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Targeting Inflation and the Fiscal Balance: What is the Optimal Policy Mix?

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Abstract: This paper identifies optimal policy rules in the presence of explicit targets for both the inflation rate and public debt. This issue is investigated in the context of a dynamic stochastic general equilibrium model that describes a small open economy with capital accumulation, distortionary taxation and nominal price rigidities. The model is solved using a second-order approximation to the equilibrium conditions. Optimal policy features a strong anti-inflation stance and strict fiscal discipline. Targeting a domestic inflation index - as opposed to CPI - improves welfare because it reduces the inefficiencies that stem from both price stickiness and income taxes.

Keywords: Fiscal and inflation targets, optimal policy rules, sticky prices, distortionary taxation

JEL classification: D60, E63, F41, O23

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1 Introduction

The pursuit of a quantitative target for the inflation rate and for the fiscal balance characterizes macroeconomic policy in several industrial and emerging market economies. The adoption of these targets and success in achieving them became, in the case of emerging markets, a necessary condition for continued access to funds made available by international lenders of last resort. Yet, there has not been a systematic attempt to evaluate the welfare consequences of such policy mix in this kind of economic environment. The objective of this paper is to fill in this gap.

Specifically, it makes two contributions. First, using a dynamic stochastic general equilibrium model that is calibrated to the case of Brazil, this paper provides a second-order-accurate measure of welfare and calculates the welfare loss incurred in a regime in which there are explicit targets for both the level of public debt and the consumer price index (CPI) inflation.

Second, this paper contributes to the literature on welfare maximizing fiscal and monetary policy rules in economies with nominal price rigidities. It shows that the main conclusions of this literature still hold in a more general economic environment that features an open economy with capital accumulation and distortionary taxation.

Focusing on policy regimes such that the inflation and the fiscal target are both attainable, the main finding is that a strong anti-inflation stance, coupled with strict fiscal discipline is optimal. Specifically, low volatility of public debt and inflation around their targets increases welfare. This result holds even though inflation and government expenditures in emerging markets are more volatile than in industrial countries - hence despite the fact that a strict pursuit of the inflation and the fiscal target will imply more volatile tax and interest rates.

There is a simple intuition behind these results. A strong anti-inflation stance is optimal because, consistent with previous findings in the literature, price dispersion due to nominal price rigidities generates an output loss.[1] At the same time, in the model economy studied in this paper, fast fiscal adjustments are optimal because they are conducive to lower average tax rates. In other words, low public debt volatility is associated to a lower *intratemporal* tax distortion in the stochastic equilibrium

[1] References are Goodfriend and King (1997) and King and Wolman (1999).

(at the cost of higher tax rate volatility and increased *intertemporal* distortion). Depending on the type of inflation index being targeted, there is even the possibility that the unconditional mean tax rate will be lower than its non-stochastic stationary level. This channel is present because agents face non-diversifiable risks that increase precautionary savings. The increase in savings can boost capital accumulation, which increases the tax base and makes room for the tax rate reduction. In the absence of strict fiscal discipline, part of these savings will fund additional government borrowing, which crowds out investment. As a consequence, the tax base does not increase and the welfare-improving reduction of the tax rate is not observed.

These conclusions might suggest that emerging markets are pursuing optimal policies, provided that the volatility of inflation and public debt around their targets is kept small. This paper shows that this is not an accurate statement, because typically the inflation target is expressed in terms of the consumer price inflation. The problem is that CPI targeting does not deliver the maximum level of welfare. Optimal policy requires that the Monetary Authority chooses to target a domestic inflation index - one that is not directly affected by exchange rate fluctuations - as opposed to targeting the CPI. This conclusion is consistent with previous findings in the literature of optimal monetary policy in open economies, in the presence of sticky prices.

The framework employed in this paper provides an additional explanation for why it is optimal to target a domestic inflation index. For reasons that will become clear later, the positive fiscal channel described above - the possibility that the average tax rate will be lower in the stochastic equilibrium - is only observed with domestic inflation targeting.[2]

These findings are reached in the context of a dynamic stochastic general equilibrium model that features a small open economy with distortionary taxes, capital accumulation and staggered price setting à la Calvo (1983). The economy has both a tradable and a nontradable goods sector, with monopolistic competition present in the latter.

Policy instruments are set according to policy rules such as in Leith and Wren-Lewis (2000),

[2] The model predicts that, with domestic inflation targeting, unconditional mean tax rates are lower than their non-stochastic level. With CPI targeting, the unconditional mean tax rate is higher than its nonstochastic stationary level. Interestingly, the data shows that, indeed, mean tax rates did increase in emerging markets after the adoption of CPI targeting.

Schmitt-Grohé and Uribe (2004b), Collard and Dellas (2005) and Kollman (2006). Specifically, the Monetary Authority announces a target for inflation and sets the nominal interest rate according to a simple Taylor-type rule. Meanwhile, the Fiscal Authority announces a public debt target and sets the tax rate according to a rule that links the evolution of the primary surplus to the behavior of public liabilities. Policy optimality is defined as the specific set of parameters in these rules that maximize welfare.

The investigation conducted here differs from previous studies in three fundamental ways. First, while earlier research on optimal fiscal and monetary policy rules focuses on closed economies, this paper studies this issue in the context of an open economy.

Second, previous research on optimal monetary policy in open economies abstracted from the influence of fiscal policy by assuming that Government expenditures could be financed by non-distortionary lump sum taxes.[3] This paper contributes to this line of research by proposing an integrated framework for the analysis of optimal monetary and fiscal policy rules, in an environment where distortionary income taxes affect equilibrium allocations.

Finally, a distinctive feature of the model developed in this paper is that is tailored to capture essential features of emerging market economies, many of which have numeric targets for both the inflation rate and fiscal performance. Brazil, an economy that has had primary surplus and inflation targets since 1999, was chosen as the benchmark case and the model was calibrated in order to match its features.[4]

A stylized fact captured by the model is that emerging market economies typically cannot borrow in their own currency in foreign markets. This type of financial vulnerability has already been studied by Morón and Winkelreid (2005), who investigate whether liability dollarization affects the optimal implementation of inflation targeting. The role of external borrowing constraints was explored in depth by Devereux, Lane and Xu (2005) in a sticky-price open economy model with tradables and nontradables, that investigates welfare maximizing monetary policy rules in emerging markets. In neither of these models do fiscal constraints and fiscal policy play a role in welfare determination.

[3] References are Svensson (2000), Clarida, Gali and Gertler (2001), Kollman (2002), Benigno and Benigno (2003), Laxton and Pesenti (2003), Devereux, Lane and Xu (2005), Gali and Monacelli (2005) among others.

[4] Kopits (2004) provides an overview of fiscal policy rules in Brazil and in several other economies. Table (1) in the appendix provides information about fiscal-inflation targets in a sample of emerging markets.

The remainder of this paper is structured as follows. Section two lays out the analytical framework. Next, in sections 3 and 4 the calibration procedure is described, along with the dynamic responses of the economy to shocks. Section 5 discusses welfare results. Section 6 concludes.

