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# Optimal Monetary Policy with Non-Zero Net Foreign Wealth

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## Abstract

I study the impact of net foreign wealth on the optimal monetary policy of an open economy in a two-country DSGE model with incomplete markets, sticky prices and deviations from the Law of One Price. I find that by optimally manipulating monetary policy, central banks can affect the timing of interest receipts (or payments) and therefore increase the risk-sharing role of the internationally traded asset. In particular, debtor nations find it optimal to allow their currency to float relatively more freely than do creditor nations. In order to maximize consumer welfare, in most specifications of the model central bank should target a weighted average of CPI inflation and changes in the nominal exchange rate.

Key words: optimal monetary policy, welfare, open economy, net foreign wealth.

JEL classification: E44, E52, F32, F34

## 1 Introduction

Interaction between exchange rates and the choice of monetary policy rules has been the focus of a multitude of papers in the open economy macro literature<sup>1</sup>. Recent developments in the global financial flows (currency crises of the late 1990's, rapid accumulation of U.S. government debt by East Asian countries, and the financial crisis of 2008) have also sparked interest in the choice of optimal monetary policy regime for developing countries. Calvo and Reinhart (2002) have documented the fact that many emerging economies exhibit "fear of floating," insofar as their exchange rates, quite independently of the official stance of the central banks, appear to fluctuate within a very narrow band. This observation has motivated many economists to study the question of whether exchange rate targeting could be an optimal policy choice for emerging markets.

This paper utilizes a standard two-country DSGE modeling framework to assess the importance of exchange rate targeting for developing economies, which are characterized by an exogenous interest rate premium on their liabilities (denominated in foreign currency) and non-zero net foreign wealth (NFW) holdings in the steady state. I abstract from the issues of central bank credibility and from any effects of the form of monetary rules on the risk premium. The central question addressed is the choice of monetary policy that maximizes welfare of the emerging economy, given its structural features, the behavior of the foreign country, and exogenous disturbances.

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<sup>1</sup>A non-exhaustive list of papers includes Cova and Søndergaard (2004), De Paoli (2009), Devereux (2004), Devereux, Lane and Xu (2006), Faia and Monacelli (2008) and Obstfeld and Rogoff (2002).

The fact that strict inflation targeting is optimal only under a very restrictive set of parameters has been well-documented in the literature<sup>2</sup>. Moreover, the majority of recent papers analyze monetary policy in the framework of a small open economy, a setup that carries with it two important implications: that the real exchange rate is constant because consumption baskets of the two economies (home country and the rest of the world) are identical, and that foreign country is unaffected by the choice of monetary rule of the small economy. Therefore, the (often clear-cut) results of these papers may not be valid in a more realistic case of a small country having non-negligible impact on its trading partner.

In many papers cited above, the approach to answering the question of optimal monetary policy has been to rank the following three rules in terms of their implications for welfare and economic stability: CPI inflation targeting, PPI inflation targeting, and exchange rate peg. I extend the analysis by including "hybrid" policies that target a weighted average of inflation and exchange rates. After calibrating the model based on a consensual set of parameter values, I obtain results that are quite different from the conventional wisdom in the literature that the policy of CPI inflation targeting welfare-dominates other options.

I show that the central bank can exploit the risk-sharing value of international assets (more specifically, the degree of cyclicity of interest payments or receipts) by adjusting its monetary policy stance in response to the level of NFW. Thus, indebted countries can increase their interest payments to foreigners in good times (following, for example, a local productivity shock) by allowing for a sharper depreciation of their currency; analogously, net creditor countries optimally put relatively more weight on exchange rate targeting to reduce capital inflows when domestic marginal utility is already low. These results may partly be driven by the relative importance of various disturbances in the calibration: technology shocks tend to dominate the New-Keynesian models<sup>3</sup>. The conclusions of this paper, however, are robust to the inclusion of other common sources of uncertainty (government and demand shocks).

The results of this paper add to the current debate on the optimal monetary policy in the open economy setting. Studies like Obstfeld and Rogoff (1995, 2002) have sparked interest in the ability and advisability of monetary policy influencing exchange rates in the context of fully articulated DSGE models. Galí and Monacelli (2005) lay out the theoretical framework to analyze the choice of monetary policy for a small open economy and present a special case for which domestic inflation targeting constitutes the optimal regime. Cova and Søndergaard (2004), Benigno and Benigno (2003), and Faia and Monacelli (2008), among others, contemplate the terms of trade channel through which monetary policy can increase welfare of its domestic residents.

The rest of the paper is organized as follows. Section 2 introduces the model and discusses the monetary policy rules under consideration. Section 3 presents the values, used in simulations, of the model parameters and discusses the implications associated with particular choices of these values for the results of the paper. Section 4 analyzes the impact of non-zero steady-state international debt on the choice of welfare-maximizing policy rules. Section 5 summarizes the findings and lists several extensions for future research.

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<sup>2</sup>See, for example, Faia and Monacelli (2008), Benigno and Benigno (2003), and De Paoli (2009).

<sup>3</sup>See Canzoneri et al (2006) for a detailed study of this issue.

## 2 The Model

The model belongs to the class of DSGE models that are commonly used for evaluating effects of different monetary policies in both closed and open economy settings.

The model is composed of two countries, *home* ( $H$ ) and *foreign* ( $F$ ). Both countries are populated by infinitely lived households of measure  $M$  in the home country and  $M^*$  in the foreign<sup>4</sup>; there is no migration. Households consume all varieties of home and foreign goods and have access to international markets where they can trade a nominal bond. Each country has measure one of firms that use country-specific labor and capital to produce a continuum of domestic goods, which are then traded internationally. Firms are monopolistically competitive, and the prices they set for their products are sticky à la Calvo (1983). International goods markets are segmented because firms set prices in local currency; therefore, the Law of One Price (LoOP) fails.

The key features of the model are (1) the requirement that foreign liabilities of Home (developing) country are denominated in foreign currency; (2) non-zero steady state NFW of the two countries; and (3) local currency pricing.

The first two assumptions are driven by the data. Local currency pricing (which results in incomplete exchange rate pass-through) is motivated by two observations. On the empirical side, the LoOP has been shown to fail when applied to tradable goods (for example, Rogoff (1996)); on the theoretical side, it adds another channel through which the central bank can affect the real exchange rate and, consequently, relative consumptions of the two countries (see section 4.1 for details.)

For modeling simplicity, I assume that all goods are traded. As a matter of notation, subscripts  $H$  and  $F$  will refer to a good's country of origin; asterisks will indicate that it is consumed in country  $F$ . For example,  $C_H^*$  denotes consumption of country  $H$ 's good in country  $F$ . The two economies have a similar structure; therefore, most of the equations will be presented only for the Home country.

