Can Inflation Targeting Perpetuate Trade Deficits?

VERY ROUGH DRAFT

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Abstract

Yes. Using a general equilibrium model with traded and nontraded goods we show that, relative to other monetary regimes, inflation targeting can indeed perpetuate a trade deficit. While the issue relevant to all inflation targeting regimes, our model is focused at addressing issues in emerging markets. By considering a shock to world interest rates we generate a trade deficit. We then compare the speed of adjustment back to a trade balance under two alternative regimes and three different policy tools. The primary focus is on the different paths of adjustment between a flexible exchange rate

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regime (i.e., a fixed money supply) and an inflation targeting regime. Under the inflation targeting umbrella we consider the case where policy makers use the nominal interest rate versus their use of international reserves to meet their targets. We find that the trade deficit returns to balance most rapidly under the flexible regime, secondly under the reserve-based and most slowly under an interest-rate-based inflation target.

JEL Classification: E42, E52, F31, F32.

1. Introduction

As the US pulled out of the 2000 recession, the Fed cautiously raised interest rates to keep inflation in check. At the same time the US was running record trade deficits. Subsequent comments from Greenspan suggested to many that the dollar's adjustment (specifically its weakening) to close the U.S. trade gap might add to the Fed's inflation concerns (Ip, 2005a). In that case, it was feared, the Fed might increase interest rates at a faster pace than anticipated. Raising interest rates, however, should strengthen the value of the dollar. In that case, the Fed's anti-inflation interest rate policy might encourage the U.S. trade account to remain in deficit longer than it otherwise would. If this is an issue for the US with its implicit inflation targeting regime (Mankiw, 2005), then it is at least as important an issue for countries with official inflation targeting (IT) regimes. This paper explores this potential consequence of IT in a general equilibrium framework. We find that relative to other monetary regimes, IT does indeed prolong the length of a trade deficit.

While the US does not officially have an IT regime – since many of the institutional requirements of IT are lacking in the U.S. – the Fed does appear behaviorally to follow something similar to an inflation targeting regime[1]. Furthermore, there is talk today of the Fed officially adopting such a regime in the near future[2]. World wide the story is different. Based on the perceived successes of the U.S.'s low-inflation regime and some developed-economy IT regimes, many emerging markets have also switched to IT regimes in recent years. Table 1 shows the sixteen recognized IT countries plus the United States. For the years where all country numbers are reported, an average of 59% of the countries ran trade deficits. Thus, that IT might perpetuate trade deficits is an issue for just over half the major IT countries. This is not to imply causality, rather to suggest that the issue itself is a relevant one. While not a policy debate in every country, the persistence of the US deficit has certainly gained a lot of attention (see Obstfeld and Rogoff, 2004 for the consensus view). The issue of IT perpetuating trade deficits may be of interest to other IT countries in the coming years as well and thus warrants some serious thought.

1 Marvin (2003), Santomero (2003), Mankiw (2005).
2 Ip (2005b) and Mankiw (2005).

Table 1: IT Countries – Net Exports as Percent of GDP

Net Exports as Percent of GDP							
Country	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Australia	-2.44	-2.33	0.10	-0.17	-2.48	..	..
Brazil	-2.62	-1.56	-1.51	-0.99	2.06	3.64	5.41
Canada	1.94	3.66	5.78	5.73	4.35	..	..
Colombia	-5.89	0.54	2.10	-0.73	-1.47	-1.07	-1.96
Czech Republic	-1.12	-1.19	-3.08	-2.54	-2.05	-2.20	-0.36
Israel	-7.66	-7.89	-5.52	-7.71	-8.56	-5.94	-6.15
Japan	1.84	1.56	1.43	0.63	1.29	1.60	..
Korea, Rep.	12.87	6.69	3.15	2.29	1.38	2.51	..
Mexico	-2.14	-1.61	-1.94	-2.27	-1.86	-1.62	-1.87
New Zealand	0.32	-0.80	1.71	2.98	1.49	..	..
Peru	-5.39	-2.33	-1.91	-1.72	-0.79	0.06	1.74
Poland	-4.92	-5.99	-6.54	-3.68	-3.34	-2.49	-1.80
Switzerland	4.90	5.64	5.78	4.95	7.31	..	..
Thailand	15.89	12.57	8.63	6.49	6.70	6.77	5.07
United Kingdom	-0.99	-1.76	-2.06	-2.78	-3.01	-2.95	..
United States	-1.84	-2.83	-3.89	-3.65	-4.09	..	..
Proportion in Deficit	0.63	0.63	0.50	0.63	0.56	0.55	0.63

2. Relation to literature

The literature on IT has grown quite vast. As we see it, our work relates most to the following two veins of the broader IT literature. First is the literature on modern exchange rate regimes; in particular, fear of floating regimes. Second is the literature on sluggish real exchange rate adjustment.

Fear of floating a the modern version of dirty floating where countries influence the value of their currencies through manipulation of domestic interest rates. Calvo and Reinhart first identified fear of floating empirically and coined the phrase in their NBER paper (Calvo and Reinhart, 2000). In the later journal-published version of the paper (Calvo and Reinhart, 2002) they equated credible IT with fixed exchange rate regimes. Others like Agenor (2000) have argued that IT requires a flexible exchange rate regime. Others still have warned that IT generally requires a flexible regime but runs the danger inherent in most mixed regimes. That is, of loosing sight of its major objectives, dis-respecting the limits of policy and leading to a crisis (Fischer, 2004). Ball and Reyes (2005) show that IT is empirically distinguishable from both fixed and flexible regimes although interest rates should occasionally move in response to exchange rate movements under IT. As a result, IT regimes are easily misclassified as fear of floating.

This paper shows another side effect of IT due to its response to exchange rate movements. Along the lines of the IT and fear of floating literature, IT influences exchange rate movements, offsetting them when the inflation target is threatened. In the case of empirical exchange rate regime classification this may cause an IT regime to be misclassified as a fear of floater[3]. In the case presented here, it causes a trade deficit to persist for longer than it would under alternative monetary regimes.

The main reason the trade deficit is prolonged in our case is that the real exchange rate adjustment needed to decrease the value of imports and increase the value of exports is slowed. That is, IT keeps the real exchange rate below its net-export-clearing level. In this regard it contributes to the line of research investigating causes of real exchange rate persistence. The most prominent approach in this research argues for long-lasting contracts slowing national prices and causing real exchange rate persistence[4]. The approach most akin to ours is Beningo (2004) who generates sluggish real exchange rates based on a two country model and Taylor rule monetary policy that adjusts slowly and asymmetrically across countries. His work relies on two large countries that conduct similar policies. That is, if one pursues IT, the other must as well. Ours is more general in not restricting the policies in the rest of the world to be of a certain form. Additionally Beningo's work requires that the two countries have asymmetrically staggered contracts so that prices adjust at different rates, or at least at different times. By avoiding these restrictions two country restrictions, our work allows one to investigate a range of country types from developed to emerging markets. No special assumptions on contract lengths are required. The link between IT regimes and exchange rate movements is emphasized instead.

While the issue we address here of IT and trade deficits is relevant to all IT economy's, our model is developed with emerging market issues in mind. Three key features of the model reveal this. First, we include banks that must finance some of the

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3 This is a misclassification since fear of floating, like dirty floating, implies that the monetary authorities announce one regime officially but pursue a different one in practice. See Ball and Reyes (2005) for further discussion.

4 See Bergin and Feenstra (2001), Chari, Kehoe, and McGrattan (2002), and Kollmann (2001).

government's debt. As noted in Lahiri and Vegh (2001), this is particularly common in developing economies. This also provides a means for the government to control the domestic interest rate because banks consider loans and government bonds to be substitutes. Thus changes in the government rate drive changes in the lending rate. Second, firms in the traded good sector must borrow internationally to finance an imported input to production. Again, this reflects the lack of alternatives within the country and the need to access world markets to produce internationally traded goods of a quality equal to the rest of the world. Lastly, we consider two types of IT. One where the government meets its target by adjusting the nominal interest rate. This is by far the most common across IT economies worldwide. And, second, where the government meets its inflation target by using international reserves. This is more common in developing economies as argued by Calvo and Reinhart (2002)[5].

The rest of the paper is organized as follows. Section 3 presents and develops the model used for the analysis. Sections 4 and 5 describe the equilibrium of the model and the different monetary policy regimes analyzed. Section 6 goes through a simulation of the model where a change in the world interest rate is introduced and then presents the adjustment process for the model under a monetary rule and under IT. Section 7 summarizes the results and presents a brief welfare analysis. Section 8 comments on the parameters used for the simulation. Finally section 9 concludes the paper.

3. The Model

The model is a continuous time, infinite horizon, representative agent model for a small open economy building on the models of Lahiri and Vegh (2001) and Auernheimer and George (2000)[6]. There are two types of goods, traded and non-traded, produced by the private sector. Individuals live forever and maximize utility derived from the consumption of both types of goods. The economy can borrow or lend freely in the world

[5] One need only look at a country like Hungary that claims to maintain simultaneously an IT regime and an exchange rate band.

