Monetary Policy in Emerging Markets: Can Liability Dollarization Explain Contractionary Devaluations?

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Abstract

In emerging markets, external debt is denominated almost entirely in large, developed country currencies such as the U.S. dollar. This liability dollarization offers a channel through which exchange rate variation can lead to business cycle instability. When firms’ assets are denominated in domestic currency and liabilities are denominated in foreign currency, an exchange rate depreciation worsens firms’ balance sheets, which leads to higher capital costs and contractions in capital spending. To illustrate this, I construct a quantitative, sticky price, small open economy model in which a monetary policy induced devaluation leads to a persistent contraction in output. In this model, fixed exchange rates offer greater stability than an interest rule that targets inflation.

Keywords: Credit Channel, Foreign Currency Debt, Sticky Prices, Devaluation.

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1 Introduction

It is well understood that developing economies can grow quickly by financing investment spending in international capital markets (see Barro, Mankiw and Sala-i-Martin [6] and Cohen and Sachs [26]). Therefore, it is no surprise that emerging economies have large international debts. IMF data shows that in 1995, some East Asian emerging markets (Indonesia, Korea, Malaysia, the Philippines, and Thailand) had outstanding debt to the banks of developed countries that ranged between 11% (in the Philippines) and 55% of GDP (in Thailand). The vast majority of international emerging market debt is denominated in U.S. dollars, Japanese yen, or other large country currencies (a condition that is referred to by Calvo [15] as liability dollarization). The IFR Platinum database shows that 88% of syndicated bank loans in emerging Asian countries between 1992 and 1997 were denominated in large country currencies. The negative macroeconomic implications of private debts that are denominated in foreign currency became apparent during the currency crises of the mid-to-late 1990’s. In late 1997, many East Asian currencies depreciated substantially versus the dollar. These depreciations were followed by sharp real contractions. A number of authors (including Calvo [17] and Mishkin [54]) argue that the impact of the currency depreciations on the balance sheets of firms with foreign currency debt greatly exacerbated the post-crisis contraction.

A long literature, summarized by Agenor and Montiel [1], has emphasized the possibility that devaluations are contractionary in emerging markets. This idea conflicts with the logic of the sticky price Mundell-Fleming model (and more modern sticky price open economy models following Obstfeld and Rogoff [58]). According to the textbook logic, devaluations are expansionary in the short-run. Given that the prices of an open economy’s goods are fixed in its own currency, a monetary expansion that leads to currency depreciation reduces the relative price of the economy’s goods, which leads to an expansion in demand through net exports. In this paper, I construct a quantitative dynamic general equilibrium (DGE) of a small open economy in which exogenous currency depreciations are contractionary through the channel of liability dollarization. An exogenous depreciation is defined as a currency depreciation that is induced by a surprise monetary policy expansion. In the model, a monetary expansion that leads to a currency depreciation damages the balance sheets of domestic firms by making hard currency debt more expensive to repay. This, in turn, leads to a contraction in investment demand that more than offsets the rise in exports that is caused by the depreciation.

There are two key links in the narrative chain of this story. The first link is that a
currency depreciation damages the balance sheets of firms that hold foreign currency debt. Define real net worth as the value of a firms’ assets relative to its liabilities. Consider a firm that has issued a fixed quantity of foreign currency debt to finance the accumulation of a fixed quantity of physical capital. Given pre-determined quantities of real assets and liabilities, real net worth is given by a key relative price: the domestic currency price of assets (the nominal market price of capital) relative to the domestic currency price of liabilities (the nominal exchange rate). In the absence of nominal rigidities, monetary neutrality implies that monetary policy has no effect on this (or any) relative price. Thus, the logic that an exogenous depreciation reduces the real net worth of firms with foreign currency debts implicitly requires the presence of a nominal rigidity such that a monetary expansion reduces the price of real assets relative to the exchange rate. I assume that the nominal output prices of firms with foreign currency debt are sticky. During a monetary expansion, input prices increase faster than output prices, which reduces the profits that accrue to the owners of capital assets. As the value of a firm’s assets are equivalent to the present discounted value of capital income, a monetary expansion reduces the value and price of those assets relative to foreign currency. An exogenous depreciation thus reduces the value of firms assets relative to liabilities, and reduces the real net worth of firms.

The second link in the narrative chain is that a reduction in the net worth of firms reduces real investment. Under perfect capital markets, optimal investment is invariant to the financial structure of firms. The idea that damage to balance sheets reduces investment implicitly requires the presence of some capital market imperfection. Bernanke and Gertler [7] construct a model (based on asymmetric information between borrowers and lenders) in which heavily leveraged borrowers have a higher probability of defaulting on their debt and, thus, pay a higher interest rate. A reduction in a firm’s net worth increases its leverage, increases its real cost of capital, and reduces optimal investment. The model in this paper incorporates this channel in a manner closely following the closed economy, dynamic general equilibrium model of Bernanke, Gertler and Gilchrist [9]. By incorporating both sticky prices and imperfect capital markets, it is possible to construct a model in which a monetary expansion leads to a depreciation that damages firms’ balance sheets and reduces aggregate investment.

It is interesting to note that sticky nominal prices are a key element in the channel through which a monetary expansion has contractionary effects on real demand. A large number of papers study the channels through which exogenous monetary expansions are expansionary in sticky price optimizing models of both closed economies (for example, Chari, Kehoe and McGrattan [21]) and open economies (for example, Obstfeld and Rogoff [58]). Sticky prices
delay the response of inflation to monetary expansions. Thus, monetary expansions reduce real interest rates by increasing expected future inflation. Moreover, because domestic goods have sticky prices in the domestic currency, a nominal exchange rate depreciation implies a real exchange rate depreciation\(^1\). The model here includes these expansionary channels and the contractionary channel of foreign currency debt. Whether the contractionary channel or the expansionary channels dominate the impact of monetary expansion on aggregate demand is a quantitative question that can be explored in the model. In a quantitative model that is calibrated to data from East Asian countries that had large private hard currency debts, an exogenous monetary expansion has initially mild but persistent contractionary effects.

If exchange rate fluctuations destabilize balance sheets and real investment, then exchange rate stability may be an important goal of monetary policy. To analyze this possibility, I compare the effects of some external shocks on a small open economy under various monetary policy regimes. Of particular interest is a comparison of the stabilization properties of two regimes at opposite ends of the spectrum: a fixed nominal exchange rate regime and a flexible exchange rate monetary policy that targets domestic inflation. Fixed exchange rates obviously achieve the most extreme sort of exchange rate stability. Since the East Asian crisis, Malaysia has implemented a pegged exchange rate while a number of countries (including Korea, the Philippines and Thailand) have since adopted inflation targeting regimes (see Amato and Gerlach [2]). A number of papers show that developed economy regimes that focus on inflation can be parsimoniously represented by simple interest rate rules (see Taylor [63] and Clarida, Gali and Gertler [25]).

An inflation targeting interest rate rule suggests a policy of reducing nominal interest rates in the face of deflationary shocks. Reducing domestic interest rates below the level of world interest rates results in a temporary exchange rate depreciation that might help to stabilize the economy by boosting exports. However, the exchange rate devaluation occurs at a cost to the balance sheets of domestic firms that might destabilize the economy by reducing investment. In contrast, a fixed exchange rate protects balance sheets and investment stability at the cost of less flexibility in exports. Given the counter-veiling effects of exchange rate flexibility, whether a fixed exchange rate offers greater stability than an inflation target is an inherently quantitative question. In a liability dollarization model in which devaluations are contractionary, the real effects of external shocks are larger and more persistent under inflation targeting than under a fixed exchange rate.

The model draws on a large body of previous research in constructing a quantitative,

\(^1\)Devereux and Engel [29] show that when firms price their goods in the currency of the customer, a change in the nominal exchange rate has no effect on this relative price.
DGE model of an open economy. The basic representative agent structure of the model is based on the international, real business cycle literature that stems from the work of Backus, Kydland, and Kehoe [5] and Mendoza [53]. Yun [68] incorporates sticky prices into a quantitative, DGE model. Obstfeld and Rogoff [58] demonstrate some of the key theoretical issues in incorporating sticky prices into a forward-looking open economy model stimulating a large theoretical literature (see Lane [49] for a review). In the quantitative literature, Betts and Devereux [11], Kollman [48] and Chari, Kehoe and McGrattan [22] calibrate two country sticky price models. Monacelli [56] and Schmitt-Grohé and Uribe [62] calibrate small open economy models.

Bernanke, Gertler and Gilchrist [9] draw on a large literature to provide a modelling structure in which unexpected shocks to capital returns affect the balance sheets of credit constrained firms. Townsend [64] initiated a rigorous examination of debt contracting under asymmetric information. Gale and Hellwig [37] and Williamson [65] show that given monitoring costs, the optimal financial contract resembles risky debt. In overlapping generations models, Williamson [66] and Bernanke and Gertler [7] show that balance sheet effects can influence business cycle dynamics. Fuerst [36] and Gertler [39] adapt this model to a business cycle frequency that is suitable for quantitative analysis. Carlstrom and Fuerst [18], [19] demonstrate how the intertemporal evolution of borrower net worth in response to shocks can act as a dynamic propagation mechanism for business cycle shocks. An associated empirical literature including Fazzari, Hubbard and Peterson [34], Gilchrist and Himmelberg [41], and Calomiris, Orphanides and Sharpe [13] find empirical evidence for important balance sheet effects on investment by credit constrained firms.

