}.$$

Money market clearing:

$$m^0 = \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i_t}}\right]^{\frac{1}{1+b_M}} p^C c$$

Transaction costs related marginal consumption expenditure multiplier:

$$\widetilde{\varphi}^M = 1 + c_M + \left(1+b_M\right)\left[\frac{b_M}{a_M + 1 - \frac{1}{1+i}}\right]^{\frac{-b_M}{1+b_M}}.$$

Transaction costs related consumption expenditure markup:

$$\widetilde{\tau}^M = a_M\left[\frac{b_M}{a_M + 1 - \frac{1}{1+i}}\right]^{\frac{1}{1+b_M}} + \left[\frac{b_M}{a_M + 1 - \frac{1}{1+i}}\right]^{\frac{-b_M}{1+b_M}} + c_M.$$

Loans:

$$\ell = \frac{1}{b^B}\left(i^L - i\right)$$

Deposits:

$$d = b^{CB} + \ell - eb^{*B}.$$

Productivity Growth:

$$\mu^z = \mu^{z**}$$

Identities:

$$\delta = \pi/\pi^{**N} \tag{176}$$

$$\pi^C = \pi, \qquad \pi^W = \pi\mu^z,$$

$$\pi^N = \pi, \qquad \mu^z = \mu^{z**} \tag{177}$$

$$\begin{aligned} \widetilde{\pi} &= \pi^4, & \widetilde{\pi}^C &= \left(\pi^C\right)^4, & \widetilde{\pi}^T &= \left(\pi^T\right)^4, \\ \widetilde{\pi}^{**N} &= \left(\pi^{**N}\right)^4, & \widetilde{\delta} &= \delta^4, & \widetilde{\mu}^z &= \left(\mu^z\right)^4. \end{aligned}$$

Dynamics of Consumption:

$$\lambda^\circ \widetilde{\varphi}_M (1+i) p^C c = \frac{\mu^{z**} - \beta\xi}{\mu^{z**} - \xi} \equiv \digamma > 1 \tag{178}$$

Marginal utility of real income:

$$\mu^{z**}\pi = \beta (1+i) \tag{179}$$

Risk-adjusted uncovered interest parity:

$$i = \delta \left\{ (1+i^{**}) \phi^{**B} \left[1 + \frac{\alpha_1^B}{\left(1 - \alpha_2^B e b^{*B}/y\right)^2} \right] - 1 \right\} \tag{180}$$

Loan market clearing:

$$i^L = i + \frac{b^B \varsigma}{b^D} \mu^{z**} \overline{w} h \tag{181}$$

Government tax collection policy:

$$t = t$$

Real interest rate:

$$r = \frac{1+i}{\pi}$$

Wage inflation Phillips equation:

$$\overline{w} = \frac{\psi}{\psi - 1} \frac{\eta h^\chi}{\lambda^\circ} \tag{182}$$

Domestic inflation Phillips equation:

$$1 = \frac{\theta}{\theta - 1} mc. \tag{183}$$

Imported inflation Phillips equation:

$$p^N = \frac{\theta^N}{\theta^N - 1} e \tag{184}$$

A first glance at these equations shows that several of the steady state variables are readily determined. All three domestic inflation rates for goods are equal and (179) gives the SS interest rate:

$$1 + i = \frac{\mu^{z**}\pi}{\beta}. \tag{185}$$

In the case of an interest rate feedback rule, combining this equation with (161) yields

$$\pi^C = \pi = \pi^N = \pi^T.$$

And using this and (176) in (163) shows that the Central Bank attains its foreign reserves target:

$$er^{*CB}/y = \gamma^{CBT}.$$

(183) shows that the real marginal cost in the domestic sector equals the inverse of the markup factor:

$$mc = \frac{\theta - 1}{\theta}. \tag{186}$$

Reference calibration of parameters and great ratios

In the rest of this section I build a reference calibration of the structural parameters and calculation of the NSS for ARGEMmy. I used this process as input to produce a MATLAB m-file that generates the non-stochastic steady state. When I use Dynare for Bayesian estimation this file interacts with the Dynare mod-file that implements the model. When I don't use Dynare, as in the analysis of optimal monetary and exchange policies, it becomes a substantial part of one of the main three m-files in which I organize my code.

In the construction of this m-file, however, many changes were introduced to better reflect my dogmatic priors. Hence, some of the calibrations below that appear imposed but for which I do not have strong priors were later made endogenous and made to depend on parameters that were estimated with Bayesian methods. Hence, many of the calibrations below are only illustrative of the procedure used in the calculation of the steady state.

The assumptions on the RW's variables are similar to those in ARGEM. Using annual rates, the SS gross growth rate is assumed to be $(\mu^{z**})^4 = 1.033$, and the foreign (export and "domestic") inflation rates are: $\left(\pi^{**N}\right)^4 = (\pi^{**})^4 = 1.023$. The riskfree nominal interest is assumed to be $(1 + i^{**})^4 = 1.06$ which implies a real (riskfree) annual interest rate of:

$$\left(\frac{1 + i^{**}}{\mu^{z**}\pi^{**}}\right)^4 = \frac{1.06}{1.033 * 1.023} = 1.003066924.$$

I also assume that the intertemporal discount rate is $\beta^4 = 0.999^4$, and that the SS detrended annual GDP level is 10% above the 2005 level (in billions of pesos and in terms of 1993 prices):

$$y = 532.270 * 1.10 = 585.5.$$

The calibrations that depend on the balance of payments or the banking system, however, must suffer some significant changes due to the simplifications in ARGEMmy vis a vis ARGEM. I use the Central Bank and Bank balance sheet constraints to calibrate the ratios to GDP of assets and liabilities:

$$\begin{aligned} \frac{er^{*CB}}{y} &= \frac{m^0}{y} + \frac{b^{CB}}{y} \\ 0.13 &= 0.08 + 0.05. \end{aligned}$$

$$\begin{aligned} \frac{b^{CB}}{y} + \frac{\ell}{y} &= \frac{eb^{*B}}{y} + \frac{d}{y} \\ 0.05 + 0.23 &= 0.0658 + 0.2142 \end{aligned}$$

The assumptions on Central Bank international reserves and peso cash is the same as in ARGEM (except that since banks do not hold cash here, households have all the cash). The same can be said for the assumption on loans to GDP (except that here firms obtain all the loans since the government does not receive bank credit) and on Banks' foreign debt to GDP. Hence, the ratio of Central Bank bonds to GDP must be 5%, which is somewhat larger than in ARGEM, and the deposits to GDP ratio is 21.42, slightly lower than in ARGEM.

In the SS the UIP condition (69) is:

$$\frac{\frac{i}{\delta}+1}{1+i^{**}} = \frac{\pi^{**N}\left(\frac{\mu^{z**}}{\beta}-\frac{1}{\pi}\right)+1}{1+i^{**}} = \phi^{**B}\left[1+\varphi_B\left(\frac{eb^{*B}}{y}\right)\right]. \tag{187}$$

Given the assumptions on μ^{z**}, β, i^{**}, and π^{**N}, it is readily seen that the minimum SS rate of inflation that guarantees a positive risk premium (i.e. the r.h.s. of (187) greater than one) is:

$$\begin{aligned} \pi &> \frac{1}{\frac{\mu^{z**}}{\beta}-\frac{i^{**}}{\pi^{**N}}} = \frac{1}{\frac{1.033^{0.25}}{0.999}-\frac{1.06^{0.25}-1}{1.023^{0.25}}} = 1.005461341, \\ \pi^4 &> 1.022024974. \end{aligned}$$

I choose a significantly larger SS inflation (more in line with the policy environment):

$$\pi^4 = 1.065, \qquad \pi = 1.015868285,$$

which implies that the annual nominal interest rate and nominal rate of currency depreciation are:

$$\begin{aligned} (1+i)^4 &= \left(\frac{\mu^{z**}\pi}{\beta}\right)^4 = 1.104556599, \qquad 1+i = 1.025172608 \\ \delta^4 &= \left(\frac{\pi}{\pi^{**N}}\right)^4 = 1.041055718, \qquad \delta = 1.010109588. \end{aligned}$$

The choice for SS inflation also implies that the value of the gross UIP risk premium is:

$$\begin{aligned} \phi^{**B}\left[1+\varphi_B\left(0.0658\right)\right] &= \frac{\frac{i}{\delta}+1}{1+i^{**}} \\ &= \frac{\frac{0.025172608}{1.010109588}+1}{1.06^{0.25}} = 1.010098638. \end{aligned} \tag{188}$$

I make the further assumption that in the SS the value of the exogenous component of the risk premium for banks as well as the government is half of a percentage point:

$$\begin{aligned} \left(\phi^{**B}\right)^4 &= \left(\phi^{**G}\right)^4 = 1.005 \\ \phi^{**B} &= \phi^{**G} = \left(1.005\right)^{0.25} = 1.001247663. \end{aligned} \tag{189}$$

Hence, using (99) yields:

$$\begin{aligned}\varphi_B\left(0.0658\right) &= \frac{\alpha_1^B}{\left(1-0.0658\alpha_2^B\right)^2} = \frac{1.010098638}{\phi^{**B}} - 1 \\ &= \frac{1.010098638}{\left(1.005\right)^{0.25}} - 1 = 0.008839945664.\end{aligned} \tag{190}$$

Additional information on the coefficients in the risk premium can be obtained using the balance of payments (164), or country resource constraint, which expressed in terms of GDP, and using (168), (170), (98) and the assumptions made above is:

$$\begin{aligned}\frac{e}{y}tb &= \gamma^{GT}\left[\left(\frac{1.06*1.005}{1.033*1.023}\right)^{0.25}\left(1+\frac{\alpha_1^G}{1-\left(\gamma^{GT}-\gamma^{CBT}\right)\alpha_2^G}\right)-1\right] \\ &+0.0658\left[\left(\frac{1.06*1.005}{1.033*1.023}\right)^{0.25}\left(1+\frac{\alpha_1^B}{1-0.0658\alpha_2^B}\right)-1\right] \\ &-\gamma^{CBT}\left[\left(\frac{1.06}{1.033*1.023}\right)^{0.25}-1\right].\end{aligned} \tag{191}$$

The Government's foreign debt (i.e. its debt to non-residents) amounted to US$ 60.9 billion at the end of 2005 (representing 33.5% of GDP) and declined to US$ 56.2 billion at the end of 2006 (26.4% of GDP). I assume that the Government aims for and achieves a SS foreign debt of 20% of GDP. Hence $\frac{eb^{*G}}{y} \equiv \gamma^{GT} = 0.20$. As seen above, I assume that the Central Bank aims for and achieves international reserves amounting to 13% of GDP. Hence $\frac{er^{*CB}}{y} \equiv \gamma^{CBT} = 0.13$.

As background information for my assumption below for the interest rate the Government faces on its external debt, it is known that this foreign debt has an average maturity of 14.36 years (weighted average of US$ 14 bn. debt to international organizations with average maturity of 5.7 years and US$ 46 bn. debt mainly in bonds with average maturity of 17 years). Also, the weighted average interest rate on the Government's foreign debt stands at 5.24% (weighted average of 5.6% on its debt to international organizations and 5% on its bond debt). I am simplifying by assuming that all the foreign debt is dollar denominated whereas in fact only around 77% of it is. My assumption is that in the SS the government faces an average 7% annual interest rate abroad. Hence,

$$1+i^G = 1.07^{0.25} = 1.017058525.$$

Therefore, (168) and (101) imply that α_1^G and α_2^G must satisfy:

$$1+i^G = 1.07^{0.25} = \left(1.06*1.005\right)^{0.25}\left(1+\frac{\alpha_1^G}{1-0.07\alpha_2^G}\right)$$

i.e.:

$$p_G(0.07) = \frac{\alpha_1^G}{1-0.07\alpha_2^G} = \left(\frac{1.07}{1.06*1.005}\right)^{0.25} - 1 = 0.001101156. \tag{192}$$

In order to calibrate these coefficients, I use the fact that α_2^G defines the elasticity

$$\varepsilon_G(0.07) \equiv \frac{1}{\frac{1}{\alpha_2^B(0.07)} - 1} \tag{193}$$

and α_1^G defines the level of the risk premium function. In fact, the function

$$\frac{\alpha_1^G}{1 - x\alpha_2^G}$$

crosses the y axis at $x = \alpha_1^G$ and tends to infinity as $x \to 1/\alpha_2^G$. To obtain an elasticity of, say, $\varepsilon_G = 1$, I need

$$\alpha_2^G = \frac{1}{0.07\left(\frac{1}{\varepsilon_G} + 1\right)} = 7.142857143,$$

Then (192) gives:

$$\alpha_1^G = \left(1 - 0.07\alpha_2^G\right)\left[\frac{1 + i^G}{(1 + i^{**})\,\phi^{**G}} - 1\right] = 0.0005505780000$$

(which implies that even a very small positive net debt would command an endogenous risk premium of around 0.05%). I will use these calibrations in the sequel. Also, the fiscal balance equation (169) gives the primary surplus needed to sustain the government debt:

$$\begin{aligned}
\frac{1}{y}(t - g) &= \left(\frac{1 + i^G}{\mu^{z**}\pi^{**N}} - 1\right)\gamma^{GT} - \left(\frac{1 + i^{**} - 1/\delta}{\mu^{z**}\pi^{**N}}\right)\gamma^{CBT} + \frac{i}{\mu^{z**}\pi}\frac{b^{CB}}{y} \\
&= \left(\frac{1.07^{0.25}}{(1.033 * 1.023)^{0.25}} - 1\right)0.2 - \left(\frac{1.06^{0.25} - \frac{1}{1.010109588}}{(1.033 * 1.023)^{0.25}}\right)0.13 \\
&\quad + \frac{0.025172608}{(1.033 * 1.065)^{0.25}}0.05 \\
&= -0.001312188863
\end{aligned}$$

I also assume that SS government expenditures are 16% of GDP (13% for public consumption and 3% for public investment). Hence:

$$\frac{t}{y} = 0.1586878111, \quad t = 92.9117134.$$

The balance of payments (191) hence yields:

$$\begin{aligned}
\frac{e}{y}tb &= 0.20\left[\left(\frac{1.07}{1.033 * 1.023}\right)^{0.25} - 1\right] \\
&\quad + 0.0658\left[\left(\frac{1.06 * 1.005}{1.033 * 1.023}\right)^{0.25}\left(1 + \frac{\alpha_1^B}{1 - 0.0658\alpha_2^B}\right) - 1\right] \\
&\quad - 0.13\left[\left(\frac{1.06}{1.033 * 1.023}\right)^{0.25} - 1\right] \\
&= 0.0006565601244 + 0.06593255209\frac{\alpha_1^B}{1 - 0.0658\alpha_2^B},
\end{aligned}$$

or:

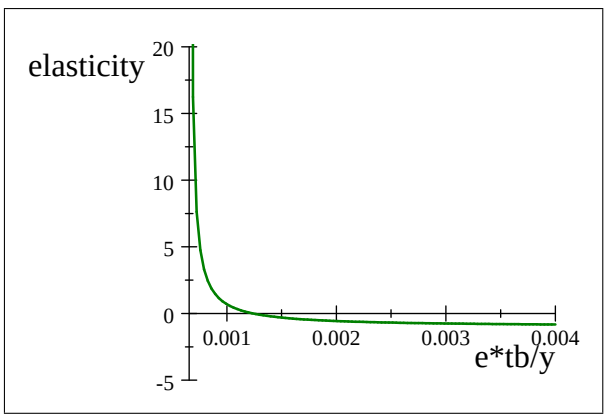
$$\begin{aligned} p_B(0.0658) &\equiv \frac{\alpha_1^B}{1-0.0658\alpha_2^B} \\ &= 15.1670149\frac{e}{y}tb - 0.00995805719. \end{aligned} \tag{194}$$

Therefore, (70), (100), (190), and (194) imply:

$$\begin{aligned} \frac{\varphi_B(0.0658)}{p_B(0.0658)} &= 1+\varepsilon_B(0.0658) = \frac{1}{1-\alpha_2^B(0.0658)} \\ &= \frac{0.008839945664}{15.1670149\frac{e}{y}tb - 0.00995805719.}. \end{aligned} \tag{195}$$