### 2.1 Firms

Each country has a continuum of firms indexed by  $f$  on the unit interval. At time  $t$ , each Home firm rents capital  $K_{t-1}(f)$  from the domestic households at the rate  $R_t$ , hires a labor bundle  $N_t(f)$  at the rate  $W_t$  and produces one of the varieties of the domestic good. Each firm is free to set its own price level  $P_{H,t}(f)$  (denominated in local currency) at home and  $P_{H,t}^*(f)$  (denominated in foreign currency) abroad.

Home firms use the following CRS technology to produce output:

$$Y_{H,t}^s(f) = Z_t K_{t-1}(f)^\nu N_t(f)^{1-\nu},$$

where  $0 < \nu < 1$ , and  $Z_t$  denotes the level of productivity enjoyed by all the home firms at time  $t$ . Productivity in the two countries evolves according to the following autoregressive process:

$$\begin{bmatrix} \ln Z_t \\ \ln Z_t^* \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} \ln Z_{t-1} \\ \ln Z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{z,t} \\ \varepsilon_{z,t}^* \end{bmatrix}$$

All goods varieties are then bundled into a composite home and foreign goods using the Dixit-Stiglitz

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<sup>4</sup>See Mykhaylova (2009) for a detailed analysis of the explicit modeling of relative country size.

aggregator:

$$Y_{H,t}^s = \left[ \int_0^1 Y_{H,t}^s(f)^{\frac{\sigma-1}{\sigma}} df \right]^{\frac{\sigma}{\sigma-1}}$$

where  $\sigma > 1$ . This composite good can then be used for public and private consumption or private investment.

Imposing the zero-profit condition, the Home and Foreign prices of the bundle are given by  $P_{H,t} = \left[ \int_0^1 P_{H,t}(f)^{1-\sigma} df \right]^{\frac{1}{1-\sigma}}$  and  $P_{H,t}^* = \left[ \int_0^1 P_{H,t}^*(f)^{1-\sigma} df \right]^{\frac{1}{1-\sigma}}$ , and therefore aggregate demand (from consumers, investors and governments) for firm  $f$ 's product is  $Y_{H,t}^d(f) = \left[ \frac{P_{H,t}(f)}{P_{H,t}} \right]^{-\sigma} Y_{H,t}$  and  $Y_{H,t}^{*d}(f) = \left[ \frac{P_{H,t}^*(f)}{P_{H,t}^*} \right]^{-\sigma} Y_{H,t}^*$ .

As in Calvo (1983), home and foreign firms reset their prices each period with a constant probability  $(1-\alpha)$  and  $(1-\alpha^*)$ , respectively; otherwise, the old prices remain in effect. If a (home) firm  $f$  gets to announce a new price in period  $t$ , it chooses  $\tilde{P}_{H,t}(f)$  and  $\tilde{P}_{H,t}^*(f)$  to maximize its expected discounted future profits

$$E_t \sum_{j=t}^{\infty} \Omega_{t,j} \alpha^{j-t} \left\{ \tilde{P}_{H,t}(f) Y_{H,j}^d(f) + S_j \tilde{P}_{H,t}^*(f) Y_{H,j}^{*d}(f) - TC_j [Y_{H,j}^d(f) + Y_{H,j}^{*d}(f)] \right\}$$

$\Omega_{t,j}$  is the home households' stochastic discount factor:  $\Omega_{t,j} = \beta^{j-t} \left( \frac{\lambda_j}{\lambda_t} \right)$ , where  $\lambda_t$  is the marginal utility of nominal wealth (defined in section 2.2). Notice that in equilibrium,  $Y_{H,j}^d(f) + Y_{H,j}^{*d}(f) = Y_{H,t}^s(f)$ .

The optimal prices are given by

$$\begin{aligned} \tilde{P}_{H,t} &= \frac{\sigma}{\sigma-1} \frac{E_t \sum_{j=t}^{\infty} (\alpha\beta)^{j-t} \lambda_j P_{H,j}^{\sigma} Y_{H,j} MC_j}{E_t \sum_{j=t}^{\infty} (\alpha\beta)^{j-t} \lambda_j P_{H,j}^{\sigma} Y_{H,j}} \\ \tilde{P}_{H,t}^* &= \frac{\sigma}{\sigma-1} \frac{E_t \sum_{j=t}^{\infty} (\alpha\beta)^{j-t} \lambda_j P_{H,j}^{*\sigma} Y_{H,j}^* MC_j}{E_t \sum_{j=t}^{\infty} (\alpha\beta)^{j-t} \lambda_j P_{H,j}^{*\sigma} Y_{H,j}^* S_j} \end{aligned}$$

and the nominal marginal cost of production is

$$MC_t = \frac{R_t^{\nu} W_t^{1-\nu}}{Z_t \nu^{\nu} (1-\nu)^{1-\nu}}$$

Notice that in the presence of price stickiness, Home firms optimally take into account the entire path of future expected nominal exchange rates  $S_t$  when setting foreign prices for their products; the LOOP need not hold.

I consider a symmetric equilibrium in which every firm that gets a chance to reset its prices in period  $t$  will set it to the same value; therefore, optimal prices are not denoted by a firm subscript ( $f$ ). As  $\alpha \rightarrow 0$  and prices become perfectly flexible, each period firms set two new prices

$$\tilde{P}_{H,t} = S_t \tilde{P}_{H,t}^* \rightarrow \varphi_p MC_{H,t}.$$

Note that LoOP holds in this case.

Given the price-setting behavior of individual firms, the aggregate price indices of the Home goods at home and abroad can be written as

$$\begin{aligned} P_{H,t}^{1-\sigma} &= (1-\alpha)\tilde{P}_{H,t}^{1-\sigma} + \alpha P_{H,t-1}^{1-\sigma} \\ P_{H,t}^{*(1-\sigma)} &= (1-\alpha)\tilde{P}_{H,t}^{*(1-\sigma)} + \alpha P_{H,t-1}^{*(1-\sigma)} \end{aligned}$$

## 2.2 Households

There is a continuum of households in the home country, indexed by  $i$  on the interval  $[0, M]$ . A representative household maximizes expected lifetime utility<sup>5</sup>

$$U_t(h) = E_t \sum_{j=t}^{\infty} \beta^{j-t} \left\{ \frac{C_j(h)^{1-\Theta}}{1-\Theta} - \frac{L_j(h)^{1+\chi}}{1+\chi} \right\} \quad (1)$$

Here  $C_t(h)$  denotes the household's consumption of the composite good, which is aggregated from home and foreign goods using the CES aggregator:

$$C_t(h) = \left[ \mu_t^{\frac{1}{\eta}} C_{H,t}(h)^{\frac{\eta-1}{\eta}} + (1-\mu_t)^{\frac{1}{\eta}} C_{F,t}(h)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (2)$$

where  $\eta$  is the elasticity of substitution between home and foreign goods, and  $0 < \mu_t < 1$  determines the degree of home bias in consumption.  $C_t^*(h)$  denotes consumption of the aggregate good (with a different home bias  $\mu_t^*$ ) in the foreign country.