A number of authors have conducted theoretical and quantitative analysis of the impact of foreign currency debt on monetary policy. As in this paper, Cespedes, Chang and Velasco [20], Gertler, Gilchrist and Natalucci [40] and Devereux and Lane [30] incorporate a model of investment in which net worth affects the cost of capital for firms with foreign currency debt into a small, open economy model with optimizing agents and nominal rigidities. Cespedes et al.[20], Gertler, et al. [40] and Devereux and Lane [30] find that domestic inflation or price targeting is unambiguously more stabilizing in the face of external interest rate shocks than fixed exchange rates, which is the opposite result from this paper. Why are the results in this paper so different? The key difference is the manner in which nominal price rigidities are incorporated into the equilibrium model. In the absence of nominal rigidities, monetary policy has no effect on the relative value of firms’ assets and liabilities. In this paper, the output prices of financially constrained firms with foreign currency debt are nominally sticky,
but input prices are not. Thus, a monetary expansion reduces the profits of firms and reduces the value of firms’ assets relative to their foreign currency liabilities. In contrast, Cespedes, et al.[20] examine an economy with sticky wages. When workers nominal wages are fixed but prices are not, a monetary expansion reduces real wages and shifts income from workers to the owners of capital, increasing the relative value of the capital assets of firms with foreign currency debt. Gertler, et al. [40] and Devereux and Lane [30] assume that domestic retailers (who have not issued foreign currency debt) have sticky prices, while financially constrained manufacturers (who have financed real assets with foreign currency debt) have flexible prices. The manufacturers sell their product to the retailers. In such an economy, a monetary expansion increases the sticky price retailers’ real demand for wholesale goods, increasing the real value of capital used to produce those goods. In cases in which financially constrained firms do not have sticky prices, but other agents in the economy do, a monetary expansion is likely to increase the value of financially constrained firms’ capital assets relative to their foreign currency debt, thus increasing the net worth of credit-constrained domestic firms and increasing investment.

Aghion, Bacchetta, and Banerjee [3], [4] and Krugman [47] describe two-period multiple equilibrium models in which the presence of foreign currency liabilities are a part of endogenous currency crises. In Aghion et al.[3], sticky prices prevent the nominal value of firms’ output from rising with the value of their debt during a currency depreciation. Thus, a depreciation damages firms’ balance sheets, which is a key element in the onset of endogenous currency crises. The strength of this paper, relative to Aghion et al.[3] and Krugman [47], is that I focus on a completely specified DGE business cycle model that balances the expansionary and contractionary effects of an exchange rate depreciation. Thus, my model is useful for studying monetary policy in a familiar setting and can be used for the quantitative analysis of the relative strength of the offsetting effects of an exchange rate depreciation.

2 The Model

The small open economy consists of two agents: workers and capitalists. Workers purchase final goods for consumption, $C_t$. Capitalists purchase final goods for both consumption, $CK_t$, and new investment, $I_t$. The government purchase goods, $G_t$.

$$C_t + CK_t + I_t + G_t = A_t$$  (1)

These categories constitute the sum total of absorption, $A_t$, which is a combination of domestically produced goods, $D_t$, purchased at domestic currency price, $P_t$, and foreign imports,
$IM_t$, purchased at domestic currency price, $S_t \cdot P_t^*$, where the spot exchange rate is $S_t$ and $P_t^*$ is the foreign price level.

$$A_t = (a^{1-\alpha} D_t^\alpha + (1 - a)^{1-\alpha} IM_t^\alpha)^\frac{1}{\alpha}$$  \hspace{1cm} (2)

The cost minimizing price of absorption goods, $CPI_t$, defines the relative demand for domestic goods and imports.

$$CPI_t \cdot a^{1-\alpha} \left(\frac{D_t}{A_t}\right)^{\alpha-1} = P_t \quad CPI_t (1-a)^{1-\alpha} \left(\frac{IM_t}{A_t}\right)^{\alpha-1} = S_t P_t^*$$  \hspace{1cm} (3)

Domestic goods output, $Y_t$, is equal to the domestic goods that are used for domestic absorption, $D_t$, plus exports, $EX_t$.

$$D_t + EX_t = Y_t$$

The rest of the world has a demand for the exports of the small open economy, that is parallel to the small economy’s demand for imports. The absorption of goods by the world economy, $A_t^W$, is a function of domestic exports and the world economy’s own domestic value added, $D_t^W$.

$$A_t^W = (a_W^{1-\alpha} D_t^W^\alpha + (1 - a_W)^{1-\alpha} EX_t^W)^\frac{1}{\alpha}$$

Given a world absorption goods price level, $CPI_t^W$, and the foreign currency price of exports from the small open economy, $\frac{P_t}{S_t}$, the world economy demands a quantity of exports to minimize the cost of final goods absorption. Thus, exports are determined by variables endogenous to the small economy and some exogenous variables, $CPI_t^W$ and $A_t^W$.

$$EX_t = \frac{1}{(1-a_W)} \left( \frac{P_t}{S_t \cdot CPI_t^W} \right)^{\frac{1}{1-\alpha}} \cdot A_t^W$$  \hspace{1cm} (4)

### 2.1 Workers

Workers gain utility from consumption and time, $T$, not spent in market labor, $H_t$. Define felicity, $Z_t$, as the momentary utility received by workers from consumption and leisure.

$$Z_t = C_t \cdot (T - H_t)^\Gamma$$  \hspace{1cm} (5)

Infinitely lived workers maximize the discounted sum of a isoelastic function of felicity. The time discount factor is a decreasing, concave function of felicity, as in Mendoza [53].

$$V_t = \max_z \frac{1}{1-\psi} Z_t^{1-\psi} + \beta (Z_t) E_t [V_{t+1}] \hspace{1cm} \beta(z) = \beta_0 \cdot z^{-\gamma}$$
The household earns money income by working at wage, \( W_t \). Beyond a lump sum fiscal tax, \( CPI_t \cdot G_t \), income can be used to purchase consumption goods or bonds, \( B_t \), which pay a nominal interest, \( 1 + i_t \).

\[
B_t = W_t H_t + (1 + i_{t-1}) \cdot B_{t-1} - CPI_t \cdot [C_t + G_t] \tag{6}
\]

Define the shadow value of a unit of nominal income at time \( t \) as \( \Lambda_t \).

\[
(T - H_t)^{\Gamma} \cdot Z_t^{-\psi} + \beta' (Z_t) \cdot E_t[V_{t+1}] = CPI_t \Lambda_t \tag{7}
\]

The optimal choice of bonds implies an Euler equation.

\[
1 = E_t[\beta (Z_t) \cdot (1 + i_t) \cdot \frac{\Lambda_{t+1}}{\Lambda_t}] \tag{8}
\]

The first order conditions include an equation governing the consumption leisure trade-off.

\[
\frac{W_t}{CPI_t C_t} = \frac{\Gamma}{T - H_t} \tag{8}
\]

Domestic bonds are freely traded in international financial markets. Foreign investors are able to diversify the risk of the small economy bonds, so uncovered interest parity holds with a world interest rate, \( 1 + r_t^W \).

\[
1 + i_t = E_t[\frac{(1 + r_t^W) \cdot S_{t+1}}{S_t}] \tag{9}
\]

### 2.2 Capitalists

**2.2.1 Constructing Capital**

Capitalists bear the risk of holding physical capital through time. In period \( t \), capitalists combine the existing stock of capital, \( K_t \), and new investment, \( I_t \), to construct next period’s capital stock, \( K_{t+1} \).

\[
K_{t+1} = (1 - \delta) K_t + I_t - \frac{\zeta}{2} (\frac{I_t}{K_t} - \delta)^2 K_t \tag{10}
\]

The market price of used capital is \( Q_t \); the price of new investment is the final goods price, \( CPI_t \). Given these prices, capitalists chose a cost minimizing ratio of new investment to used capital. The cost minimizing marginal cost of installing any given capital stock, \( K_{t+1} \), is scale invariant and can be thought of as the price of the next period’s capital goods. This ‘price’
of capital, \( P^K_t \), is implicitly defined by the first order conditions of the cost minimization problem.

\[
1 - \left( \frac{CPI_t}{P^K_t} \right) = \zeta \left( \frac{I_t}{K_t} - \delta \right) \quad Q_t = P^K_t \cdot \left[ (1 - \delta) + \frac{I_t}{K_t} \zeta \left( \frac{I_t}{K_t} - \delta \right) \right] \tag{11}
\]

### 2.2.2 Financing Capital

A unit range of capitalists, indexed by \( l \), are endowed with a stochastic technology that allows them to store capital across time. If \( k^l_t \) is stored at time \( t \), the capitalist will have \( \omega k^l_t \) at time \( t+1 \). Stochastic technology, \( \omega \), is independently distributed (across capitalists and time) with a log normal cdf, \( \Phi(\omega) \), with a mean of 1. The stochastic technology is observable to outsiders only if they pay a monitoring cost of \( \mu \omega k^l_t \).

At time \( t+1 \), the capitalists receive a domestic currency pay-off of \( PAY^K_t \) for each unit of capital that they own. The capitalists begin with a domestic currency net worth, \( nw^l_t \), and borrow foreign currency on international financial markets to finance the purchase of capital. The foreign currency debt incurred is \( debt^l_t \).

\[
debt^l_{t+1} = \frac{P^K_t k^l_{t+1} - nw^l_t}{S_t} \]

The financial contract resembles risky debt. Creditors monitor the technology outcome only if the borrower defaults. In the case of default, creditors repossess the assets of firms less the monitoring cost. Given an interest rate that is specified by the debt contract, \( 1 + i^{rp} \), there is a minimum technology outcome, \( \varpi \), such that the payoff to capital is just sufficient to repay the debt and avoid default. Default will occur when technology is less than \( \varpi \).

\[
\varpi \equiv \frac{(1 + i^{rp}) \cdot debt^l_t}{PAY^K_{t+1} \cdot k^l_t}
\]

The capitalists’ expected income is the expected pay-off to capital (conditional on technology being greater than \( \varpi \)) less the interest payment, multiplied by the probability of no default. Following Carlstrom and Fuerst [18], the share of the capital payoff that is retained by the capitalist can be written as a decreasing function of the minimum no-default technology level, \( f(\varpi) \).

\[
Pr(\omega \geq \varpi) [E(\omega PAY^K_{t+1} \cdot k^l)|\omega \geq \varpi] - S_{t+1}(1 + i^{rp})debt^l_t = f(\varpi)PAY^K_{t+1} \cdot k^l
\]

\[
f(\varpi) \equiv Pr(\omega \geq \varpi) \{ E(\omega | \omega \geq \varpi) - \varpi \} \quad f'(\varpi) < 0
\]
The expected income of creditors is the interest income multiplied by the probability of no default plus the expected value of the repossessed capital (less monitoring costs) multiplied by the probability of default. The share of the capital payoff that is paid to creditors is a function of the minimum no-default technology level, \( g(\omega) \).

\[
\Pr (\omega \leq \omega) E(\omega (1 - \mu) \frac{PAY^K}{S_{t+1}} k^1 | \omega \leq \omega) + \Pr (\omega \geq \omega) (1 + r^p) debt^l = g(\omega) \frac{PAY^K}{S_{t+1}} k^l
\]

\[
g(\omega) \equiv \Pr (\omega \leq \omega) E(\omega (1 - \mu) | \omega \leq \omega) + \Pr (\omega \geq \omega) \cdot \omega \quad g'(\omega) > 0
\]