As the following figure illustrates, to have both a positive elasticity as well as a risk premium that is greater than one it is necessary that the trade balance to GDP ratio fall in the following interval:

$$6.565601244 \times 10^{-4} < \frac{e}{y}tb < 1.239400302 \times 10^{-3}$$



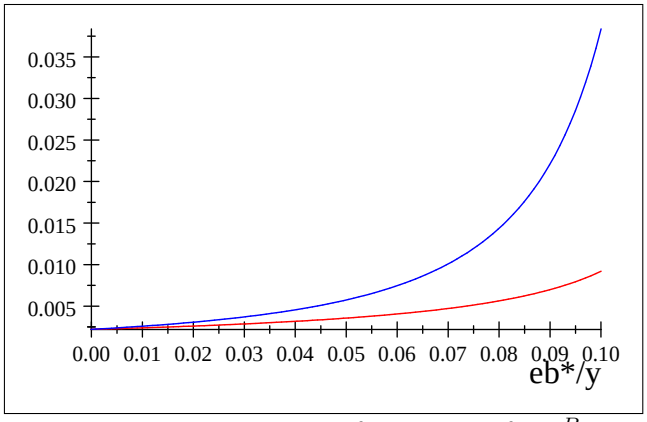
To calibrate α_1^B and α_2^B I first choose $\varepsilon_B = 1$. Then (99), (100), (190) and (194) imply

$$\begin{aligned} \alpha_1^B &= \frac{\varphi^B}{(\varepsilon_B+1)^2} = \frac{0.008839945664}{4} = 0.002209986416, \\ \alpha_2^B &= \frac{1}{\gamma^B}\left(1-\frac{1}{\varepsilon_B+1}\right) = \frac{1}{0.0658}\frac{1}{2} = 7.598784195, \\ p_B(0.0658) &\equiv \frac{\alpha_1^B}{1-0.0658\alpha_2^B} = \frac{0.002209986416}{1-0.0658(7.598784195)} = 0.004419972832, \\ etb/y &= 0.0006565601244 + 0.06593255209 * 0.004419972832 \\ &= 9.479802134 \times 10^{-4}. \end{aligned}$$

These are the calibrated values I use in the sequel. From (170) I now obtain the bank foreign financing rate:

$$1+i^B = (1.06 * 1.005)^{0.25} * (1+0.004419972832) = 1.020430244.$$

The following graph shows the bank risk premium as it is found in the balance of payments equation (the lower curve) and in the UIP equation (the upper curve) The vertical distance between them is the elasticity of the risk premium function times the gross risk premium in the balance of payments. The coefficients α_1^B and α_2^B employed for the graph are the ones calculated above.



r.p. and UIP r.p. as functions of eb^{*B}

I assume as in ARGEM that SS imports are 22% of GDP. Hence, (174) and (166) yield:

$$\begin{aligned} 1 &= \frac{p^C c}{y} + \frac{g}{y} + \frac{1}{\left(\mu^{z**}\pi\right)^4} \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{b^A y} - \frac{p^N n}{y} \\ &= \frac{p^C c}{y} + 0.16 + \frac{1}{1.033 * 1.065} \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{b^A 585.5} - 0.22 \end{aligned}$$

This gives:

$$\frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{585.5 b^A} = 1.033 * 1.065 \left(1 + 0.22 - 0.16 - \frac{p^C c}{y}\right) \tag{196}$$

Also, (165), (166), (167) and (184) imply:

$$\begin{aligned} \frac{e}{y} tb &= 9.479802134 \times 10^{-4} = \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{1.033 * 1.023 * 585.5 b^A} - \frac{e}{p^N} \frac{p^N n}{y} \\ &= \frac{1.065}{1.023} \left(1 + 0.22 - 0.16 - \frac{p^C c}{y}\right) - \left(1 - \frac{1}{\theta^N}\right) 0.22 \\ &= \frac{1.065}{1.023} \left(1.06 - \frac{p^C c}{y}\right) - 0.22 \left(1 - \frac{1}{\theta^N}\right). \end{aligned}$$

In particular, given the trade balance ratio, there is an inverse relation between the steady state monopolistic markup for imported goods $\left(\theta^N / \left(\theta^N - 1\right)\right)$ and the steady state consumption ratio (absorption ratio, since there is no investment here). Assume, for example, $p^C c/y = 0.855$. Then

$$\begin{aligned} \theta^N &= 29.21042381 \\ \frac{\theta^N}{\theta^N - 1} &= 1.03544789, \end{aligned}$$

and (196) gives:

$$\begin{aligned}\frac{\left(b^A e p^{**}\right)^{\frac{1}{1-b^A}}}{b^A} &= 1.033 * 1.065 * 585.5\,(1 + 0.22 - 0.16 - 0.855) \\ &= 132.0476540.\end{aligned} \tag{197}$$

From (81), the share of inputs in imports is:

$$\frac{p^N n^D}{p^N n} = 1 - (1 - a_D)\,\frac{p^C c/y}{p^N n/y}.$$

Then, assuming as in ARGEM, that 46% of imports are inputs (and hence, 54% are for private consumption (absorption)), the share of imports and domestic goods in consumption (absorption) expenditures are:

$$1 - a_D = a_N = 0.54\frac{0.22}{0.855} = 0.1389473684, \qquad a_D = 0.8610526316,$$

and the ratio of imported inputs to GDP is:

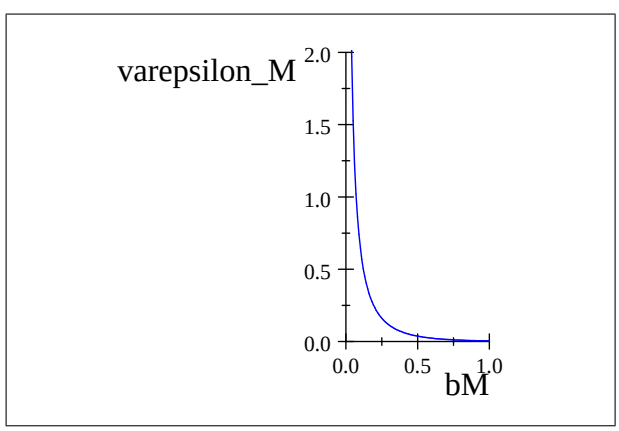
$$\frac{p^N N^D}{Y} = \frac{p^N N^D}{p^N N}\frac{p^N N}{Y} = 0.46\,(0.22) = 0.1012. \tag{198}$$

Given previous assumptions, the SS cash/consumption ratio is:

$$\varpi \equiv \frac{m^0/y}{p^C c/y} = \frac{0.08}{0.855} = 0.09356725146.$$

I now use the assumed functional form for the transactions cost function (93) and the resulting functional form for the gross interest rate elasticity (97), as well as additional assumptions, to calibrate the three parameters involved. First, assuming that the SS gross interest rate elasticity of private demand for cash is 0.85 yields:[14]

$$\varepsilon_M = 0.85 = \frac{\varpi^{1+b_M}}{(1+b_M)\,b_M\,(1+i)} = \frac{(0.09356725146)^{1+b_M}}{(1+b_M)\,b_M\,(1.025172608)}.$$



[14] A rough calculation for the elasticity of Argentina's currency demand (as a fraction of absorption) with respect to the gross interest rate during the period 1994-2005 yields 0.84, which is equivalent to an elasticity with respect to the interest rate of 0.09. The latter figure is much lower than the typical estimate for the U.S. and other developed countries, which is in a neighborhood of 0.5. This may be due (at least partly) to the much smaller fraction of the population that uses the banking system in Argentina.

Hence:

$$b_M = 0.08089510761.$$

Second, I use the cash demand function (as a ratio of private absorption) to obtain the value for a_M:

$$\begin{aligned}\varpi &= 0.09356725146 = \left(\frac{b_M}{a_M + 1 - \frac{1}{1+i}}\right)^{\frac{1}{1+b_M}} = \left(\frac{0.08089510761}{a_M + 1 - \frac{1}{1.025172608}}\right)^{\frac{1}{1+0.08089510761}}, \\ a_M &= 1.022645002.\end{aligned}$$

Finally, I calibrate the remaining parameter in the transactions cost function, c_M, so that the SS transactions cost in terms of domestic goods τ_M is only 0.01% of private consumption (which in units of GDP is $0.05006025 = 0.0001(0.855(585.5))$:

$$\begin{aligned}0.05006025 = \tau_M \equiv a_M\varpi + \varpi^{-b_M} + c_M &= 1.022645002 * 0.09356725146 \\ &+0.09356725146^{-0.08089510761} + c_M.\end{aligned} \tag{199}$$

which implies:

$$c_M = -1.256868176.$$

These calibrations imply that in the SS the total effect on expenditure (i.e., including transactions cost related expenditures) of a marginal increase in consumption is:

$$\begin{aligned}\varphi_M(\varpi) &= 1 + c_M + (1 + b_M)\,\varpi^{-b_M} = 1 - 1.256868176 \\ &\quad + (1 + 0.08089510761)\,0.09356725146^{-0.08089510761} \\ &= 1.052357748.\end{aligned}$$

Now I use the bank loan supply function (68) to calibrate both the loan rate and the coefficient in the bank cost function. Dividing this expression by GDP and using the assumed loan to GDP ratio gives:

$$0.23 = \frac{\ell}{y} = \frac{1}{b^B * 585.5}\left(i^L - i\right).$$

I assume that the loan rate is

$$\left(i^L\right)^4 = 0.12, \qquad i^L = 0.028737345$$

which implies:

$$b^B = \frac{1}{0.23 * 585.5}\left(0.028737345 - 0.025172608\right) = 2.647114692 \times 10^{-5}.$$

Under the assumption that the share of wage income is 0.7129, which is the sum of wage income and rent income from physical capital (which does not exist here) in ARGEM, I use (47) and (198) to calibrate the domestic sector production function:[15]

$$\begin{aligned}\frac{\overline{w}h}{y} &= 0.7129 = \frac{b^D}{1-b^D}\frac{p^N n^D}{y} = \frac{b^D}{1-b^D}0.1012 \\ b^D &= 0.8756909471.\end{aligned}$$

[15] Since I estimate b^D, in the m-file in which I implement all this I do the opposite: I assume a value for b^D and obtain the resulting wage share. My prior for b^D is hence implicitly my prior for the wage ratio. The same can be said for other estimated parameters which are intimately related to great ratios.

And dividing the SS loan demand (48) by GDP and using the previous assumptions I obtain the fraction of domestic firm cost that is bank financed:

$$\varsigma = \frac{\ell/y}{\overline{w}h/y}\frac{b^D}{\mu^{z**}} = \frac{0.23}{0.7129}\frac{0.8756909471}{1.033^{0.25}} = 0.280236694.$$

As in ARGEM, I use INDEC's 1997 input-output table to calibrate the domestic sector inputs used by the primary producing sector (given by (56)) as 3.9% of GDP:

$$\frac{q^{DX}}{y} = \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{585.5} = 0.039.$$

Along with (196), this equation yields:

$$\begin{aligned}\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}} &= 132.047654 b^A = 0.039 * 585.5 \\ b^A &= \frac{0.039 * 585.5}{132.047654} = 0.1729262074,\end{aligned}$$

and hence I obtain the SS value of ep^{**}:

$$\begin{aligned}\frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{b^A} &= \frac{\left(0.1729262074 ep^{**}\right)^{\frac{1}{1-0.1729262074}}}{0.1729262074} = 132.047654 \\ ep^{**} &= 76.87667886\end{aligned}$$

I can now use the domestic goods market clearing equation (173) to obtain the domestic output to GDP ratio:

$$\begin{aligned}\frac{q}{y} &= \left[a_D + \widetilde{\tau}_M\right]\frac{p^C c}{y} + \frac{g}{y} + \frac{\left(b^A ep^{**}\right)^{\frac{1}{1-b^A}}}{y} + \frac{\left(i^L - i\right)^2}{2yb^B} \\ &= \left(0.8610526316 + 0.05006025\right) 0.855 + 0.16 + 0.039 \\ &\quad + \frac{\left(0.028737345 - 0.025172608\right)^2}{2 * 585.5 * \left(2.647114692 \times 10^{-5}\right)} \\ &= 0.9784114585,\end{aligned}$$

and (43) to obtain marginal cost:

$$\begin{aligned}mc &= \frac{\left(1 + \varsigma i^L\right)\left(\frac{\overline{w}h}{y} + \frac{p^N n^D}{y}\right)}{q/y} \\ &= \frac{\left(1 + 0.280236694 * 0.028737345\right)\left(0.7129 + 0.1012\right)}{0.9784114585} \\ &= 0.8387638459.\end{aligned}$$

Hence, using (186), the markup in the domestic goods sector is:

$$\frac{\theta}{\theta - 1} = \frac{1}{mc} = 1.192230691,$$

and the elasticity of substitution between varieties of domestic goods is:

$$\theta = 6.202082949.$$

Furthermore, under the assumption that $\xi = 0.2$ (178) directly gives the SS value of the marginal utility of real income:

$$\digamma \equiv \frac{\mu^{z**} - \beta\xi}{\mu^{z**} - \xi} = \frac{1.033^{0.25} - 0.999 * 0.2}{1.033^{0.25} - 0.2} = 1.000247479,$$
$$\lambda^{\circ} = \frac{\digamma}{\widetilde{\varphi}_M \frac{p^C c}{y} y} = \frac{1.000247479}{1.052357748 * 0.855 * 585.5} = 0.00189867682.$$

(182) and the assumption on labor share gives the SS supply of labor, and hence the real wage, in terms of three related parameters:

$$\begin{aligned} h &= \left(\frac{0.7129 * 585.5 * 0.00189867682}{s^{\psi}\eta}\right)^{\frac{1}{\chi+1}} \\ &= \left(\frac{0.7925133058}{s^{\psi}\eta}\right)^{\frac{1}{\chi+1}}. \end{aligned}$$

Assuming $\chi = 1$ and that the steady state wage gross markup is $s^{\psi} = 1.1$, I calibrate η so that the h can be interpreted as the number of hours worked in a quarter. Let the number of hours be 528 (=8 hours, 22 days per month, 3 months). Hence

$$\begin{aligned} \left(\frac{0.7925133058}{1.1\eta}\right)^{\frac{1}{1+1}} &= 528 = h, \\ \eta &= 2.584318475 \times 10^{-6} \\ \psi &= 11.0. \end{aligned}$$

The SS real wage is hence:

$$\overline{w} = \frac{0.7129 * 585.5}{528} = 0.7905358902.$$

Now, labor market equilibrium yields the MRER, and hence the domestic terms of trade:

$$\begin{aligned} 528 &= h = \frac{b^D}{\kappa}\left(\frac{\frac{\theta}{\theta-1}e}{\overline{w}}\right)^{1-b^D} q \\ &= \frac{0.8756909471}{0.6869983047}\left(\frac{1.03544789e}{0.7905358902}\right)^{1-0.8756909471} 0.9784114585 * 585.5, \\ e &= 0.05624118063, \\ p^N &= 1.03544789 * 0.05624118063 = 0.05823481181. \end{aligned}$$

Also, (175) gives a relation between p^C and θ^C:

$$p^C = \left(0.8610526316 + (1 - 0.8610526316)\,(0.05823481181)^{1-\theta^C}\right)^{\frac{1}{1-\theta^C}}$$

Assuming $\theta^C = 1.1$ gives

$$\begin{aligned} p^C &= 0.6396589143 \\ e^C &= e/p^C = 0.08792370336. \end{aligned}$$

Hence, the SS consumption index is:

$$c = \frac{0.855 * 585.5}{p^C} = \frac{0.855 * 585.5}{0.6396589143} = 782.6084946.$$

Finally, the external terms of trade is:

$$p^{**} = \frac{ep^{**}}{e} = \frac{76.87667886}{0.05624118063} = 1366.910829.$$

For the steady state of the recursive form of the Phillips equation in the domestic sector, (138) and (139) yield:

$$\Gamma^D = \frac{1}{1-\beta\alpha_D}\lambda^\circ\widetilde{\varphi}_M q\pi^{\theta-1}$$

$$\Psi^D = \frac{\theta}{\theta-1}\frac{1}{1-\beta\alpha_D}\lambda^\circ\widetilde{\varphi}_M q\pi^{\theta}mc.$$