[6] Lahiri and Vegh's model has been modified to include one traded good and one non-traded good instead of two traded goods. The model is also extended to include the inflation targeting constraint. Inflation Targeting is not discussed in the Lahiri and Vegh (2001) paper; they used the model to analyze dirty floating in the context of nominal wage rigidities. From Auernheimer and George (2000) the current model only uses their specification for the sluggish non-traded good price and their assumptions for the production of the non-traded good

capital markets. The world price of the traded good is taken as given and the law of one price is assumed to hold for this good at all times.

3.1 Consumers

The representative individual consumes traded and non-traded goods, holds nominal domestic deposits, H_t, and foreign bonds. Deposits are held in domestic commercial banks and yield the deposit interest rate, i_t^d, while foreign bonds yield the world real interest rate, r_t, since world inflation is assumed to be zero. The individual's lifetime utility function is given by:

$$U \equiv \int_0^\infty \left(\frac{1}{1-1/\sigma} \left[\left(c_t^T\right)^\rho \left(c_t^H\right)^{1-\rho} \right]^{1-1/\sigma} \right) e^{-\beta t} dt \qquad (1)$$

where c_t^T and c_t^H denote traded and non-traded goods consumption, respectively, while σ and β represent the inter-temporal elasticity of substitution and the rate of time preference. Individuals do not hold cash. Instead, they perform transactions with deposits and face transaction costs, TC_t.

Let P_t^T, P_t^H, P_t^{T*} and E_t denote the domestic price level for the traded good, domestic price level for the non-traded good, foreign price level of the traded good and the nominal exchange rate, respectively. The nominal exchange rate is defined as the price of foreign currency in terms of domestic currency and the rate of currency depreciation is denoted by $\hat{E}_t \equiv \dot{E}_t / E_t$ and dots above variables denote time derivatives. The real exchange rate is defined as $\varepsilon \equiv P_t^T / P_t^H$, and the law of one price for the traded good determines that $E_t P_t^{T*} = P_t^T$. If P_t^{T*} is normalized to one, without loss of generality, the individual's flow budget constraint in terms of the traded good is:

$$i_t{}^d h_t \frac{P_t}{E_t} + \frac{x_t^H}{\varepsilon_t} + \Omega_t^T + \Omega_t^B + \tau + r_t a_t^I = \dot{a}_t^I + c_t^T + \frac{c_t^H}{\varepsilon_t} + \dot{h}_t \frac{P_t}{E_t} + \Pi_t h \frac{P_t}{E_t} + TC_t(\alpha, h_t) \qquad (2)$$

where a_t^I represents real foreign bond holdings $\left(a_t^I \equiv \frac{A_t^I}{P_t^{T*}} \right)$ that yields the world interest rate; Ω_t^T and Ω_t^B are profits from firms producing the traded good and dividends from commercial banks, respectively; τ_t represents lump sum transfers from the government; Π_t is the overall inflation rate for the consumption based domestic price index, P_t, discussed below, and x_t^H denotes production of the non-traded good[7].

The last term in equation (2), TC_t, denotes the transaction costs incurred by the individuals. Transaction costs are lower as individuals increase their holdings of real deposits. α is a positive constant and $h_t = H_t / P_t$ denotes real deposits in terms of the composite consumption good that yield the interest rate on deposits, i_t^d. H_t denotes the nominal stock of deposits in domestic currency and P_t is the consumption based domestic price index determined by the minimum expenditure required to purchase one unit of the composite good[8], $(c_t^T)^{\rho}(c_t^H)^{1-\rho}$:

$$P_t = \frac{E_t^{\rho}(1-\rho)^{(\rho-1)}}{(P_t^H)^{\rho-1}\rho^{\rho}} \tag{3}$$

The problem for the representative individual consists of maximizing (1) subject to (2) by choosing optimal values for consumption of traded and non-traded goods, deposits and foreign asset holdings while taking as given i_t^d, r_t, the level of τ_t, as well as the path for Ω_t^T and Ω_t^B.

Assuming the following explicit form for the transaction costs technology[9]:

$$TC_t(\alpha, h_t) = h_t^2 - \alpha h_t + \kappa \qquad , \qquad h_t \in (0, \frac{\alpha}{2}) \tag{4}$$

[7] For simplicity the production of the non-traded good is not modeled explicitly, the assumptions about the production are explained in detail later in this section.
[8] The Price Index, P_t, is the solution to the minimization of the expenditure function $P_t = P_t^T c_t^T + P_t^H c_t^H$ subject to $\left(c_t^T\right)^{\rho}\left(c_t^H\right)^{1-\rho} = 1$. Recall also that the law of one price holds for the traded good and $P_t^{T*} = 1$. Therefore the nominal exchange rate is equal to the domestic price level of the traded good.
[9] Expression (4) considers only positive transaction costs, since individuals can only perform transactions with deposits. The transaction cost used here is the same used in Lahiri and Vegh (2001).

where α and κ are positive constants and given that $\partial TC_t / \partial h_t < 0$ and $\partial^2 TC_t / \partial h_t^2 > 0$, then individuals reduce transaction costs as they increase their holdings of real deposit. The first order conditions for the utility maximization problem imply:

$$\frac{\rho}{1-\rho}\frac{c_t^H}{c_t^T} = \varepsilon_t \tag{5}$$

$$h_t = \frac{\alpha}{2} - \frac{I_t^d}{2}\frac{P_t}{E_t} \tag{6}$$

where I_t^d denotes the real deposits spread, $i_t - i_t^d = r_t + \hat{E}_t - i_t^d$, which represents the opportunity cost of holding real deposits relative to reserves costing i_t.

Equation (5) is the usual condition that equates the marginal rate of substitution between consumption of traded and non-traded goods to their relative price. Equation (6) shows that real demand deposits are increasing in α and decreasing in the opportunity cost of holding them, I_t^d.

3.2 Overall Price Level and Inflation

The consumption price index derived earlier, equation (3), can be rewritten as follows:

$$P_t = E_t^{\rho} (P_t^H)^{1-\rho} \rho^{-\rho} (1-\rho)^{-(1-\rho)} \tag{7}$$

Taking logs and differentiating with respect to time the overall inflation rate, Π_t, can be expressed as:

$$\Pi_t = \rho \hat{E}_t + (1-\rho)\pi_t^H \tag{8}$$

It is assumed that the non-traded good price responds sluggishly, specifically as a function of the anticipated rate of domestic currency depreciation, $\hat{E}_t^a$, and the difference between the current and the steady state equilibrium of the real exchange rate:

$$\pi_t^H = \hat{E}_t^a + \gamma(\varepsilon_t - \varepsilon^*) \tag{9}$$

where ε^* represents the steady state equilibrium for the real exchange rate[10]. Since $\hat{E}_t^a = \hat{E}_t$ with perfect foresight, we will simply use the current rate of depreciation. Equation (9) implies that the real exchange rate will adjust according to[11]:

$$\hat{\varepsilon}_t = \gamma(\varepsilon^* - \varepsilon_t) \tag{10}$$

Using Equations (8) and (9), the overall inflation rate is:

$$\Pi_t = \hat{E}_t + \gamma(1-\rho)(\varepsilon_t - \varepsilon^*) \tag{11}$$

Equation (11) implies that exchange rate movements translate into inflationary pressure due to the sluggish adjustment of the non-traded good price level. These exchange rate movements can be in response to exogenous shocks like changes in the world interest rate, r_t, or money demand shocks that cause a reallocation of assets. Inflationary pressure arises from the catching up effect of the non-traded good price level. These effects continue until the real exchange rate is back to steady state equilibrium for the real exchange rate, ε^*, defined below.

3.3 Production the Non-Traded Good (x^H)

The production of the non-traded good, x_t^H, is a constant endowment. While output is demand determined in the short run, in the long run output is at its long-run full employment level, $x_t^H = x^{H*}$. Since the home goods market always clears, the non-traded good market will always clear, $x_t^H = c_t^H$ in the short run and in the long run (steady state) equilibrium, $c^{H*} = x^{H*}$. This means that the long run real exchange rate can be derived from (5) after taking into account the market clearing condition,

$$\varepsilon_t^* = \frac{\rho}{1-\rho}\frac{x^{H*}}{c_t^T} \tag{12}$$

Equation (12) implies that for a given level of consumption of the traded good, the real exchange rate is constant in its long run equilibrium.

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[10] This sluggish non-traded good price mirrors the resulting price stickiness that would be obtained with the forward-looking sticky price model of non-traded goods by Calvo (1983) and the modified version of this framework presented in Kumhof (2000).

[11] Recall that $\varepsilon_t = P_t^T / P_t^H$ and that that the law of one price for the traded good determines that $E_t = P_t^T$, therefore $\hat{\varepsilon}_t = \hat{E}_t - \pi_t^H$.