Financial contracts specify a level of debt and a level of \( (\text{conditional on aggregate prices}) \) that maximizes the expected pay-off of the capitalists, subject to the creditors receiving a return equivalent to the world interest rate, \( 1 + r^W_t \).

\[
\max_{\omega, k} E_t \left[ f(\omega_{t+1}) PAY^K_{t+1} \cdot k^l_{t+1} \right]
\]

\[
s.t. \quad g(\omega_{t+1}) \frac{PAY^K_{t+1}}{S_{t+1}} \cdot k^l_{t+1} = (1 + r^W_t) \cdot \left[ \frac{PAY^K_{t+1} - nw^l}{S_t} \right]
\]

Define the ex post domestic currency returns, \( 1 + r^K_t \), and the ex post foreign currency returns, \( 1 + \tilde{r}^K_t \).

\[
1 + r^K_{t+1} \equiv \frac{PAY^K_{t+1}}{P^K_t} \quad 1 + \tilde{r}^K_{t+1} \equiv 1 + r^K_{t+1} \cdot \frac{S_t}{S_{t+1}}
\]

The first order condition of the optimal contract equates the foreign currency return on capital with the foreign currency interest rate plus an endogenous risk premium term, \( \rho \).

\[
E_t \left[ \frac{1 + \tilde{r}^K_{t+1}}{\rho(\omega_{t+1})} \right] = 1 + r^W_t
\]

\[
\rho(\omega_{t+1}) = \left( \frac{g'(\omega_{t+1}) \cdot f(\omega_{t+1})}{f'(\omega_{t+1})} - g(\omega_{t+1}) \right)^{-1} \quad \rho'(\cdot) > 0
\]

### 2.2.3 Returns to Capital

The value of capital stems from its value in producing goods. Thus, an analysis of the returns to capital must start with a description of the production process. The final goods that are produced by the small open economy are a Dixit-Stiglitz combination of a unit range of goods, \( y^i_t \), produced by monopolistically competitive firms and sold at price \( p^i_t \).

\[
Y_t = \left[ \int_0^1 (y^i_t)^v dj \right]^{\frac{1}{v}} \quad P_t = \left[ \int_0^1 (p^i_t)^{\frac{1}{1-\nu}} dj \right]^{\frac{\nu-1}{\nu}}
\]
The cost-minimizing elasticity of demand for each good in its own price, $p^j_t$, is constant.

$$\frac{p^j_t}{\bar{P}_t} = (\frac{Y^j_t}{\bar{Y}_t})^{\nu-1}$$

The market power of the producers and distributors of the good imply a level of profits, $\Pi^j_t$. Monopolistically competitive distributors set prices and sell the goods in return for a share, $\varrho$, of the profits derived by Nash bargaining with the monopoly producers of the goods. The cost minimizing marginal cost of production is $MC_t$.

$$\Pi^j_t = (p^j_t - MC_t) \cdot y^j_t = (p^j_t - MC_t) \cdot \left(\frac{p^j_t}{\bar{P}_t}\right)^{\frac{1}{\nu}} \cdot Y_t$$

At the end of every period, a fixed percentage of distributors, $1 - \kappa$, are given the opportunity to reset their posted nominal prices. Each distributor with this opportunity selects a price, $P^*_t$, to maximize the discounted sum of future profits over the period that sticky prices are in place.

$$P^*_t = \arg\max_p E_t \sum_{s=t+1}^{\infty} (\beta \kappa)^{s-t} \cdot \varrho \Pi^j_s$$

Define $F_t \equiv \varrho \bar{P}_t^{1-\nu} Y_t$. A firm given the opportunity to change prices will choose $P^*_t$.

$$P^*_t = \arg\max_p E_t \sum_{s=t+1}^{\infty} (\beta \kappa)^{s-t} \left( p^{\frac{1}{\nu}} F_s - p^{\frac{1}{\nu}} F_s \cdot MC_s \right) = \frac{1}{\nu} \frac{E_t \sum_{s=t+1}^{\infty} (\beta \kappa)^{s-t} F_s \cdot MC_s}{E_t \sum_{s=t+1}^{\infty} (\beta \kappa)^{s-t} F_s}$$

(15)

Prices follow the same dynamics as the modification by Rotemberg and Woodford [61] modification of Calvo [14] or Yun [68].

$$P^*_t = \kappa P^*_t^{\frac{1}{\nu}} + (1 - \kappa) P^*_t^{\frac{1}{\nu}}$$

(16)

At time $t$, the nominal price of each good is predetermined, as is the aggregate price, $\bar{P}_t$.

The model of capital accumulation represents a situation in which the ownership of physical capital and the ownership of monopolistic firms is inextricably linked. There are a unit range of production technologies indexed by $j$, which correspond to each of the differentiated goods. Only the existing set of capitalists can gain access to these technologies. The capitalists have the ability to transform their capital into a monopoly position in the production of each of these goods. However, there are a fixed number of technologies; the cost
of acquiring a randomly distributed monopoly position in a technology is the inverse of the aggregate capital stock. The share of monopoly positions acquired by capitalist \( l \) is \( \omega_l k^l / K \).

The owners of physical capital become the owners of a conglomerate of monopolistic firms proportional in size to the amount of capital owned. Different goods in the conglomerate are sold at different prices, because of the price stickiness of distributors. However, because the goods in the conglomerate are randomly distributed, the law of large numbers insures that each conglomerate has aggregate properties similar to the economy as a whole. The average price level of the conglomerate is equal to the aggregate price level, \( P_t \); the profits of the conglomerate are proportional to aggregate profits defined as \( \Pi_t \equiv (P_t - MC_t) \cdot Y_t \). The share of profits earned by capitalist \( l \) is determined by Nash bargaining with distributors, 

\[(1 - \varrho)\Pi_t \omega_l k^l / K_t.\]

Once used to acquire a monopoly production opportunity, capital can be used to produce goods with a constant returns to scale production function.

\[y^j_t = k^j_t h^j_t^{1-\theta}\]  

(17)

The firms are price takers in factor markets. There is a competitive capital rental market in which capital is rented for \( R_t \). The cost-minimizing, scale invariant marginal cost of production, \( MC_t \), is given implicitly by the first order conditions of the cost minimization function.

\[MC_t \cdot \theta \cdot \frac{\tilde{y}^j_t}{h^j_t} = R_t \quad MC_t \cdot (1 - \theta) \cdot \frac{\tilde{y}^j_t}{h^j_t} = W_t\]

These first order conditions imply a common capital-labor ratio across goods \( j \). This and equilibrium in factor markets implies the aggregation

\[MC_t \cdot \theta \cdot \frac{\tilde{Y}_t}{K_t} = R_t \quad MC_t \cdot (1 - \theta) \cdot \frac{\tilde{Y}_t}{H_t} = W_t \quad \tilde{Y}_t \equiv \int_0^1 \tilde{y}^j_t \, dj.\]

(18)

The Benchmark case assumes high bargaining power for producers; in this case, \( \varrho \) approaches zero. The Benchmark case represents a situation that the distributors are essentially part of the capitalists’ conglomerate, so capitalists absorb all profits. After production, the capitalists sell their capital stock at the used capital price, \( Q_t \). The total pay-off per unit of capital owned by capitalist \( l \) includes the profit income, \( \Pi_t / K_t \), rental value, \( R_t \), and resale

\footnote{The conglomerate of firms operated by a capitalist is proportional to the capital that they store. In equilibrium, each capitalist uses the capital they own and there is no capital exchanged in the rental market.}
value, \( Q_t \), of the capital.

\[
PAY^K_t = \frac{\Pi t}{K_t} + R_t + Q_t = \frac{P_tY_t - W_tH_t}{K_t} + Q_t
\]  

(19)

This model of production and firm ownership specifies a domestic currency return to domestic capital, \( r^K_t \).

\[
1 + r^K_t \equiv \frac{PAY^K_t}{P^K_{t-1}} = \frac{\Pi t}{K_t} + R_t + Q_t
\]

2.2.4 Aggregate Capital Dynamics

In equilibrium, equation (13) shows that optimal \( w_{t+1} \) is a function of aggregate variables and is the same for all capitalists. Thus, the first order conditions of the financial contract are easily aggregated. The aggregate stock of foreign debt, \( DEBT_{t+1} \), is the price of aggregate capital, \( K_{t+1} \), less aggregate net worth, \( NW_t \).

\[
DEBT_{t+1} = \left[ \frac{P^K_{t+1} - NW_t}{S_t} \right]
\]  

(20)

The risk neutral capitalists absorb all of the risks of the pay-off to capital. The first order condition (12) holds ex post.

\[
g(w_{t}) \frac{PAY^K_{t}}{S_t} \cdot K_t = (1 + r^K_{t-1}) \cdot DEBT_t
\]  

(21)

A fraction, \( \gamma \), of capitalists die in each period, thus consuming their net worth.

\[
CK_t = \gamma \cdot \frac{f(w_{t}) \cdot PAY^K_{t} K_t}{CPI_t}
\]  

(22)

Aggregate net worth is a constant share of capitalists’ income\(^3\).

\[
NW_t = (1 - \gamma) \cdot f(w_{t}) \cdot PAY^K_{t} \cdot K_t
\]  

(23)

There are several important aspects of the dynamics of net worth and capital accumulation. In equation (21), outstanding foreign currency debt obligations, \((1 + r^K_{t-1}) \cdot DEBT_t\),

\(^3\)Strictly speaking the dynamic process of entrepreneurs is not internally consistent. As default is an absorbing state, the population of entrepreneurs should eventually disappear. One way of overcoming this inconsistency is to assume that newly born entrepreneurs are endowed with some labor income that constitutes part of net worth. I follow Carlstrom and Fuerst [19] in dispensing with this term, which adds little to the dynamics of the economy and is thus something of a nuisance parameter.
and the real capital stock, $K_t$, are pre-determined state variables. Thus, unexpected changes in the key relative price, $\frac{PAY^K}{S_t}$, directly cause inverse changes in the share of the value of capital that must be paid to creditors, $g(\varpi_t)$. An unexpected increase in $\frac{PAY^K}{S_t}$ increases the value of capital assets relative to the debt obligations of firms. This reduces the share of the capital pay-off, $g(\varpi_t)$, that is necessary to repay debts, thus providing windfall income to capitalists. Conversely, a negative shock to $\frac{PAY^K}{S_t}$ results in an increase in the share of the value of capital that must be paid to repay debt, thus negatively affecting the capital income retained by the capitalists. A rise in $g(\varpi_t)$ implies a fall in $f(\varpi_t)$. Equation (23) shows that an unexpected increase in $\frac{PAY^K}{S_t}$ increases the share of the payoff to capital retained as net worth, while an unexpected decline in $\frac{PAY^K}{S_t}$ results in a decline in net worth. Moreover, the foreign currency returns of domestic capital, $1 + \tilde{r}_t^K = \frac{PAY^K}{S_t} \cdot \frac{S_{t-1}}{P_{t-1}}$, are by definition the product of this key relative price and predetermined variables. Thus, shocks to $\frac{PAY^K}{S_t}$ have equivalent effects on $1 + \tilde{r}_t^K$.