The specification of consumption aggregator (2) breaks away from the standard simplification in the open economy literature of equating relative country size and share of domestic good in the consumption basket (i.e., the assumption that small countries consume mostly imported goods) for several reasons. On the empirical side, home bias in consumption has been well documented in the trade literature (for example, Obstfeld and Rogoff (2000)). Moreover, by allowing for a different composition of Home and Foreign baskets, I decouple movements in the two countries' CPI levels and thus introduce richer dynamics of the real exchange rate, which has non-trivial implications for the choice of optimal monetary policy, as discussed in detail in Section 4.1. Finally, introducing a stochastic process for the home bias parameter  $\mu$  will allow us to model demand (preference) shocks.

The prices of the two final goods, which also represent the countries' CPIs, are given by

$$P_t = \left[ \mu_t P_{H,t}^{1-\eta} + (1-\mu_t) P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \quad (3a)$$

$$P_t^* = \left[ \mu_t^* P_{F,t}^{*(1-\eta)} + (1-\mu_t^*) P_{H,t}^{*(1-\eta)} \right]^{\frac{1}{1-\eta}} \quad (3b)$$

Consequently, the household ( $h$ )'s demands for the composite goods are given by  $C_{H,t}^d(h) = \mu_t \left[ \frac{P_{H,t}}{P_t} \right]^{-\eta} C_t(h)$  and  $C_{F,t}^d(h) = (1-\mu_t) \left[ \frac{P_{F,t}}{P_t} \right]^{-\eta} C_t(h)$ .

<sup>5</sup> Following Woodford (2003), Chapter 3, I model monetary policy as directly targeting (some measure of) inflation, and therefore drop real balances from the consumer utility function.

Households supply differentiated labor services to all the firms in their country. The composite labor bundle used in production by any given home firm is given by<sup>6</sup>

$$N_t(f) = M^{\frac{1}{1-\phi}} \left[ \int_0^M L_t(h, f)^{\frac{\phi-1}{\phi}} dh \right]^{\frac{\phi}{\phi-1}}$$

Each household enjoys a degree of monopolistic power in setting its wage  $W_t(h)$ . The demand for household ( $h$ )'s labor services given its wage is

$$L_t(h) = \left[ \frac{W_t(h)}{W_t} \right]^{-\phi} \frac{N_t}{M} \quad (4)$$

Here  $N_t = \int_0^1 N_t(f) df$  is the aggregate demand for the household's labor services from all firms in the economy, and  $W_t$  is the aggregate real wage:  $W_t = M^{\frac{1}{\phi-1}} \left[ \int_0^M W_t(h)^{1-\phi} dh \right]^{\frac{1}{1-\phi}}$ .

Each household faces the following budget constraint:

$$\begin{aligned} E_t[\Delta_{t,t+1} D_t(h)] + B_t^d(h) + S_t A_t(h) + P_t [C_t(h) + I_t(h) - T_t(h)] = \\ = W_t(h) L_t^d(h) + D_{t-1}(h) + (1 + i_{t-1}) B_{t-1}^d(h) + [1 + i_{t-1}^* - p(e^{a_t-1} - 1)] S_t A_{t-1}(h) + \\ R_t K_{t-1}(h) + \Pi_t(h) \end{aligned} \quad (5)$$

The first term on the left-hand side is the price of a portfolio of state-contingent bonds traded domestically, and  $D_{t-1}$  is the payoff of such portfolio in period  $t$ .  $B_t^d(h)$  represents household's demand for the riskless one-period nominal domestic government bond<sup>7</sup>. Households receive transfers  $P_t T_t(h)$  from their government (which can be negative in the event of lump-sum taxation).  $\Pi_t(h)$  represent household's dividend income.

The modeling of incomplete markets is borrowed from Benigno (2009) and Andrés et al (2006). Home households can buy the foreign bond  $A_t(h)$ , but at a different price than foreign households. Home consumers' price  $S_t [1 + i_t^* - p(e^{a_t-\bar{a}} - 1)]^{-1}$  depends on their position in the international asset market. Here  $a_t \equiv M \frac{S_t A_t}{4 P_t Y_t}$  is the ratio of the aggregate real foreign asset holdings by home consumers to domestic output,  $\bar{a}$  is the steady state level of  $a_t$ , and the parameter  $p$  captures transaction costs<sup>8</sup>. As lenders ( $a_t > 0$ ), domestic households pay a higher price for the bond, and as borrowers they must offer a rate of return higher than  $(1 + i_t^*)$ .

The household's capital accumulation is given by

$$K_t(h) = (1 - \delta) K_{t-1}(h) + I_t(h) - \frac{1}{2} \psi \left[ \frac{I_t(h)}{K_{t-1}(h)} - \delta \right]^2 K_{t-1}(h) \quad (6)$$

Here, the investment good  $I_t(h)$  has the same composition as consumption in (2) and  $\psi$  controls the value of capital adjustment costs.

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<sup>6</sup>The scaling factor  $M^{\frac{1}{1-\phi}}$  is necessary to maintain the aggregate relationship  $N_t = \int_0^1 N_t(f) df = M L_t(h)$ . Together with the expression  $K_t = M K_t(h)$  this will ensure that the production function exhibits constant returns to scale. Additionally, in the steady state the aggregate wage  $W$  will equal the individual wage  $W(h)$ .

<sup>7</sup>In the presence of the complete set of Arrow securities  $D_t$ , government bonds are redundant for the purposes of risk-sharing; I introduce them to model the dynamics of national debt.

<sup>8</sup>Equilibrium dynamics of a small open economy with incomplete asset markets generally include a random walk component; the transaction cost modification guarantees stationarity of the model. See Schmitt-Grohé and Uribe (2003) for explicit treatment of the problem.

Households maximize utility (1) subject to the budget constraint (5), labor demand (4) and capital accumulation constraint (6) by choosing wage rate  $W_t(h)$ , consumption  $C_t(h)$ , portfolio holdings  $D_t(h)$ ,  $B_t^d(h)$  and  $A_t(h)$ , and investment  $I_t(h)$ .