2 The Model

2.1 Households

Households are endowed with a constant, nonstorable amount of a tradable good Y^T every period. They consume the tradable good $\left(C^T\right)$ and a bundle of nontradable goods $\left(C^H\right)$. The consumption index is given by:

$$C_t = \left(C_t^T\right)^{\alpha} \left(C_t^H\right)^{1-\alpha}, \tag{1}$$

where the parameter α captures the degree of openess of the economy. Nontradable goods consumption C^H is an aggregate index of different varieties of nontradable goods produced by monopolistic producers, and ϕ is the elasticity of substitution across different varieties. The nontradable goods price index P_t^H and the nontradables consumption index are given by, respectively:

$$P_t^H = \left[\int_0^1 (P_{i,t}^H)^{1-\phi} di\right]^{\frac{1}{1-\phi}}, \tag{2}$$

$$C_t^H = \left[\int_0^1 (C_{i,t}^H)^{1-1/\phi} di\right]^{\frac{1}{1-1/\phi}}. \tag{3}$$

Let P_t^T denote the domestic price of the tradable good. Then the consumption price index is:

$$P_t = \left(P_t^T\right)^{\alpha} \left(P_t^H\right)^{1-\alpha}. \tag{4}$$

Optimal shares of consumption of tradables and nontradables are:

$$C_t^T = \alpha \frac{P_t}{P_t^T} C_t. \tag{5}$$

$$C^H = (1-\alpha)\frac{P_t}{P_t^H}C_t. \tag{6}$$

The real exchange rate is:

$$e_t = \frac{P_t^T}{P_t^H}. \tag{7}$$

The international price of the tradable good P^{T^*} is constant and, without loss of generality, equal to one. Let the nominal exchange rate be denoted by S_t, then:

$$P_t^T = S_t P^{T^*} \Rightarrow e_t = \frac{S_t}{P_t^H}. \tag{8}$$

The nominal exchange rate change in period t is:

$$\varepsilon_t = \frac{S_t}{S_{t-1}}. \tag{9}$$

Households buy tradable and nontradable goods. Part of nontradable good purchases is consumed and the remaining is invested (i.e., it becomes addition to the capital stock). One period later, this increase in the capital stock and existent undepreciated capital is rented to nontradable goods producing firms. Households also decide how many hours to work (N_t) at these firms. Capital income (Q_t) and labor income (W_t) are subject to proportional taxation, at rate τ_t. Households own the nontradable good producing firms, and receive profits Π_t.

Households hold two types of bonds. One is a domestic bond issued by the Government, denominated in domestic currency (B_t), and pays, one period later, the risk free gross return $(1+i_t)$. Households also hold internationally traded bonds D_t^p denominated in units of the tradable good. Assume, without loss of generality, that households are net debtors in the external market, so D_t^p is the amount of net external liabilities that matures one period later, paying the gross interest rate $\left(1+i_t^F\right)$. Finally, there is a cash-in-advance constraint (always binding)[5], where M_t are nominal money balances:

$$M_t = \gamma P_t C_t. \tag{10}$$

[5] The cash in advance constraint always binds because in this model the nominal interest rate will always be positive.

The household's problem is to maximize expected discounted lifetime utility:

$$U = E_t \sum_{t=s}^{\infty} \beta^{t-s} U\left(C_t; N_t\right), \tag{11}$$

subject to the flow budget constraint,

$$\begin{aligned} &\frac{M_{t-1}}{P_t} + \left(1 + i_{t-1}\right) \frac{B_{t-1}}{P_t} + \frac{P_t^H}{P_t}\Pi_t + \frac{S_t}{P_t} D_t^p + \frac{P_t^T}{P_t} Y_t^T + \left(1 - \tau_t\right) \frac{W_t}{P_t} N_t + \left(1 - \tau_t\right) \frac{Q_t}{P_t} K_{t-1} \\ \geqslant\ & C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} + \frac{P_t^H}{P_t}\left(K_t - \left(1 - \delta\right) K_{t-1}\right) + \left(1 + i_{t-1}^F\right) \frac{S_t}{P_t} D_{t-1}^p, \end{aligned} \tag{12}$$

and subject to (5), (6) and (10). They cannot engage in Ponzi schemes.

Denoting U_C and U_N the partial derivatives of the utility function with respect to its arguments, and substituting (10) in (12), optimization requires the following first order conditions to hold (where λ_t is the Lagrange multiplier of the flow budget constraint):

$$\frac{1}{1+i_t} = \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} \right), \tag{13}$$

$$\frac{1}{1+i_t^F} = \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} \frac{S_{t+1}}{S_t} \right), \tag{14}$$

$$U_{C_t} = \lambda_t \left(1 + \gamma \frac{i_t}{1+i_t} \right), \tag{15}$$

$$U_{N_t} = \lambda_t (1 - \tau_t)\ w_t, \tag{16}$$

$$1 = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} e_t^{\alpha} \left[\left(1 - \tau_{t+1}\right) q_{t+1} + \left(1 - \delta\right) e_{t+1}^{-\alpha} \right], \tag{17}$$

where w_t and q_{t+1} are, respectively, the real wage $w_t = \frac{W_t}{P_t}$ and the one period ahead real rental rate of capital defined as $q_{t+1} = \frac{Q_{t+1}}{P_{t+1}}$. The real exchange rate e is part of the capital Euler equation because the cost and return on capital are affected by the current and future price of nontradable goods relative to the price index P_t.

2.2 Upward sloping supply of foreign funds

The interest rate on foreign loans i^F is given by:

$$\left(1+i_t^F\right)=\left(1+i^*\right)\left(1+\xi_t\right)^{\kappa_1}\left(\frac{D_t}{D^*}\right)^{\kappa_2}. \tag{18}$$

There is a wedge between the interest rate charged on foreign loans to domestic residents, i^F, and the constant world risk free nominal rate i^*. The wedge will depend on an exogenous variable ξ and on an endogenous term $\left(\frac{D_t}{D^*}\right)$, defined as the ratio of the economy's total net foreign liabilities D_t to the threshold D^*.

Whenever $D_t \succ D^*$, the wedge between i^F and i^* increases, depending on the elasticity κ_2. A debt-elastic interest rate on foreign loans guarantees stationarity of net foreign assets.

The term ξ is as an exogenous risk premium term, that captures international liquidity and risk aversion conditions. Unanticipated innovations in the process driving this variable plays the role of an external shock that hits the economy from time to time. The nonstochastic level $\overline{\xi}$ is greater than zero, capturing the fact that the cost of borrowing for emerging markets is higher than the international risk free rate.

The risk premium follows an autoregressive process (in log deviations from the steady state $\overline{\xi}$):

$$\xi_t=\rho_\xi * \xi_{t-1}+\varepsilon_{\xi,t} \qquad \left\{\varepsilon_{\xi,t}\right\}_{t=0}^{\infty} \sim iid\left(0,\sigma_{\varepsilon_\xi}^2\right). \tag{19}$$

The assumption that the risk premium is exogenous with respect to domestic fundamentals is also adopted in other studies that seek to model emerging markets economic dynamics, like in Neumeyer and Perri (2005). Other authors, like Uribe and Yue (2005) criticize this assumption, showing empirical evidence that risk spreads depend on domestic variables. The approach followed here falls somewhere in between these two alternatives, since it is assumed that the country spread can be factored into an exogenous component ξ and an endogenous component $\left(\frac{D_t}{D^*}\right)$.

2.3 Firms

There is a continuum of firms in the nontradables sector, (indexed by i, $i \in [0,1]$), each producing output combining capital K and labor N, according to the constant returns to scale technology:

$$y_{i,t}^{h} = F(K_{it}; N_{it}) = K_{i,t}^{\theta} N_{i,t}^{(1-\theta)}. \tag{20}$$

Each firm is a monopolistic producer of a particular variety of nontradable good, facing a constant elasticity of demand ϕ. Demand faced by producer i is:

$$y_{i,t}^{h} = \left(\frac{P_{i,t}^{H}}{P_{t}^{H}}\right)^{-\phi} Y_{t}^{H}, \tag{21}$$

where $\frac{P_{i,t}^{H}}{P_{t}^{H}}$ is the relative price of each variety with respect to the aggregate price index P_{t}^{H}, $y_{i,t}^{h}$ is demand for output produced by firm i and Y_{t}^{H} is aggregate demand for nontradables.