3.4 Production of the Traded Good (x^T)

Firms producing the traded good have a production technology that uses an imported input, K_t, as its sole input. Firms have the following production function:

$$x_t^T = [K_t]^\theta \quad 0 < \theta < 1 \tag{13}$$

They also face a credit-in-advance constraint to pay for the imported input, in other words they use bank loans denominated in domestic currency to pay for their working capital:

$$n_t \geq \psi K_t , \quad \psi > 0 \tag{14}$$

where $n_t = N_t / E_t$ denotes loans, in terms of the traded good, from commercial banks[12]. And the equality holds whenever there is a positive cost for loans, i.e., $i_t^L - i_t^m = I_t^L > 0$. Firms producing the traded good hold foreign bonds, a_t^T, that yield the world interest rate, r_t. These firms have a real financial wealth defined by the difference between their foreign bond holdings and the loans that they acquire from commercial banks, $q_t^T = a_t^T - n_t$, real financial wealth.

From (13) and (14) and imposing the standard transversality condition, the firm's lifetime profit maximizing problem reduces to:

$$\underset{K}{Max} \int_0^\infty \Omega_t^T e^{-rt} dt = q_0^T + \int_0^\infty \left[K_t^\theta - K_t \left(1 + \psi I_t^L\right) \right] e^{-rt} dt \tag{15}$$

The first order condition for the profit maximization problem results in the following demand function for the imported input:

$$K_t = \left[\frac{\theta}{1 + \psi I_t^L} \right]^{\frac{1}{1-\theta}} \tag{16}$$

Equation (16) shows that the demand for the imported input is decreasing in the loans spread, I_t^L, and it determines implicitly the demand for commercial banks loans.

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[12] These loans are revolving loans, meaning that firms do not accumulate debt. The firms first get the loan with which they acquire the input needed for the production of the current period, then they sell the good and repay the loan immediately.

3.5 Banking Sector

The representative bank extends loans, n_t to the firms producing the traded good, charging them the interest rate on loans, i_t^L, holds government bonds, $z_t = Z_t / E_t$, that pay the interest rate, i_t^G, accepts deposits from consumers paying them an interest rate of i_t^d, and holds required nominal reserves, M_t, for these deposits. In real terms, $M_t / P_t = m_t \geq \delta H_t / P_t = \delta h_t$. The banking sector is assumed to be perfectly competitive. This implies that the banks balance sheet in terms of the traded good is $m_t (P_t / E_t) + n_t + z_t = h_t (P_t / E_t)$, and the problem facing the representative bank to maximize with respect to h_t, n_t, and z_t,

$$\Omega_t^B = I_t^d h_t \frac{P_t}{E_t} + I_t^L n_t + I_t^G z_t - i_t^m m \frac{P_t}{E_t} \tag{17}$$

subject to their balance sheet and fractional reserve constraint. I_t^G is the government interest rate spread, $i_t^G - i_t^m$. Noting that δ is set exogenously by the monetary authority, commercial banks receive no interest payment on their reserve holdings other than the return on real money balances meaning that banks will not hold excess reserves. Then using the banks balance sheet, the first order conditions for the maximization problem are:

$$(1 - \delta)\left(i_t^L - i_t^m\right) + \left(i_t^m - i_t^d\right) = \delta \; i_t^m \tag{18}$$

$$\left(i_t^L - i_t^m\right) = \left(i_t^G - i_t^m\right) \tag{19}$$

Equation (18) is the standard result that banks equalize the marginal revenue and the marginal cost. The marginal revenue depends on the spread on deposits and loans. Using equation (19) it is easy to notice that the interest rate on loans must be equal to the interest rate obtained from government bonds; which is the condition for an interior solution. Intuitively this is the result of the perfect substitution between government bonds and commercial loans from the view point of commercial banks. From equation (18) the resulting expression shows that at every point in time the interest rate on deposits is determined by the interest rate paid by government bonds, $i_t^d = (1-\delta)i_t^G$, giving effective interest rate control to the government[13].

In order to insure a determinate demand for deposits and loans, the following restriction for the interest rate is imposed in the model, $0 \le i_t^G - i_t^m \le \delta\, i_t^G$. This is derived from assuming non-negative loan and deposit spreads. It is worthwhile to note that there is an implicit relationship between the demand for deposits in commercial banks and the money demand, which is determined by the reserve requirements that banks must hold

3.6 Government

The government is comprises the fiscal authority and the central bank. The first issues government bonds, paying the government interest rate, i_t^G, and makes lump-sum transfers, τ_t, to the public that are endogenously determined so that the government's constraint is never violated. The second sets δ, issues domestic currency, M_t, and holds international reserves, R_t, that bear the world interest rate, r_t. The flow budget constraint for the government in terms of the traded good is:

$$r_t R_t + \dot{m}_t \frac{P_t}{E_t} + m_t \hat{E}_t \frac{P_t}{E_t} + \dot{z}_t + z_t \hat{E}_t = \tau_t + \dot{R}_t + i_t^G z_t \qquad (20)$$

The central bank's balance sheet identity is given by:

$$E_t R_t + D_t = M_t \quad , \quad D_t = D_t^G - Z_t \qquad (21)$$

where D_t denotes the net nominal domestic credit that results from subtracting nominal government bonds, Z_t, from gross nominal domestic credit, D_t^G[14].

In (20), the lump sum transfers to the consumers consist of seigniorage revenue from issuing cash and bonds and the interest earned on international foreign holdings by the government. Finally we assume that the rate of accumulation of international reserves equals zero in steady state, $\dot{R}_t = 0$.

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[13] This is based on the setup introduced by Calvo and Vegh (1995), where the government issues interest-bearing money.

[14] Net nominal domestic credit, D_t, represents government debt with the central bank. Government bonds work in a very similar way to bank loans. They are revolving loans to the government.

3.7 The Aggregate Budget Constraint

The aggregate budget constraint is derived from summing up the budget constraints of consumers, firms, banks and government. The resulting aggregate constraint is the following:

$$\dot{W}_t = W_t r_t + \frac{x_t^H}{\varepsilon_t} + x_t^T - c_t^T - K_t - \frac{c_t^H}{\varepsilon_t} - [h_t^2 - \alpha h_t + \kappa] \qquad (22)$$

where W_t represents total level of net foreign assets, $R_t + a_t^I + a_t^T$. Recall that the equilibrium condition in the market for the non-traded good holds at all times. Consumption of the traded good then adjusts to the level that satisfies the condition $\dot{W}_t = 0$ in steady state. Then, for a level of total net foreign assets given by past history, W_0, the steady state level of traded good consumption is

$$c_t^T = W_0 r_t + x_t^T - K_t - [h_t^2 - \alpha h_t + \kappa] \qquad (23)$$

4. Characterizing the Equilibrium

The objective of this paper is to compare the duration of a trade deficit under three different monetary policy regimes. The first is the standard monetary rule regime, where the central bank fixes the rate of growth of the nominal money stocks. The other two regimes are both IT regimes, but they differ in the policy instrument used to comply with the inflation target. Since home prices are slow to adjust, the instrument will generally be used to fight inflation pressure coming from exchange rate movements which means that the instrument will have to affect – directly or indirectly – the level of the nominal exchange rate. The first IT regime uses direct central bank intervention in the foreign exchange market, using international reserves. The second one uses interest rate policy to indirectly affect the level of the nominal exchange rate.

Recalling that banks have reserve requirements on deposits they received, then it can be stated that $M_t / P_t = m_t \geq \delta H_t / P_t = \delta h_t$ and the evolution of real money in the economy is given by:

$$\frac{\dot{h}_t}{h_t} = \frac{\dot{m}_t}{m_t} = (\mu_t - \Pi_t) \qquad (24)$$

where μ_t is the rate of money growth and Π_t is the overall inflation rate. Combining equations (11) and (24) and using (6) to substitute for $\hat{E}$ results in the following:

$$\frac{\dot{h}_t}{h_t} = \mu_t + r_t - i_t^d - \alpha \frac{E_t}{P_t} + 2h_t \frac{E_t}{P_t} - (1-\rho)\gamma(\varepsilon_{t-1} - \varepsilon^*) \tag{25}$$

Equations (25) and (10) define the dynamics of our system and can be represented in the phase diagram, Figure (1)[15].

When the central bank implements a monetary rule it fixes the rate of money growth, μ_t.. Given the steady state levels for the real exchange rate, real demand deposits and the level of net foreign assets given by past history (W_0), consumption for the traded good is then determined by equation (23).

In the case where the monetary authority implements IT, the central bank sets the overall inflation target, Π. When the economy is not at the steady state equilibrium, the central bank will control the level of the nominal exchange rate by directly intervening in the foreign exchange market or by using an interest rate policy. The objective of the central bank is to keep the rate currency depreciation at a rate that is consistent with overall inflation. In doing this it surrenders control over the money supply which becomes endogenous as in the case of the standard fixed exchange rate regime. Under this framework, equation (6) establishes the relationship that holds at all times between the demand for real deposits and the real exchange rate. When the system returns to the steady state, the levels of consumption, production and real deposits held by individuals will be the same as in the case of the monetary rule.