Hence,

$$\frac{\Psi^D}{\Gamma^D} = \frac{\theta}{\theta-1}\pi mc.$$

Inserting this in the SS version of (140) and eliminating π gives, as in (186):

$$\frac{\theta}{\theta-1}mc = 1.$$

Numerically, assuming $\alpha_D = 0.5$ the steady states for the two new variables are:

$$\begin{aligned} \Gamma^D &= \frac{1}{1-\beta\alpha_D}\lambda^\circ\widetilde{\varphi}_M q\pi^{\theta-1} \\ &= \frac{1}{1-0.999*0.5}0.00189867682 * 1.052357748 \\ &\quad *0.9784114585 * 585.5 * \left(1.065^{0.25}\right)^{6.202082936-1} \\ &= 2.482147188, \end{aligned}$$

$$\begin{aligned} \Psi^D &= \frac{\theta}{\theta-1}\frac{1}{1-\beta\alpha_D}\lambda^\circ\widetilde{\varphi}_M q\pi^{\theta}mc \\ &= 1.192230691\frac{1}{1-0.999*0.5}0.00189867682 * 1.052357748 \\ &\quad *0.9784114585 * 585.5 * \left(1.065^{0.25}\right)^{6.202082936} * 0.8387638459 \\ &= 2.521534606. \end{aligned}$$

For the steady state of the recursive form of the Phillips wage equation I assume that $\alpha_W = 0.6$. Then the steady states for the two new variables are:

$$\begin{aligned}
\Gamma^W &= \frac{1}{1-\beta\alpha_W}\lambda^\circ h\overline{w}\left(\pi^W\right)^{\psi-1} \\
&= \frac{1}{1-0.999*0.6}0.00189867682*0.7129*585.5*\left(1.033^{0.25}1.065^{0.25}\right)^{11-1} \\
&= 2.511426316,
\end{aligned}$$

$$\begin{aligned}
\Psi^W &= \frac{\psi}{\psi-1}\frac{1}{1-\beta\alpha_W}\eta\left(h\right)^{1+\chi}\left(\pi^W\right)^{\psi(1+\chi)} \\
&= 1.1\frac{1}{1-0.999*0.6}\left(2.584318475\times 10^{-6}\right)\left(528\right)^{1+1}\left(1.033^{0.25}1.065^{0.25}\right)^{11(1+1)} \\
&= 3.344030491
\end{aligned}$$

Finally, for the steady state of the recursive form of the Phillips equation in the import sector I assume $\alpha_N = 0.4$. Then the steady states for the two new variables are:

$$\begin{aligned}
\Gamma^N &= \frac{1}{1-\beta\alpha_N}\lambda^\circ\widetilde{\varphi}_M p^N n(\pi^N)^{\theta^N-1} \\
&= \frac{1}{1-0.999*0.4}0.00189867682*1.052357748*0.05823481181 \\
&\quad *\left(0.22*585.5/0.05823481181\right)*\left(1.065^{0.25}\right)^{29.21042381-1} \\
&= 0.6683583135
\end{aligned}$$

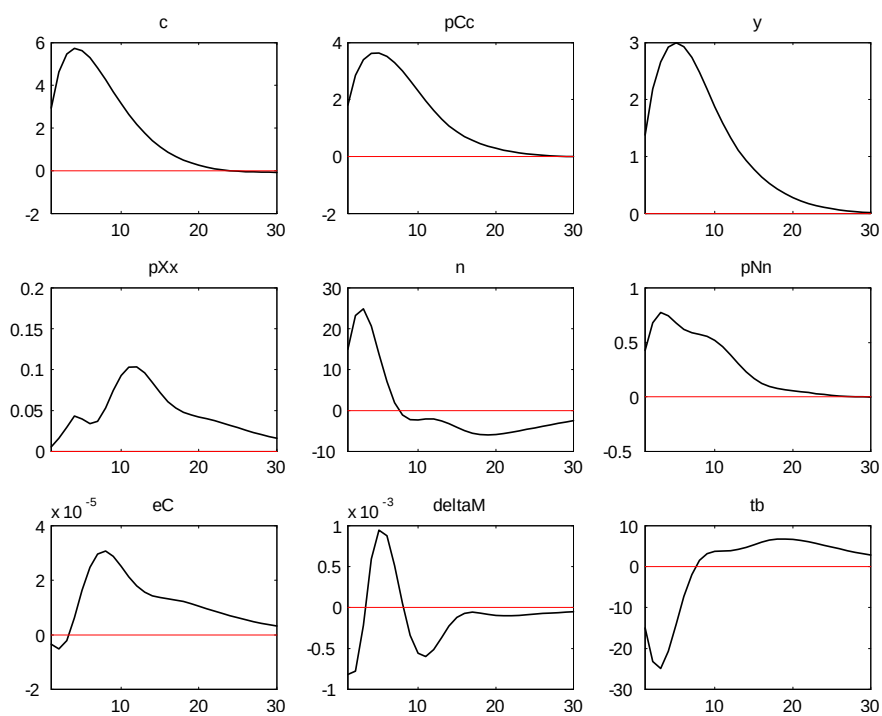
$$\begin{aligned}
\Psi^N &= \frac{1}{1-\beta\alpha_N}\frac{\theta^N}{\theta^N-1}\lambda^\circ\widetilde{\varphi}_M p^N n(\pi^N)^{\theta^N}\frac{e}{p^N} \\
&= \frac{1}{1-0.999*0.5}1.03544789*0.00189867682*1.052357748 \\
&\quad *0.05823481181*\left(0.22*585.5/0.05823481181\right)*\left(1.065^{0.25}\right)^{29.21042381} \\
&\quad *\left(0.05624118063/0.05823481181\right) \\
&= 0.6789640136.
\end{aligned}$$

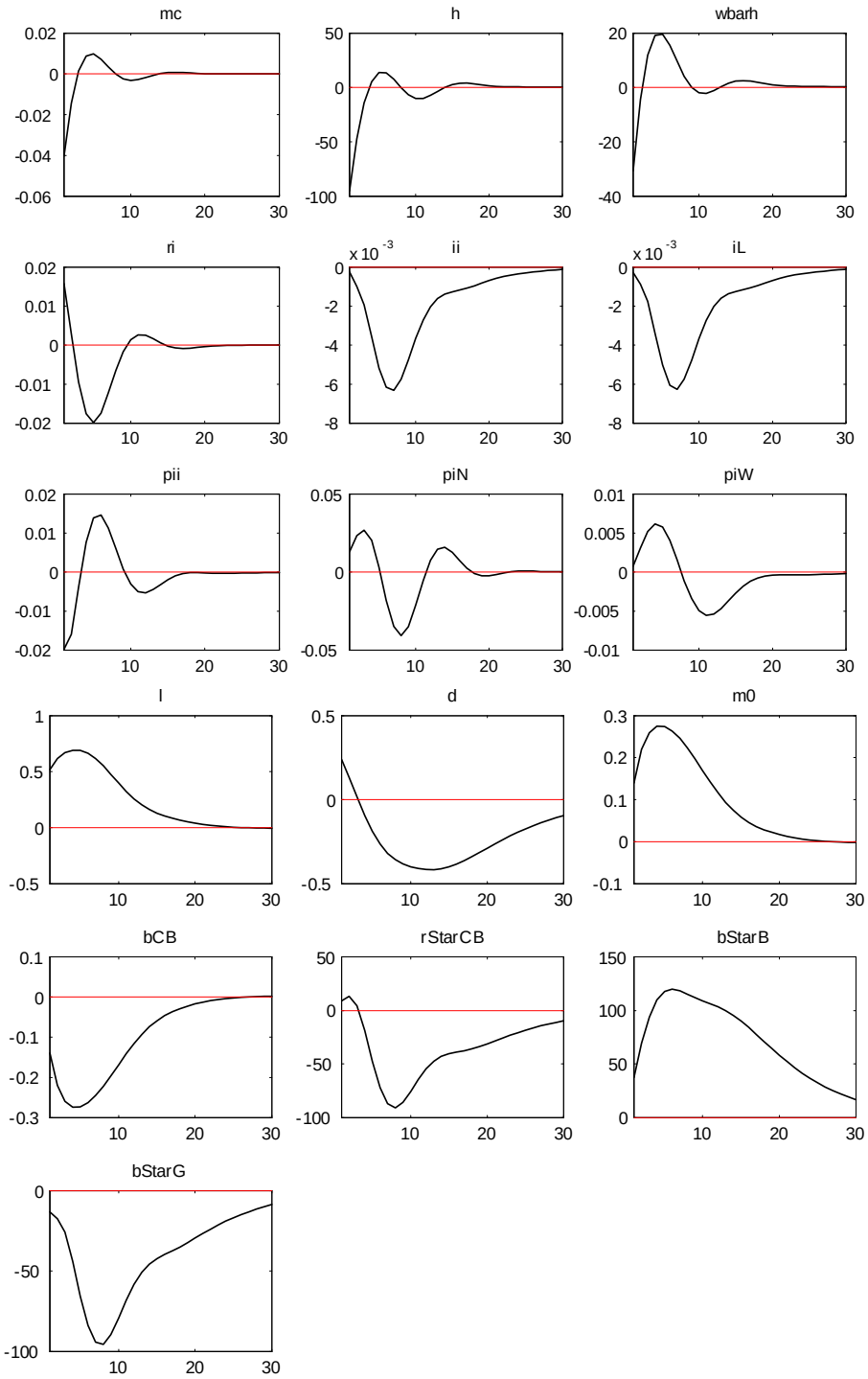
Appendix 6

Impulse Response Functions

This Appendix shows the IRFs for the model using the estimated/calibrated parameters. Because they are many I select the 27 most interesting endogenous variables. Variables ii, iL, and eC are the nominal interest rate i_t, the loan interest rate i_t^L, and the consumption MRER e_t^C. And variables $wbarh$, pCc, pNn, pXx, are simply the multiplication of price times quantity indexes, e.g., $\overline{w}_t h_t$. This makes their responses directly comparable with those of y_t.

Response to a consumption demand shock $\varepsilon_t^{z^C}$,

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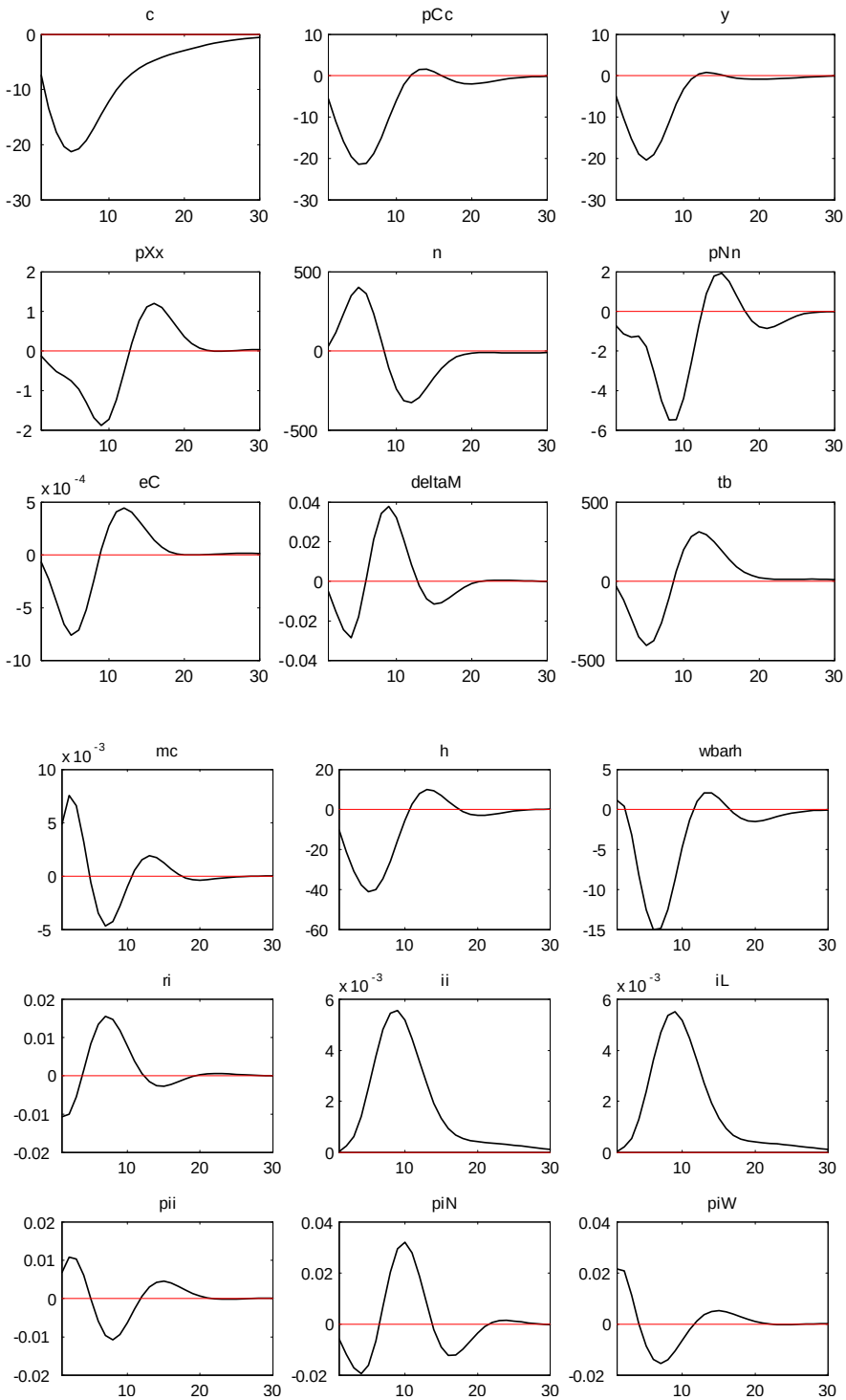
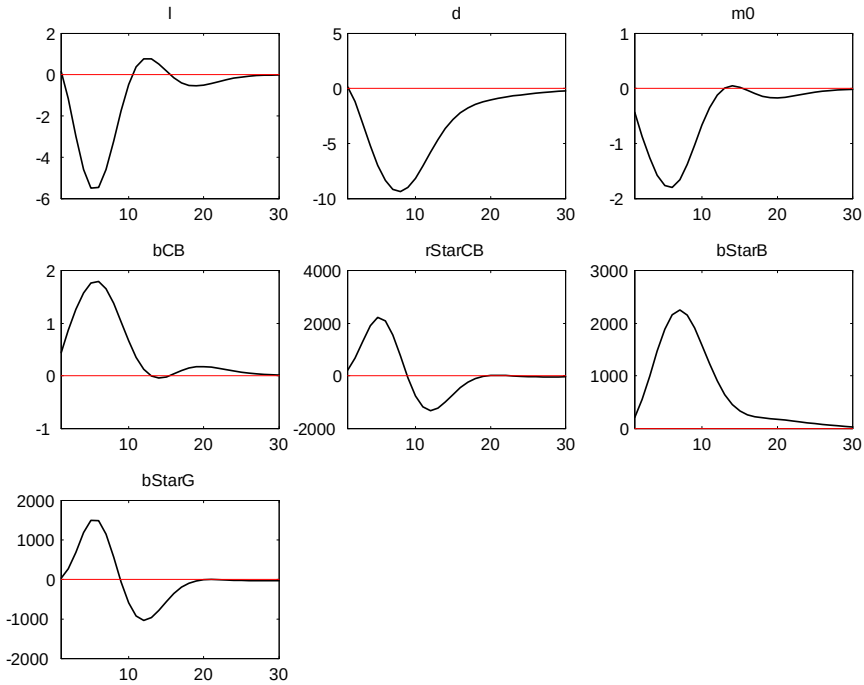
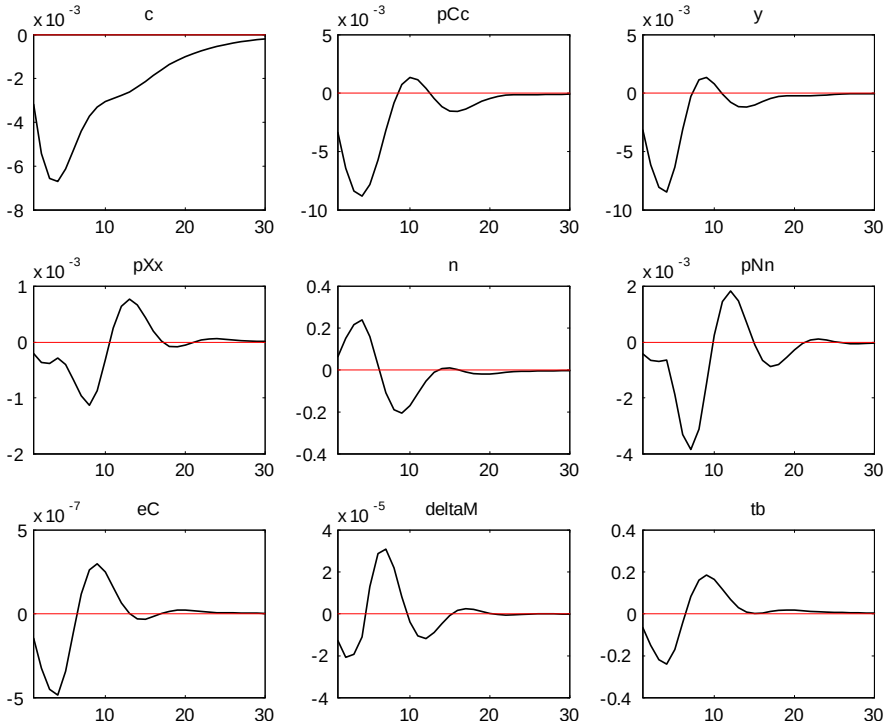
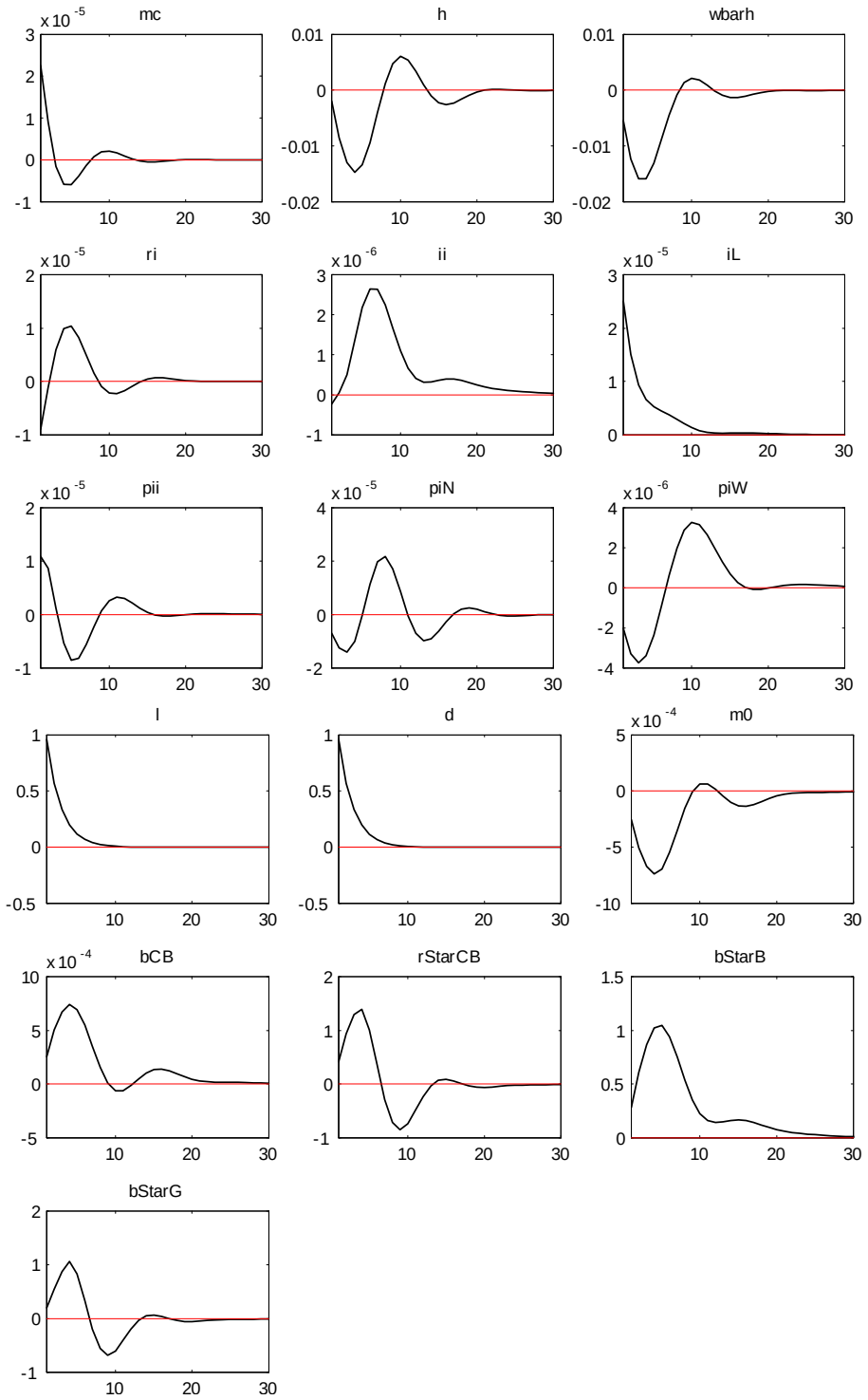
Response to a (negative) labor supply $\varepsilon_t^{z^H}$,