Wages are sticky, and in any given period a household gets to reset its wage with probability  $(1 - \omega)$  ( $(1 - \omega^*)$  abroad). The optimal new wage satisfies

$$\tilde{W}_t^{\phi\chi+1} = \frac{\phi}{\phi - 1} \frac{E_t \sum_{j=t}^{\infty} (\omega\beta)^{j-t} W_j^{\phi(\chi+1)} N_j^{1+\chi}}{E_t \sum_{j=t}^{\infty} (\omega\beta)^{j-t} \lambda_j W_j^{\phi} N_j}$$

Assuming that every household that chooses its wage in period  $t$  sets it to the same new value, I drop the subscript  $(h)$  on the optimal wage rule. Similar to the derivations of the aggregate price level given firms' first-order conditions, the aggregate wage level is given by

$$W_t^{1-\phi} = (1 - \omega)\tilde{W}_t^{1-\phi} + \omega W_{t-1}^{1-\phi}$$

The rest of the first order conditions for the household problem are listed in Appendix A.

### 2.3 The Government

The aim of this paper is to analyze the effects of various monetary policy rules on consumer welfare. I do not address the question of monetary policy cooperation; instead, it is assumed that the central bank of the Foreign country credibly targets domestic CPI inflation (so that  $\pi_t^{*CPI} = 0$  at all times), and look for the welfare-maximizing rule that can be adopted by the Home monetary authority.

The first three monetary policy functions we consider (and which are analyzed in most of the related literature) can be generally written as<sup>9</sup>

$$i_t = X_t^\gamma, \text{ for } X_t \in \{\pi_t^{CPI}, \pi_t^{PPI}, \Delta s_t\} \text{ and } \gamma \rightarrow \infty$$

Here  $\pi_t^{CPI}$  and  $\pi_t^{PPI}$  denote Home country's CPI and PPI inflations, respectively, and  $\Delta s_t$  measures (log) depreciation of the domestic currency. The parameter  $\gamma$  controls the degree to which each variable is stabilized around the desired target level (of zero). As  $\gamma \rightarrow \infty$ , the central bank eliminates all fluctuations in either of the two measures of inflation, or nominal exchange rates.

Alternatively, the Home central bank can adopt a variation of the Taylor rule commonly used in monetary literature:

$$i_t = (1 - \rho_i)\bar{i} + \rho_i i_{t-1} + (1 - \rho_i) [\varpi \pi_t^{CPI} + (1 - \varpi) \Delta s_t] \quad (7)$$

Here  $\bar{i} = \frac{1}{\beta} - 1$  is the steady state level of the interest rate, and  $\varpi$  indicates the relative weight on inflation vs. exchange rate targeting. I study a range of values for this parameter:  $\varpi \in [0, 1]$ . Section 3 provides more detail on the calibration of the model.

The Home country fiscal authority has the following budget constraint:

$$B_t^s = (1 + i_{t-1})B_{t-1}^s + P_t G_t + P_t T_t$$

Per-capita government purchases  $G_t$  have the same composition as consumption in (2).

<sup>9</sup>Cova and Søndergaard (2004) report that these three rules are identical to the more standard specifications  $\pi_t^{CPI} = 0$ ,  $\pi_t^{PPI} = 0$  and  $\Delta s_t = 0$ , respectively.



Each government can affect the functioning of its domestic economy through transfers and purchases. I let government purchases be described by an autoregressive process

$$\ln G_t = (1 - \rho_g) \ln \bar{G} + \rho_g \ln G_{t-1} + \varepsilon_{g,t},$$

and shocks to government purchases are uncorrelated white noise processes<sup>10</sup>. Transfers react to the debt-to-GDP ratio to ensure long-run fiscal solvency:

$$\ln T_t = (1 - \rho_{tr}) \ln \bar{T} + \rho_{tr} \ln T_{t-1} + \rho_b (\ln \bar{B} - \ln B_{t-1})$$

In the above equations bars denote steady state values of variables.

## 2.4 Equilibrium

Goods market clearing conditions are described by

$$\begin{aligned} Y_{H,t} + Y_{H,t}^* &= M (C_{H,t} + I_{H,t} + G_{H,t}) + M^* (C_{H,t}^* + I_{H,t}^* + G_{H,t}^*) \\ Y_{F,t} + Y_{F,t}^* &= M (C_{F,t} + I_{F,t} + G_{F,t}) + M^* (C_{F,t}^* + I_{F,t}^* + G_{F,t}^*) \end{aligned}$$

Equilibrium in the asset markets requires that

$$\begin{aligned} \int_0^M D_t(h) dh &= \int_0^{M^*} D_t^*(h) dh = 0 \\ \int_0^M B_t^d(h) dh &= MB_t^s \\ \int_0^M A_t(h) dh + \int_0^{M^*} B_t^{d*}(h) dh &= M^* B_t^{s*} \end{aligned}$$

Equilibrium in the economy is defined by these market clearing conditions and the first order conditions of the agents, given the form of monetary and fiscal policy rules described above.

## 2.5 Measure of National Welfare

I define the value function that measures national welfare as

$$V_t = \max E_t \sum_{j=t}^{\infty} \beta^{j-t} \left\{ \frac{MC_j^{1-\Theta}}{1-\Theta} - \frac{1}{1+\chi} AL_j \right\},$$

where  $AL_j \equiv \int_0^M L_j(h)^{1+\chi} dh$  measures the aggregate disutility of work. This function will allow me to make quantifiable comparisons of consumer welfare across different specifications of the two economies (for example,  $V_t$  measures welfare of a flexible price economy, and  $\tilde{V}_t$  captures the case of sticky prices). In the case of log utility, the difference between the two value functions,

$$\epsilon = V_t - \tilde{V}_t$$

can be interpreted as cost, expressed as percent of consumption, of moving away from the flexible price specification to (in the above example) the economy with nominal rigidities.

<sup>10</sup>Adding government spending shocks moves the economy farther away from the complete markets allocation and makes monetary policy more relevant for consumer welfare.

Parameter	Description	Value
$\Theta$	Relative risk aversion	1.0
$\chi$	Inverse of Frisch labor elasticity	3.0
$\mu$	Consumption home bias (domestic good)	0.75
$\eta$	Elasticity of substitution between home and foreign goods	1.5
$A$	Matrix of technology coefficients	$\begin{pmatrix} 0.90 & 0.09 \\ 0.09 & 0.90 \end{pmatrix}$
$\delta$	Capital depreciation rate	0.025
$\psi$	Capital adjustment cost	8.0
$\sigma$	Elasticity of substitution between goods varieties	8.0
$\phi$	Elasticity of substitution between labor varieties	7.0
$\alpha$	Price stickiness	0.67
$\omega$	Wage stickiness	0.75
$p$	Risk premium on int'l borrowing/lending	0.001
$\rho_i$	Interest rate inertia in the Taylor Rule	0.9

Table 1: Benchmark parameter values

### 3 Parameterization

Each time period in the model corresponds to one quarter. The benchmark specification is described in Table 1. My goal was to choose the most non-controversial set of parameter values to illustrate the results. Therefore, most of the reported values are standard in the literature; a few others merit further description. Unless otherwise indicated, all parameters describing the Foreign economy are identical to the ones in the Home country.