5. Various Instruments under Inflation Targeting

When the central bank follows a monetary rule, the rate of depreciation, $\hat{E}_t$, is endogenously determined and the monetary authorities do not react to exogenous shocks that affect the economy. Under the IT case, the central bank has two different instruments to influence the nominal exchange rate in order to keep it at or move it to a level that is

[15] It is important to note that both variables in the phase diagram are control variables, but after introducing a shock to the system, there exist only one ε_t that puts the system on the saddle path given the unique relation that exists between the real exchange rate, ε_t and the level of real deposits, h_t.

consistent with the inflation target. This can be seen by rewriting the central bank's balance sheet, equation (21), as follows:

$$E_t = \left(m_t - \frac{D_t}{P_t} \right) \frac{P_t}{R_t} \tag{26}$$

Equation (26) shows that given a level of international reserves, R_t, the monetary authorities can use the interest rate, i_t^d, to modify the level of E_t, since changes in the interest rate influence m_t given the relationship that exists between high powered money and real deposits. The central bank could also, given m_t, intervene directly in the foreign exchange market using international reserves, and hence alter the level of E_t.

Given the differences between the monetary rule and IT, the following section introduces a shock to the world interest rate and compares the results obtained under the monetary rule against those from the two IT regimes. The focus is on the duration of the trade deficit resulting from the interest rate shock.

6. Generating Trade Deficits: Shock to World Interest Rates

Equation (25) shows that shocks to the world interest rate change the steady state equilibrium for the model. Intuitively the world interest rate is directly related to the opportunity cost of holding real deposits. That is, a higher world interest rate increases this opportunity cost. Therefore these shocks also affect the nominal exchange rate as individuals reallocate their assets in response to changes in r_t. These effects are the same for the three regimes considered here, IT with international reserves, IT with interest rate, and a monetary rule, consequently the steady state is the same for all of these regimes.

6.1 The Case of a Monetary Rule

This section describes the adjustment process that the model follows under a monetary rule after an increase in the world interest rate, r_t. Figure (1) illustrates the effects of the change in r_t. First the $\dot{h}_t / h_t = 0$ locus shifts leftward since for the same real exchange rate higher world interest rates raise the opportunity cost of deposits resulting in a lower level of equilibrium them. The locus of $\dot{\varepsilon}_t / \varepsilon_t = 0$ points is unaffected.

The adjustment process is as follows. There is an immediate jump in the nominal exchange rate given the individuals undesired excess level of real deposits. This jump occurs so as to determine the unique real exchange rate that puts the system on the new saddle path. Thereafter the system follows the saddle path moving toward the new steady state level of real deposits

The adjustment paths for the different variables in the system are depicted in Figure (2) and the parameters used in the simulation are presented in Table 1. The graphs corresponding to the consumption levels of the traded and non-traded goods show that these will be higher than their new steady state level for the duration of the adjustment period. This result follows from the higher interest returns that individuals receive for their holdings of foreign assets and because, for a period of time, production of the traded good exceeds its new steady state equilibrium level given that the opportunity cost of loans, I_t^L, drops at first and adjusts slowly towards its new steady state. Another source of the higher consumption levels is that even though transaction costs rise immediately after the change in r_t, they do not reach their steady state level, they will also be lower for a period of time. Thus the increase in traded consumption exceeds the increase in production, generating a trade deficit. Finally the sluggish adjustment of the non-traded good price results in a higher overall inflation rate throughout the adjustment process. Once the real exchange rate returns to the steady state level, the overall inflation rate will be equal to the unchanged rate of monetary growth set by the central bank.

6.2 The IT Case

Before discussing the IT regimes it is important to notice that the government does not need to intervene to avoid the initial jump of the nominal exchange rate. This is a once and for all jump that would not affect the overall inflation rate thereafter. The problem comes from the sluggishness of the non-traded good price. After the jump of the nominal exchange rate, the non-traded good inflation rate will be affected by the catching up effect that comes from the misalignment of the steady state and the current real exchange rates. Given this inflationary pressure the monetary authority will be forced to intervene. The central bank will need to set a depreciation rate that will be consistent with the overall inflation target. This is because the long-run equilibrium real exchange rate has changed and thus stopping home price adjustment is impossible given equation (11). In other words, the central bank must set a lower depreciation rate, $\hat{E}_t$, to offset the rise in home inflation since the convex combination of these two defines overall inflation. The system will eventually return to the steady state, where the real exchange rate will be equal to its new steady state equilibrium level. If the monetary authorities do not allow the initial jump then they would be fixing the exchange rate. This action would be consistent with the inflation target but then the system would be prone to the same problems that the non-credible pegged exchange rates are prone too[16].

6.2.1 IT regime with International Reserves

First consider the case where the central bank uses international reserves to influence the nominal exchange rate and satisfy the overall inflation target after there has been an increase in the world interest rate. In this case, as was mentioned before, equation (6) determines the relation between real demand deposits and the real exchange rate that holds at all times. The central bank will adjust its level of international reserves according to the real money demand determined by the relation between reserve requirements and real deposits, the real exchange rate level and the depreciation rate consistent with the overall inflation target.

The depreciation rate that is consistent with the inflation target will be lower than the depreciation rate that was observed when the central bank was implementing a monetary rule. This is because policy based on the monetary rule doesn't take exchagne rate (or any price) movements into account at all. Thus, the exchange rate rises its maximum required amount under that regime. Figure (3) shows this and the other paths for the variables in the system for IT with international reserves and for the case of a monetary rule. The lower depreciation rate has two different effects: a positive and a negative one. Together these effects result in lower levels of consumption of the traded and non-traded goods, relative to those observed under the monetary regime. The

[16] Calvo (2001) notes that if inflation targeting is equivalent to pegging the currency to a basket of goods, then inflation targeting and a fixed exchange rate regime are essentially equivalent if this basket is composed of tradable goods.

negative effect comes from the effect that the rate of depreciation has on the opportunity cost of loans, I_t^L.

In contrast to the monetary rule, the interest spread on loans still drops after the change in r_t but it stays above the new steady state level throughout the adjustment period. This causes a lower level of production of the traded good relative to the one observed in the monetary rule case. In turn, this generates a larger trade deficit. The positive effect comes from the level of real deposits, which throughout the adjustment period will be higher than under a monetary rule since the opportunity cost of holding them in this case is lower. Therefore transaction costs are lower under the IT regime with international reserves. These two effects enter equation (23) and determine that consumption for the traded good and therefore production and consumption of the non-traded good are lower under IT with reserves. This follows from the negative effect on production of the traded good dominating the positive effect of lower transaction costs.

6.2.2 IT regime with Interest Rate Policy

Now consider the case where the central bank pursues IT with interest rates. In this case the monetary authorities try to induce a demand for real deposits that is consistent with the exchange rate path and the inflation target. To do so they use the interest rate on domestic government bonds, i_t^g[17]. Recall that these bonds are held by commercial banks and using equations (18) and (19) this policy directly affects the interest rate on real deposits. Again, there is a positive effect reflected in lower transaction costs and a negative effect reflected in lower production levels for the traded good. These cause, relative to the two regimes discussed above, a lower level of traded and home good consumption along the entire adjustment path. The transmission channels again are the lending spread and the opportunity cost of holding real demand deposits. First the depreciation rate is lower relative to the monetary rule regime. Second, from the effects that the changes in i_t^g will have on I_t^d and I_t^L. Figure (3) shows the paths that the variables of the system follow under IT with interest rates, IT with direct intervention in the foreign exchange market (via international reserves) and under the monetary rule

[17] The monetary authority in conjunction with the fiscal authority determines the interest rate that is consistent with the inflation target. In this sense the central bank independence is maintained.

regime. Under both types of IT, the central bank is trying to force a lower rate of depreciation. Under interest-rate IT this translates into a higher i_t^g along the transition path. The higher interest rate on government bonds increases the interest rate spread on loans and lowers the opportunity cost on holding real demand deposits, relative to the IT case with international reserves. This situation is reflected in lower levels of production for the traded good and higher real deposits holdings. Hence, there is a larger trade deficit and it persists for a longer period of time (since more adjustment is required).

7. Summarizing the General Results

The differences across regimes are driven by the differences observed in the financial cost for commercial loans and the opportunity cost of domestic deposits among the regimes considered. Table 2 summarizes these differences and their implications. The differences observed throughout the transition translate into different levels of production and transaction costs. A higher financial cost for commercial loans reduces the level of production of the traded good, while a lower opportunity cost for real deposits decreases transaction costs. Intuitively after a world interest rate increases, the commitment to inflation targeting introduces costs and benefits relative to the monetary rule. When the monetary authority uses international reserves to comply with the inflation target the rate of depreciation will be lower than the one observed under the monetary rule, then $I_{MR}^L < I_{IT-Res}^L$ and $I_{MR}^d > I_{IT-Res}^d$. Therefore the costs of IT, relative to the monetary rule, would be associated with a lower level of traded good production, while the benefits arise from the lower transaction costs[18]. For the case where interest rates are used to fight inflation, the monetary authority will increase the interest rate on government bonds, i_t^G, which directly affects the interest rate on real deposits, i_t^d, and reduces the rate of depreciation, $\hat{E}_t$ to a level that is consistent with the inflation target. Then $I_{IT-Res}^L < I_{IT-i}^L$ and $I_{IT-Res}^d > I_{IT-i}^d$ which translate into even lower production levels of the traded good and lower transaction costs for IT with interest rate policy in comparison to those observed for the other two regimes considered here. This generates the greatest trade

[18] Lower transaction costs are the result of the higher level of real deposits that individuals will hold since the opportunity cost of holding them drops.

deficit of the three regimes. See Figure 5. There we show the results for a comparison between just interest-rate-based IT and the monetary rule (termed "Flex" in Fig. 5). The trade deficit is larger and more persistent under IT.