Staggered price setting à la Calvo (1983) is assumed. At each point in time, a fraction $(1-\psi)$ of the firms receives a signal that will give them the possibility of setting new prices. Given the optimal quantities of capital and labor, a firm that resets the price at time t (and has it fixed for (s-t) periods, with probability ψ^{s-t}) chooses the optimal price $P_{i,t}^{*}$, in order to maximize expected profits:[6]

$$\underset{P_{i,t}^{*}}{Max} V_t = E_t \sum_{s=t}^{\infty} r_{t,s} \psi^{s-t} P_{s}^{H} \left\{ \left[\frac{P_{i,t}^{*}}{P_{s}^{H}} y_{i,s}^{h} - \frac{Q_s}{P_{s}^{H}} K_{i,s} - \frac{W_s}{P_{s}^{H}} N_{i,s} \right] + \left[rmc_{is} \left(F\left(K_{is}; N_{is}\right) - y_{i,s}^{h} \right) \right] \right\}, \tag{22}$$

where $r_{t,s}$ is the stochastic discount factor defined as $r_{t,s} = \beta E_t \frac{U_{c_s}}{U_{c_t}}$. The real marginal cost of production $rmc_{i,s}$ is:

$$rmc_{i,s} = \frac{W_s}{P_{s}^{H}} \frac{1}{F_N\left(K_{is}; N_{is}\right)} = \frac{W_s}{P_s} \frac{P_s}{P_{s}^{H}} \frac{1}{F_N\left(K_{is}; N_{is}\right)} = w_s e_s^{\alpha} \frac{1}{(1-\theta) K_{i,s}^{\theta} N_{i,s}^{-\theta}}. \tag{23}$$

[6] Sveen and Weinke (2004) and Woodford (2005) show that, in environments with firm-specific capital and convex costs of capital adjustment, the optimal price depends on the optimal factor usage and the firm's investment decisions. This issue is not present in the model developed in this paper, since it is assumed that firms rent capital, paying the competitive rental price, and that they do not face any kind of capital adjustment costs.

Optimal factor utilization also implies:

$$rmc_{i,s} = q_s e_s^{\alpha} \frac{1}{\theta K_{i,s}^{\theta-1} N_{i,s}^{1-\theta}}. \tag{24}$$

Given the assumption of constant returns to scale and of perfectly competitive input markets, $rmc_{i,s}$ will be identical across firms. Then the optimal choice of $P_{i,t}^{*}$ is described by the first order condition:

$$E_t \sum_{s=t}^{\infty} r_{t,s} \psi^{s-t} \left[\left(\frac{P_{i,t}^{*}}{P_s^H} \right)^{-\phi-1} Y_s^H \left(rmc_s - \frac{(\phi-1)}{\phi} \frac{P_{i,t}^{*}}{P_s^H} \right) \right] = 0, \tag{25}$$

Equation (25) says that the firm will choose the optimal price P_t^{*} in order to reach a certain mark-up of the expected discounted weighted sum of marginal revenues over marginal costs.

Typically, (25) is linearized around a non-distorted deterministic steady state with zero inflation, which yields the familiar New-Keynesian Phillips curve. The alternative is to refrain from imposing this restriction. Specifically, the approach suggested by Schmitt-Grohé and Uribe (2004b) is adopted here. This procedure yields two dynamic equations (described in the appendix) for the weighted present discounted value of expected marginal costs x_1 and expected marginal revenues x_2. In turn, profit maximization requires:

$$x_{2,t} = \frac{\phi}{\phi - 1} x_{1,t}. \tag{26}$$

In a symmetric equilibrium, firms that can change their prices chose the same optimal price P_t^{*}. Continuing to follow the notation of Schmitt-Grohé and Uribe (2004b), the nontradables price index will be given by:

$$(P_t^H)^{1-\phi} = \psi (P_{t-1}^H)^{1-\phi} + (1-\psi)(P_t^{*})^{1-\phi}, \tag{27}$$

and hence inflation π_t^H in the nontradables sector is given by:

$$1 = \psi (\pi_t^H)^{-1+\phi} + (1-\psi)(\widetilde{P}_t)^{1-\phi}, \tag{28}$$

where $\widetilde{P}_t = \frac{P_t^{*}}{P_t^H}$.

Market clearing requires that total supply of nontradable goods will be either consumed (C_t^H), invested (inv_t), or purchased by the government (g_t). Integrating over all firms:

$$F(K_t; N_t) = (C_t^H + inv_t + g_t) \int_0^1 \left(\frac{P_{i,t}^H}{P_t^H}\right)^{-\phi} = Y_t^H \int_0^1 \left(\frac{P_{i,t}^H}{P_t^H}\right)^{-\phi}. \tag{29}$$

The output loss due to price dispersion is given by $s_t = \int_0^1 \left(\frac{P_{i,t}^H}{P_t^H}\right)^{-\phi}$ and implies the relationship

$$\frac{F(K_t; N_t)}{s_t} = Y_t^H, \tag{30}$$

where s_t dynamics is given by:

$$s_t = (1-\psi)\,(\widetilde{P}_t)^{-\phi} + \psi(\pi_t^H)^{\phi} s_{t-1}. \tag{31}$$

2.4 Monetary Policy: Inflation Targeting

The Monetary Authority has an explicit target for CPI inflation, which in turn is given by the weighted sum of the change in the nominal exchange rate and nontradables inflation (in logs):

$$\pi_t = \alpha\varepsilon_t + (1-\alpha)\,\pi_t^H. \tag{32}$$

The nominal interest rate i_t is the policy instrument, and is managed according to the following Taylor-type rule (Taylor (1993)):

$$\log\left(\frac{1+i_t}{1+\bar{i}}\right) = \mu_\pi \log\left(\frac{1+\pi_t}{1+\pi^*}\right) + \mu_y \log\left(\frac{1+y_t}{1+\overline{y}}\right), \tag{33}$$

where $\overline{y}$ is the non-stochastic stationary value of total output, $\bar{i}$ is the non stochastic stationary value of the nominal interest rate, and π^* is the target for CPI inflation.[7]

The inflation target is equal to steady state inflation. For this assumption to be compatible with the existence of a stationary level of real money balances, it follows that money supply M^S must be

[7] Some authors model inflation targeting as a policy that delivers an inflation rate equal to the target at all points in time. Here, inflation targeting is interpreted as a monetary regime in which there is an explicit numeric target for inflation, and actual inflation is, *on average*, equal to the target.

increasing at a rate equal to the inflation rate. In equilibrium, money supply equals money demand $\left(M^S = M^D = M\right)$. Moreover, the existence of a stationary level of money demand implies:

$$\frac{M_{t+1}}{P_{t+1}} = \frac{M_t}{P_t} \Rightarrow \frac{M_{t+1}}{M_t} = \frac{P_{t+1}}{P_t} = \nu = (1+\pi^*)^{\frac{1}{4}} \tag{34}$$

2.5 Fiscal Policy: A Public Debt Target

The Government flow budget constraint is:

$$M_t - M_{t-1} + B_t + S_t D^g + T_t - P_t^H g_t = (1+i_{t-1})\, B_{t-1} + \left(1+i_{t-1}^F\right) S_t D^g. \tag{35}$$

where

$g_t =$ government expenditure on nontradable goods;

$B_t =$ risk-free nominal one period domestic government bonds;

$D^g =$ Government foreign debt, measured in units of the tradable good;

$T_t = \tau_t(W_t N_t + Q_t K_t) =$ nominal tax revenues.

The flow constraint says that public debt maturing at time t have to monetized $(M_t - M_{t-1})$, rolled over (B_t and $S_t D^g$), or paid-off with a primary surplus $\left(T_t - P_t^H g_t\right)$. Let $\frac{T_t}{P_t} = t_t$, $m_t = \frac{M_t}{P_t}$, $b_t = \frac{B_t}{P_t}$, and use the definition (7) of the real exchange rate e_t and of the price index (4). The real stock of government external debt, D^g is assumed constant. In real terms, the budget constraint is:

$$m_t - \frac{m_{t-1}}{1+\pi_t} + b_t + e_t^{1-\alpha} D^g + t_t - \frac{g_t}{e_t^{\alpha}} = \left(\frac{1+i_{t-1}}{1+\pi_t}\right) b_{t-1} + \left(1+i_{t-1}^F\right) e_t^{1-\alpha} D^g. \tag{36}$$

The real primary surplus is:

$$s_t = \frac{T_t}{P_t} - \frac{P_t^H}{P_t} g_t = t_t - \frac{g_t}{e_t^{\alpha}}. \tag{37}$$

Let h be real end of period government liabilities:

$$h_t = m_t + b_t + e_t^{1-\alpha} D^g. \tag{38}$$

The No Ponzi Game Condition requires:

$$\lim_{T\to\infty} E_t\left(\frac{1}{R_{t,T}}h_T\right) = 0, \tag{39}$$

where $R_{t,T}$ is the expected stochastic discount factor.