Define the aggregate leverage ratio of the economy, $LV_t$, as the replacement cost of capital $P_t^K K_{t+1}$ relative to net worth $NW_t$.

$$LV_t \equiv \frac{P_t^K K_{t+1}}{NW_t}$$

Equations (21) and (13) show that, local to the steady state, the risk premium term, $\rho$, is an increasing function of leverage. Percentage deviations (denoted with the hat ‘$\hat{\cdot}$’ superscript) of the risk premium from steady state are proportional to deviations of the leverage ratio.

$$\hat{\rho}_{t+1} = \rho_L \cdot \hat{LV}_t \quad \rho_L = \frac{\rho' \cdot LV}{\rho'g + g'\rho} > 0$$

An unexpectedly low realization of the key relative price $\frac{PAY^K}{S_t}$ results in a fall in the net worth of the economy’s capitalists, a rise in leverage, and a rise in the cost of capital at any world real interest rate. As future returns to capital are diminishing in the capital stock, a rise in the cost of capital reduces the optimal future capital level and reduces the current investment needed to achieve that optimal level. Thus, the effect of shocks on this key relative price will play an important role in business cycle propagation.

The key distinction between this paper and the sticky price literature (including Bernanke, et al. [9]) is the inclusion of monopolistic profits as part of the returns to capital. In this
model economy, the ownership of capital and monopolistic firms is inextricably linked and capitalists must absorb the risk of sticky prices. A monetary expansion increases the nominal wage. Given sticky prices, a rise in nominal wages reduces the capitalists’ share of income which determines the pay-off to capital (as shown in equation 19). A monetary expansion will have a negative real effect on the value of capital. Thus, an exogenous depreciation caused by a monetary expansion will have a negative impact on the price of capital relative to the exchange rate, $\frac{PAY_t^K}{S_t}$. Equivalently, an exogenous depreciation will have a negative impact on foreign currency denominated return to capital, $1 + \tilde{r}_t^K$.

This model of capital accumulation includes all of the elements through which an exogenous currency depreciation might lead to a real contraction. First, because capital returns include profits, which decline during inflationary periods, an unexpected nominal expansion will not lead to a sharp increase in the domestic currency price of capital. Second, because a nominal expansion will immediately depreciate the currency exchange rate, it will also reduce the value of domestic capital in terms of foreign currency. Third, because firms have foreign currency debt, a reduction in the foreign currency value of domestic capital assets will reduce the real net worth of firms. Fourth, because of imperfections in financial markets, the decline in real net worth will increase the risk premium over the world real interest rate. Fifth, because returns to capital are diminishing in the capital stock, a rise in the effect cost of capital will reduce the profit maximizing capital stock and reduce the optimal level of investment. Subsequent sections will explore whether the contraction in investment is quantitatively sufficient to offset any effects of nominal expansions under sticky prices.

### 2.3 Monetary Policy and Equilibrium

Monetary policy is represented by a nominal interest rate rule.

$$i_t - i = \varphi^i (i_{t-1} - i) + \xi^P (\pi_t^P - \pi) + \xi^S (\pi_t^S - \pi) + \varepsilon_t^i \quad \varepsilon_t^i \sim E_{t-1} [\varepsilon_t^i] = 0$$

(24)

Domestic price inflation is represented by $\pi_t^P = \frac{P_t}{P_{t-1}}$ and exchange rate depreciation is represented by $\pi_t^S = \frac{S_t}{S_{t-1}}$. Unexpected monetary shocks are represented by $\varepsilon_t^i$. This monetary policy framework encompasses a number of interesting monetary policy choices. If the weighting on exchange rate changes $\xi^S$ is zero, the policy sets interest rates to target domestic inflation. Clarida, Gali, and Gertler [24] show, in a simple model of a small open economy with complete exchange rate pass-through, that targeting inflation in domestic value added prices (as opposed to inflation in domestic absorption prices) achieves the optimal inflation-
output trade-off of government policy makers. Woodford [67] shows that a persistent interest rate smoothing parameter, $\varphi^i$, allows the government to commit to future inflation targets. Bernanke, et al. [9] use a rule of this sort to model monetary policy in a closed economy. Monacelli [56] shows that a positive coefficient on exchange rate depreciation can be used to model a managed floating exchange rate and that as $\xi^S \rightarrow \infty$, the interest rate rule converges to a fixed exchange rate rule.

Two external shocks drive the economy. The world interest rate follows an AR(1) process in the logarithms.

$$r^W_t = (1 - \vartheta^r) \cdot r^W + \varphi^r r^W_{t-1} + \varepsilon^r_t \quad \varepsilon^r_t \sim N(0, \sigma^2_r)$$  \hspace{1cm} (25)

Exogenous world demand also follows an AR(1) process.

$$\ln A^W_t = (1 - \vartheta^A) \cdot A^W + \varphi^A \ln A^W_{t-1} + \varepsilon^W_t \quad \varepsilon^W_t \sim N(0, \sigma^2_W)$$  \hspace{1cm} (26)

Define $\Psi_t$ as the history of all shocks up to time $t$. An equilibrium is a monetary policy rule, a set of allocation functions $C(\Psi_t), CK(\Psi_t), I(\Psi_t), Y(\Psi_t), \bar{Y}(\Psi_t), D(\Psi_t), IM(\Psi_t), EX(\Psi_t), H(\Psi_t), NW(\Psi_t), K_{+1}(\Psi_t), B_{+1}(\Psi_t), DEBT_{+1}(\Psi_t)$ that solve the problems of households, firms, entrepreneurs, and financial intermediaries given a set of price functions $CPI(\Psi_t), P_{+1}(\Psi_t), R(\Psi_t), W(\Psi_t), MC(\Psi_t), S(\Psi_t), Q(\Psi_t), \pi(\Psi_t)$, and $i(\Psi_t)$, such that supply is equal to demand in all markets. This equilibrium dynamically solves equations (1)-(11), (13), (17)-(23), and (24) given the dynamic processes, (25) and (26).

### 2.4 Calibration

I solve log-linearized versions of the above model, using the numerical algorithms outlined in King and Watson [46], in terms of percentage deviations from steady state denoted with the hat “^\sim” superscript. The parameters of the capital accumulation process are drawn from Bernanke et al. [9]. First, the microparameters of the capitalist’s problem are the standard deviation of $\ln \omega_i = .28$; the share of capitalists that die, $\gamma = .0272$; and monitoring costs $\mu = .12$. Second, the macroparameters of capital accumulation are the depreciation rate, $\delta = .025$; the adjustment parameter, $\zeta = 10$, so that the elasticity of the investment-capital ratio with respect to Tobin’s q is 4. In lieu of good estimates of price stickiness in East Asia, I calibrate $\kappa = .2$ to match the estimates of Gali and Gertler [38] based on U.S. data.

\footnote{Following Bernanke, et al.[9] money demand is not specifically identified. Under the policy rule, the interest rate is sufficient to describe the monetary stance of the economy. The assumption is that real balances appears separably in the workers utility function. This, or non-separable real balances could be explicitly modeled without changing any of the important results in the paper.}
The external stochastic processes that represent the world economy are calibrated according to quarterly data from the G7 countries covering the period from 1980:1 to 1995:4. The parameters of the dynamic process of world demand are drawn from the estimates of an AR(1) process of logged, detrended G-7 GDP: \( \varphi^Y = .99 \) and \( \sigma_W = .005 \). The world, ex ante interest rate is not observed. I assume that the ex post real interest rates of the G7 countries are the sum of an unobserved state variable, the world real interest rate, and a serially uncorrelated, country specific shock. The common unobserved factor is assumed to follow an AR(1) process. I use state space methods to derive maximum likelihood estimates of the parameters of the AR(1) process. The parameters of the stochastic process of the world interest rate in the model are set according to the following estimates: \( r^W = .01 \), \( \varphi^r = .84 \) and \( \sigma_r = .0018 \).

The remaining parameters are calibrated, to the extent possible, to match data from the emerging markets of Asia that were most deeply affected by the 1998 East Asian crisis (i.e. Korea, Thailand, Indonesia, Malaysia and the Philippines). The intertemporal elasticity of substitution, \( \frac{1}{\psi} = .5 \), following estimates of Ogaki, Ostry and Reinhart [57] for the Philippines and Korea. Data from the Lane/Milesi-Ferretti data set (see Lane and Milesi-Ferretti [50] for details) shows that over the period from 1980 to 1995, the average net external wealth in the relevant countries ranged from -19 % of GDP in Korea to -46% of GDP in the Philippines. The discount factor is calibrated such that when \( \frac{1}{\beta} = 1 + r^W \), the small open economy has a net external wealth, \( \frac{B_t}{S_t} - DEBT_t \), equal to -31.5% of GDP, the average of these estimates. The first and second derivatives of \( \beta \) at the steady state are calibrated to have a minuscule effect on the short-term dynamics of the system.