8. A Brief Comment on the Parameters of the Model.

The results are robust to different combinations of all the parameters. There is one parameter however that affects the conclusions. This parameter is θ. The value of θ determines the concavity of the production function for the traded good and therefore is directly related to the magnitude of the adjustments in production due to changes in the financial cost of commercial loans, in other words θ affects the interest rate elasticity of production. The simulations discussed above used a high value for θ (0.90), situation that translates into significant costs for the cases of direct or indirect intervention under IT, with respect to the monetary rule, that overwhelm the possible benefits that IT introduces. These costs are reflected in lower production levels of the traded good due to the higher financial costs that firms face when the monetary authority implements IT instead of a monetary rule in response to an increase in the world interest rate or a positive money demand shock. When θ is low enough, the benefits from lower transaction costs under IT, relative to the monetary rule, overwhelm the production costs that arise from the intervention under IT and therefore consumption and welfare would be higher for the case where IT is used instead of the monetary rule, and interest rate policy would be the preferred instrument for IT. We use a higher θ because it better captures issues relevant to emerging markets. For those economies changes in the financial costs on loans tend to have strong effects on production. Varying this parameter to explore issues for a wider range of economy type is left for future research.

9. Conclusions on Trade Deficits and IT

This paper has presented a model that explores whether IT can extend the duration of a trade deficit. It argues that, yes, IT can. The model focuses on issues most relevant to emerging markets. This is due to the need for traded good producers to finance and import inputs, the requirement that banks hold government debt, and, finally, in the possibility of using international reserves to maintain an IT regime.

Under three alternative monetary regimes (Flex, IT with interest rates, and IT with international reserves) we examine the response of the economy to a shock to the world real interest rate. The fundamental impact of an increase in the world real interest rate is to raise the opportunity cost of demand deposits. The result is that the level of demand deposits are lower in the new steady state under all three regimes. Furthermore, the new steady state is the same under all three regimes. The transition to the new steady state is not, however, the same. While output and consumption both fall initially and rise over the transition path, their magnitudes differ.

Under the monetary rule regime (i.e., “Flex”), consumption and production of the traded good adjust by approximately the same amount. The resulting impact on the trade balance is negligible. The same is true under IT using international reserves except that the initial impact on the trade account is to generate a small deficit. Under IT with interest rates, what is most commonly meant when referring to “inflation targeting”, when the initial shock occurs, the real exchange rate jumps upward and needs to slowly fall as home-good prices rise. This home good inflation causes overall inflation to exceed its targeted level. To maintain the target, the central bank must set the rate of currency depreciation so that it keeps overall inflation at its target. The result is that it slows the adjustment of the real exchange rate and thus perpetuates the trade imbalance. Furthermore, to do this, the central bank raises domestic nominal interest rates (specifically the rate paid on government debt in the model). This has a negative effect on traded good production, thus generating a much larger trade deficit than under either of the other two regimes. In terms of the questions raised in this paper, this generates a larger and more prolonged trade deficit. Thus, IT can indeed perpetuate a trade deficit.

References

Agénor, Pierre-Richard. (2002). "Monetary Policy under Flexible Exchange Rates: An Introduction to Inflation Targeting." in Norman Loayza and Raimundo Soto, eds., *Inflation Targeting: Design, Performance, Challenges.* Santiago de Chile, Central Bank of Chile, 2002, pp. 79 – 169

Auernheimer, Leonardo and Susan M. George. (2000). "Bad Dreams Under Alternative Anchors: Are the Consequences Different?" International Monetary Fund Working Paper WP/00/20.

Banco de Mexico. (2000). "Exposicion Sobre la Politica Monetaria para 2000." Banco de México, www.banxico.org.mx.

Ball, Christopher and Javier Reyes. (2005). "Inflation Targeting or Fear of Floating in Disguise: A Broader Perspective." Manuscript.

Bergin, P.R., and R.C. Feenstra, 2001, "Pricing to market, staggered contracts, and real exchange rate persistence. Journal of International Economics 54, pp. 333 – 359.

Bernanke, Ben S., Thomas Laubach, Frederick S. Mishkin and Adam.S. Posen. (1999). "Inflation Targeting." Princeton, NJ: Princeton University Press.

Blanchard, Olivier, Francesco Giavazzi, and Filipa Sa, 2005, "The U.S. Current Account and The Dollar" NBER Working Paper No. 11137, p. 15.

Calvo, Guillermo. (2001). "Capital Markets and the Exchange Rate with Special Reference to the Dollarization Debate in Latin America." Journal of Money, Credit and Banking, vol. 33, issue 2, pages 312-34

Calvo, Guillermo and Carmen Reinhart. (2000). "Fear of Floating." National Bureau of Economic Research (Cambridge, MA) Working Paper 7993.

----- (2002) "Fear of Floating" Quarterly Journal of Economics, Issue 2, Vol. CXVII, May 2002, pp. 379 – 408.

Calvo, Guillermo and Carlos Vegh. (1995). "Fighting Inflation with High Interest Rates: The Small Open Economy Case Under Flexible Prices." Journal of Money, Credit and Banking, Vol. 27, pp. 49-66.

Carstens, Agustin and Alejandro Werner. (1999). "Mexico's Monetary Policy Framework Under a Floating Exchange Rate Regime." Banco de Mexico, Documentos de Investigacion No. 9905.

Chari, V.V., P.J. Kehoe, and E.R. McGrattan. (2002) "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates? Review of Economic Studies 69, pp. 533 – 563.

Eichengreen, Barry. (2001). "Can Emerging Markets Float? Should They Inflation Target?" Unpublished manuscript, University of California, Berkeley.

Eichengreen, Barry, P. Masson, M. Savastano and S. Sharma. (1999). "Transition Strategies and Nominal Anchors on the Road to Greater Exchange Rate Flexibility." Essays in International Finance No.213, International Finance Section, Department of Economics, Princeton University (April).

Gali, Jordi and T. Monacelli. (2002). "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." National Bureau of Economic Research (Cambridge, MA) Working Paper 8905.

Giannoni, Marc, and Michael Woodford, 2003, "Optimal Inflation Targeting Rules" NBER Working Paper No. 9939

Goldfajn, I. and S. Ribeiro da Costa Werlang. (2000). "The Pass-through from Depreciation to Inflation: A Panel Study." Banco Central do Brasil, Working Paper Series No.5.

Goodfriend, Marvin, 2003, "Inflation Targeting in the United States?" NBER Working Paper No. 9981.

Fischer, S., 2004 Exchange Rate Regimes: Is the Bipolar View Correct? In: Fischer, S., IMF Essays From a Time of Crisis: The International Financial System, Stabilization, and Development. MIT Press, Cambridge, Massachusetts, pp 227-254.

Ip, Greg, 2005a, "Greenspan Expects Trade Gap to Improve After Dollar's Drop", Wall Street Journal, February 7, 2005: A2.

Ip, Greg, 2005b, " 'Core' Inflation Is Heading Higher", Wall Street Journal, February 24, 2007: A2

Kollmann, R. (2001) "The Exchange Rate in a Dynamic Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation. Journal of International Economics 55, pp. 243 – 262.

Kumhof, Michael. (2001). "A Critical View of Inflation Targeting: Crises, Limited Sustainability, and Aggregate Shocks." Central Bank of Chile, Working Papers No. 127.

Kumhof, Michael. (2000). "Inflation Targeting Under Imperfect Credibility." Unpublished manuscript, Stanford University, Stanford, CA.

Kumhof, Michael, Shujing Li and Isabel Yan. (2001). “Balance of Payment Crises under Inflation Targeting.” Unpublished manuscript, Stanford Stanford University, Stanford, CA.

Lahiri, Amartya and Carlos Vegh. (2001). “Living with the Fear of Floating: an Optimal Policy Perspective.” National Bureau of Economic Research (Cambridge, MA) Working Paper No.8391.

Masson, Paul, Miguel A. Savastano and Sunil Sharma. (1997). “The Scope for Inflation Targeting in Developing Countries.” International Monetary Fund Working Paper WP/97/130.

Mishkin, Frederick S. (2000). “Inflation Targeting in Emerging Countries.” American Economic Review, vol. 90, no.2 May 2000, pp 105 - 109

Mishkin, Frederick S. and Miguel A. Savastano. (2001). “Monetary Policy Strategies for Latin America.” Journal of Development Economics, vol. 66, no. 2, December 2001, pp.415 - 444.