Response to a domestic firm loan demand shock $\varepsilon_t^{\varsigma}$,

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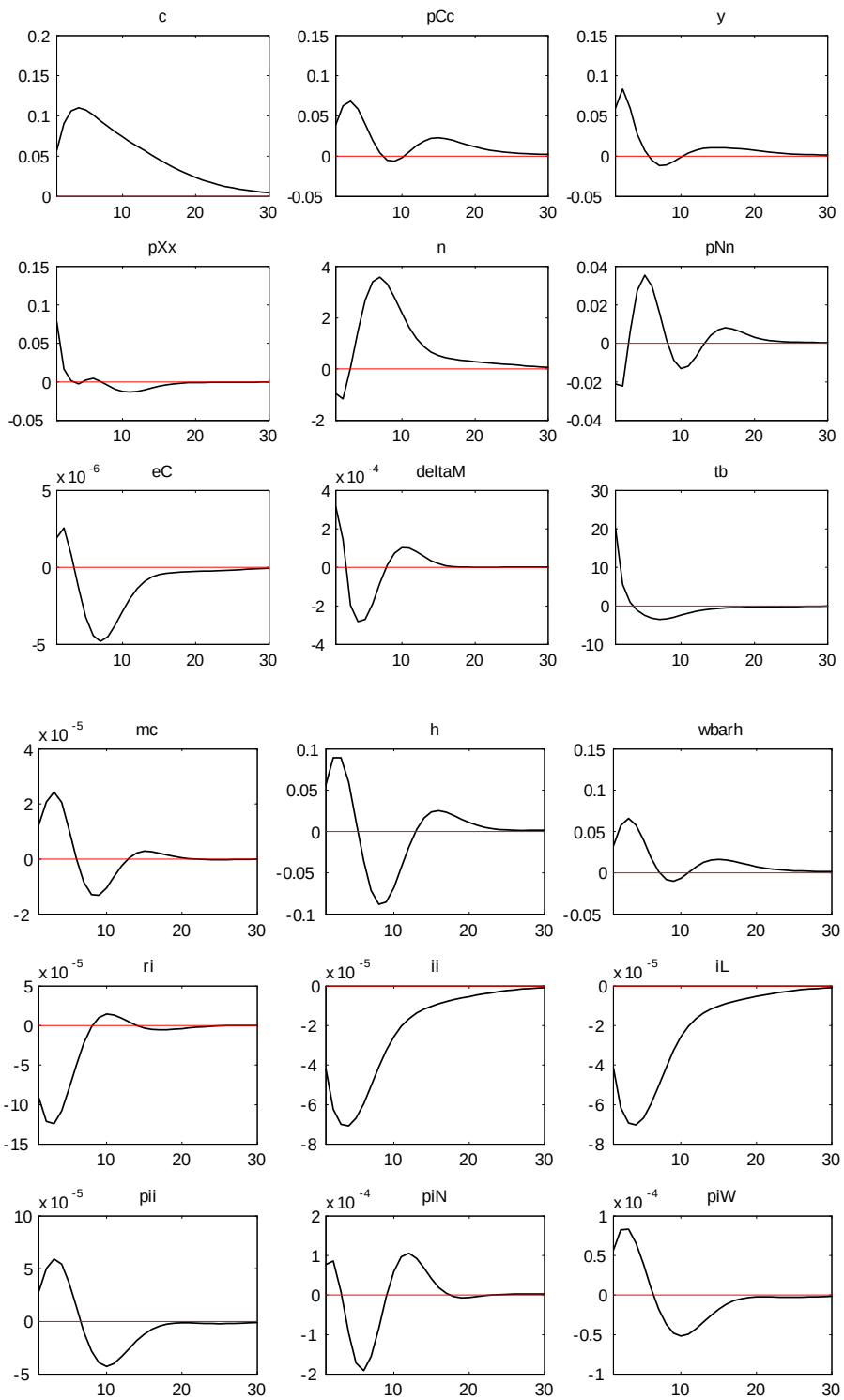
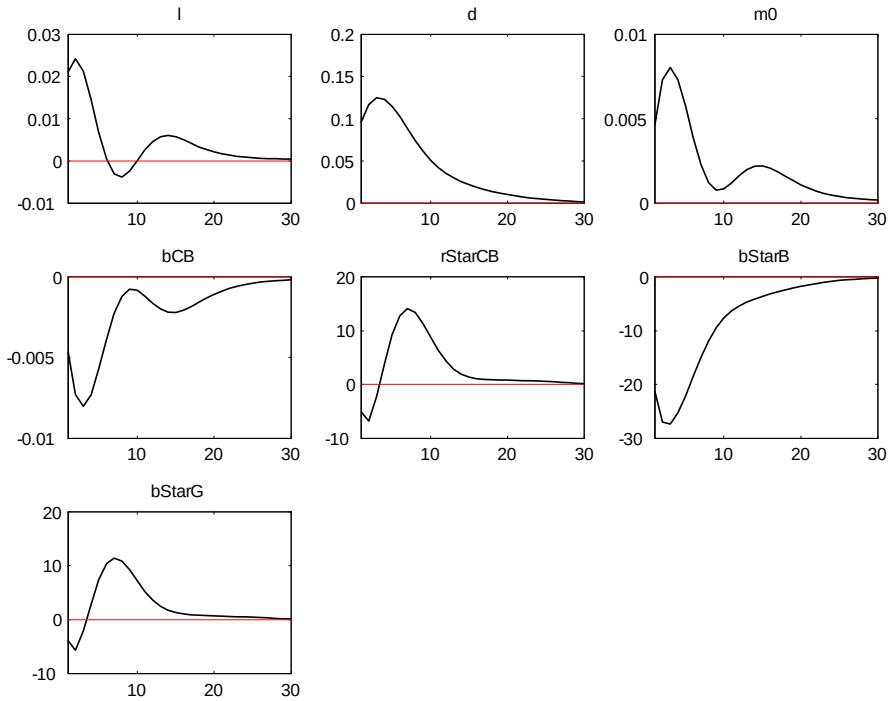
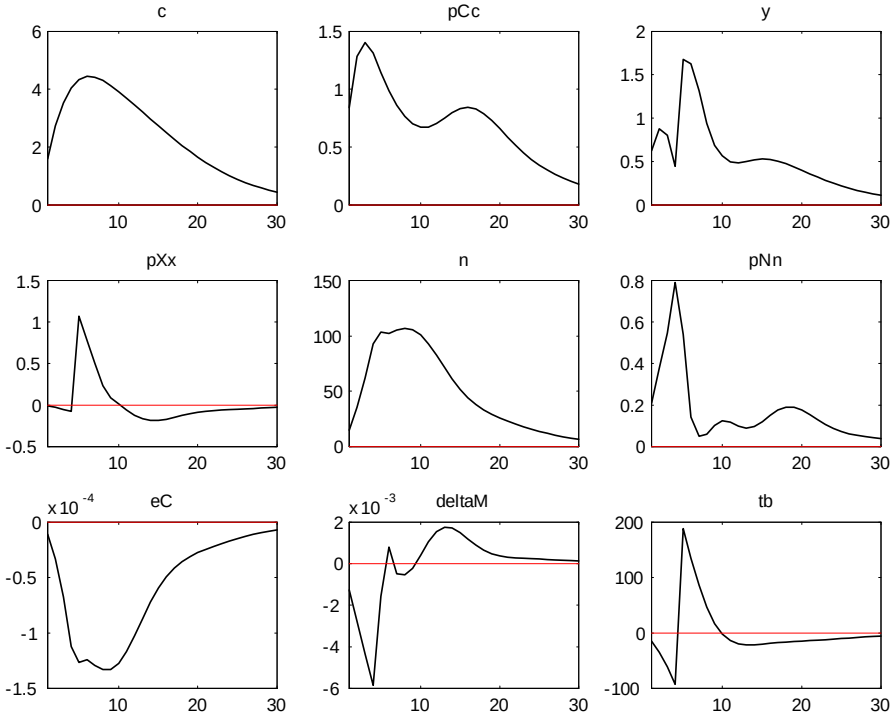
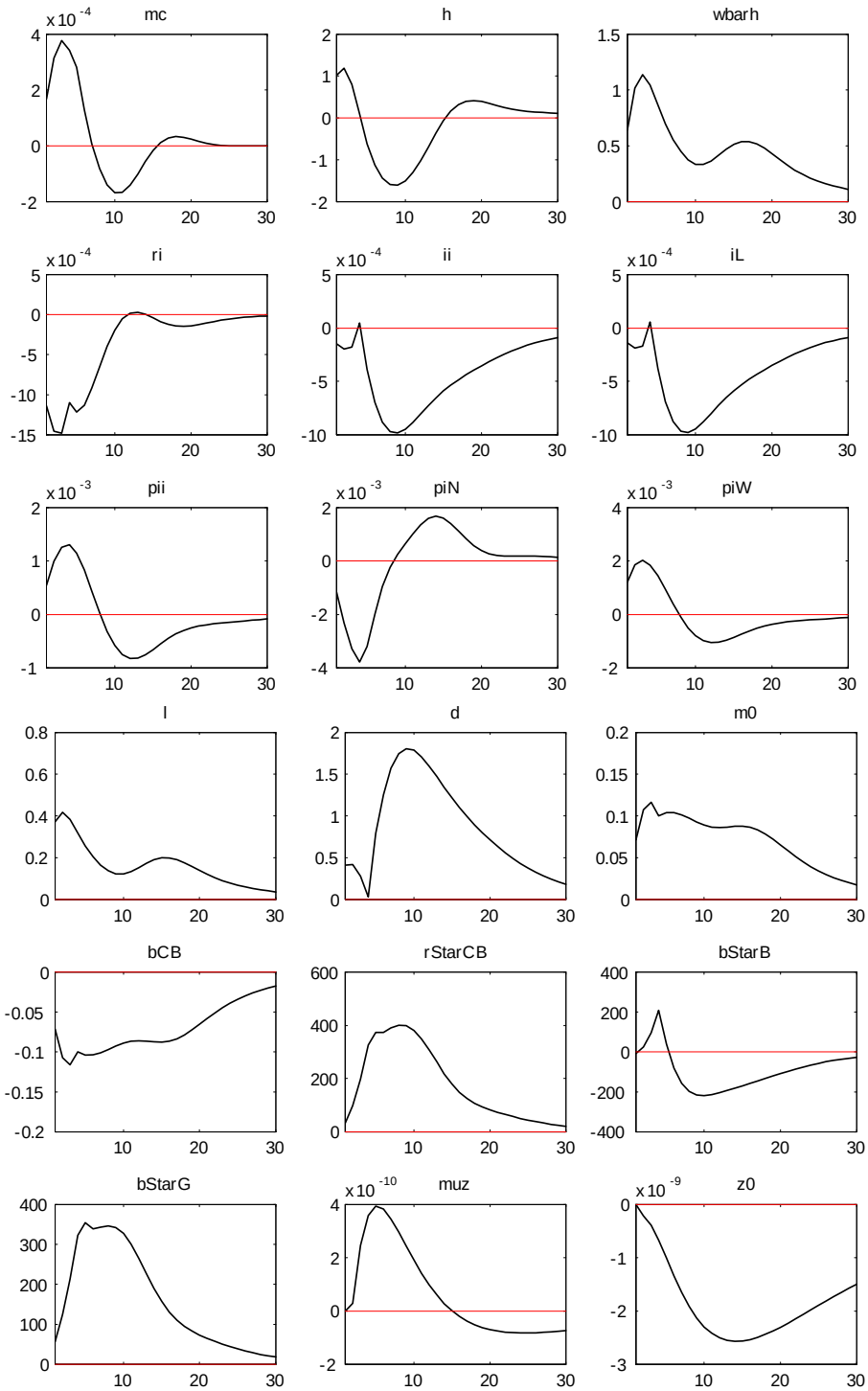
Response to a harvest shock $\varepsilon_t^{z^A}$,