The average export shares of the relevant countries vary between 25.5% for Indonesia to 33.2% for Korea (I exclude Malaysia whose export numbers are much higher, assuming these numbers are distorted by its interlocking production relationship with Singapore). The parameter \( a = .72 \) is set so the steady state ratio of exports to GDP is 29.5%, the average of these estimates. Reinhart [60] estimates the price elasticities of exports and imports for four Asian countries. The average of these estimates is approximately -.6. The price elasticity of exports and imports, \( -\frac{1}{1-\alpha} \), is calibrated at -.6, which is also Kollmann’s [48] parameterization for a model of developed economies. The steady state markup is assumed to be small, \( \frac{1}{\upsilon} = 1.1 \). The capital intensity parameter is set to match labor’s average share of GDP in Korea (the only relevant country with available data) over the period 1980-1995, \( \theta = .52 \). Average government expenditure as a share of GDP over the period from 1980 to
1996 ranges between 9 and 11% in the relevant countries. I set steady state $\frac{G}{Y} = .1$. The labor supply parameter, $\Gamma$, is calibrated so that in steady state, 25% of the time endowment is spent in work. Information on the amount of total hours spent in market employment in the relevant countries is not available, so the labor supply parameter is inferred from historical Japanese data. Madisson [52] reports the total hours worked per unit of population in Japan in 1973. Assuming an aggregate time endowment of 16 waking hours per person aged 15-64 years old, this implies an average of 25% of the time endowment was spent in market activity.

3 Contractionary Devaluation

Examine the effects of an unexpected monetary expansion, defined as an exogenous 25 annualized basis point contraction in the nominal interest rate (i.e. $\varepsilon^M = -0.0625$). The parameters of the monetary policy rule are set at $\varphi^i = .95$, $\xi^p = .1$, $\xi^s = 0$. I consider this inflation targeting specification for three reasons. First, a monetary shock in this model produces a persistent decline in the domestic interest rate, a permanent monetary expansion, and a permanent nominal exchange rate depreciation. Second, the monetary rule is numerically similar to the policy rule of Bernanke, et al. [9]. Thus, the effect of monetary shocks in this model are very comparable to the previous literature. Third, this monetary policy has interesting business cycle stabilization properties, as discussed in the next section.

The unique aspect of the Benchmark model is the way in which monopoly profits are part of capital income. It is useful to compare the Benchmark model to a model in which profits are not capital income. In the NP model, the distributors have high bargaining power relative to capitalists and distributors receive all profits, i.e. $\varphi$ approaches one. Workers own the distributors and receive profits, lump-sum. Workers, not capitalists, are exposed to the impact of inflation on profits of firms with sticky prices. The NP model might be motivated, as is that in Bernanke, et al. [9], by thinking of the monopolistic firms as retailers who purchase wholesale goods from perfectly competitive manufacturers at marginal cost, $MC_t$. The capitalists, who hold foreign currency debt, are strictly manufacturers who do not receive profit income.

The first order conditions that describe the NP equilibrium are identical to the Benchmark first order conditions, except that the payoff to capital no longer includes profits ($PAY_t = R_t + Q_t$) and worker income does include aggregate profits (equation (27) replaces equation...
\[ B_t = W_t H_t + \Pi_t + (1 + i_{t-1}) \cdot B_{t-1} - CPI_t \cdot [C_t + G_t] \] 

When the prices of goods are sticky but the prices of the factors of production are not, a monetary expansion transfers real income from the owners of firms to the owners of the factors of production. In the Benchmark model, capitalists own the firms. A monetary expansion transfers real income away from capitalists toward the workers, thus reducing capitalists’ net worth. In the NP model, workers own the firms. A monetary expansion transfers real income away from the workers, thus increasing the real net worth of capitalists.

Figure 1 shows the response of some nominal prices, some relative prices, and capitalists’ balance sheets to an exogenous interest rate cut in the Benchmark and the NP model. Figure 1 (A) shows the response of the nominal interest rate to the monetary shock. In each model, the nominal interest rate initially drops 6.25 basis points and then converges back to steady state. As the nominal interest rate policy is endogenous to domestic goods inflation, the interest rate dynamics differ across models. Figure 1 (B) shows the response of the GDP deflator, \( P_t \), to the nominal interest rate cut. The price level rises much more slowly in the Benchmark model than in the NP model. It will become clear that an important difference between the models is that the interest rate cut leads to a decline in the equilibrium demand for domestic goods in the Benchmark model and an expansion in demand in the NP model. The Benchmark decline in demand results in less demand for labor at equilibrium prices and less upward movement in wages and marginal costs. The slower Benchmark rise in marginal costs results in less upward pressure on prices. Returning to Figure 1 (A), the lower inflation observed in the Benchmark model explains why the interest rate returns to steady state more slowly than in the NP model: the inflation targeting interest rate rule proscribes a lower rise in the nominal interest rate when inflation is low.

Figure 1 (C) shows the response of the exchange rate to the monetary expansion/interest rate cut. In both models, the monetary expansion leads to a persistent depreciation of the nominal exchange rate. When the domestic interest rate is below the world interest rate, uncovered parity requires future appreciation in the domestic currency. In the period of the interest rate cut, the nominal exchange rate initially depreciates and then appreciates back to a long-term level. Define the real exchange rate as \( \frac{S_t P_W}{P_t} \). The nominal exchange rate depreciation leads to an immediate and equivalent real exchange rate depreciation (see Figure 1 D). As the price level adjusts upwards in the periods following the shock, so does the real exchange rate return to the steady state level. However, the speed with which domestic prices adjust differs across models. The slow rise in prices in the Benchmark model implies
a more persistent real exchange rate depreciation.

Figure 1 (E) shows the response of the real interest rate, defined as the nominal interest rate minus the expected CPI inflation.

\[ r_t = i_t - E_t [\hat{\pi}^{CPI}_{t+1}] \]

To a first order approximation, CPI inflation can be written as a weighted average of exchange rate depreciation and domestic goods price inflation.

\[ \hat{\pi}^{CPI}_{t+1} = a \cdot \hat{\pi}^P_{t+1} + (1 - a) \cdot \hat{\pi}^S_{t+1} \]

This, in turn, implies that the real interest rate is a weighted average of the world real interest rate and the nominal interest rate less expected goods price inflation.

\[ r_t = a \cdot \left( i_t - E_t [\hat{\pi}^P_{t+1}] \right) + (1 - a) \cdot r^W_t \]

(28)

The exogenous domestic interest rate cut does not affect the world real interest rate. The nominal interest rate cut leads to an increase in the price level, but sticky prices delay the price rise until future periods. A decline in the nominal interest rate can imply a rise in inflation expectations and a decline in the real interest rate. However, the rise in expected inflation is smallest in the Benchmark model. Thus, the real interest rate decline is smaller in the Benchmark model than in the NP model.

It is important to focus on Figure 1 (F), which shows the response of foreign currency denominated returns to domestic capital, \(1 + \hat{r}^K_t\). As discussed in the previous section, the foreign currency returns embody the key relative price, \(\frac{PAY}{S_t}\), which determines whether a shock will have a positive or negative effect on balance sheets. In the Benchmark model, the interest cut causes an exchange rate depreciation that makes the foreign currency debt more costly to repay in domestic currency terms. Further, the nominal expansion induced by the monetary shock leads to a rise in nominal wages. Nominal rigidities prevent output prices from rising at the same rate as input prices which reduces profits. As profits are part of capital income, the reduction in profits reduces the real value of capital. The value of capital falls relative to the value of foreign currency. In the period of the shock, there is a large contraction in ex post foreign currency denominated returns to domestic capital investments. The implied reduction in the value of assets relative to foreign liabilities reduces the income and net worth of capitalists.

In the NP model, a domestic interest rate cut has the opposite effect on foreign currency returns to domestic capital. In the NP model, the monetary expansion implied by an interest
cut transfers income from the owners of firms with sticky prices (the workers) to the owners of capital (the capitalists). This unexpected income transfer raises the ex post value of capital relative to the value of currency (i.e. \( \frac{P_{AY}}{S_t} \) rises). Figure 1 (F) shows that the interest rate cut leads to a large increase in ex post foreign currency denominated capital returns in the NP model. Though the monetary expansion depreciates the domestic currency, the increase in domestic dollar returns is so large that even foreign currency returns increase in the NP model, as do the income and net worth of capitalists. In subsequent periods, the returns to capital rise in the Benchmark model and fall in the NP model. This reflects the fact that in the Benchmark model, the depreciation damages the balance sheets of firms, thus increasing their cost of future capital. In the NP model, the depreciation improves the balance sheets of firms and reduces their future capital costs.

Figure 1 (G) shows the response of the leverage ratio, \( LV_t \), to the exogenous interest rate cut. Exchange depreciation reduces the net worth of capitalists in the Benchmark model, thus increasing their leverage in subsequent periods. In the NP model, the depreciation increases the net worth of capitalists, thus reducing their future leverage. The risk premium, \( \rho_{t+1} \), is a positive function of the leverage ratio. In the Benchmark model, the rise in the leverage ratio of firms following the exchange rate depreciation increases the probability of default and also increases the interest rate spread over the world interest rate (see Figure 1 H). The size of the increase in the default spread is larger and more persistent than the actual decline in the real interest rate. Thus, the interest rate cut actually increases the actual cost of capital (the sum of the risk free rate plus the risk premium). In the NP model, the monetary expansion improves balance sheets, reduces the risk premium, and thus reduces the cost of capital.

Figure 2 shows the response of real macroeconomic aggregates in the Benchmark model. A nominal interest cut leads to a nominal and real exchange rate depreciation. This real exchange rate depreciation leads to a persistent expansion in exports (see Figure 2 (A)). However, the exchange rate depreciation also damages firms’ balance sheets, thus raising their cost of capital through the default risk premium. Figure 2 (B) shows that the depreciation leads to a persistent decline in investment. The decline in capital income and the rising cost of repaying foreign currency debt has a negative impact on the consumption of capitalists (see Figure 2 C). The persistent investment contraction results in a long-term decline in the capital stock, labor productivity, real wages, and workers’ income. The reduction in the permanent income of workers also implies that there will be a small contraction in workers’ consumption despite the fact that the nominal interest rate cut results in a small cut in
the real interest rate (see Figure 2 D). In the period of the shock, the decline in domestic investment and consumption cancels out the impact on goods demand of the increase in exports. The effect of the monetary expansion on employment and output is essentially nil in the period of the shock (see Figures 2 E and F). Over time, as the capital stock falls due to persistently low investment levels, output contracts.