I assume log utility of consumption, and set  $\chi = 3$ , which implies a labor supply elasticity of  $\frac{1}{3}$ . I set  $\beta = 0.99$ , which produces a steady state riskless annual return of 4 percent. Cobb-Douglas parameter  $\nu$  in the production function is set to 0.33. Calibration of productivity processes is borrowed from Backus, Kehoe and Kydland (1993), with  $Var(\varepsilon_z) = Var(\varepsilon_z^*) = 0.000074$ , and  $Cov(\varepsilon_z, \varepsilon_z^*) = 0.0000185$ . Elasticities of substitution between goods varieties,  $\sigma$ , and labor varieties,  $\phi$ , result in price markup of 14 percent and wage markup of 17 percent, respectively.

I follow Canzoneri et al. (2007) in setting the value of nominal price and wage rigidities:  $\alpha = 0.67$  and  $\omega = 0.75$ , resulting in price and wage contracts that on average last three and four quarters, respectively.

I set the home bias parameter  $\mu = 0.75$  for all specifications of the relative country sizes. However, the parameter  $\mu^*$  must be adjusted as the Foreign country becomes progressively larger, to avoid disproportionate demand on either country's output; otherwise, discrepancy in steady state unemployment and wages would complicate welfare comparisons<sup>11</sup>.

There is no agreement in the literature on the appropriate value for the elasticity of substitution between Home and Foreign goods,  $\eta$ . However, recent studies report the value of  $\eta$  between 1.5 and 2; see Faia and Monacelli (2008) and papers cited therein. I follow Monacelli (2003) in setting this parameter equal to 1.5. The non-trivial implication of this choice of  $\eta$  (in conjunction with

<sup>11</sup>More specifically, the following relationship must hold in all specifications of the model:  $M\mu + M^*(1 - \mu^*) = M$  (and, similarly,  $M(1 - \mu) + M^*\mu^* = M^*$ ).

log-utility of consumption) is that Home and Foreign bundles in (2) are substitutes. I perform a robustness check by running the simulations with  $\eta = 0.9$  (complements), and find that the conclusions are robust to this change in the parameter value.

The cost of participating in the international asset markets,  $p$ , is set to  $10^{-3}$ , as in Benigno (2009).

### 3.1 Government Policies

It is a well-known and documented fact that many countries have non-zero net holdings net of foreign assets<sup>12</sup>. In such cases, the policy of producer or consumer price stability may no longer be optimal, since nominal exchange rate fluctuations may have significant impact on the interest rate spread and the amount of interest paid on international loans.

The ratio of government debt to GDP has to be stationary in the model; fiscal policy, therefore, must respond in some way to either deficit or debt. In the model government transfers respond to the deviation of debt ratio from its steady-state value, which is set at 20 and later 50 percent of GDP<sup>13</sup>.

The parameters of the government policy functions are set as follows:  $\rho_g = \rho_{tr} = \rho_i = 0.9$  and  $Var(\varepsilon_g) = 0.0082$ ; see Mykhaylova (2009) for details of estimation. Responsiveness of transfers to the level of debt  $\rho_b$  was set to 0.1 in order to satisfy the Blanchard-Kahn conditions.

Solution to the model is found using perturbation methods described in Schmitt-Grohé and Uribe (2004) and Collard and Juillard (2001); computer code is written in Dynare (Collard and Juillard (2003)). Second order approximations were used to compute moments, variance decompositions, value functions and impulse response functions presented below.

## 4 Welfare Results

I consider three different specifications of the relative country size: symmetric case, and Foreign country being four and then nineteen times the size of the Home economy. Recall, however, that in all specifications a large portion ( $\mu = 0.75$ ) of Home consumer basket consists of domestically produced goods, which makes this analysis different from the standard small open economy setup. All numbers are reported for the Home country, since the policy of the Foreign central bank is taken to be exogenous.

Before presenting the results of the simulations, it is worth mentioning the mechanisms behind welfare numbers. The first two economic inefficiencies characterizing the model are nominal rigidities, which lead to inefficient allocation of goods produced with the same technology and call for at least some degree of price stabilization, and monopolistic competition, which results in suboptimal levels of output and work effort and introduces an incentive for the central bank to pursue expansionary policy. In addition, the failure of the aggregate PPP introduces a channel through which monetary authority can affect domestic consumption by manipulating the real exchange rate and terms of trade.

For each relative size specification, I study the impact of international asset holdings on the welfare-maximizing choice of monetary policy rule. As a benchmark (and for easier comparison with the existing literature), I consider the no-debt steady state, and then discuss welfare implications of non-zero holdings of foreign assets or liabilities on the optimal monetary regime.

<sup>12</sup>Lane and Milesi-Ferretti (2007a, 2007b) present evidence on NFW positions of developing and industrial countries.

<sup>13</sup>As a matter of reference, the U.S. national debt was close to 70% of GDP as of October 2008.

## 4.1 Benchmark Zero-Debt Case

I find that in all three size specifications, welfare-maximizing policy takes the form of the Taylor rule with a lagged interest-rate term and a weighted average of CPI inflation and exchange rate depreciation, as in equation (7).

The first (non-controversial) finding is that adding a lagged interest rate term to the monetary policy rule improves welfare numbers. Thus, pursuing the policy described by  $i_t = (\pi_t^{CPI})^\infty$  is welfare-dominated by the rule of the form  $i_t = (1 - \rho_i)\bar{i} + \rho_i i_{t-1} + (1 - \rho_i)\pi_t^{CPI}$ ; the same holds true for pure exchange rate targeting. In a forward-looking model, increasing interest rate persistence means that stabilization (of inflation, output, exchange rate or any other target of the central bank) requires a much smaller movement of the time- $t$  interest rate, since such movement is expected to prevail far into the future. Lower volatility of interest rates, in turn, implies lower volatility of consumption, output, and labor effort, and thus higher consumer welfare. This result has been discussed in great detail in Woodford (1999), and has also been reported more recently by Senay (2008).

The second result is that the optimal policy in the majority of considered specifications is a mix of CPI and exchange rate targeting; more specifically,  $\varpi$  in (7) belongs to the open interval  $(0, 1)$ . There are several reasons (documented in literature) why central bank in a New-Keynesian model should pay some attention to the exchange rate movements. As noted in Faia and Monacelli (2008) and De Paoli (2009), the presence of home bias in the international consumption aggregator (2) generates endogenous movements of the real exchange rate in response to the actions of the monetary authority aimed at manipulating terms of trade; real exchange rate, in turn, affects relative consumptions in the two countries<sup>14</sup>. To see this, we substitute (3a) and (3b) into the definition of the real exchange rate  $Q_t \equiv \frac{S_t P_t^*}{P_t}$  and linearize around  $P_H^* = P_F^* = P^*$  and  $P_{F,t} = P_{H,t}$ :

$$q_t = [\mu_t^* + \mu_t - 1] \tau_t + \mu_t \varepsilon_t^H + \mu_t^* \varepsilon_t^F, \quad (8)$$

where  $\tau_t \equiv p_{F,t} - (p_{H,t}^* + s_t)$  is the terms of trade, and  $\varepsilon_t^H$  and  $\varepsilon_t^F$  measure deviations from the LoOP arising due to local currency pricing coupled with nominal rigidities:  $\varepsilon_t^F \equiv p_{F,t}^* + s_t - p_{F,t}$  and  $\varepsilon_t^H \equiv p_{H,t}^* + s_t - p_{H,t}$ .