The Government purchases exclusively nontradable goods. Real nontradable goods purchases, g_t, measured in log-deviations from their stationary level, follows a stochastic process given by:[8]

$$g_t = \rho_g * g_{t-1} + \varepsilon_{g,t} \qquad \{\varepsilon_{g,t}\}_{t=0}^{\infty} \sim iid\left(0, \sigma^2_{\varepsilon_g}\right). \tag{40}$$

Given g_t, the Fiscal Authority sets the tax rate τ in order to generate a primary surplus so that the real stock of Government liabilities h will remain in the neighborhood of the target h^*, according to the rule:

$$primary\ surplus_t = s_t = t_t - \frac{g_t}{e_t^{\alpha}} = \gamma_0 + \gamma_1\left(h_{t-1} - h^*\right), \tag{41}$$

where γ_0 denotes the real primary surplus observed at the non-stochastic steady state.

2.6 Aggregate Resource Constraint

The aggregate resource constraint concludes the description of the model. The households (12) and Government flow budget constraints (36) are combined and yield an expression for the current account, where D is the total stock of foreign liabilities:

$$D_t - D_{t-1} = C_{T,t} - Y^T + i^F_{t-1}D_{t-1}. \tag{42}$$

2.7 Equilibrium

Given the households initial stock of assets, the initial price dispersion distortion, the tradable endowment, and the stochastic processes $\{\xi, g\}$, an (imperfectly) competitive equilibrium is an allocation$\{N,\ C^H,\ C^T,\ M,\ D^p,\ B,\ K\}$, a price system $\{i^F, P^H, P^T, S_t, W_t, Q_t\}$, and a Govern-

[8] Like in the case of investment, government purchases g is an aggregate index of different varieties of nontradable goods.

ment policy $\{i, \tau, \pi^*, h^*\}$ such that:

(1) Households maximize utility subject to constraints, (5), (6), (10), (12), the initial asset position and the No-ponzi game condition.

(2) Firms maximize profits.

(3) Markets Clear:

(i) Nontradable goods market: $Y^H = g + C^H + inv$

(ii) Labor market: $N^S = N^D$

(iii) Money market: $M^S = M^D$

(iv) Domestic bonds market: $B^S = B^D$

(v) Foreign loans market: $D^S = D^D$

(by Walras Law the capital market is cleared).

(4) The Government No Ponzi condition is satisfied.

3 Calibration

Parameters were calibrated in order to match characteristics of the Brazilian economy. The time unit is a quarter and steady state ratios reflect, approximately, average values observed in Brazil in the period 1995-2004. Quarterly data was used to estimate the processes of the exogenous shocks.

The period utility function is given by:

$$U(C_t; N_t) = \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right\}. \tag{43}$$

Preferences and technology parameters are in a range consistent with empirical findings. Table (2) summarizes the calibration.

[Table (2) here]

Data on the Brazilian JP Morgan EMBI spread was used as a measure of the left hand side of

(18), after rewriting this expression as:

$$\left(\frac{1+i_t^F}{1+i^*}\right) = (1+\xi_t)^{\kappa_1}\left(\frac{D_t}{D^*}\right)^{\kappa_2}. \tag{44}$$

The threshold D^* is the average level of net foreign liabilities between 1995 and 2004. The interest rate spread between US corporate investment grade and "junk" bonds was used as a proxy for the risk premium ξ_t, consistent with the interpretation that this variable captures exogenous changes in international liquidity and risk aversion. The parameters κ_1 and κ_2 were calibrated in order to match the mean and the variance of the variables in (44).

The next step was to estimate the AR(1) process that describes the dynamics of the risk premium ξ_t, according to (19). The estimated autoregressive coefficient ρ_ξ is 0.92 and the residual of the regression has a standard deviation of 0.006.

The estimation of the autoregressive process (40) that characterizes Government expenditures on goods was based on constant prices, seasonally adjusted, 4 quarters moving average of quarterly data on expenditures (excluding interest payments) of the overall public sector as a share of output. A dummy was included in the regression in order to capture the effect of the political cycle. The estimated coefficient of lagged government expenditures ρ_g is 0.56 and the standard deviation of the estimated residual is 0.014.

4 Dynamic Responses

The model is solved numerically, based on a second order approximation of the equilibrium conditions of the model around the (log) of steady state values, using the method developed by Schmitt-Grohé and Uribe (2004a). The system of equations used when solving the model is detailed in the appendix.

The parameter μ_π was allowed to vary in the range [1.05 ; 5] , μ_y in the range [0 ; 1.05], both with increments equal to 0.05. The parameter range for the response of the primary surplus target to fluctuations in government liabilities, γ_1, is given by the interval [0.05 ; 1], once again with increments equal to 0.05.[9]

[9] In order to investigate the possibility that an even lower degree of volatility of inflation around the target is

The coefficient of deviations of inflation from the target in the monetary policy rule is strictly larger than 1, whereas the coefficient γ_1 in the fiscal rule is strictly larger than zero. Interest lies, therefore, on a fiscal-monetary regime in which the fiscal and inflation targets are attainable and where monetary policy pins down the equilibrium path of prices. Using Leeper (1991) terminology, the search for welfare maximizing parameters will focus on a class of fiscal-monetary regime characterized by *passive* fiscal policy and *active* monetary policy. The corresponding policy rules and policy parameter ranges yield, in most cases, a determinate equilibrium.[10]

Figures (1) and (2) in the appendix display impulse responses to a one standard deviation shock to government spending on goods and to the risk premium. These impulse responses were generated after solving the model under two different scenarios:

(1) The monetary and the fiscal authorities target CPI inflation and public debt, respectively, according to rules (33) and (41). The policy rule parameters are those that maximize welfare[11], given the parameter range previously described. Specifically, $\mu_\pi = 2.15$, $\mu_y = 0.55$, $\gamma_1 = 1$.

(2) In the alternative scenario, instead of targeting CPI inflation, the Monetary Authority targets domestic (nontradables) inflation. In order to accomplish this, nontradables inflation replaces CPI inflation in the policy rule (33). The impulse responses illustrate the dynamics with optimal policy parameters $\mu_\pi = 3.35$, $\mu_y = 1$ and $\gamma_1 = 0.35$.

4.0.1 The Effect of a Government Spending Shock

Figure (1) in the appendix illustrates the effect of a government spending shock. The increase in demand raises nontradables production and puts upward pressure on marginal costs.

Producers have then the incentive to raise their prices. Nontradables inflation increases, which triggers monetary policy tightening under CPI targeting. Consistent with uncovered interest rate parity, the nominal exchange rate appreciates on impact, and then depreciates henceforth. The initial

optimal, the welfare consequences of $\mu_\pi \in [5; 15]$ (with increments = 0.5) were also considered.

[10] Ascari and Rotele (2005) show that equilibrium determinacy is affected by the presence of trend inflation, or the fact that inflation is larger than zero in the long run. This feature enlarges the indeterminacy region in the parameter space. For example, with two percent trend inflation, they find that the determinacy region lies (roughly) below a 45 degree line departing from $(\mu_\pi, \mu_y) = (1, 0)$. A similar result is found in this paper, since trend inflation is also present in the environment considered here.

[11] See discussion in the next session.

appreciation of the nominal exchange rate causes a decline in the price of tradable goods, measured in domestic currency. Therefore, the overall increase in the CPI index is not as large as it would have been, in the absence monetary policy tightening and the corresponding exchange rate movement.

The appreciation of the nominal exchange rate, coupled with higher nontradables inflation result in an appreciation of the real exchange rate. This, in turn, triggers an expenditure switching effect, and households consume less nontradable goods and more tradable goods. The result is a temporary current account deficit and increase in net foreign liabilities.

The tightening of monetary policy also results in a temporary increase in government debt h, due to higher interest rate payments on debt. The tax rate is increased in order to generate enough tax revenues to compensate for increased government spending on goods, and also because the relative price of goods purchased by the government increased (due to the real exchange rate appreciation). Tax rates also have to be raised so that the Fiscal Authority starts paying off higher interest rate expenses.