Response to a terms of trade shock $\varepsilon_t^{p^{**}}$,

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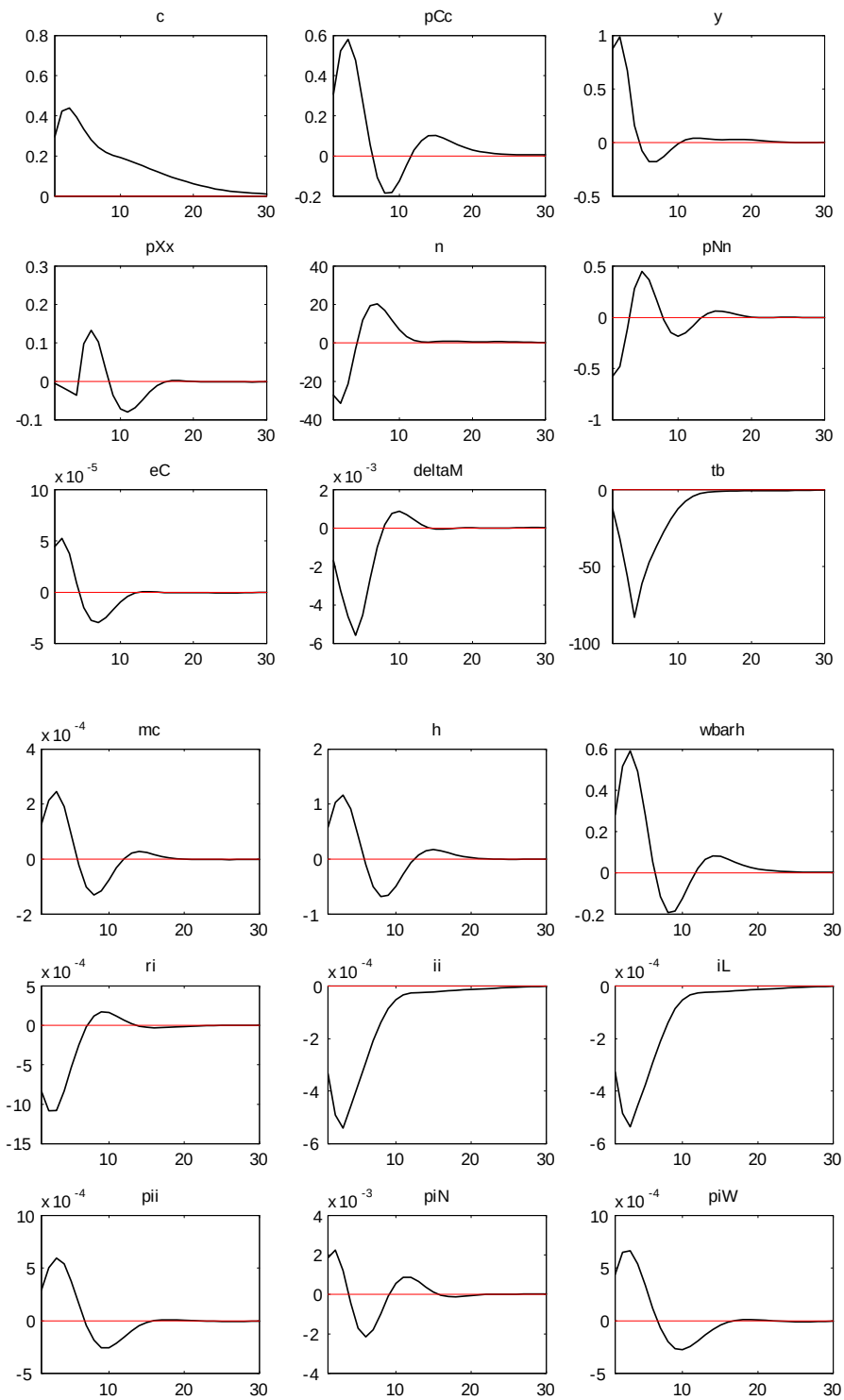
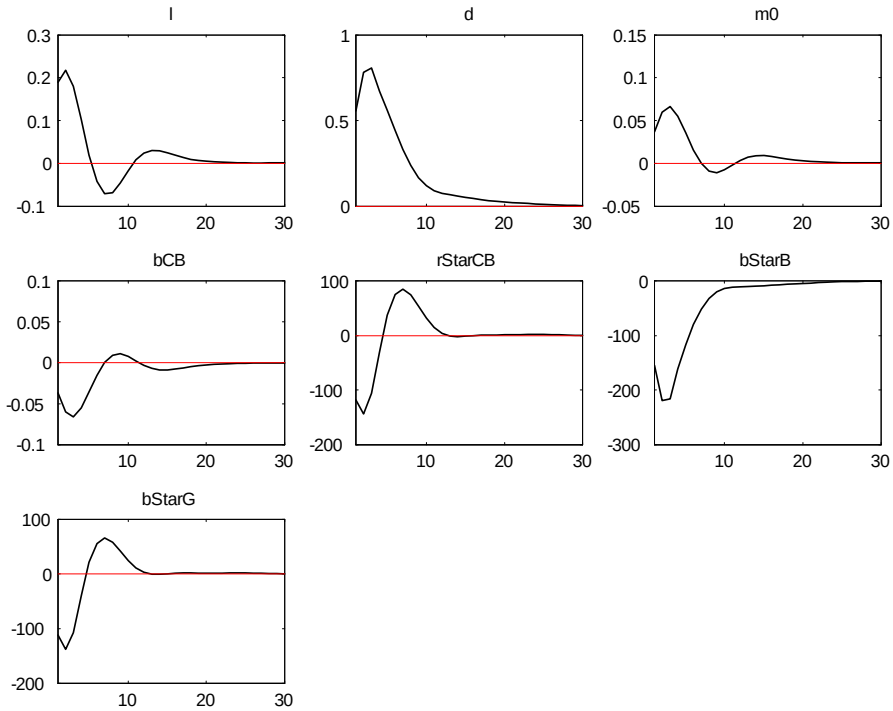
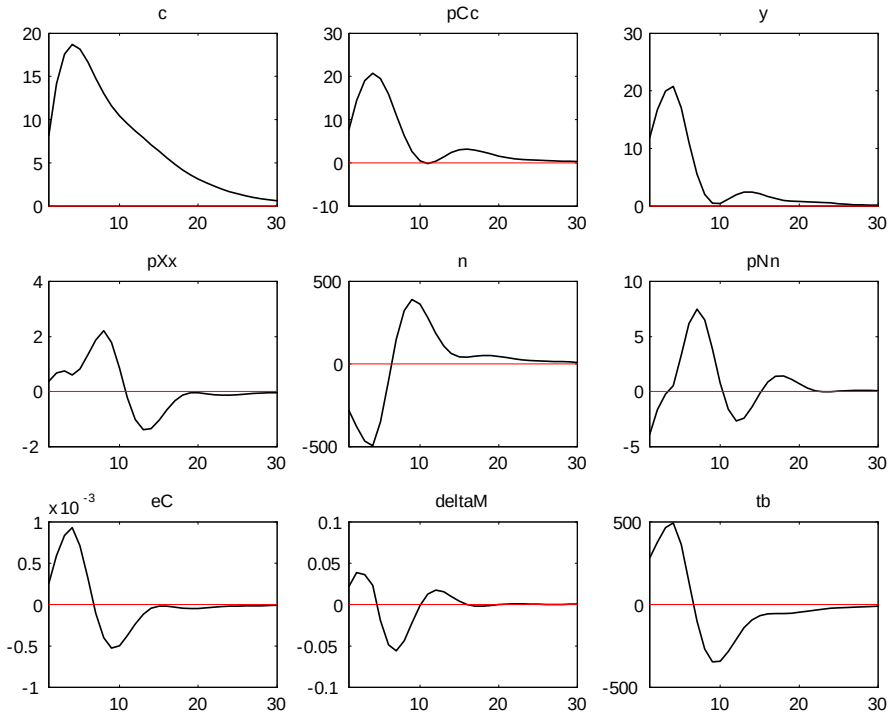
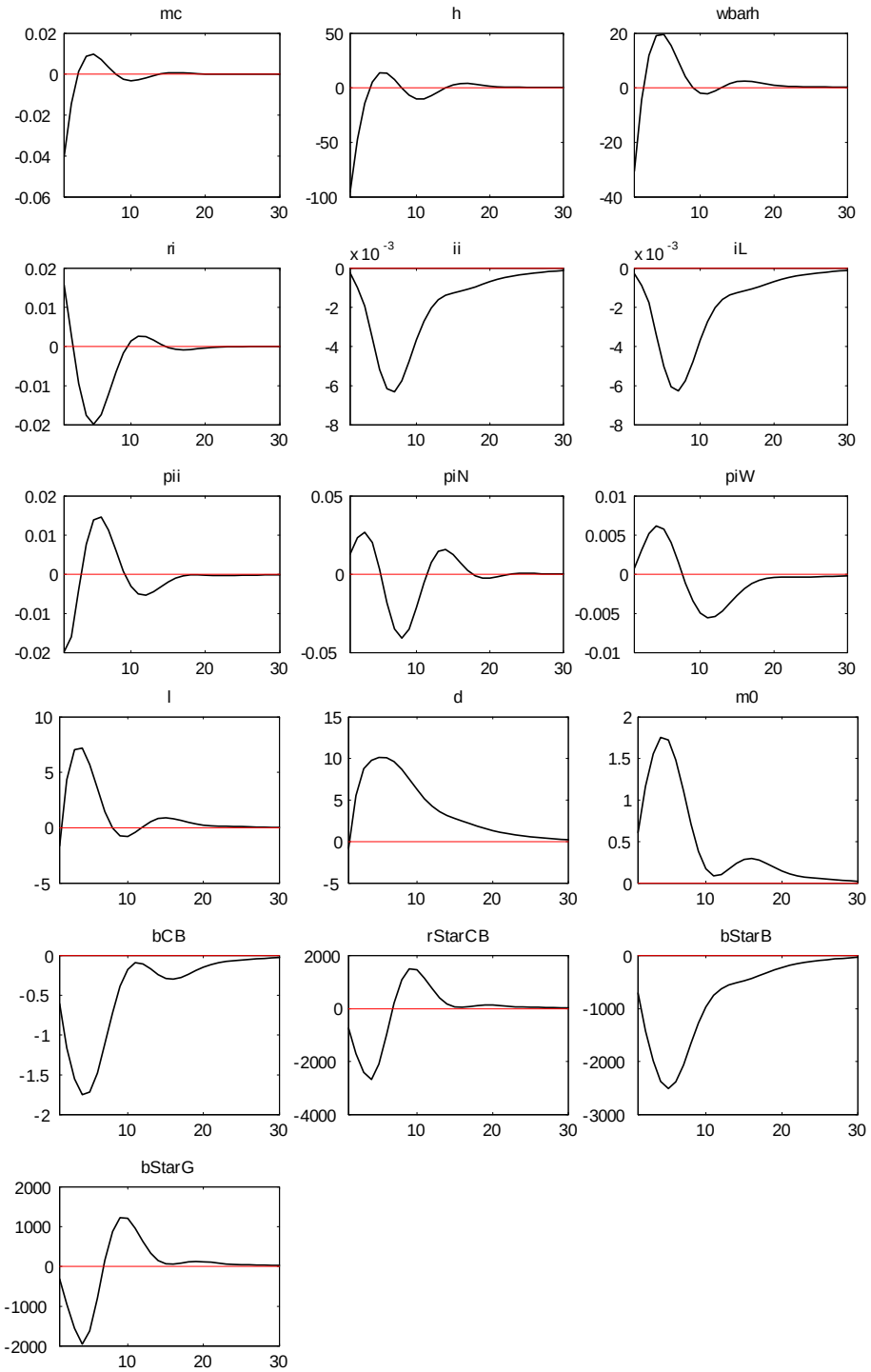
Response to a RW inflation shock $\varepsilon_t^{\pi^{**N}}$,