As can be seen from (8), these deviations create an additional channel through which nominal exchange rate can affect consumer welfare (again, through its impact on relative consumptions in the two countries). As discussed in detail in Monacelli (2003), the presence of imperfect exchange rate pass-through calls for an optimal management of nominal exchange rates by the central bank.

## 4.2 Non-Zero NFW and the Timing of Payments

Having established the fact that some degree of nominal inertia is beneficial, I now turn to the main question of this paper: the optimal weight on CPI targeting vs. exchange rate targeting in the policy rule of the central bank (the parameter  $\varpi$  in (7)). One of the contributions of this work lies in considering the welfare impact of such "hybrid" rules; most of the related literature only considers pure CPI, PPI or exchange rate targeting regimes.

<sup>14</sup>International asset markets are incomplete, so the usual link between home and foreign consumption levels,  $C_t = Q_t C_t^*$ , does not hold. However, the degree of international risk-sharing remains very high:  $Corr(c_t - c_t^*, q_t)$  remains above 0.95 in most cases and drops down to 0.50-0.60 when Home country holds claims on Foreign country in the steady state.

Size	No Debt	50% Liab.		50% Assets	
	$\varpi$	$\varpi$	Gain	$\varpi$	Gain
1:1	0.29	0.60	0.004	0.00	0.001
1:4	0.73	0.93	0.002	0.57	0.004
1:19	0.81	1.00	0.004	0.65	0.002

Table 2: Optimal monetary policy ( $\varpi$  is the relative weight on CPI targeting in the monetary policy rule), and welfare gains (measured in percent of consumption), achieved by shifting from the benchmark no debt level of  $\varpi$  to its optimal level.

The main results of the simulations are presented in Table 2. The second column shows the optimal (consumer welfare-maximizing) weight on CPI targeting for the three size specifications; columns III and V demonstrate how the stance of the monetary policy should be changed when countries accumulate foreign liabilities (in the amount of 50% of their GDP) or foreign assets, respectively. Finally, columns IV and VI show the welfare gain that can be achieved by shifting from the benchmark policy rule (column II) towards the new optimal policy (column III or V, respectively).

Rather provocatively, our welfare calculations suggest that a country that carries a large amount of dollarized foreign debt should pay more attention to targeting CPI inflation than a country with no foreign debt. Countries that have large holdings of foreign assets, on the other hand, can maximize their consumers' welfare by shifting towards exchange rate targeting. This finding goes contrary to the usual wisdom that it is beneficial to highly indebted countries to lower their exchange rate volatility and therefore stabilize the value of foreign liabilities. Calvo and Reinhart (2002), for example, present a partial equilibrium model in which the tendency of countries to target the exchange rate is driven by shocks to the international risk premia, an ad-hoc objective function of the central bank that is quadratic in inflation deviations, and high pass-through of exchange rates into local prices. This study, in contrast, explicitly models the trade and financial interactions of the two economies and encompasses a wider array of disturbances.

Intuition for the results in Table 2 can be gained by considering the risk-sharing service offered by the international asset. Any asset whose payoff covaries negatively with consumption offers insurance to Home consumers, and is therefore more desirable<sup>15</sup>.

In order to understand how a shift in the monetary policy stance in our model can achieve lower correlation between Home consumption and the payoff of the international bond, consider the expression for real income receipts (or payments) on NFW:

$$\text{Receipts} = NFW_{t-1} [1 + i_{t-1} - p(e^{a_{t-1} - \bar{a}} - 1)] \frac{\Delta S_t}{\Pi_t} - 1$$

Here  $NFW_t \equiv \frac{MA_t S_t}{P_t}$  denotes real NFW of the Home country, expressed in Home consumption units.

I start by considering the effects of productivity shocks on the Home economy; Graphs 1 and 2 show the impulse response functions of several key variables to this shock for a net creditor country (China, for example) and a net debtor country (Argentina) under different monetary policy rules. To take advantage of a positive technological shock, which is accompanied by a drop in the Home marginal utility of consumption, a debtor nation ( $NFW < 0$ ) would prefer to temporarily increase

<sup>15</sup>See Cochrane (2001), Chapter 1 for an in-depth discussion.

Size	50% Liab.		50% Assets	
	<i>Bench</i>	<i>Optimal</i>	<i>Bench</i>	<i>Optimal</i>
1:1	0.44	0.43	-0.40	-0.41
1:4	0.31	0.30	-0.23	-0.24
1:19	0.29	0.28	-0.21	-0.22

Table 3: Correlation between Home consumption and debt service for debtor (columns II and III) and creditor (columns IV and V) countries: benchmark (zero-debt) vs. optimal policy.

its interest payments to foreigners. This can be done immediately by allowing a sharp depreciation of the nominal exchange rate, i.e., by shifting the focus of monetary policy away from pegging and towards inflation targeting. Conversely, a country with positive holdings of foreign assets ( $NFW > 0$ ) would prefer to dampen its currency depreciation following an increase in home productivity so as to lower interest income from foreigners when Home marginal utility of consumption is already low<sup>16</sup>. Table 3 offers further evidence in support of this claim: optimally deviating from the benchmark policy (of the no-debt scenario) decreases correlation between domestic consumption and debt service for both debtor and creditor nations.

The strength of this channel (which affects the timing of payments and thus enhances the risk-sharing feature of the international bond) depends on the relative importance of the various shocks present in the model. In the next section, I discuss the effects on the optimal policy and consumer welfare of adding a shock to preferences for Home good and increasing the risk premium. The main conclusion, however, remains unchanged: indebted countries tend to benefit from shifting some of their attention to CPI targeting.

The last thing to note about the results of Table 2 is the increasing preference for inflation targeting of small countries (as can be seen in column II, for example). As the Home country becomes progressively smaller, the share of its output in the Foreign country's consumption,  $C_t^*$ , decreases; consequently, changes in the stance of the Home central bank have an ever-smaller impact on the expected value of foreign consumption,  $E[C_t^*]$ . Through (albeit imperfect) risk-sharing, Home consumption, which is linked to  $C_t^*$  through the real exchange rate, becomes effectively shielded from Home monetary policy. The latter can then be focused more on stabilizing inflation, à la the closed-economy setting.