The dynamics is similar when the Monetary Authority targets nontradables inflation (dotted lines in the impulse responses). In this case, monetary policy tightening engineers an increase in the expected real interest rate that is large enough to reduce households' nontradables consumption, to a point such that the tendency of marginal costs of production to increase is significantly reduced. The combination of loose government spending and tight monetary policy implies that government spending crowds out private nontradables consumption.

4.0.2 The Effect of a Risk Premium Shock

Figure (2) in the appendix illustrates the effect of risk premium shock. The increase in the cost of foreign funding prompts a temporary reduction in net external debt. This is achieved with a reduction in overall consumption, combined with expenditure switching away from tradable goods. In turn, potentially higher demand for nontradable goods provides incentive for nontradable producers to raise their prices. Monetary policy is tightened and the increase in the real interest rate results in a reduction in consumption.

Nontradables inflation rises and then decreases gradually, while the nominal exchange rate depreciates (once again, consistent with the uncovered interest rate parity condition). This results in a gradual depreciation of the real exchange rate, which, combined with lower overall consumption, is conducive to a decline of net foreign liabilities.

Because the depreciation of the exchange rate leads to a temporary expansion of nontradables output, the tax base increases and initially the Fiscal Authority can reach its primary surplus objective with a lower tax rate. However, the cost of servicing public debt increases over time due to higher real interest rates and the primary surplus has to be revised upwards, leading to an increase in tax rates.

The dynamics is similar under a policy of nontradables inflation targeting. The difference now is that in order to keep nontradables inflation close to the target, the Monetary Authority has to engineer a larger reduction in consumption, so that nontradables consumption does not increase much. The stronger monetary policy tightening results in an appreciation of the nominal exchange rate on impact.

5 Welfare Analysis

5.1 Methodology

Welfare is the present discounted value of expected lifetime utility, conditional on the state variables of the economy being at the stationary steady state at time zero.[12] The welfare loss is the percentage of consumption under the optimal policy that the household would be willing to give up, in order to be indifferent between the optimal policy and the alternative policy. (The appendix provides details of the computation).

Once the model is solved for all the possible parameter combinations, attention is restricted to the set of policy parameter combinations that yield a determinate equilibrium and also that correspond to a stochastic equilibrium such that the unconditional means of state variables do not deviate

[12] The use of the conditional welfare measure is advocated by Schmitt-Grohé and Uribe (2004a) and by Kim, Kim, Schaumburg and Sims (2003).

significantly from their stationary values. Specifically, the following condition should be satisfied:

$$\left|EX_t - \overline{X}\right| < 0.01, \tag{45}$$

where EX_t is the vector of unconditional means of the state variables of the model and $\overline{X}$ the vector of nonstochastic steady state values of these variables. The motivation for imposing such restriction is that some policy parameter combinations result in unconditional means that deviate from their nonstochastic steady state value by an amount that renders the second-order approximation around the stationary value very imprecise. Kollman (2006) also detects this problem and imposes a similar restriction.

5.2 Main Findings

The main conclusions can be summarized as follows:

(i) A strong anti-inflation stance is optimal, even though complete inflation stabilization is not.

(ii) Should policymakers target a domestic inflation index, as opposed to CPI, there would be large welfare gains.

(iii) Despite the intertemporal distortions imposed by time varying taxes, the model favors fast fiscal adjustments, with the optimal responsiveness of the primary surplus to debt deviations from target ranging from 0.35 to 1, depending on the specific inflation index being targeted.

These results are reported in Table (3), which shows the volatility of selected variables, the optimal policy and the welfare loss associated to alternative policies:

(a) CPI targeting - Line (A) in Table (3) reports parameters that maximize welfare in the baseline case of CPI inflation and public liabilities targeting. The policy mix delivers small volatility of CPI inflation and of public debt around their respective targets. Welfare maximizing monetary policy entails an active response of the nominal interest rate to inflation ($\mu_\pi = 2.15$), and also to output fluctuations $\left(\mu_y = 0.55\right)$. The primary surplus responsiveness to increases in public debt is high, with the optimal parameter $\gamma_1 = 1$ being at the upper bound of the parameter range investigated.

(b) CPI targeting with a sluggish fiscal response - It would be interesting to investigate the welfare loss associated to a fiscal rule that features a sluggish response of the primary surplus to deviations of public debt with respect to the liabilities target. Welfare implications are reported in line (B) in Table (3). The monetary policy rule parameters remain the same $\left(\mu_\pi = 2.15; \mu_y = 0.55\right)$ but now $\gamma_1 = 0.05$ is imposed. The volatility of public debt becomes significantly higher, but the welfare loss is small (compared to the case of optimal CPI targeting with fast fiscal adjustment). One of the reasons is that the policy that prescribes a slow fiscal adjustment delivers a very similar level of tax rate volatility. The intuition is that, as the adjustment gets postponed, the size of the fiscal imbalance gets larger, hence higher tax rate adjustments are required in the future.

(c) Complete stabilization of domestic (nontradables) inflation - Next, the welfare consequences of a policy that completely stabilizes nontradables inflation at its nonstochastic level is investigated. The literature on optimal monetary policy in open economies has shown that this policy yields superior welfare compared to CPI targeting. The rationale is that with CPI inflation targeting, the nominal exchange rate fluctuation is being implicitly targeted, especially if the degree of pass through from the exchange rate to prices is large. In the case of emerging markets, even when the degree of pass-through is low, the impact of the exchange rate on tradable prices is large, because of the large magnitude of exchange rate fluctuations.[13] The problem is that exchange rate is only indirectly related to the primary source of inefficiency in the economy, which is price dispersion in the sector that faces nominal price rigidities. Therefore, a policy that directly addresses this problem - by eliminating or reducing the incentive of producers to change prices - can potentially improve welfare.

[13] For instance, Freitas, Goldfajn, Minella and Muinhos (2003:1035) document that in Brazil, "the inflationary pressures resulting from exchange rate depreciation are more related to the magnitude of the depreciation than to the pass-through coefficient".

It is interesting to examine if this conclusion carries through to an environment with distortionary taxes and with a simultaneous fiscal target. The procedure was to use domestic inflation instead of CPI in the monetary policy rule. The parameter μ_π was set arbitrarily large, in order to ensure a complete stabilization of nontradables inflation at π^*. The remaining policy parameters are left unconstrained.

Line (C) in Table (3) shows that a policy that eliminates nontradables inflation volatility delivers a higher level of welfare compared to CPI targeting. Optimal policy features a fast fiscal adjustment $(\gamma_1 = 1)$. In this case, the response to output fluctuations μ_y is immaterial for welfare (results reported corresponding to the case $\mu_y = 0$).

(d) Domestic Inflation Targeting - Line (D) reports welfare under the overall optimal policy, namely public liabilities and domestic (nontradables) inflation targeting, this time without imposing the restriction that nontradables inflation will be fully stabilized (hence the parameter μ_π is finite and belongs to the range previously specified).

This is a case of interest because the nonstochastic inflation level does not necessarily deliver an efficient allocation. Therefore, a policy of keeping nontradables inflation constant at that level might not be optimal. This suspicion is confirmed by results in line (D) in Table (3). There is an additional welfare gain when domestic inflation is targeted as opposed to CPI, this time allowing for some (small) volatility of nontradables inflation around its non-stochastic level.

Optimal policy features a quite active response to output fluctuations ($\mu_y = 1$) and a somewhat more sluggish responsiveness of the primary surplus to deviations of public debt with respect to the target ($\gamma_1 = 0.35$). This result was partially driven by constraint (45). This is the only case in which this constraint binds, ruling out parameter combinations that yield an even higher level of welfare. In fact, given μ_π, welfare tends to be higher with a smaller μ_y (zero, in most cases) and with a larger fiscal response $\gamma_1 = 1$. However, with this parameter configuration the deviation of the capital stock unconditional mean with respect to its nonstochastic level is larger than one percent.

(e) Fixed exchange rate regime - Finally, line (E) in Table (3) reports the welfare loss associated to a fixed exchange rate regime, which is accomplished by a monetary policy rule that is designed to eliminate nominal exchange rate fluctuations. Nominal exchange rate changes replace the inflation index in the monetary policy rule and the response of the interest rate to exchange rate fluctuations, μ_{er} is set arbitrarily large. This policy implies a large welfare loss.