Figure 3 shows the response of the NP model to the interest rate cut. In the NP model, a nominal interest cut leads to a temporary real exchange rate depreciation. The real exchange rate depreciation causes an increase in real exports (see Figure 3 A). The monetary expansion reduces real interest rates and the risk premium paid by capitalists in the NP model. This implies an increase in investment (see Figure 3 B) as well as the consumption of capitalists (see Figure 3 C). The reduction in the real interest rate leads the representative household of workers to increase current consumption (see Figure 3 D). The expansion in all elements of demand for domestic goods leads to an increase in output (see Figure 3 E) and employment (see Figure 3 F). Note the size of the expansion in the NP model is much larger in absolute terms than the contraction in the Benchmark model. The scale is so different that I put the real responses of the two models on separate graphs. The reason is that in the Benchmark model there are two key offsetting effects of a monetary expansion: the exchange rate depreciation increases exports, while the rise in the risk premium reduces investment. In the NP model, the monetary expansion leads to large increases in both exports and investment.

4 External Shocks and Monetary Policy

In this section, I consider the response of the economy to external interest rate and demand shocks under a number of monetary policies. In a quantitative model of a small open economy, Schmitt-Grohe and Uribe [62] rank the business cycle stabilization of various monetary policies with a single utility based metric: the volatility of the felicity of the representative agent. The intuition follows Lucas [51] in noting that the concavity of the representative agent’s utility function implies that volatility in the consumption stream has a negative, second order welfare effect. The comparable metric in this model is the variance of $\tilde{Z}_t$. I calculate the unconditional standard deviation of $\tilde{Z}_t$ in the Benchmark model for a range of parameters of the monetary policy function, $[\phi^i, \xi^P, \xi^S]$. I divide a three dimensional range that covers $[0 \leq \phi^i \leq 1, 0 \leq \xi^P \leq 5, 0 \leq \xi^S \leq 5]$ into a discrete grid with steps of .05. Over this grid, the parameters $\phi^i = .95, \xi^P = 0, \xi^S = 1.2$ minimize the standard deviation of $\tilde{Z}_t$ (ignoring parameterizations with indeterminate or unstable equilibria). Interestingly,
this Managed Float parameterization ignores domestic inflation entirely to concentrate on stabilizing growth in the nominal exchange rate. Imposing the restriction that the monetary authority strictly targets domestic inflation (i.e. $\xi_S = 0$), the monetary policy that minimizes the standard deviation of $\tilde{Z}_t$ is referred to as the Inflation Target policy: $\varphi = .95$, $\xi^P = .10$. The Inflation Target rule is identical to the rule used to study exogenous monetary shocks in Section 3. These policies will be compared with a fixed exchange rate policy rule (i.e. $\xi_S \rightarrow \infty$) that will be referred to as the Exchange Peg rule. The Exchange Peg rule is interesting to examine for a number of reasons. First, many emerging market economies in Asia and elsewhere have adopted fixed exchange rates. Second, because this model emphasizes the vulnerability of firm balance sheets to exchange rate fluctuations it is useful to study the most extreme sort of exchange rate stability.

Though the metric of business cycle volatility here is based on workers’ utility functions, it is important to be careful not to equate the business cycle volatility of felicity with welfare. In an endowment model, Lucas [51] shows that (to a second order approximation) agents’ utility is proportional to the variance of their felicity. However, Kim and Kim [43] and Obstfeld and Rogoff [59] demonstrate open economy examples where concentrating on the second order moments around the non-stochastic steady state can give incomplete and misleading information about the welfare effects of certain policies in models with incomplete markets. The complexity of the model here precludes a closed form solution to the problem as in Kim, Kim and Levin [44]. Thus, in strict terms, this analysis only studies the business cycle stabilization properties of various monetary policies.

4.1 Interest Rate Shocks

Figures 4 and 5 show the dynamic response of the Benchmark economy to a 1 standard deviation shock to the world interest rate at period 1 (i.e. $\varepsilon^r_t = .0018$). A rise in the world interest rate is equivalent to a rise in the real intertemporal price of foreign goods. As foreign goods are complements to domestic goods in absorption, a decline in the demand for foreign goods results in a decline in demand for domestic goods at any given real exchange rate. In equilibrium, a rise in the world interest rate leads, over time, to a reduction in demand for foreign goods and to deflation in the domestic production sector. The response of the central bank under the Inflation Target rule is shown in Figure 4 (A). The Inflation Target rule requires a cut in the nominal interest rate. In contrast, the Exchange Peg requires that the domestic nominal interest rate be equivalent to the world interest rate at all times. Thus, a rise in the world interest rate implies an equal rise in the nominal interest rate. The
Managed Float monetary policy responds to an exchange rate depreciation by increasing
the nominal interest rate. The rise in the nominal interest rate is somewhat less under the
Managed Float than under a true Exchange Peg, but the two are numerically very close.

Under all monetary policies, the rise in the intertemporal price results in a steady re-
duction in demand for domestic goods at given prices. Figure 4 (B) shows the response of
the price level, $P_t$, to the interest rate shock. In the period of the shock, the price is pre-
determined. Over time, the price level falls in response to the drop in demand. However,
the monetary contraction required to stabilize or fix the exchange rate in response to an
increase in the external interest rate implies a sharper deflation under the Managed Float
and the Exchange Peg than under the Inflation Target rule. Figure 4 (C) shows the response
of the nominal exchange rate to the external interest rate shock. Under the Exchange Peg,
the rate is constant. As discussed, the Managed Float allows a small depreciation in the
nominal exchange rate. Under the Inflation Target, the nominal interest rate drops below
the external interest rate, thus inducing a large depreciation in the exchange rate (followed
by expected appreciation back to the long-term level). The domestic price level is quasi-
fixed. Under the Fixed Exchange rate policy, the external interest rate has no effect on any
of the components of the real exchange rate in the period of the shock. Over time, as the
domestic price level falls, the real exchange rate depreciates (see Figure 4 D). Under the
Inflation Target, the nominal depreciation results in a real depreciation in the period of the
shock. The Managed Float is an intermediate case. There is a small real depreciation in the
period of the shock due to the relatively mild nominal depreciation and further depreciation
in subsequent periods due to domestic deflation. As shown in equation (28), the real interest
rate is a weighted average of the external interest rate and the nominal rate less expected
inflation. Figures 4 (A) and (B) show that the Exchange Peg requires a rise in the nominal
interest rate and a sharp fall in expected inflation. The Inflation Target requires a cut in the
nominal interest rate and a milder deflation. Thus, there is a larger rise in the real interest
rate under the Exchange Peg than under the Inflation Target (see Figure 4 E). The Managed
Float is again an intermediate case, though quantitatively much closer to the Exchange Peg
rule.

Under each of the monetary rules, the external interest rate rise leads to deflation, thus
reducing the nominal value of the assets owned by capitalists. Given the sharper deflation
under the Exchange Peg, the interest rate shock results in a sharper decline in the ex post
domestic currency denominated returns to capital under the Peg than under the Inflation
Target. However, it is the ex post foreign currency denominated returns which determine
whether a shock improves or damages balance sheets of capitalists who have borrowed in foreign currency. Figure 4 (F) shows that the contraction of the foreign currency returns to the external shock is sharper under the Inflation Target than under the Exchange Peg. Under either policy rule, the external shock reduces the nominal value of capital income relative to the exchange rate, either quickly through exchange rate depreciation or slowly through domestic deflation. The pay-off to capital is equivalent to the discounted sum of future capital income. In the absence of nominal rigidities, the response of the relative price, \( \frac{P_{AY}}{S_t} \), to the interest rate shock does not depend on monetary policy. However, because output prices are sticky, input prices fall more quickly during unexpected deflation, thus leading to a rise in monopolistic profits. The high monopolistic profits during the deflation under the Exchange Peg offset some of the negative impact of the interest rate shock on the value of capital. The reduction in the value of capital relative to foreign currency is more severe when the monetary authority allows an exchange rate depreciation under the Inflation Target. The Managed Float is again an intermediate case, protecting capitalists’ balance sheets to a much greater extent than does the Inflation Target, but allowing for a slightly larger negative outcome for foreign currency returns than under the Exchange Peg.

The effect of the more severe damage to firm’s balance sheets under inflation targeting is seen in Figures 4 (G) and (H). Under all monetary policies, the external interest rate shock leads to a fall in capitalists’ assets relative to liabilities, as evidenced by the persistent rise in the leverage ratio in Figure 4 (G). The Fixed Exchange rule and the Managed Float rule insulate the balance sheets of domestic capitalists to a greater degree than does the Inflation Target rule. The leverage ratio rises by a greater amount and more persistently under the Inflation Target than under the Exchange Peg and the Managed Float. Figure 4 (H) shows that the rise in leverage results in a persistent rise in the risk premium. The rise in the Risk Premium is larger under the Inflation Target than under the Exchange Peg or the Managed Float. Moreover, the effect of the external interest rate shock on the cost of capital, the real interest rate plus the risk premium, is persistently larger under the Inflation Target than under the Exchange Peg. The Managed Float is an intermediate case, quantitatively closest to the Exchange Peg.

Figure 5 shows the effect of the external interest rate shock on macroeconomic aggregates under the three policy rules. In the short-term, the main difference between the policy rules is apparent in the effect of the shock on exports, investment, and capitalist’s consumption. Under all three policies, an external interest shock induces a real exchange rate depreciation. The real depreciation is relatively large and occurs immediately through a nominal depre-
ciation in the Inflation Target case, while the depreciation is relatively small and occurs slowly through deflation under the Exchange Peg. Under the Managed Float, the depreciation occurs through both channels. Figure 5 (A) shows that exports increase due to the real depreciation. Under the Inflation Target, there is a large, immediate, and persistent increase in exports responding to the large, immediate and persistent real depreciation. Under the Exchange Peg, the real exchange rate is quasi-fixed in the period of the shock and depreciates only slowly with deflation. Exports do not respond to the external interest rate rise in the period of the shock and experience a mild increase thereafter. The Managed Float allows some real exchange rate depreciation in the period of the shock. However, the small real exchange rate depreciation induces only a small increase in exports.