### 4.3 Other Shocks and Robustness Checks

Welfare gains reported in the previous section, although admittedly very small, represent the lower bound for the true benefits from reoptimizing the monetary rule based on net foreign asset position of a country. Most papers studying the question of optimal monetary policy in the open economy setting do not report welfare calculations. Several papers that do perform such calculations report results very similar to ours: welfare gains from optimally adjusting monetary policy are on the order of 0.001-0.01 percent of consumption. See, for example, Benigno (2009), Cova and Søndergaard (2004), and Galí and Monacelli (2005). Below we consider two realistic scenarios that could result in higher welfare gains of reoptimizing monetary policy stance for developing economies than the levels reported in Table 2.

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<sup>16</sup>While it is difficult to distinguish between different policies by comparing the graphs, close examination of the underlying data shows that depreciation is larger (smaller) for a debtor (creditor) country under the optimal policy as compared to the benchmark policy.

Several related papers have examined the impact of demand shocks on the optimal behavior of central banks in open economy settings. Here we assume that a positive shock increases demand in both countries for Home good ( $Y_H$ ) by influencing the home bias coefficients:

$$\begin{aligned}\mu_t &= \bar{\mu} \exp(\varrho_t), & \mu_t^* &= \bar{\mu}^* / \exp(\varrho_t) \\ \varrho_t &= 0.9\varrho_{t-1} + \varepsilon_{\varrho,t}\end{aligned}$$

The same adjustment is made to the investment and government spending home biases. Since this shock cannot be measured empirically, its variance was set equal to that of productivity shocks;  $E(\varrho) = 0$ . Adding demand shocks does not change the main conclusion of this paper: debtor nations can increase the welfare of their domestic residents by putting a relatively heavier weight on CPI inflation in the Taylor rule of their central banks<sup>17</sup>. Adding this extra source of uncertainty doubles the welfare gains relative to those in Table 2.

Developing countries with significant external asset positions often find themselves subject to very high interest rate premia, well above our rather conservative 10 basis point spread. For example, Bouvatier (2007) estimates risk premia in several Asian countries to exceed 5 percent during the mid-1990s. Therefore, I repeat the simulations for a higher value of the risk premium,  $p = 0.01$ . Unsurprisingly, welfare gains from optimally adjusting monetary policy increase nearly tenfold.

Put together, these two effects imply that readjusting monetary policy in response to changes in a country's NFW position could improve consumer welfare by up to 0.1% of steady state consumption.

## 5 Conclusion

This paper analyzes the impact of non-zero steady-state net foreign wealth on the optimal monetary policy in a dynamic forward-looking model of monetary policy. The utilized framework accounts for the presence of home bias in consumption (which causes deviations from absolute PPP), nominal rigidities in price and wage setting, and incomplete international asset markets. I show that international debt changes the welfare-maximizing choice of monetary policy by allowing it to take advantage of the risk-sharing nature of the international bond. The main finding is that the optimal monetary policy, which is always a mix of CPI and exchange rate targeting, shifts more towards stabilizing inflation as countries accumulate foreign debt, and leans closer to pegging in countries that hold foreign assets.

Based on this study, it seems that central banks of developing countries are too concerned with their external position (maintaining the stability of their exchange rate) and are not paying enough attention to internal business cycles (the state of productivity), to the detriment of consumer welfare. However, this model is not well suited to understand such a preference for external stability since it assumes away the link between international risk premia, local monetary policy and central bank credibility. Therefore, this study may be missing an additional channel through which exchange rates affect the behavior of domestic interest rates, output and consumption. In the future work, I hope to pursue this question further by endogenizing the risk premium and studying the impact of policy regime on the behavior of international capital flows.

The model developed in this paper lends itself to several other possible extensions. In order to better understand the interplay of relative country size, NFW position and optimal policy,

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<sup>17</sup>Naturally, the optimal monetary policy is different from the case of no demand shocks, but the relative shifts in the optimal central bank stance following addition of international liabilities or assets remain the same.

it is desirable to derive the welfare loss function of the households. I also hope to explore the game-theoretic dimension of the international monetary policy coordination. Finally, it would be interesting to test the results of the paper for countries that borrow internationally in their own currency.



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## A Household First Order Conditions

$$\begin{aligned}
\frac{1}{C_t^\Theta P_t} &= \lambda_t \\
\beta E_t \left[ \frac{\lambda_{t+1}}{\lambda_t} \right] &= \frac{1}{1+i_t} \\
1 &= \beta E_t \left\{ [1+i_t^* - p(e^{a_t} - 1)] \frac{\lambda_{t+1} S_{t+1}}{\lambda_t S_t} \right\} \\
\lambda_t P_t &= \xi_t \left\{ 1 - \psi \left[ \frac{I_j(h)}{K_{j-1}(h)} - \delta \right] \right\} \\
\xi_t &= \beta E_t \{ \lambda_{t+1} [(1 - \tau_{k,t+1}) R_{t+1} + \tau_{k,t+1} \delta P_{t+1}] + \\
&\quad \xi_{t+1} \left[ (1 - \delta) - \frac{1}{2} \psi \left[ \frac{I_{t+1}(h)}{K_t(h)} - \delta \right]^2 + \psi \left[ \frac{I_{t+1}(h)}{K_t(h)} - \delta \right] \frac{I_{t+1}(h)}{K_t(h)} \right] \}
\end{aligned}$$

In a symmetric equilibrium and assuming all households in a country start off with the same level of wealth, their  $\lambda_t(h)$  and  $C_t(h)$  will be equalized.