[Table (3) here]

5.3 Discussion of Welfare Results

A useful way to interpret these results is to think about how agents in this incomplete markets, bonds-only economy react to risk. Precautionary savings imply that it is optimal to reduce the level of foreign borrowing, especially taking into account that the nonstochastic level of foreign debt is not efficient (remember that with an upward sloping supply of funds, each individual agent's borrowing decisions influence the cost of external borrowing faced by the economy, generating a negative externality).

This is why, in all policy regimes considered here, the unconditional mean of net foreign assets will be lower than its stationary nonstochastic level. This can be seen in Table (4), which reports the percentage deviation of the unconditional means of some key variables with respect to their nonstochastic steady state level.

[Table (4) here]

Table (4) shows that the decline in the foreign debt position is smaller, the larger is the weight of exchange fluctuations in the monetary policy rule. The reason is that policies that implicitly target the nominal exchange rate - at the extreme, a fixed exchange rate regime - minimize the volatility of the cost of external borrowing, and end up promoting an inefficiently high level of external debt. Moreover, they do not address directly one of the main distortions in the model, namely the price dispersion in the nontradables sector.

A policy of targeting domestic nontradables inflation is optimal because it addresses these two sources of inefficiency simultaneously. Since it does not target exchange rate movements, this policy does not interfere with fluctuations in the cost of borrowing from abroad in foreign currency. In light of that, agents adjust accordingly, reducing their debt exposure down to an efficient level. At the same time, by reducing the volatility of inflation in the nontradables sector, this policy is mitigating the output loss associated to price dispersion in this sector.

There is a third channel that reinforces the optimality of a policy of domestic inflation targeting. The reduction in foreign debt exposure comes from a combination of higher savings and expenditure switching away from tradable goods. This boosts domestic capital accumulation and nontradables output, increasing the tax base. As a consequence, the unconditional mean tax rate will be lower than its stationary level, as can be seen in Table (4).

This provides some intuition for why the model delivers the result that fast fiscal adjustments are optimal. With fast fiscal adjustments, the increase in savings fund capital accumulation and not additional government borrowing. The positive impact on the tax base makes room for a reduction of tax rates. Therefore, even though a fast fiscal adjustment increases the *intertemporal* tax distortion, it is conducive to a reduction of the level of taxes and hence to a decrease of the *intratemporal* tax distortion in the stochastic equilibrium.

6 Conclusions

This paper identifies welfare maximizing policy rules when there are explicit numeric targets for both the inflation rate and public debt. The framework is tailored to capture essential features of emerging markets economies, whose adoption of inflation-fiscal targeting regimes was typically a consequence of IMF conditionality. The model is calibrated using Brazilian data.

Welfare is investigated in the context of a dynamic stochastic general equilibrium model that describes a small open economy with capital accumulation, distortionary taxation and nominal price rigidities. The model is solved using a second-order approximation to the equilibrium conditions, and optimal policy parameters are identified.

The paper shows that previous findings in the literature on optimal policy rules - in particular, that a strong anti-inflation stance is optimal, in the presence of price rigidities - continue to hold in a more general environment. Specifically, low inflation volatility is still a feature of optimal policy in an open economy, after accounting for the effect of distortionary taxation and for the coexistence of fiscal and inflation targets. Moreover, despite intertemporal distortions triggered by fiscal adjustments, fiscal discipline (in the form of low public debt volatility around its target) is optimal due to its welfare improving, long term effects on tax rates.

These are important findings, in light of the fiscal constraints that are typical of emerging market economies, namely a large stock of short term debt and a corresponding spillover from short term interest rate management to the cost of servicing public debt. Specifically, negative implications of restrictive monetary policy to the fiscal accounts are frequently identified as a reason why monetary policy should be less restrictive. In the context of inflation targeting, it is argued that the Monetary Authority should tolerate deviations of inflation from the target, as a way to avoid higher interest rates and the corresponding increase of the cost of outstanding debt. This paper shows that this strategy can have large negative implications for welfare, and that the policy debate should rather be focused on which inflation index to target, given that the strategy currently pursued - CPI targeting - is not optimal.

7 Appendix

7.1 Welfare Measure

Welfare is the conditional expectation of discounted lifetime utility of the representative agent (conditional on the economy being at the non-stochastic steady state at time zero). Let W^{opt} be the welfare associated to the optimal policy:

$$W^{opt} = E_0 \sum\nolimits_{t=0}^{\infty} \beta^t U\left(C_t^{opt}; N_t^{opt}\right).$$

Let W^{sub} be the lower level of welfare associated to a different, suboptimal policy. The measure of the welfare loss is the percentage λ of consumption under the optimal policy that the representative agent would have to give up in order to be indifferent between a policy that delivers W^{opt} and a policy that delivers W^{sub}. Formally,

$$W^{sub} = E_0 \sum\nolimits_{t=0}^{\infty} \beta^t U\left((1-\lambda) C_t^{opt}; N_t^{opt} \right).$$

Some algebra manipulation yields an expression for λ :

$$W^{sub} = E_0 \sum\nolimits_{t=0}^{\infty} \beta^t \left[(1-\lambda)^{1-\sigma} \frac{(C_t^{opt})^{1-\sigma}}{1-\sigma} - \frac{(N_t^{opt})^{1+\varphi}}{1+\varphi} \right].$$

$$W^{sub} = E_0 \sum\nolimits_{t=0}^{\infty} \beta^t \left[(1-\lambda)^{1-\sigma} \left(\frac{(C_t^{opt})^{1-\sigma}}{1-\sigma} - \frac{(N_t^{opt})^{1+\varphi}}{1+\varphi} \right) + (1-\lambda)^{1-\sigma} \frac{(N_t^{opt})^{1+\varphi}}{1+\varphi} - \frac{(N_t^{opt})^{1+\varphi}}{1+\varphi} \right].$$

$$W^{sub} = (1-\lambda)^{1-\sigma} W^{opt} + ((1-\lambda)^{1-\sigma} - 1) W_N^{opt},$$

where

$$W_N^{opt} = E_0 \sum\nolimits_{t=0}^{\infty} \beta^t \frac{(N_t^{opt})^{1+\varphi}}{1+\varphi}.$$

Rearranging terms:

$$\lambda = 1 - \left(\frac{W^{sub} + W_N^{opt}}{W^{opt} + W_N^{opt}} \right)^{\frac{1}{1-\sigma}}.$$

7.2 Equilibrium conditions

Let y_t be the vector of endogenous variables and $z_t = [z_t^1 \; z_t^2]$ be the vector of predetermined variables at time t, with z_t^1 being the vector of endogenous state variables and z_t^2 the vector of exogenous state variables. In the context of the present model, $y_t = [\; \pi_t^H \;\; \varepsilon_t \;\; c_t \; i_i \;\; n_t \;\; x_{1,t} \;\; \tau_t]$, $z_t^1 = [k_{t-1} \;\; e_{t-1} \;\; s_{t-1} \;\; d_{t-1} \; c_{t-1} \;\; i_{t-1} \;\; b_{t-1}]$ and finally $z_t^2 = [g_t \;\; \xi_t]$. The remaining variables of the model can be expressed as function of y_t and z_t, using (6), (10), (18), (23), (24), (26), (28), (30), the definition of CPI inflation (32), the primary surplus rule (41) and the aggregate resource constraint (42).