Mishkin, Frederick S. and Klaus Schmidt-Hebbel. (2001). “One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?” National Bureau of Economic Research (Cambridge, MA) Working Paper No. 8397.

Obstfeld, Maurice, and Kenneth Rogoff, 2004, “The Unsustainable U.S. Current Account Revisited” NBER Working Paper No. 10869.

Parrado, Eric and Andres Velasco. (2001). “Alternative Monetary Rules in the Open-Economy: A Welfare-Based Approach.” Central Bank of Chile, Working Papers No. 129.

Reinhart, Carmen M. (2000). "The Mirage of Floating Exchange Rates." American Economic Review, vol. 90, no. 2, May 2000, pp. 65-70

Santomero, Anthony, 2003, "Flexible Commitment or Inflation Targeting for the U.S.?", Federal Reserve of Philadelphia, Business Review, Third Quarter pp. 1 – 7.

Svensson, Lars, 1997, "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets", European Economic Review. 41, 1111-1146

Svensson, Lars E.O. (2000). "Open Economy Inflation Targeting." Journal of International Economics, 50(1) p. 155 - 183.

Taylor, John, 1998, "Staggered Price and Wage Setting in Macroeconomics" NBER Working Paper No. 6754

Wyne, Mark, 1995, "Sticky Prices: What is the Evidence?" Federal Reserve Bank of Dallas Economic Review" First Quarter pp. 1 – 12.

Appendix: A Guide to the Model

Identities

We define the following terms to be used in developing the fundamental equations in this model:

(A.1) real international asset holdings, $a \equiv \dfrac{A}{P_T^*} \qquad \Rightarrow \qquad \dot{a} = \dfrac{\dot{A}}{P_T^*} - a\Pi_T^*$

(A.2) law of one price, $P_T = EP_T^*$ and normalize $P_T^* = 1$

By these two assumptions it follows that $a = A$ and, thus, $\dot{a} = \dot{A}$

(A.3) international interest parity holds, $i = i^* + \dfrac{\dot{E}}{E} \equiv i^* + \hat{E}$

(A.4) Fisher equation holds in each country, $i = r + \Pi$ and $i^* = r + \Pi^*$

(A.5) real exchange rate, $\varepsilon_t = \dfrac{P_t^T}{P_t^H}$

(A.6) real domestic deposits, $h_t \equiv \dfrac{H_t}{P_t}$

(A.7) total profits from production and banking services, $\Omega \equiv \Omega_t^T + P_t^T \Omega_t^B$

Consumers

Consumers have the following nominal budget constraint, using (A.7),

(A.8) $i_t^d H_t + P_t^H x_t^H + \Omega_t + P_t^T \tau_t + i_t E_t A_t = E_t \dot{A}_t + \dot{E}_t A_t + P_t^T c_t^T + P_t^H c_t^H + \dot{H}_t + P_t^T TC_t$

First note that, by (A.1) – (A.5), $i_t E_t A_t - \hat{E}_t E_t A_t = \left(i_t - \hat{E}_t\right) A_t = rA_t$. Using this to simplify (A.8) yields

(A.9) $i_t^d H_t + P_t^H x_t^H + \Omega_t + P_t^T \tau_t + r_t E_t A_t = E_t \dot{A}_t + P_t^T c_t^T + P_t^H c_t^H + \dot{H}_t + P_t^T TC_t$

Divide through by the price of the traded good, using identities (A.1) – (A.7), and note that $h_t \equiv \frac{H_t}{P_t} \Rightarrow \dot{h}_t = \frac{\dot{H}_t}{P_t} - \Pi_t h_t \Rightarrow P_t \dot{h}_t = \dot{H}_t - \Pi_t h_t P_t$ so that $\frac{\dot{H}_t}{E_t} = \Pi_t h_t \frac{P_t}{E_t} + \dot{h}_t \frac{P_t}{E_t}$, to obtain the flow budget constraint, equation (2) in the paper, restated here

(A.10) $i_t^d h_t \frac{P_t}{E_t} + \frac{x_t^H}{\varepsilon_t} + \Omega_t + \tau_t + r_t a_t = \dot{a}_t + c_t^T + \frac{c_t^H}{\varepsilon_t} + \Pi_t h_t \frac{P_t}{E_t} + \dot{h}_t \frac{P_t}{E_t} + TC_t$

The lifetime budget constraint is obtained by first multiplying (A.10) by e^{-rt} and integrating forward from date 0 to infinity. With some rearranging (solving out real assets and using the transversality condition, $\lim_{t \to \infty} e^{-rt} a_t = 0$) yields

(A.11)

$$a_0 + \int_0^\infty \left(\frac{x_t^H}{\varepsilon_t} + \Omega_t + \tau_t \right) e^{-rt} dt + \int_0^\infty \left(\left[i_t^d h_t - \Pi_t h_t - \dot{h}_t \right] \frac{P_t}{E_t} \right) e^{-rt} dt = \int_0^\infty \left(c_t^T + \frac{c_t^H}{\varepsilon_t} \right) e^{-rt} dt + \int_0^\infty TC_t(\alpha, h_t) e^{-rt} dt$$

This formulation breaks lifetime income on the right hand side into initial endowment of assets (RHS term 1), production, profits, and transfers (RHS term 2), and returns from deposits less their depreciation due to inflation and the need for building them up (RHS term 3). On the right hand side, lifetime consumption is devoted to consuming traded and home goods (RHS term 1) and transaction costs (RHS term 2).

Utility Maximization

Individuals maximize the following lifetime utility functional, given by equation (1) in the paper,

(A.12) $$U\left(c_t^T, c_t^H\right) \equiv \int_0^\infty \left(\frac{1}{1-1/\sigma} \left[\left(c_t^T\right)^\rho \left(c_t^H\right)^{1-\rho} \right]^{1-1/\sigma} \right) e^{-\beta t} dt$$

subject to constraint (A.11). Letting λ be the Lagrangian multiplier associated with this problem, the first order conditions are

(A.13) $$U_T(c_T, c_H) e^{-\beta t} = \lambda e^{-rt}$$

(A.14) $$U_H(c_T, c_H) e^{-\beta t} = \frac{\lambda}{\varepsilon_t} e^{-rt}$$

Combining (A.12) – (A.14) yields equation (5) in the paper.

(A.15) $$\lambda e^{-rt} \left[\left(i_t^d - \Pi_t\right) \frac{P_t}{E_t} - \frac{dTC_t}{dh_t} \right] = 0$$

From equation (4) in the paper, TC is defined as $TC_t(\alpha, h_t) = h_t^2 - \alpha h_t + \kappa$ and $h_t \in (0, \frac{\alpha}{2})$ so that (A.15) becomes equation (6) in the paper where real deposit returns are defined as $I^d \equiv i_t^d - \Pi_t$

Goods Markets

Home Goods

(A.16) $x_t^H = c_t^H$ Home Goods Market Equilibrium

Traded Goods

(A.17) $x_t^T = \left(K_t\right)^\theta$ $\theta \in (0,1)$ Production Fn (K – imported input)

(A.18) $n_t \geq \psi K_t$ $\psi > 0$ Cash in advance (n – firm's real cash holding)

(A.19) $p_k = 1$ Constant world price of K, normalized to one

(A.20) $n_t = \frac{N_t}{E_t}$ $\Rightarrow \dot{n}_t = \frac{\dot{N}_t}{E_t} - n\hat{E}_t$

(A.21) Ω_t^T=Profit Rev $= \frac{\dot{N}_t}{E_t} + ra_t + x_t^T$ & $Costs = \dot{a}_t + i_t^l n_t + p_K K_t$

Using (A.20 in A.21),

(A.22) $\Omega_t^T = \left(\dot{n}_t + n_t\hat{E}_t + ra_t + x_t^T\right) - \left(\dot{a}_t + i_t^l n_t + p_K K_t\right)$

Use $i_t = i_t^* + \hat{E}_t \leftrightarrow i_t = r + \hat{E}_t$ to get $\Omega_t^T = \dot{n}_t + r\left(a_t - n_t\right) + x_t^T - \dot{a}_t - \left(i_t^l - i_t\right)n_t - p_K K_t$

Define the lending spread for banks as $I_t^l \equiv i_t^l - i_t$ and real financial wealth as $q_t^T = a_t^T - n_t$ to get the flow profits for firms.