Response to a domestic transitory productivity shock ε_t^{ϵ},

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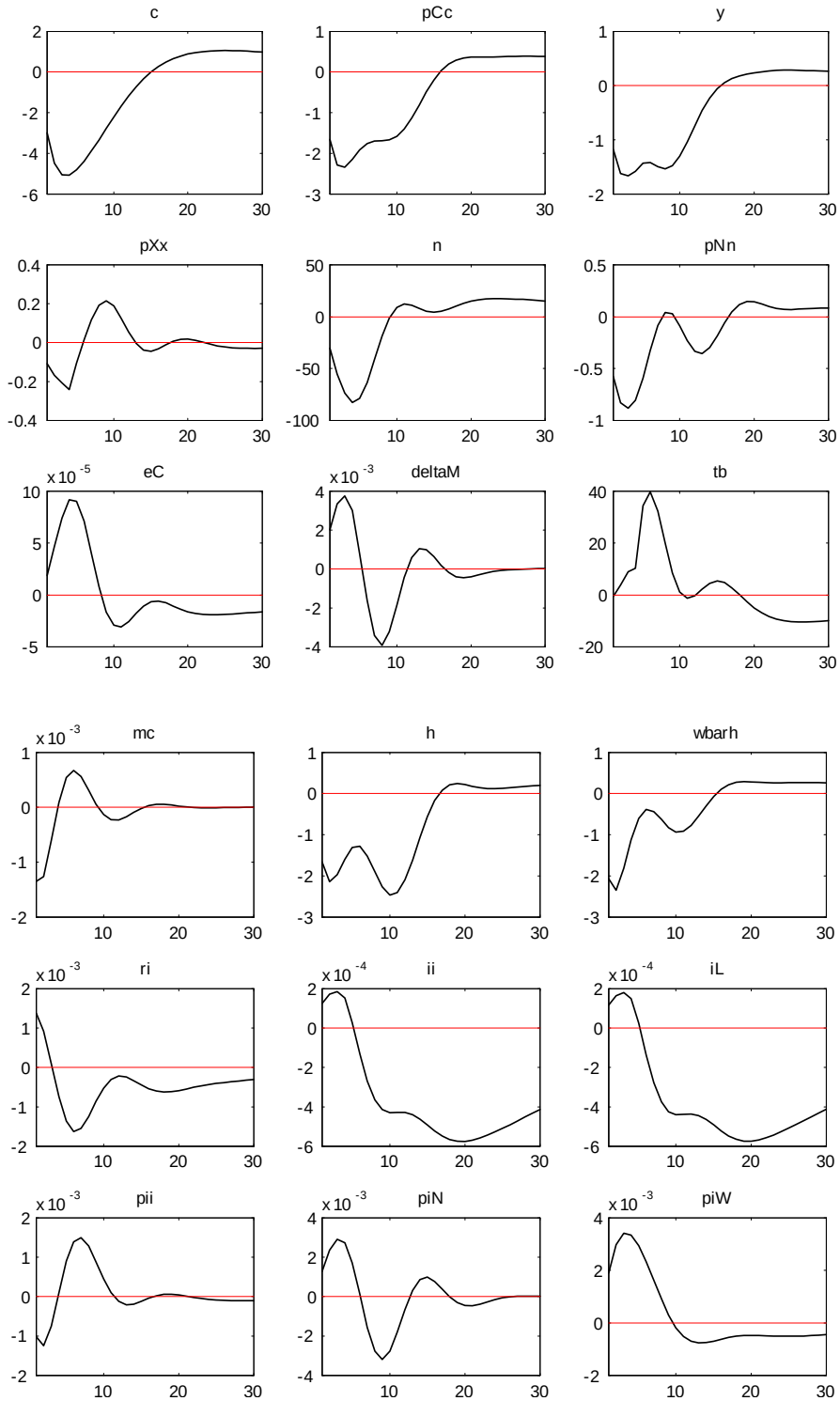
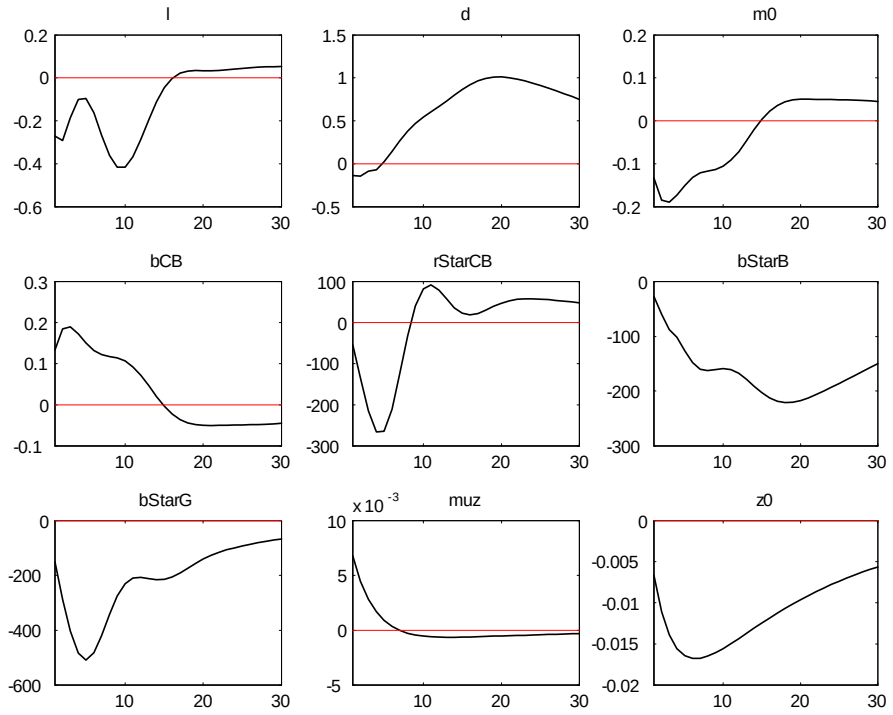
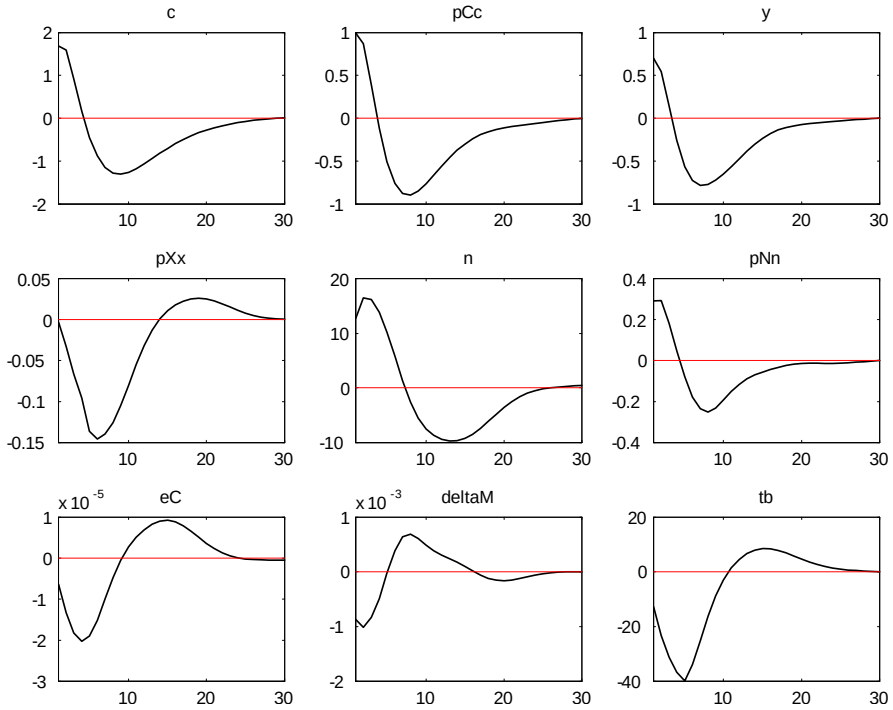
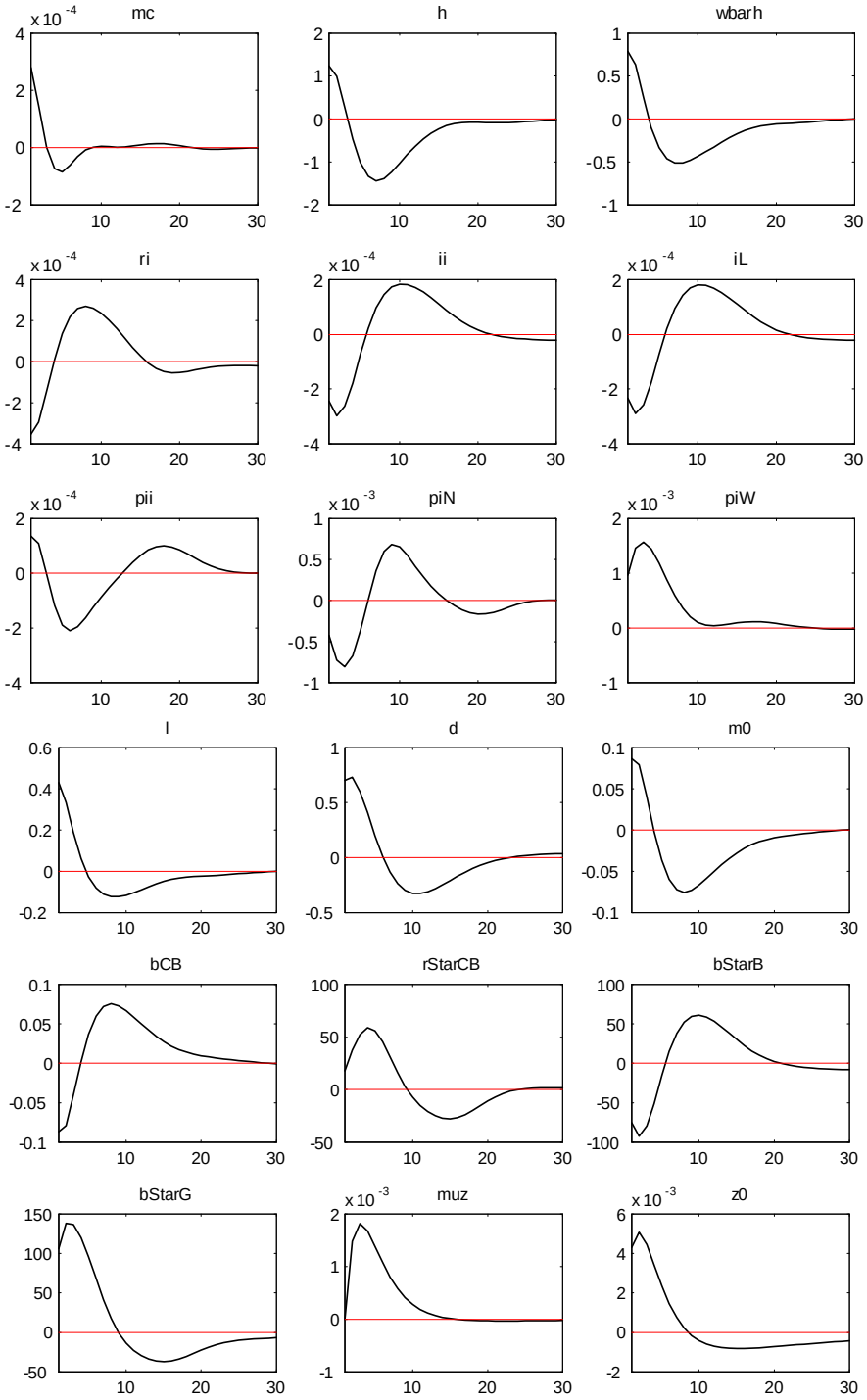
Response to a domestic permanent productivity growth shock $\varepsilon_t^{\mu^z}$,





Response to a RW permanent productivity growth shock $\varepsilon_t^{\mu^{z**}}$,

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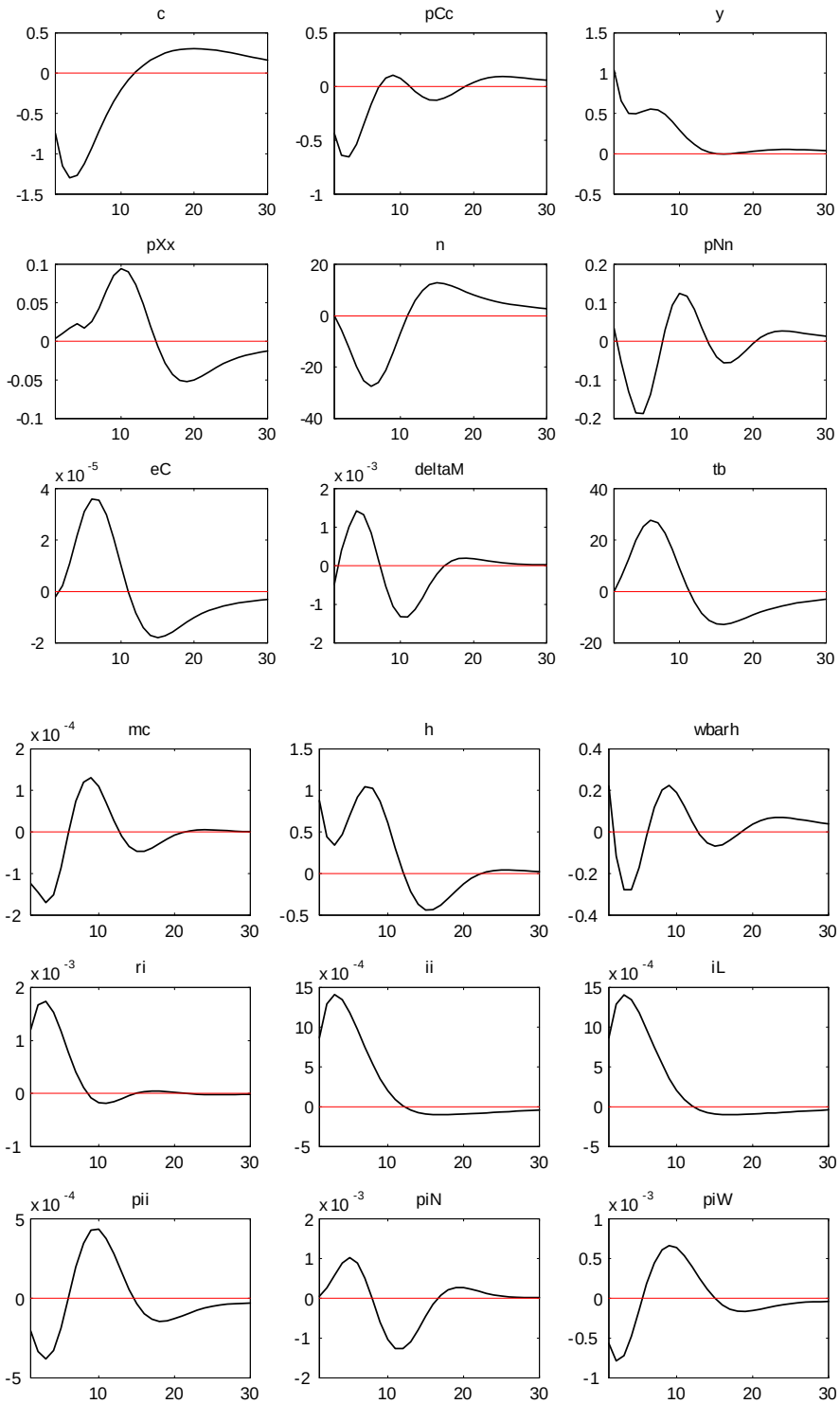
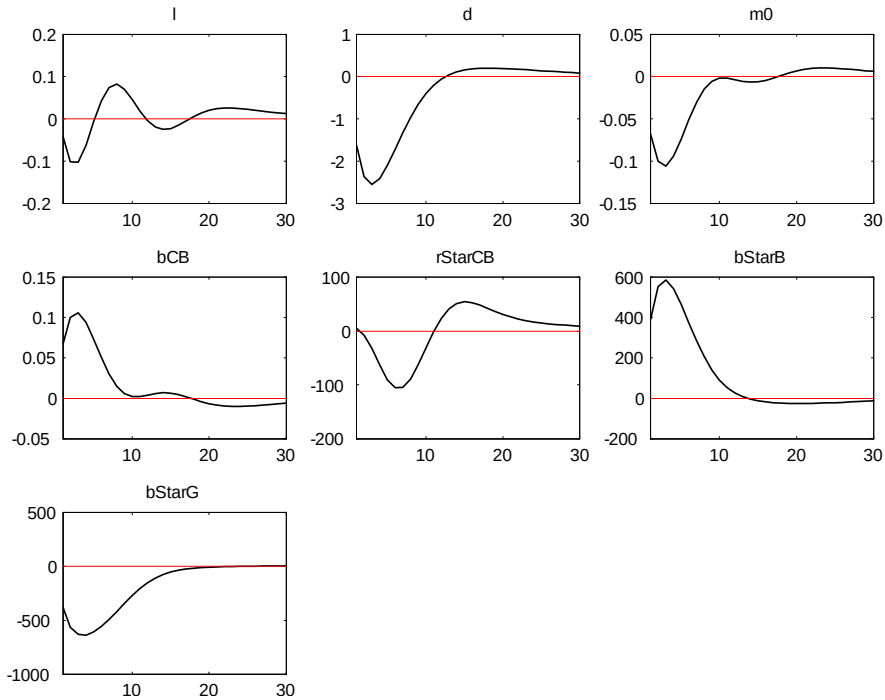
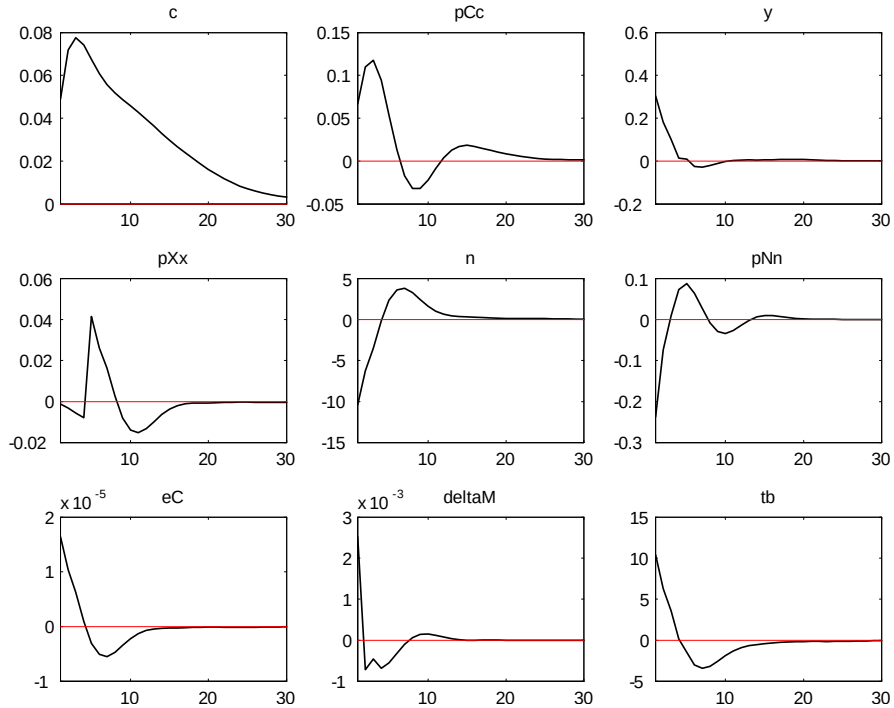
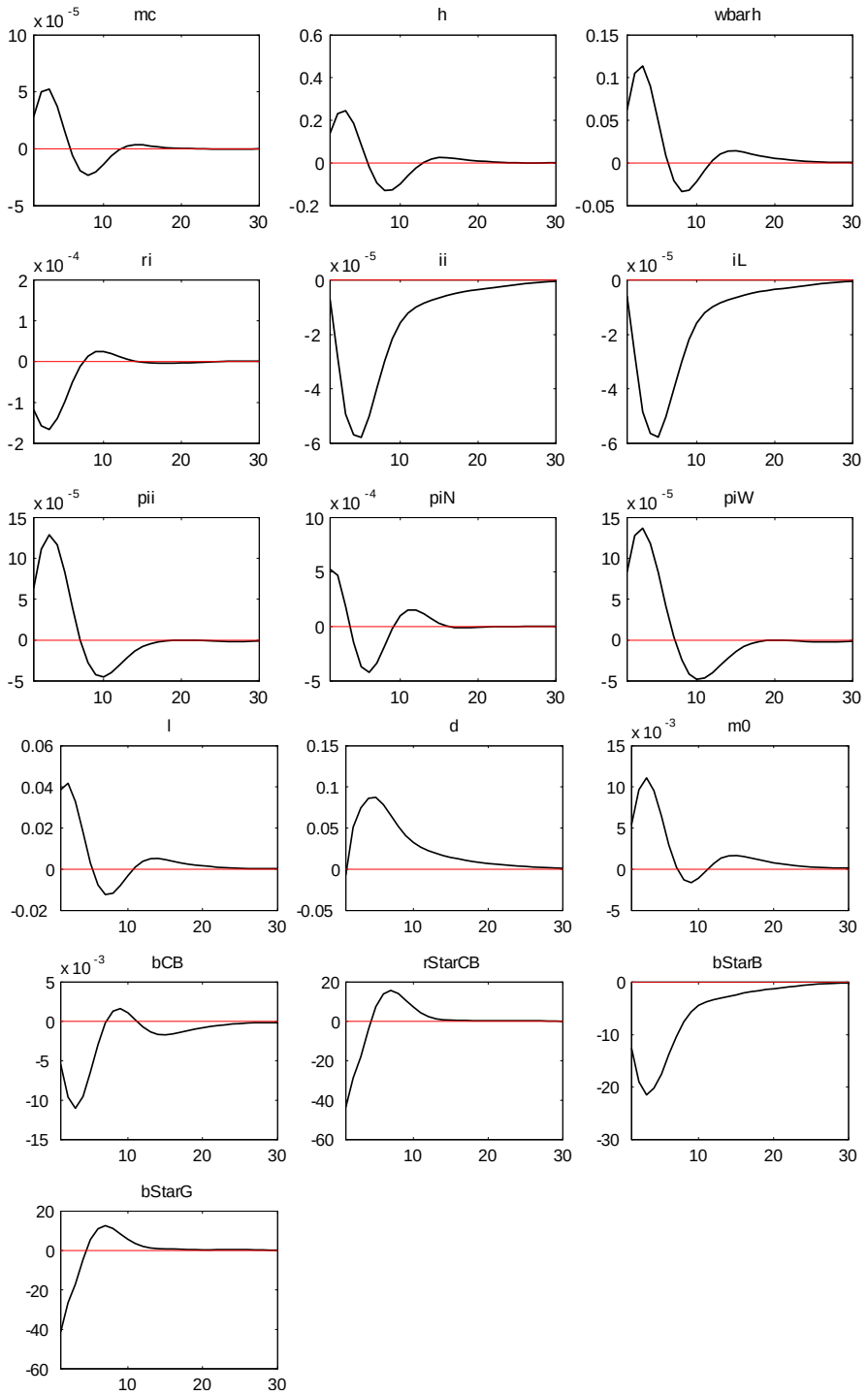
Response to a Government expenditure shock ε_t^g,