The model comprises a set of equilibrium conditions that can be written in the general format

$$E_t\ f\ (y_{t+1}; y_t; z_{t+1}; z_t) = 0,$$

where f is given by the following 14 equilibrium conditions, in which $r_{t,t+1}$is the stochastic discount factor:

Capital Euler equation:

$$1 = E_t r_{t,t+1} e_t^{-\alpha} \left[(1-\tau_{t+1})\, q_{t+1} + (1-\delta)\, e_{t+1}^{-\alpha} \right].$$

Bonds Euler equation:

$$1 = E_t r_{t,t+1} [\frac{1+i_t}{1+\pi_{t+1}}].$$

Uncovered interest rate parity:

$$1 + i_t = E_t(1 + i_t^F)(1 + \varepsilon_{t+1}).$$

Nontradables market clearing:

$$Y_t^H = C_t^H + (K_t - (1-\delta)\, K_{t-1}) + g_t.$$

Optimal tradables consumption:

$$C_t^T = \alpha e_t^{(1-\alpha)} C_t.$$

Inefficiency due to price dispersion:

$$s_t = (1-\psi)\widetilde{p_t}^{-\phi} + \psi(\pi_t^H)^{\phi} s_{t-1}.$$

Dynamic equation for the present discounted value of marginal costs:

$$x_1 = (\widetilde{p_t}^{-1-\phi}) Y_t^H rmc_t + E_t r_{t,t+1} \psi (\pi_{t+1}^H)^{\phi} \left(\frac{\widetilde{p}_t}{\widetilde{p}_{t+1}} \right)^{-1-\phi} x_{1,t+1}.$$

Dynamic equation for the present discounted value of revenues:

$$x_2 = (\widetilde{p_t}^{-\phi})Y_t^H + E_t r_{t,t+1}\psi(\pi_{t+1}^H)^{\phi-1}\left(\frac{\widetilde{p}_t}{\widetilde{p}_{t+1}}\right)^{-\phi} x_{2,t+1}.$$

Government real flow budget constraint:

$$m_t + \frac{m_{t-1}}{1+\pi_t} + b_t + e_t^{1-\alpha}D^g + t_t - \frac{g_t}{e_t^\alpha} = \left(\frac{1+i_{t-1}}{1+\pi_t}\right) b_{t-1} + \left(1+i_{t-1}^F\right) e_t^{1-\alpha}D^g.$$

Real exchange rate dynamics:

$$e_t = e_{t-1}\frac{1+\varepsilon_t}{1+\pi_t^H}.$$

Real tax revenues:

$$t_t = \tau_t\left(w_t N_t + q_t K_{t-1}\right).$$

Monetary policy rule:

$$\log\left(\frac{1+i_t}{1+\bar{i}}\right) = \mu_\pi \log\left(\frac{1+\pi_t}{1+\pi^*}\right) + \mu_y \log\left(\frac{1+y_t}{1+\overline{y}}\right).$$

Country risk premium process:

$$\xi_t = \rho_\xi * \xi_{t-1} + \varepsilon_{\xi,t}\,.$$

Government spending process:

$$g_t = \rho_g * g_{t-1} + \varepsilon_{g,t}\,.$$

7.3 Tables and Figures

Countries	Inflation Target (annual % change in CPI)	Fiscal Target	Fiscal Rule: IMF/EU Conditionality?
Brazil	5.1%	Surplus Target for Primary Balance	Yes (IMF)
Chile	3.0%	Target for Cyclically Adjusted Overall Balance	No
Colombia	5.0%	Surplus Target for Primary Balance	Yes (IMF)
Mexico	3.0%	Surplus Target for Primary Balance	Yes (IMF)
Peru	2.5%	Target for Overall Balance	Yes (IMF)
Czech Republic	2.0%	Currently implementing fiscal reform to reach primary balance surplus of 3.3 (%GDP) by 2008.	Yes (EU)
Poland	2.5%	Restrictions on deficit to revenues ratio, triggered by public debt/GDP ratio reaching thresholds of 50%, 55% and 60%	Yes (EU)

Table 1: Fiscal and Inflation Targets for the Year 2005 - Selected Emerging Market Economies

Preferences and Technology	
$\gamma = 0.1$	CIA parameter
$\sigma = 2$	intertemporal elasticity of substitution = $(1/\sigma)$
$\varphi = 3$	elasticity of labor supply = $(1/\varphi)$
$\psi = 0.75$	probability of adjusting price at time t = 0.25
$\Phi = 1.1$	average mark-up over marginal cost
$\theta = 0.4$	capital share in GDP
$\delta = 0.05$	depreciation
$\alpha = 0.5$	tradables share in consumption
$\beta = 0.9765$	subjective discount factor
$\pi^* = 0.06$	target for annual inflation: 6%
$\kappa_1 = 0.40$	elasticity of interest rate on foreign loans with respect to risk premium ξ
$\kappa_2 = 0.33$	elasticity of interest rate on foreign loans with respect to (D/D^*)
Exogenous State Variables - Autoregressive Parameters	
$\rho_g = 0.56$	autoregressive coefficient of Government spending
$\rho_\xi = 0.92$	autoregressive coefficient of risk premium
Shocks - Standard Deviations	
$\sigma_{\varepsilon_g} = 0.014$	standard deviation of government spending shock
$\sigma_{\varepsilon_\xi} = 0.006$	standard deviation of risk premium shock
Steady State Ratios	
$\frac{h^*}{\overline{y}} = 0.53$	public debt to total output ratio
$\frac{tax}{\overline{GDP}} = 0.15$	tax revenues to total output ratio
$\frac{\lambda_0}{\overline{y}} = 0.013$	primary fiscal balance to total output ratio
$\frac{b}{\overline{y}} = 0.39$	government domestic debt to total output ratio
$\frac{D^G}{\overline{y}} = 0.10$	government external debt to total output ratio
$\frac{D}{\overline{y}} = 0.25$	economy's external debt to total output ratio
$\frac{\overline{Y}^H}{\overline{GDP}} = 0.61$	nontradables output to total output ratio
$\frac{g}{\overline{Y}^H} = 0.22$	government spending on goods to nontradables output ratio

Table 2: Parameters and Steady State Ratios

Welfare	Welfare Loss (%)	CPI Inflation	Nontradables Inflation	Real Exchange Rate	Nontradables Output	Consumption	Nominal Interest Rate on Foreign Loans	Tax Rate	Total Public Debt (h)
(A) CPI Inflation Targeting with Optimal Fiscal and Monetary Policy Parameters: $\mu_\pi = 2.15$; $\mu_y = 0.55$; $\gamma_1 = 1$									
- 43.4493	**0.30**	**0.42**	**0.39**	**5.82**	**2.41**	**2.96**	**0.46**	**8.20**	**0.59**
(B) CPI Inflation Targeting with Optimal Monetary Policy Parameters, $\mu_\pi = 2.15$; $\mu_y = 0.55$ **and Imposing a Sluggish Fiscal Adjustment** ($\gamma_1 = 0.05$)									
- 43.4518	**0.31**	**0.44**	**0.41**	**6.13**	**2.58**	**3.08**	**0.45**	**7.88**	**6.52**
(C) Complete Domestic Inflation Stabilization ($\mu_\pi \to \infty$) ; $\mu_y = 0$; $\gamma_1 = 1$									
- 43.3915	**0.15**	**0.56**	**0.00**	**5.03**	**2.42**	**2.69**	**1.06**	**5.56**	**0.77**
(D) Domestic Inflation Targeting with Optimal Fiscal and Monetary Policy Parameters: $\mu_\pi = 3.35$; $\mu_y = 1$; $\gamma_1 = 0.35$									
- 43.3326	**-**	**0.89**	**0.35**	**5.00**	**1.69**	**2.78**	**1.46**	**7.63**	**2.21**
(E) Fixed Exchange Rate Regime ($\mu_{er} \to \infty$) **Optimal parameters:** $\mu_y = 0$; $\gamma_1 = 1$									
- 43.4740	**0.37**	**0.20**	**0.40**	**6.12**	**3.77**	**3.04**	**0.40**	**7.79**	**0.57**

Table 3: Welfare and standard deviation (percent) of selected variables. Methodology to compute welfare loss is described in the appendix.