(A.23) $\dot{q}_t^T = \mathrm{r}q_t^T + K_t^\theta - I_t^l n_t - p_K K_t - \Omega_t^T$

Integrating forward (A.23), imposing the standard transversality conditions, and using (A.17) – (A.19), yields

(A.24) $$\int_0^\infty \Omega_t^T e^{-rt} dt = q_0^T + \int_0^\infty \left(K_t^\theta - K_t \left[I_t^l \psi + 1 \right] \right) e^{-rt} dt$$

Maximizing (A.24) with respect to the imported input and rearranging yields the firms' demand for the imported input,

(A.25) $$K_t = \left(\frac{\theta}{1 + \psi I_t^l} \right)^{\frac{1}{1-\theta}}$$

Banks

The banking system is a fractional reserve system. Banks receive deposits, h_t, on which the bank pays return, i_t^d (with spread $I_t^d \equiv i_t - i_t^d$ which represents a cost to the bank). Out of deposits, banks must hold δ percent in reserves, m_t, so that $m_t = \delta h_t$ (where $m_t \equiv \frac{M_t}{P_t}$). The cost to holding these non-interest bearing reserves is the interest foregone. To earn revenues, banks borrow real government bonds, z_t, that pay interest rate i_t^G (the spread is $I_t^G \equiv i_t^g - i_t$) and make real-valued loans, n_t, to firms returning, i_t^l (with spread $I_t^l \equiv i_t^l - i_t$).

The representative bank's profit maximization problem is then to

(A.26) $$\underset{h,n,z}{Max}\, \Omega_t^B = I_t^d h_t \frac{P_t}{E_t} + I_t^L n_t + I_t^G z_t - i_t^m m \frac{P_t}{E_t}$$

subject to $m_t = \delta h_t$ and the bank's balance sheet,

(A.27) $$m_t \left(\frac{P_t}{E_t} \right) + n_t + z_t = h_t \left(\frac{P_t}{E_t} \right)$$

The first order conditions for this problem are equations (18) and (19) in the paper,

(A.28) $(1 - \delta)(i_t^L - i_t^m) + (i_t^m - i_t^d) = \delta \; i_t^m$

(A.29) $(i_t^L - i_t^m) = (i_t^G - i_t^m)$

Note that i_t^m cancels out in (A.28) to yield $i_t^d = (1-\delta)i_t^G$. This is what allows direct governmental control of the interest rate.

The Economy's Resource Constraint

The economy's resource constraint is derived by adding up the budget constraint for individuals (2), for firms(A.23), banks (17) and the government (20). Further, it uses banks' balance sheets (A.27), open economy interest parity, $i_t = \left(i_t^* + \hat{E}_t\right)\Big|_{\Pi^*=0} = r + \hat{E}_t$, and domestic Fisher parity, $i_t = r + \Pi_t$.

Figure 1.

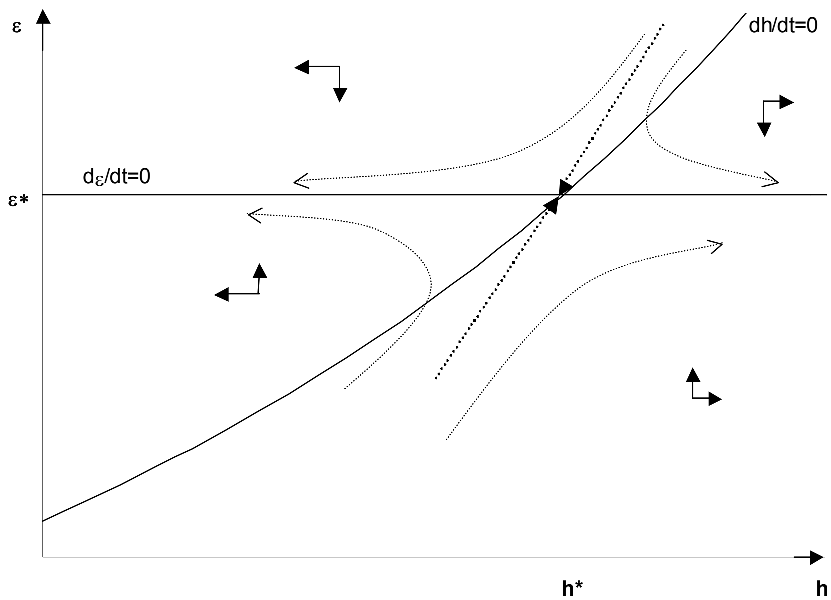


Figure 2. An Increase in the World Interest Rate

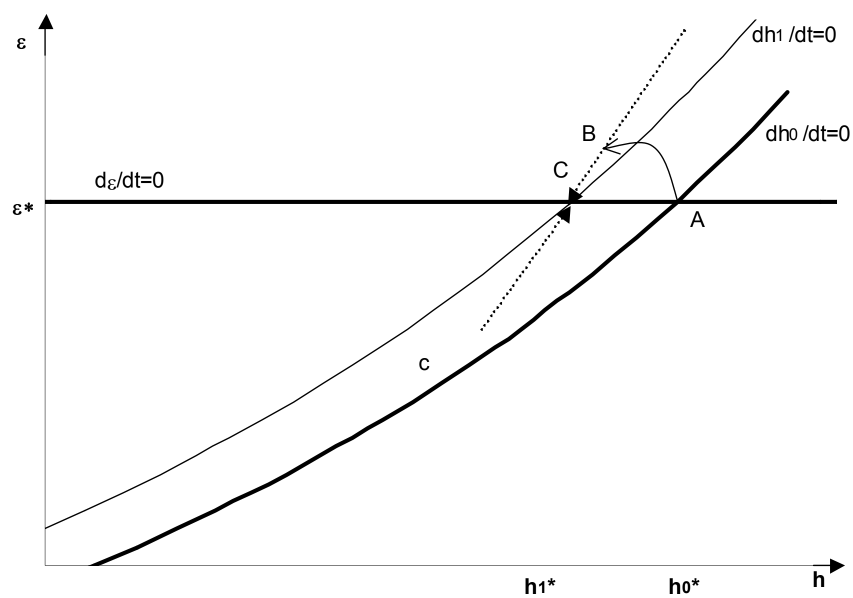


Figure 3. An Increase in the World Interest Rate: Results for the Monetary Rule and IT Regime with International Reserves