Response to a policy nominal depreciation shock ε_t^{δ},

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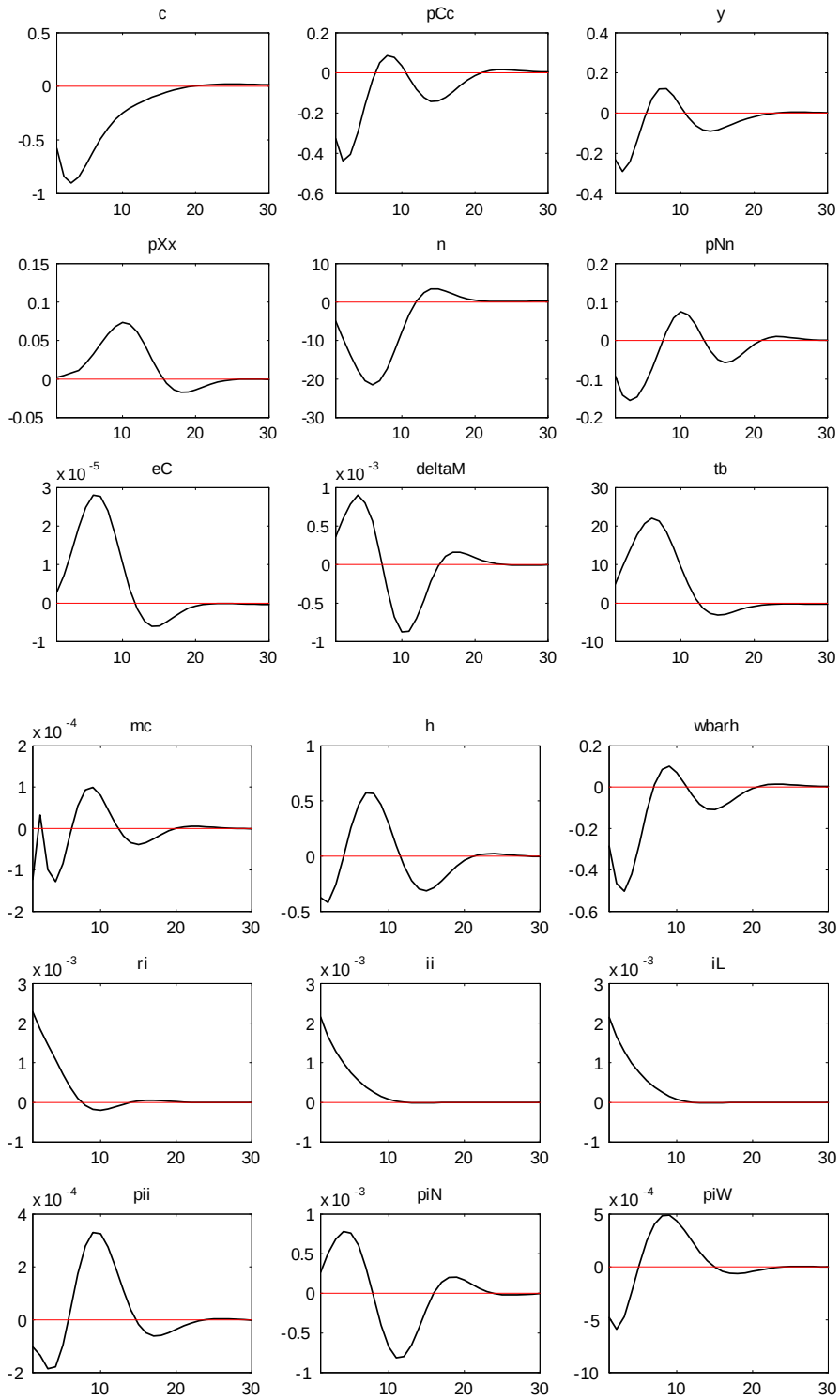
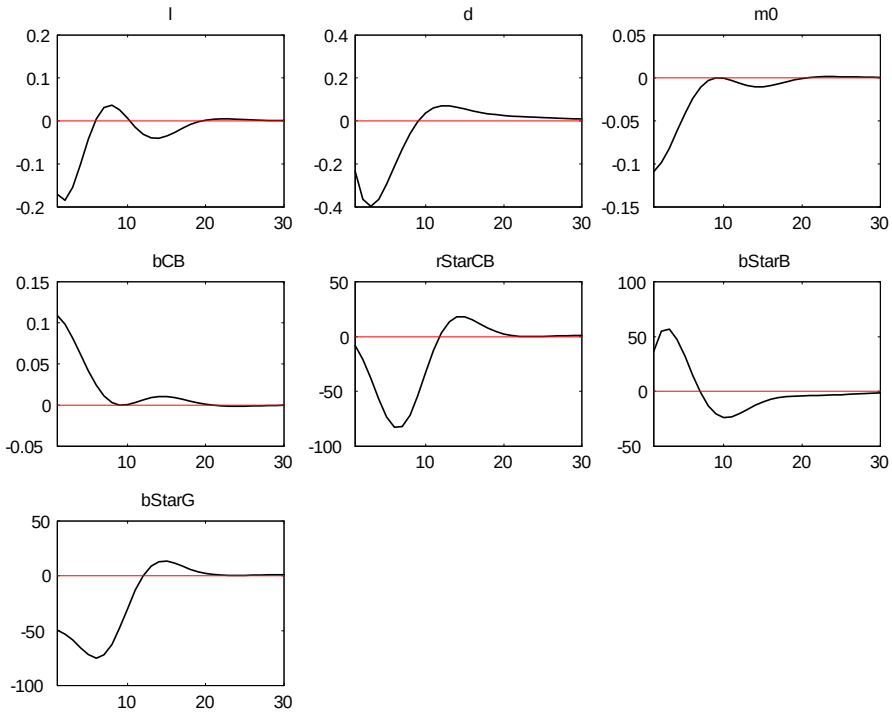
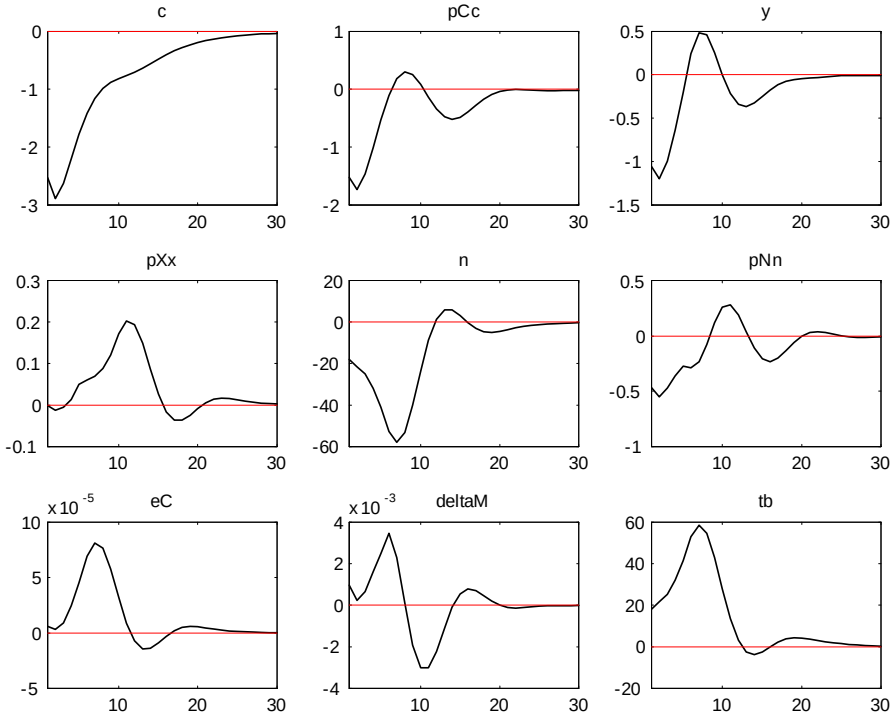
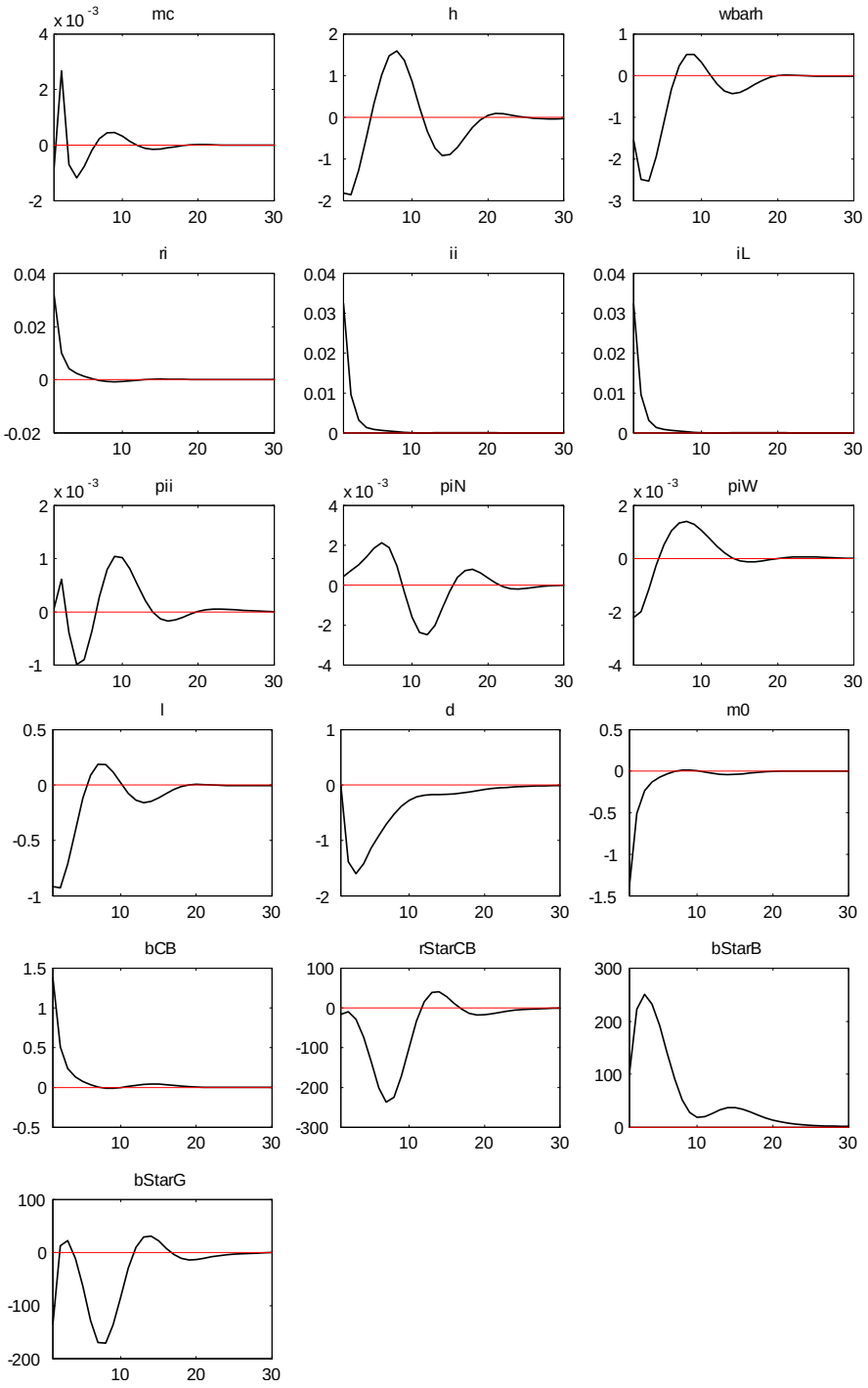
Response to a foreign interest rate shock $\varepsilon_t^{i^*}$,





Response to a foreign exogenous Bank risk premium shock $\varepsilon_t^{\phi^{B*}}$,