CPI Inflation	Nontradables Inflation	Real Exchange Rate	Nontradables Output	Consumption	Capital	Net Foreign Liabilities	Tax Rate	Total Public Debt (h)
(A) CPI Inflation Targeting with Optimal Fiscal and Monetary Policy Parameters: $\mu_\pi = 2.15$; $\mu_y = 0.55$; $\gamma_1 = 1$								
- 0.04	**-0.04**	**- 0.13**	**0.06**	**- 0.06**	**0.41**	**- 0.02**	**0.21**	**0.00**
(B) CPI Inflation Targeting with Optimal Monetary Policy Parameters, $\mu_\pi = 2.15$; $\mu_y = 0.55$ **and Imposing a Sluggish Fiscal Adjustment** ($\gamma_1 = 0.05$)								
- 0.04	**-0.04**	**- 0.21**	**0.05**	**-0.10**	**0.46**	**-0.01**	**0.51**	**0.28**
(C) Complete Domestic Inflation Stabilization ($\mu_\pi \to \infty$) ; $\mu_y = 0$; $\gamma_1 = 1$								
0.00	**0.00**	**0.43**	**0.32**	**0.24**	**0.83**	**-0.07**	**-0.71**	**-0.01**
(D) Domestic Inflation Targeting with Optimal Fiscal and Monetary Policy Parameters: $\mu_\pi = 3.35$; $\mu_y = 1$; $\gamma_1 = 0.35$								
-0.11	**-0.11**	**0.99**	**0.51**	**0.55**	**0.92**	**-0.13**	**-1.83**	**-0.03**
(E) Fixed Exchange Rate Regime ($\mu_{er} \to \infty$) **Optimal parameters:** $\mu_y = 0$; $\gamma_1 = 1$								
0.00	**0.00**	**- 0.24**	**0.10**	**- 0.12**	**0.82**	**- 0.01**	**0.66**	**0.00**

Table 4: Unconditional means, expressed in percentage deviation from non-stochastic steady state

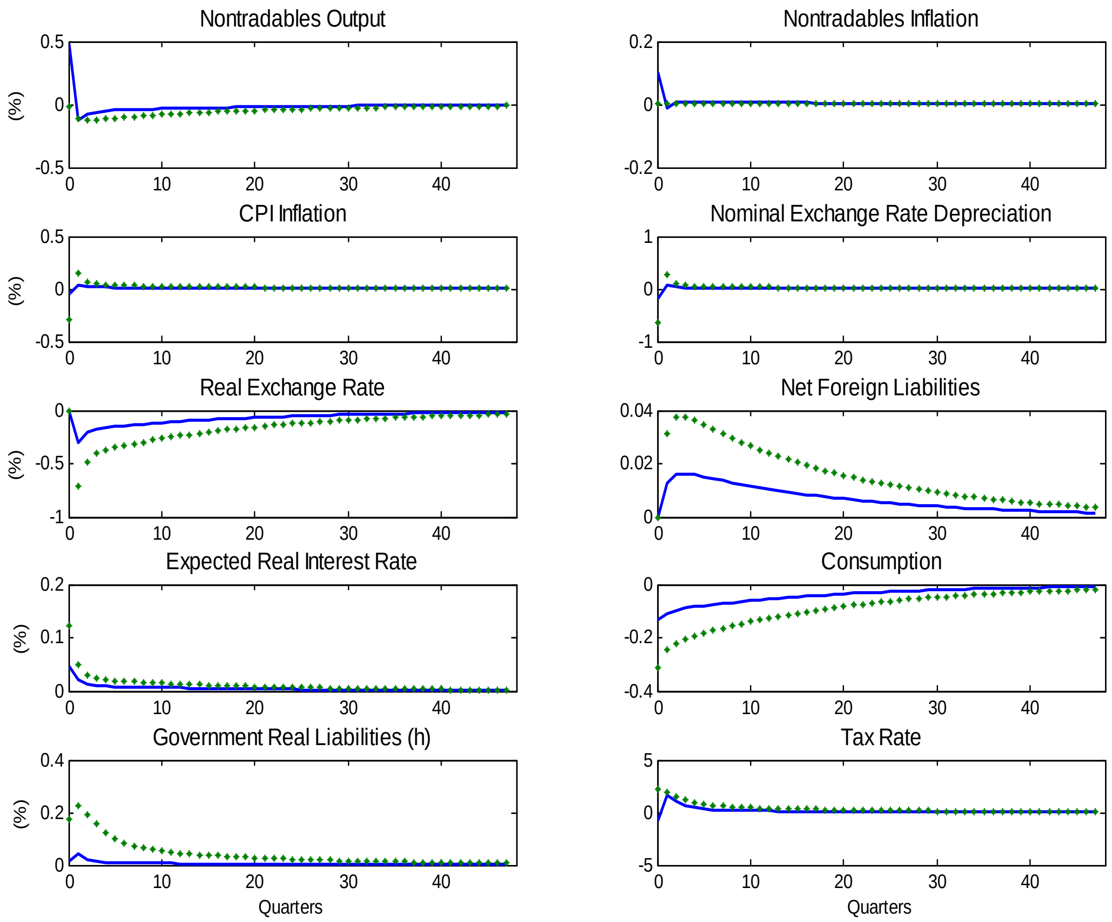

Figure 1: Impulse response to a one standard deviation shock to government spending. Solid line: CPI inflation targeting. Dotted line: Domestic (nontradables) inflation targeting.

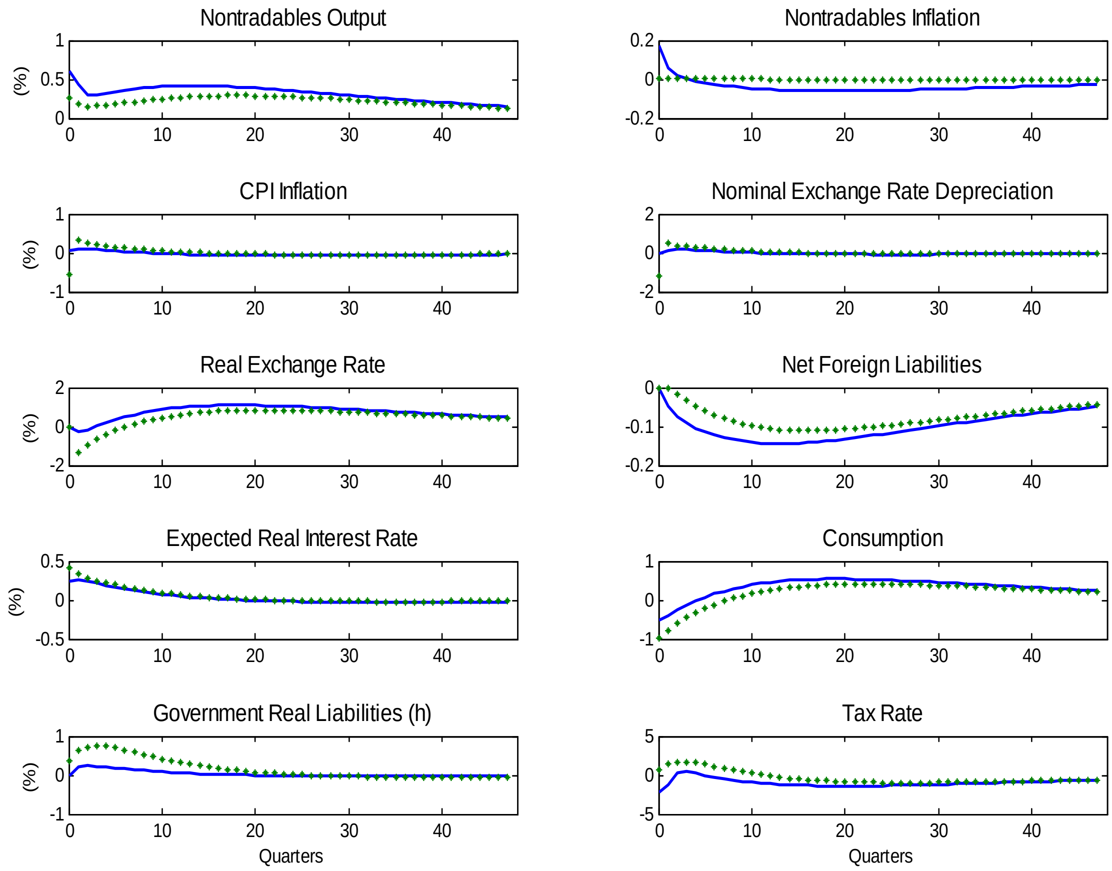

Figure 2: Impulse response to a one standard deviation shock to risk premium. Solid line: CPI inflation targeting. Dotted line: Domestic (nontradables) inflation targeting.

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