The external interest rate shock has a larger impact on the capitalists’ total cost of borrowing (the real interest rate plus the risk premium) under the Inflation Target than under the Exchange Peg or the Managed Float. The reason is that the exchange rate depreciation that is allowed under the Inflation Target damages capitalists balance sheets more than does the deflation that is allowed under the exchange rate stabilizing regimes. The persistently larger rise in the cost of capital under the Inflation Target implies a persistently larger decline in investment than under the Peg or Managed Float (see Figure 5 B). Further, the larger losses of capitalists’ net worth under the Inflation Target imply a larger contraction in capitalists’ consumption (see Figure 5 C). The Inflation Target will ameliorate (relative to the exchange rate stabilizing regimes) the effect of the external interest rate rise on the worker’s cost of debt, the real interest rate. However, the persistently more severe contraction in investment under inflation targeting reduces the workers’ marginal product, and thus their lifetime incomes. In the short term, these two effects offset each other, and the contraction in workers’ consumption is roughly equal under each of the monetary policies, as shown in Figure 5 (D). Over time, however, the negative effect of the interest rate shock on worker’s consumption is stronger under the Inflation Target than under the Managed Float or the Exchange Peg. The Inflation Target allows a greater contraction in investment, which is offset by a greater expansion in exports relative to the Peg or the Managed Float. In the short run, domestic output and employment decline by a roughly equivalent amount under each monetary policy (see Figure 5 E and F). However, the stronger decline in capital accumulation under the Inflation Target reduces the productive capacity of the economy and output in the long term.
4.2 Foreign Demand Shocks

In this section, I examine the response of the economy to a one standard deviation negative shock to world absorption (i.e. $\varepsilon^A_1 = -0.005$) in period 1. It can be seen from equation (4) that a negative outcome for world absorption reduces the demand for domestic exports at all levels of the real exchange rate. In equilibrium, the contraction in demand results in a depreciation of the real exchange rate. This depreciation can occur quickly under the flexible exchange rate policy of the Inflation Target or slowly through deflation under the Exchange Peg. Figures 6 and 7 show the response of the economy to the world demand shock under the three economic policies. In all cases, the response of the Managed Float is numerically indistinguishable from the Exchange Peg. Intuitively, both policies respond sharply to changes in the exchange rate, though the Managed Float allows slightly more exchange rate fluctuation in any period. The persistence of the demand shock ($\rho^A = 0.99$) implies that the change in the exchange rate under the Managed Float is too small to be visually distinguished from a fixed exchange rate. In the subsequent discussion I explicitly compare the response to the world demand shock under the Exchange Peg and the Inflation Target. All descriptions of the Exchange Peg equilibrium response apply equally to the Managed Float.

Under the Exchange Peg, the domestic nominal interest rate is always equal to the world interest rate. Figure 6 (A) shows that the nominal interest rate does not respond to the decline in world demand. The decline in world demand for domestic exports does result in a drop in demand for domestic goods and domestic price deflation at a given exchange rate (see Figure 6 B). The response of the Inflation Target policy is a persistent cut in the nominal interest rate. As shown in Figure 6 (B), the interest cut ameliorates the negative effect of the decline in demand on the domestic price level. The nominal interest rate decline below the world interest rate requires an exchange rate depreciation, followed by an appreciation back to the long-term level (see Figure 6 C). In the period of the shock, the real exchange rate is fixed under an Exchange Peg. Over time, domestic price deflation results in a real exchange rate depreciation (see Figure 6 D). The nominal exchange rate depreciation induced by the interest rate cut required under the Inflation Target results in a sharp, immediate yet persistent real depreciation. The real interest rate is a weighted average of the world interest rate and the domestic rate less expected inflation. Under the Exchange Peg, neither the world interest rate nor the domestic nominal rate are affected by the world demand shock. The rise in the real interest rate in Figure 6 (E) is solely the result of expected deflation. Under the Inflation Target, the domestic interest rate falls and the domestic price level
declines less sharply than under the Exchange Peg. Therefore, the rise in the real interest rate is not as severe under the Inflation Target as it is under the Exchange Peg.

Under both monetary policies, the negative world demand shock results in negative foreign currency returns to domestic capital. Figure 6 (F) shows that the outcome for foreign currency returns to capital is more negative under the Inflation Target than under the Exchange Peg. The sharper deflation under the Exchange Peg results in a greater contraction in capital income when measured in domestic currency than it does under the Inflation Target. However, the exchange rate depreciation under the Inflation Target results in a greater contraction in capital income when measured in foreign currency. Because capitalists have fixed debt obligations in foreign currency, the negative shock reduces the value of assets relative to liabilities most sharply when the exchange rate depreciates under the Inflation Target. Relatively speaking, the Exchange Peg protects the balance sheets of capitalists. Figure 6 (G) shows that the capitalists’ leverage rises more sharply and more persistently under the Inflation Target than it does under the Exchange Peg. Figure 6 (H) shows that the impact of this rise in leverage on the risk premium. Because capitalists’ probability of default increases after the negative shock, the risk premium rises persistently. As highly leveraged firms are more likely to default, the likelihood of default and the risk premium rise more sharply under the Inflation Target than under the Exchange Peg. Again, capitalists’ total cost of capital (the real interest rate plus the risk premium) also rises more persistently under the Inflation Target.

Figure 7 shows the response of some macroeconomic aggregates to the negative world demand shock. The drop in world demand reduces domestic exports at any given real exchange rate. Under the Exchange Peg, the drop in world demand directly translates into a drop in exports (see Figure 7 A) because the real exchange rate is quasi-fixed. It is intuitive that the Inflation Target ameliorates the drop in domestic exports: the flexible exchange rate under the Inflation Target implies a real exchange rate depreciation. Surprisingly, the real depreciation is large enough to induce an actual increase in the level of exports. How is an expansion in exports consistent with a drop in domestic demand that leads to deflation? The exchange rate depreciation under the Inflation Target damages the balance sheets of capitalists with foreign currency debt to a greater degree than does the deflation under the Exchange Peg. As shown in Figures 7 (B) and (C), the contraction in capitalists’ consumption and domestic investment is sharper and more persistent under the Inflation Target than under the Exchange Peg. The Inflation Target in a sense transfers the decline in demand from exports to domestic investment and consumption.
The choice of monetary policy rule has offsetting effects on the response of workers’ consumption, output, and employment. On the one hand, the Inflation Target ameliorates the short-term rise in the real interest rate (the workers’ intertemporal cost of borrowing). On the other hand, the Exchange Peg, by stabilizing capital investment, ameliorates the long-term decline in worker productivity, real wages, and real permanent income. In the short-term, workers’ consumption falls by a roughly equal amount under both policies (see Figure 7 D). Over a longer period, the effect of the depreciation on workers’ income implies that workers’ consumption falls more persistently under the Inflation Target. The choice of monetary policy rule also has offsetting effects on the response of output and employment. On the one hand, the Inflation Target reverses the decline in exports observed under the Exchange Peg. On the other hand, by protecting capitalists’ balance sheets, the Exchange Peg ameliorates the decline in investment and capitalists’ consumption relative to the Inflation Target. In the short-term, the response of equilibrium demand for domestic goods and equilibrium domestic employment are roughly equal under both policies (see Figure 7 E & F). Over time, the sharper decline in the capital stock under the Inflation Target results in a decline in the production of domestic goods.

4.3 Second Moments

Table 1, Section A reports business cycle moments for the Benchmark economy under the three monetary policies. Using random shocks that are calibrated to the processes of the world interest rate and world demand, I simulate the economy 1000 times under each of the policies. Each simulation creates a set of Hodrick-Prescott [42] filtered time series with a length of 100 periods. The standard deviation of the percentage deviations of worker felicity, $\hat{Z}_t$, along with worker consumption, $\hat{C}_t$, and employment, $\hat{H}_t$ from steady state are reported at business cycle frequencies. Also reported are output, $\hat{Y}_t$, investment, $\hat{I}_t$, exports, $\hat{E}X_t$, capitalists’ consumption, $\hat{C}K_t$, and the nominal exchange rate, $\hat{S}_t$.

Obviously, both the Inflation Target and the Managed Float allow for greater short-term volatility in the nominal exchange rate than under the Exchange Peg. The standard deviation of the nominal exchange rate is more than 10 times as large under the Inflation Target than under the Managed Float. Numerically, the business cycle behavior under the Managed Float is otherwise very similar to the behavior under the Peg.

The standard deviations of some of the variables are extremely similar across all monetary policies. Figures 5 and 7 show that the external shocks have similar short term effects on output, employment, and workers’ consumption under either an Inflation Target, a Managed
Float, or an Exchange Peg. Unsurprisingly, the standard deviations of these variables are roughly equivalent at business cycle frequencies. Moreover, as workers’ consumption and employment are the variables that determine workers’ felicity, the standard deviation of workers’ felicity, $\hat{Z}_t$, is also roughly equal across monetary policies at business cycle frequencies.

The business cycle behavior of investment, capitalists’ consumption, and exports differs across monetary policies. Each of these is substantially more volatile under the Inflation Target than under the Exchange Peg or the Managed Float. The greater volatility of the exchange rate that is allowed under the Inflation Target adds to instability in the finances of capitalists. This, in turn, destabilizes their investment and consumption spending. The Inflation Target allows more volatility in the real exchange rate and, thus, more volatility in exports. Counter-cyclical fluctuations in exports are a stabilizing channel under the Inflation Target.

It is interesting to examine the unconditional standard deviation of unfiltered worker felicity, $\hat{Z}_t$. The HP filter eliminates much of the low frequency volatility of any time series. The standard deviation of the unfiltered felicity term is much larger than that of the filtered term. In part, this reflects the fact that the model contains a near unit root. It is well known that the solution to the linearized first order conditions of an open economy with time-separable preferences that faces an exogenous world interest rate contains a unit root (see Correia, Rebelo and Neves [27]). The endogenous subjective time preference insures the largest stable eigenvalue of the transition matrix is strictly less than one in this model. However, the model is calibrated so that the endogenous subjective time preference has little impact on short term dynamics. As such, the largest root is also close to unity and much of the volatility is at very low frequencies. Moreover, the model contains a channel through which exogenous shocks cause persistent endogenous movements in the risk premium adjusted cost of capital. This leads to large, low frequency movements in the equilibrium quantity of capital, large low frequency movements in workers’ productivity, and low frequency movements in workers’ income. It is interesting to note that the unconditional standard deviation of workers’ felicity is more than twice as large under the Inflation Target rule (which was parameterized to minimize this very standard deviation within the class of rules that target domestic inflation) than it is under the Exchange Peg. In contrast, the HP filtered volatility of this series is approximately equal across monetary policies. The Inflation Target rule directly focuses on offsetting the inefficiencies that are caused by sticky nominal prices. The Exchange Peg stabilizes the balance sheets of capitalists and, thus, capital accumulation. Sticky prices are inherently a short-term phenomenon, but shocks to the balance
sheets of capitalists have persistent effects on capital accumulation. As shown in Figures 5 and 7, the short-term response of workers’ consumption is essentially the same across monetary policies. However, the effect of the shock is most persistent under the Inflation Target. Thus, in the long-term, workers’ felicity is much more stable under a fixed exchange rate.