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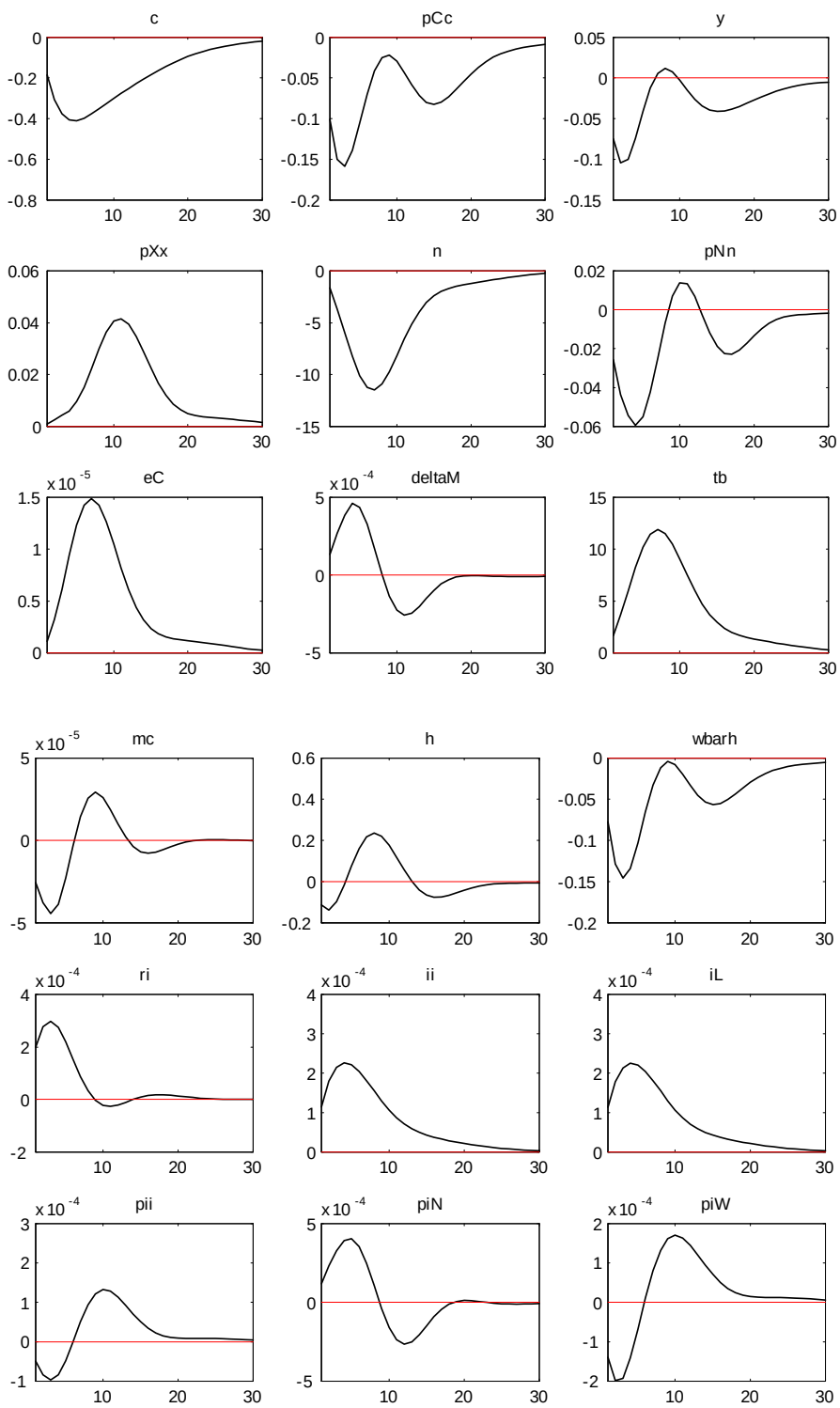
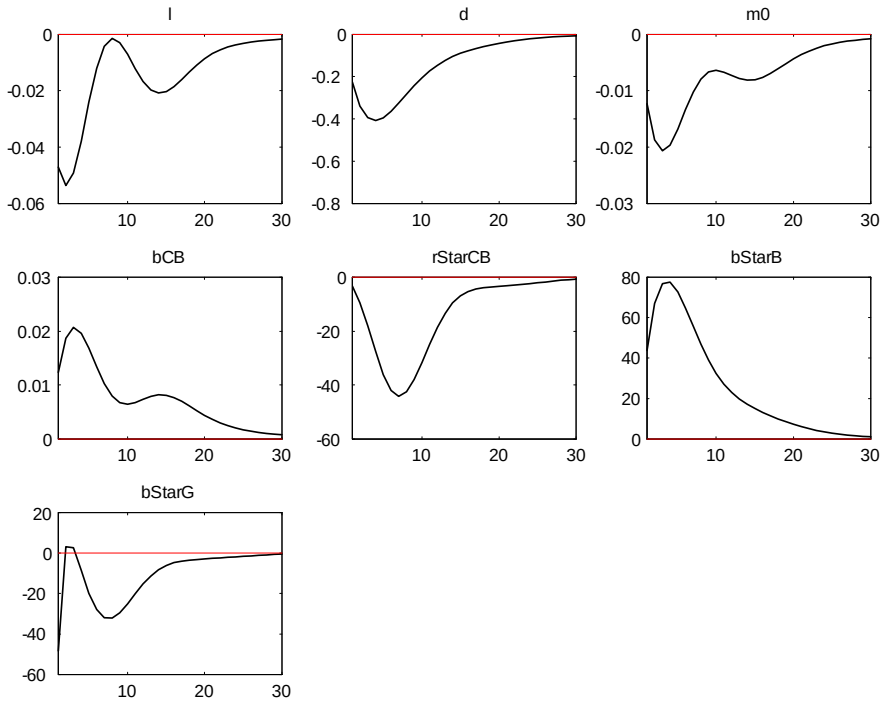
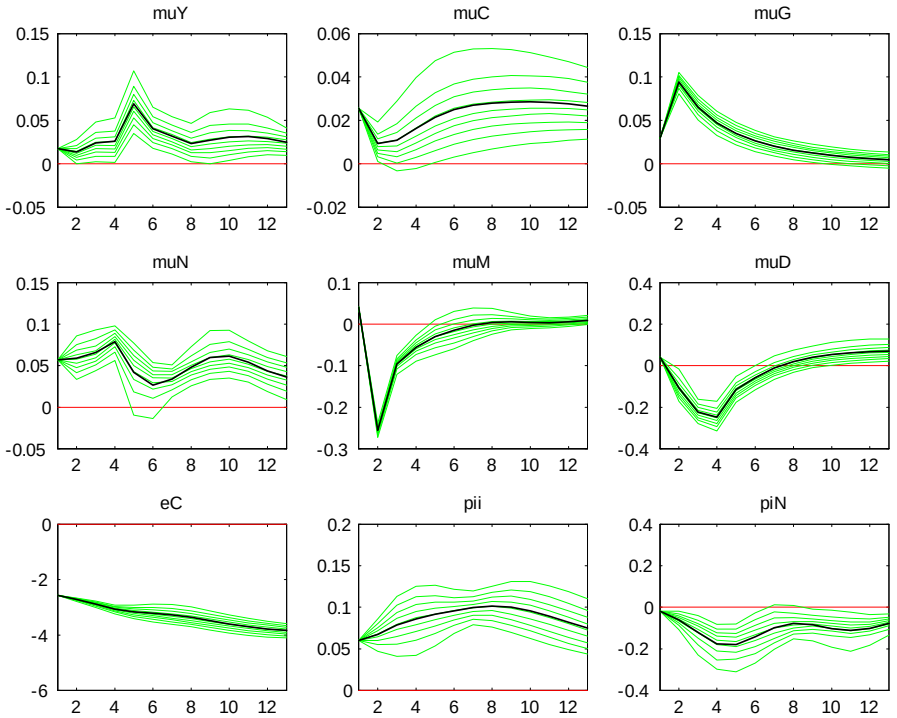
Response to a foreign exogenous Government risk premium shock $\varepsilon_t^{\phi^{G*}}$,



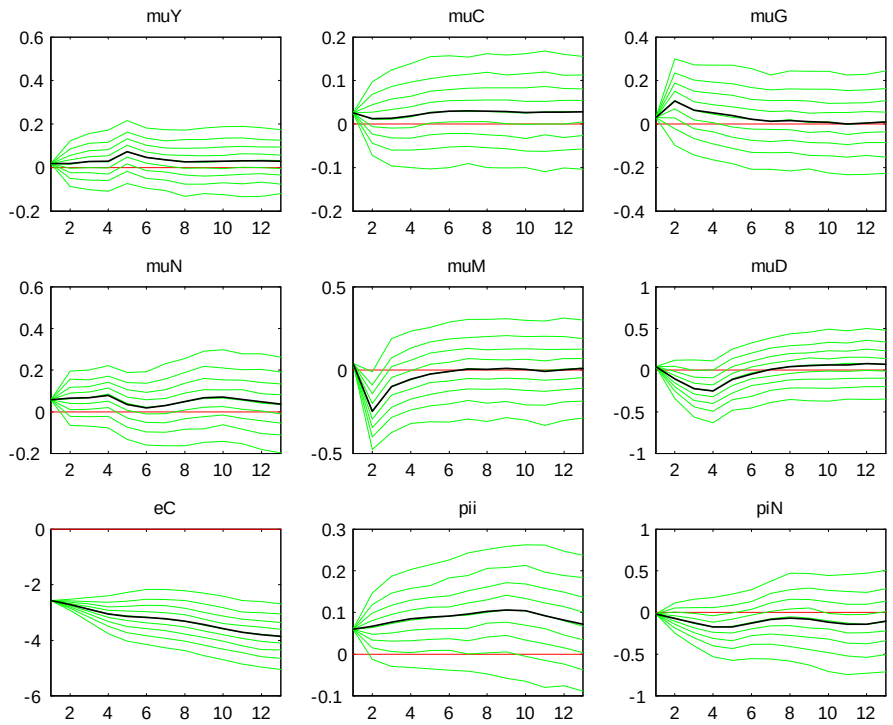


Forecasts of observable variables

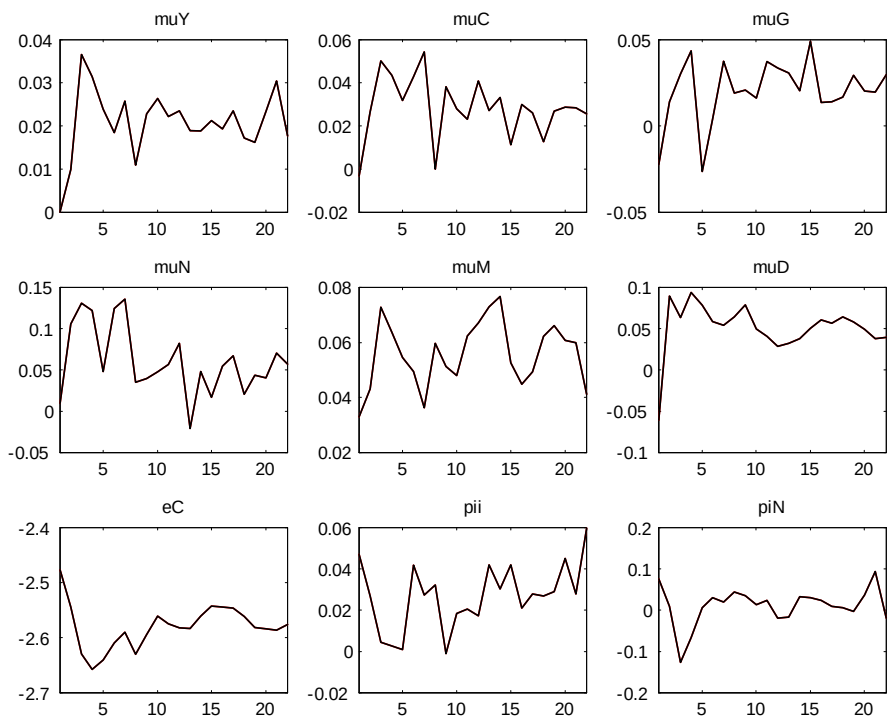
Mean forecasts for observable variables

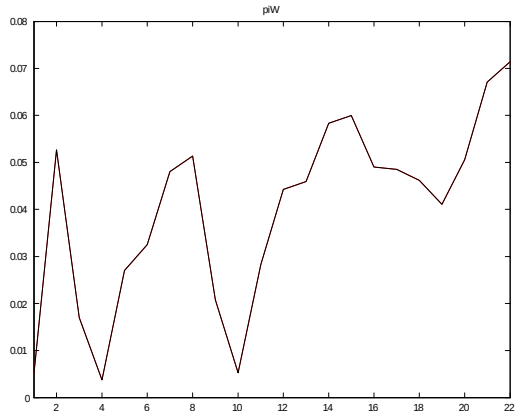


Point forecasts for observable variables

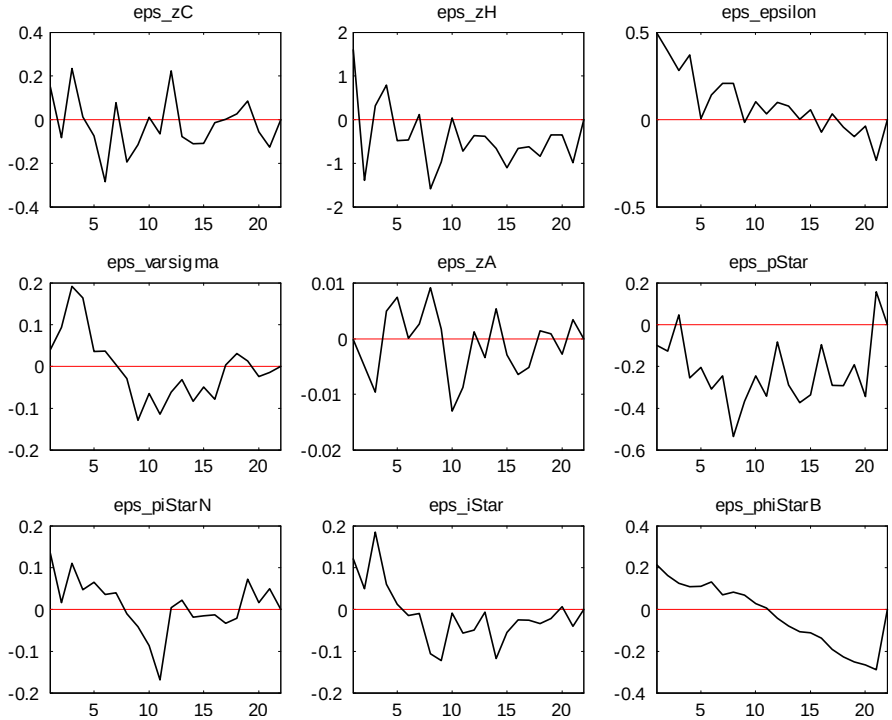


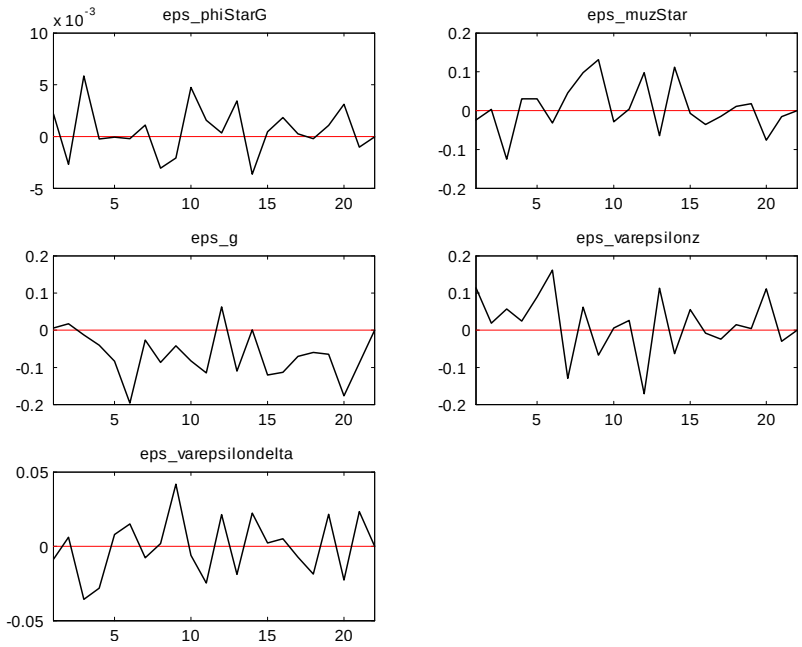
Observable variables





Smoothed shocks





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