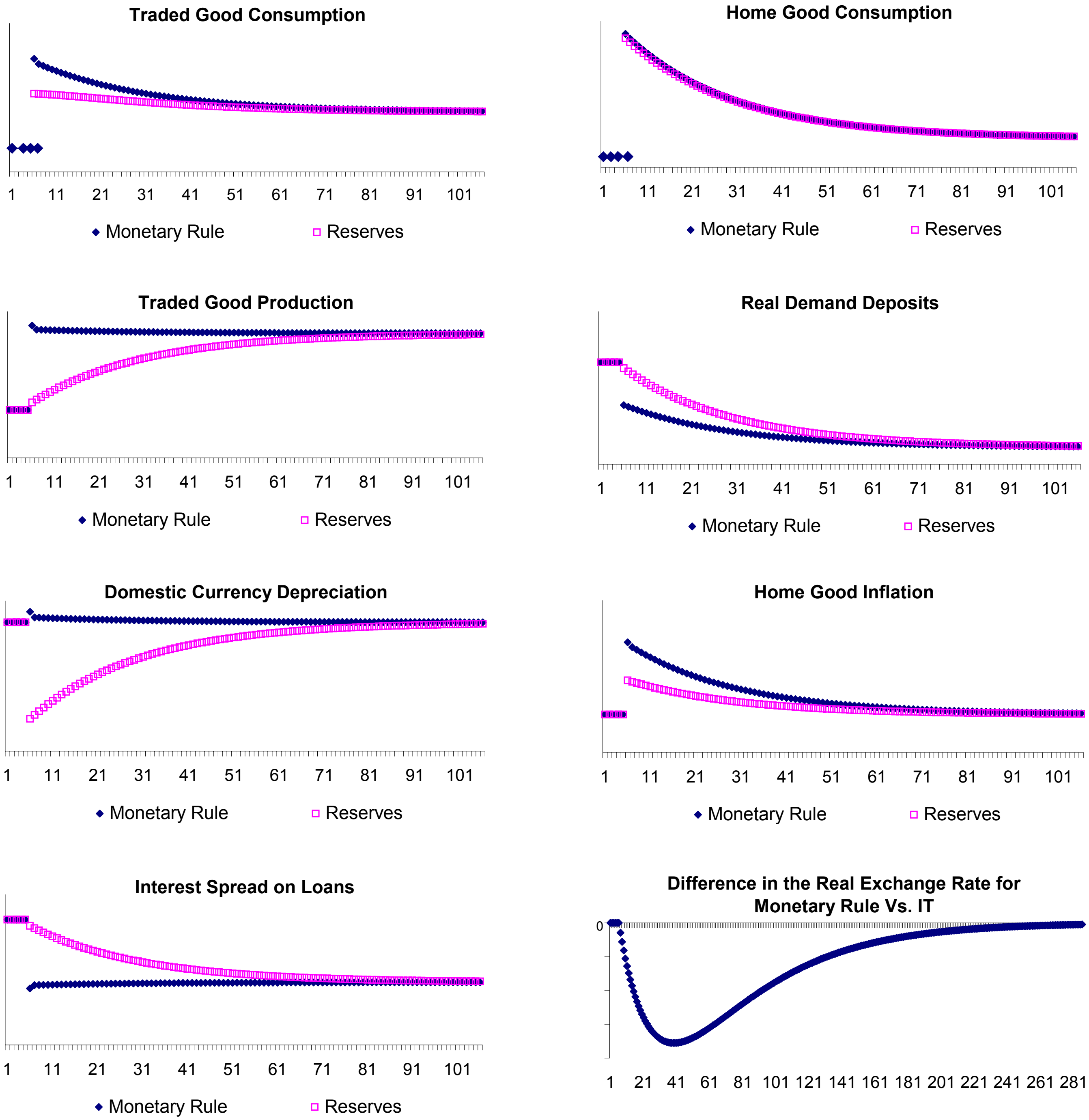
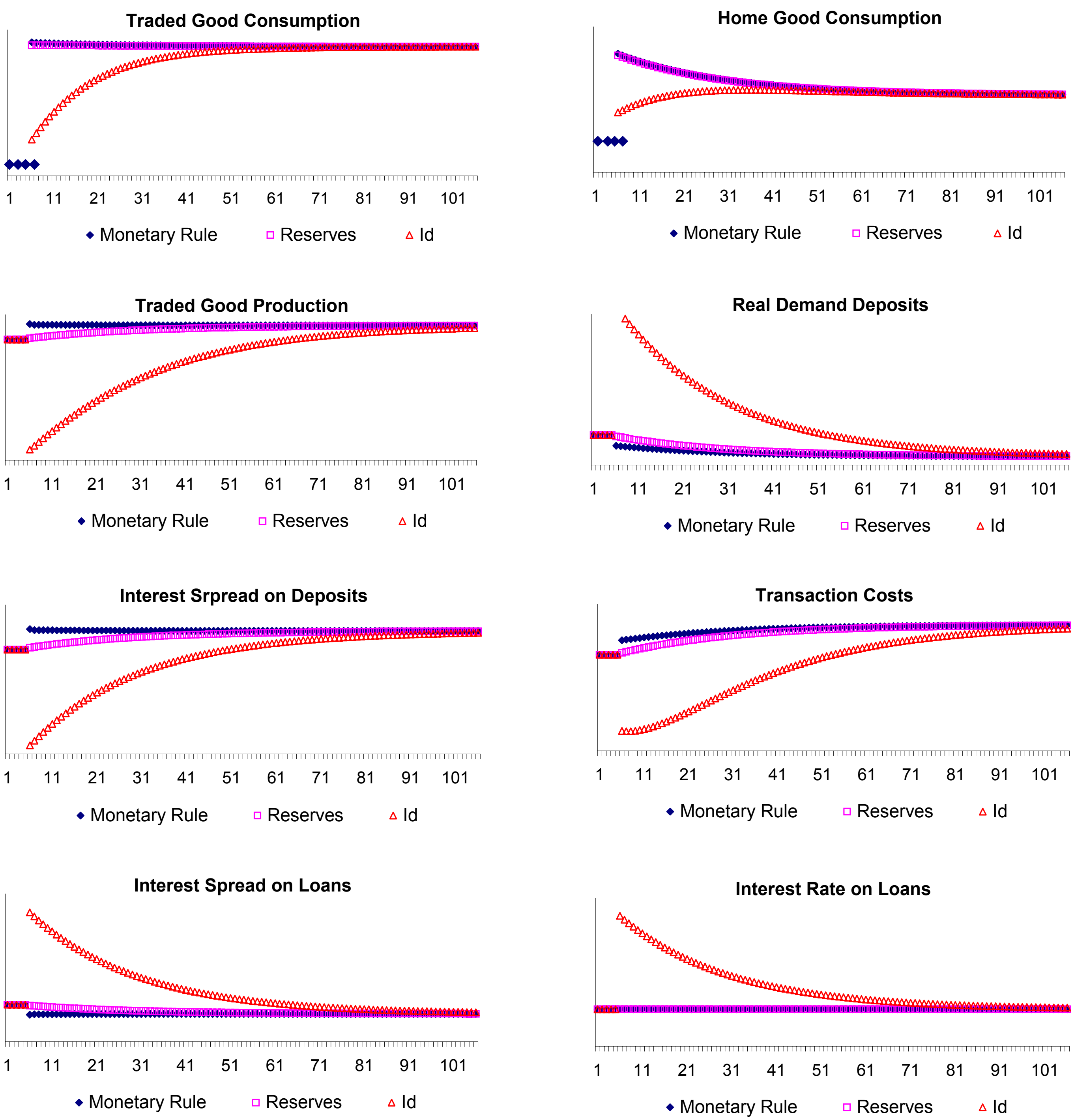
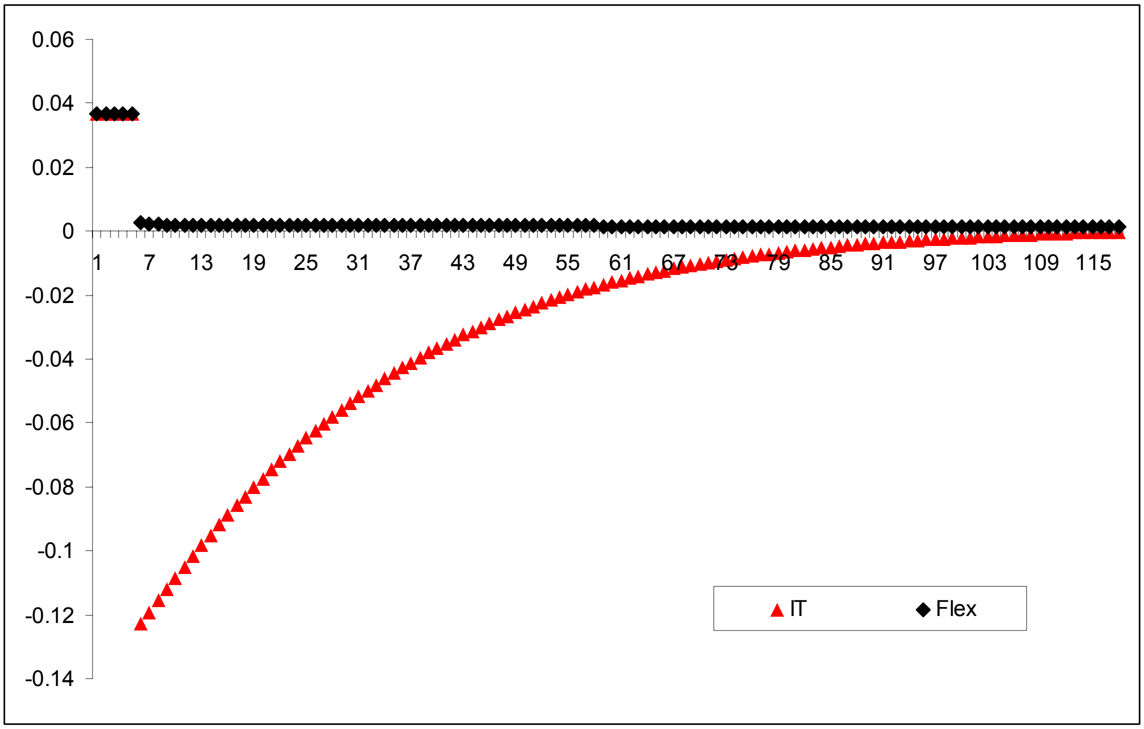


Figure 4. An Increase in the World Interest Rate: Results for the Monetary Rule, IT with International Reserves and IT with Interest



Rate Policy

Figure 5: Traded Good Production less Consumption under IT & FLEX



Note: (1) Here IT denotes interest-rate-based IT and Flex denotes the monetary rule. (2) This is from an additional simulation not fully described in the current version of the paper.

Table 1. Value for the Parameters Used in the Simulation

Parameter	Value	Parameter	Value
ρ	0.5	δ	0.40
γ	0.80	θ	0.90
α	1	μ	6%
κ	0.5	Π (target)	6%
ε^*	1	r	4% (increases to 4.5%)
ψ	1		

Table 2. Differences Among the Policy Regimes for an Increase in the World Interest Rate.

Monetary Rule (MR)		Inflation Targeting		
		w/ International Reserves (IT-Res)		w/ Interest Rate Policy (IT – i)
Π	>	Π	>	Π
Production	>	**Production**	>	**Production**
Financial Cost $i^L - r - \hat{E} = \mathbf{I}^L$ [$i^L = i^G$]	<	Financial Cost $\hat{E}_{MR} > \hat{E}_{IT-\mathrm{Re}s}$	<	Financial Cost $\hat{E}_{MR} > \hat{E}_{IT-\mathrm{Re}s}$ $i^L_{MR} < i^L_{IT-i}$
Transaction Costs	>	**Transaction Costs**	>	**Transaction Costs**

Opp. Cost of Deposits $r + \hat{E} - i^d = \mathbf{I^d}$ $[\ i^d = (1-\delta)\ i^G\ ]$	>	Opp. Cost of Deposits $\hat{E}_{MR} > \hat{E}_{IT-\text{Re}s}$	>	Opp. Cost of Deposits $\hat{E}_{MR} > \hat{E}_{IT-\text{Re}s}$ $i^d_{MR} < i^d_{IT-i}$
Consumption	>	**Consumption**	>	**Consumption**
Utility	>	**Utility**	>	**Utility**