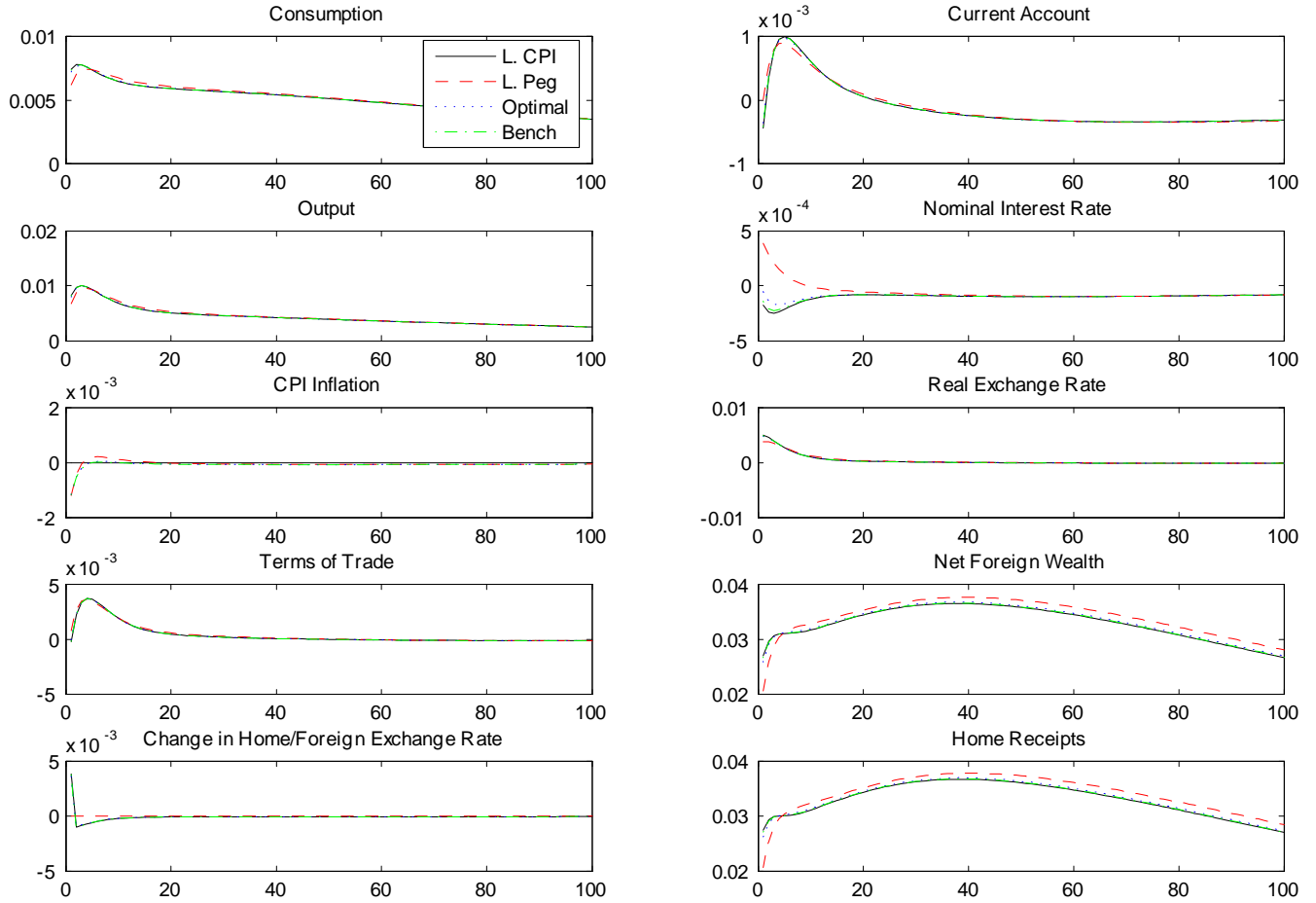


Figure 1: Response of several Home variables to a Home productivity shock for a net lender nation.

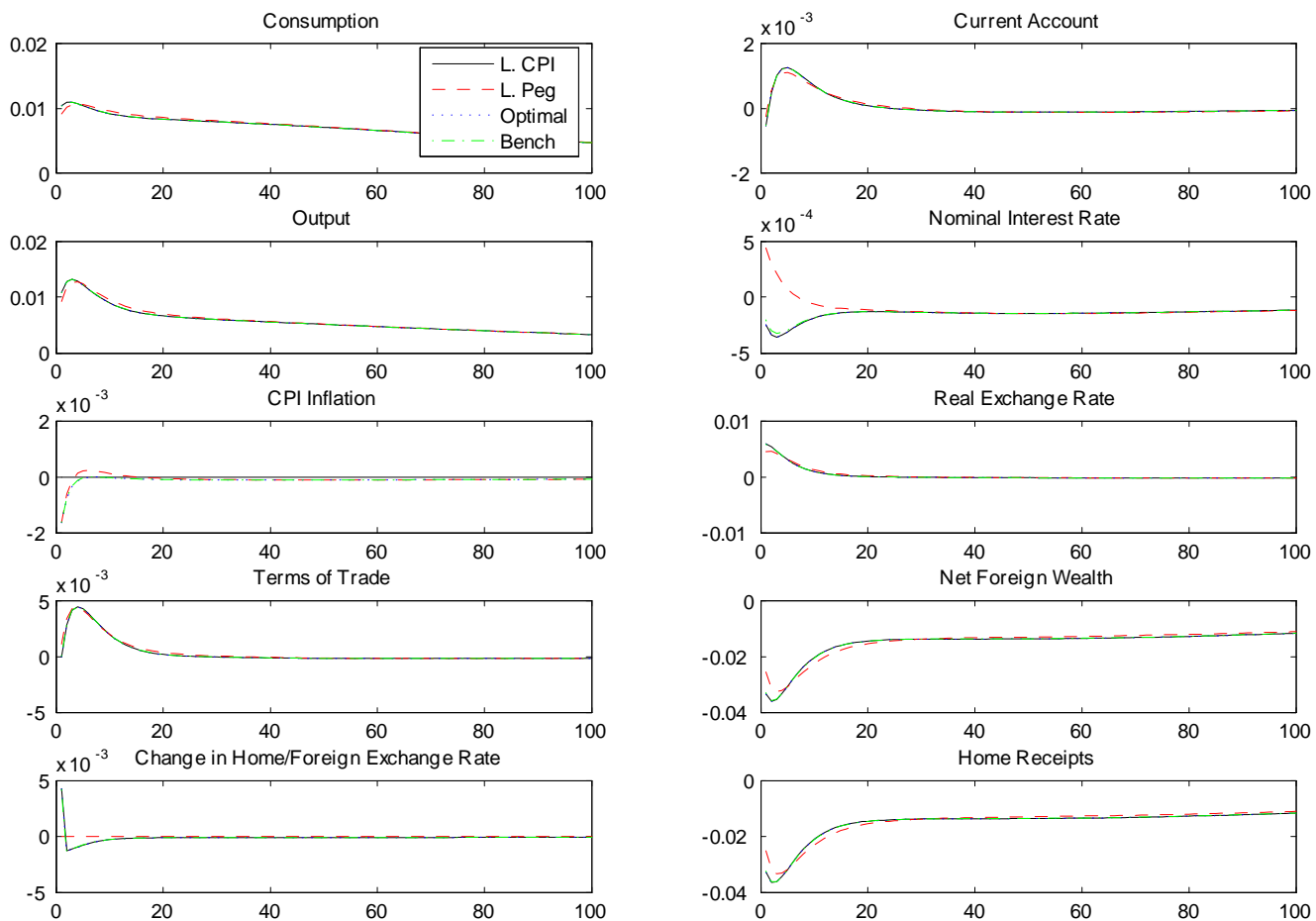


Figure 2: Response of several Home variables to a Home productivity shock for a net debtor nation.