4.4 Alternative Parameterizations of the Benchmark Model

The above results are numerical. Under some alternative, plausible parameterizations of the model it is possible to derive different results. Hence, it is useful to report the moments for two interesting alternative parameterizations. In the Benchmark model, an exogenous depreciation results in roughly off-setting effects on investment and exports and a small, net contraction in domestic output. When exports are more sensitive to an exchange rate devaluation, the net impact of an interest rate cut on demand for domestic output is positive. When investment is more sensitive to exchange rates through the liability dollarization channel, the net impact of an interest rate cut is a large contraction in demand for domestic output. In this section, I consider some alternative parameterizations in which exports and investment are, in turn, more sensitive to changes in the exchange rate.

The first alternative parameterization is the Elastic Trade model. The elasticity of substitution between domestic and foreign goods in the Benchmark model is parameterized according to results from Reinhart [60], who finds that developing economy exports and imports are relatively insensitive to movements in the real exchange rate. However, much of the open economy RBC literature, following Backus, Kehoe and Kydland [5] assumes greater substitutability between domestic and foreign goods. The Elastic Trade model uses the Backus et al. [5] parameterization of the elasticity of substitution equal to 1.5. The greater the elasticity of substitution between domestic and foreign goods, the larger is the response of exports to any given change in the real exchange rate. I report the moments of the Elastic Trade model in Table 1, Section B. Under the Inflation Target policy, equilibrium exports are more volatile in the Elastic Trade parameterization than in the Benchmark model, yet equilibrium exchange rates are less volatile. In the face of external shocks, exports play a counter-cyclical and stabilizing role, but exchange rate fluctuations destabilize the finances of capitalists. The exchange rate flexibility allowed under the Inflation Target has a more stabilizing effect on demand for domestic goods through the export channel when exports are very sensitive to the real exchange rate (as in the Elastic Trade parameterization). Moreover, as smaller exchange rate fluctuations occur in equilibrium when the elasticity of substitution is very high, exchange rate flexibility has a relatively smaller impact.
on the balance sheets of capitalists with foreign currency debt. Thus, the flexible exchange rates under the Inflation Target offer greater benefits in terms of stability through the effects on exports and lower costs, in terms of their effect on capitalists’ balance sheets in the Elastic Trade parameterization relative to the Benchmark parameterization. Compare the standard deviations of Hodrick-Prescott filtered macroeconomic aggregates for the Inflation Target and the Exchange Peg. The stabilizing properties of the export channel are so strong in the Elastic Trade parameterization that the standard deviations of output, employment, and workers’ consumption at business cycle frequencies are all substantially lower under the Inflation Target than they are under the Exchange Peg. Even investment is slightly more stable at business cycle frequencies under the Inflation Target than under the Exchange Peg. Capitalists’ consumption alone is more volatile under the Inflation Target. The Managed Float is an intermediate case, and is numerically very close to the Exchange Peg.

It is interesting, however, to examine the unconditional standard deviation of workers’ felicity, $Z_t$, which is substantially lower under the Exchange Peg relative to the Inflation Target, even in the Elastic Trade model. Though the Inflation Target rule is very effective at offsetting the short-term inefficiencies of sticky prices, the flexibility of exchange rates under this rule still destabilizes the finances of capitalists to a greater degree than under the Exchange Peg. Though this instability is less than that in the Benchmark model, most of the long-term volatility of the economy is still due to the liability dollarization channel. In the long run, the Exchange Peg offers the greatest stability to the small open economy even when trade is very sensitive to real exchange rates.

Prior to the East Asian crisis, many firms in the region were highly leveraged. In the Benchmark specification, the debt-to-equity ratio of capitalists is approximately equal to 1. Corsetti, Pesenti and Roubeni [28] report that in 1996, the average debt-to-equity ratio of the 30 largest Korean conglomerates was close to 3. In the High Leverage parameterization, the capitalists’ consumption share is parameterized as $\gamma = .145$, so that the debt-equity ratio is 3.0. The greater the leverage, the more vulnerable are balance sheets to changes in asset prices. The degree of gearing in the High Leverage parameterization is clearly an extreme case. The capital accumulation process is extremely sensitive to exchange rate fluctuations at all frequencies. Compare the standard deviation of HP-filtered macroeconomic aggregates in the High Leverage parameterization under the Exchange Peg and the flexible exchange rate Inflation Target rules (see Table 1, Section C). The exchange rate flexibility under the Inflation Target again allows for greater stabilizing fluctuations in exports relative to the Exchange Peg model. However, when capitalists’ leverage is high, the benefit of this export flexibility comes at a high cost in terms of destabilizing fluctuations in the capitalists’
finances. The standard deviations of output, investment, employment, and the consumption of workers and capitalists are all substantially larger at business cycle frequencies under the Inflation Target than under the Exchange Peg. Workers felicity is substantially more volatile under the Inflation Target than it is under the Exchange Peg at all horizons.

5 Discussion

Milton Friedman made the case for flexible exchange rates by noting that if the optimal response to shocks requires a real exchange rate devaluation, then changes in the nominal exchange rate can more quickly achieve that depreciation when domestic currency prices are sticky. In this paper, I argue that when firms in emerging markets finance real capital spending by purchasing foreign currency debt it may be preferable for real exchange rate depreciations to occur slowly through deflation rather than quickly through nominal exchange rate devaluations. The intuition is that if sticky prices cause output prices to deflate more slowly than input prices, then financially constrained domestic firms with sticky prices earn profits during the deflation that help in the repayment of debt obligations, which is a point made by Calvo [16]. In contrast, a sudden exchange rate devaluation produces greater damage to the balance sheets of domestic firms with foreign currency obligations. Central to this intuition is the precise role that nominal rigidities play in the small open economy. For example, if financially constrained firms do not have sticky prices while workers (as in Cespedes et al. [20]) or other firms (as in Devereux and Lane [30] and Gertler, et al [40]) do, deflation may reduce the relative value of the output of financially constrained firms making it more difficult to repay hard currency debt. The centrality of the precise assumption about price rigidities is illustrated by the different responses to monetary shocks of the Benchmark model (in which financially constrained firms do have sticky prices) and a subtly different alternative model (in which the financially constrained firms do not face sticky prices, but other firms in the economy do).

It may prove difficult to empirically distinguish between such subtle differences in the characterization of nominal rigidities’ given the limited data from many emerging market economies. The analysis here points to a way of empirically identifying economies in which exchange rate depreciations damage the balance sheets of firm’s with foreign currency debt more than does deflation. The effect of a currency depreciation on the foreign currency returns to capital demonstrates the effect of currency on the value of a firm’s assets relative to the value of its foreign currency debts. In the Benchmark model in this paper, a policy induced exchange rate depreciation has negative effects on foreign currency denominated re-
turns, and leads to a contractionary devaluation. In an alternative model, in which exchange rate depreciation actually improves the balance sheets of firms with foreign currency debt, exchange rate depreciation also leads to a positive outcome for foreign currency denominated returns. Identifying the effects of policy induced depreciations is beyond the scope of this paper. However, Dominguez and Tesar [32] find that a large majority of Thai stocks with significant exchange rate exposure are negatively affected by exchange rate depreciations. This contrasts with their results for developed economy equities, which is a difference that they attribute to the foreign debt of many Thai companies.

It should also be noted that this paper takes the presence of foreign currency debt as a given. Eichengreen and Hausmann [33] describe the theory that foreign currency is a fact of life for emerging markets as the “original sin” hypothesis. It is, in fact, true that virtually all international bond issues and all international syndicated bank loans to emerging markets are denominated in large country currencies. The degree to which domestic balance sheets are exposed to currency risk depends on the extent to which domestic firms are able to sell bonds to foreign creditors in domestic bonds markets, and the extent to which firms hedge their foreign currency debt. Such decisions are likely to depend on policy decisions. Burnside, Eichenbaum and Rebelo [12] argue that implicit government guarantees led East Asian banks to ignore their foreign currency risk exposure prior to the East Asian crisis. Most importantly for monetary policy evaluation, the portfolio decisions of both foreign creditors and domestic borrowers may depend on monetary policy. Fischer [35] argues that the relative stability of exchange rates in the pre-crisis period caused firms to underestimate currency risk that led to excess foreign currency debt. Conversely, it is not difficult to imagine that large exchange rate fluctuations might make it more expensive to borrow from foreign creditors in domestic currency, or to hedge foreign currency debt. Exchange rate flexibility may not necessarily lead to less foreign currency debt. The macroeconomic and monetary policy determinants of firms’ choices to issue debt in foreign or domestic currency would be a useful topic of future research.

6 Data Appendix

The data on international bank loans for East Asia are taken from the IFR Platinum database. The data on debt that is owed to banks from developed countries is taken from the BIS-IMF-OECD High Frequency Debt statistics. The data on short-term interest rates and consumer prices that are used to construct ex post real interest rates for the G7 countries are from International Financial Statistics. The data on G7 output is from the OECD Quar-
terly National Accounts. The data on national accounts of East Asian economies is from the CEIC database.

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### Table 1: Moments and Welfare Comparisons

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<th>Unconditional Standard Deviation</th>
<th>Standard Deviations of HP Filtered Series</th>
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<td>Exchange Peg</td>
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Figure 1: Dynamic Response of Prices to a 25 Annualized Basis Point Interest Rate Cut
Figure 2: Dynamic Response of Macroeconomic Aggregates to a 25 Annualized Basis Point Shock in the Benchmark Model
Figure 3: Dynamic Response of Macroeconomic Aggregates to a 25 Annualized Basis Point Interest Rate Cut
Figure 4: Dynamic Response of Prices and Balance Sheets to a 1 Standard Deviation Rise in the World Real Interest Rate
Figure 5: Dynamic Response of Macroeconomic Aggregates to a 1 Standard Deviation Rise in the World Interest Rate
Figure 6: Dynamic Response of Prices and Balance Sheets to a One Standard Deviation Drop in World Demand
Figure 7: Dynamic Response of Macroeconomic Aggregates to a One Standard Deviation Drop in World Demand