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Liability Dollarization and the Bank Balance Sheet Channel

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Abstract

Banks in developing economies often face a mismatch in the currency denomination of their liabilities (foreign currency denominated debt) and assets (domestic currency loans to domestic borrowers). We study the effect of this mismatch on business cycles and monetary policy in a sticky-price, dynamic general equilibrium model of a small open economy. We find from the model analysis that a fixed exchange rate rule that stabilizes the balance sheets of banks offers greater stability than an interest rate rule that targets inflation in the sticky-price sector of the economy.

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I. Introduction

High-growth economies often finance capital accumulation through international capital markets and, as a consequence, have large external debt positions denominated in foreign currency. Frequent financial crises in the 1990s have made apparent the impact that currency mismatches have on balance sheets during a downturn. In many countries, as in Korea and Thailand at the outset of the 1997–98 Asian financial crisis, much of these international capital flows are intermediated by domestically owned banks. Of the approximately 76 billion dollars recorded as raised by Thai firms on international debt markets between 1992 and mid-1997 (by the IFR Platinum database), approximately 3.2 percent of this debt was denominated in Thai baht. More than 41 percent of the hard currency debt was loaned to banks or other firms in the finance sector. Less than 1 percent of the approximately 144 billion dollars recorded as raised by Korean firms during the same period was denominated in Korean won, and more than 62 percent of the hard currency debt was lent to firms in the financial sector.

Institutional and regulatory arrangements in Asia may have encouraged the dollarization of bank liabilities. Most emerging countries in Asia, including Thailand and Korea, had controls on the international use of domestic currency (see Meesook and others, 2001). Dollar lending in Thailand often occurred through the Bangkok International Banking Facility, which enabled foreign banks to make dollar loans to many Thai financial firms.

If banks have a mismatch in the currency denomination of their liabilities and assets, exchange rate fluctuations will affect bank balance sheets. In this paper, we examine some of the quantitative implications that such a currency mismatch may have for the conduct of monetary policy in emerging markets and for the dynamic propagation of macroeconomic shocks in an open economy. In particular, we examine a sticky-price dynamic general equilibrium (DGE) model of a small open economy in which international capital flows are intermediated by banks whose cost of capital depends on the state of their balance sheets. An unexpected nominal exchange rate depreciation will negatively affect bank balance sheets, increasing the country risk premium and potentially offsetting the standard expansionary effects of a depreciation.

In this economy, banks face a severe currency mismatch between their domestic assets and their foreign liabilities. A number of authors have examined how the credit channel affects business cycles and monetary policy when nonfinancial corporations have currency mismatches in their assets and liabilities (see Céspedes, 2000; Céspedes, Chang, and Velasco, 1999; Cook, 2000; Devereux and Lane, 2000; and Gertler, Gilchrist, and Natalucci, 2000). From our perspective, banks differ from nonfinancial firms in two important respects. First, banks typically have much greater leverage than nonfinancial corporations. Second, the assets of banks are often nominally fixed in domestic currency terms. This increases their vulnerability to exchange rate fluctuations relative to a nonfinancial firm. Consider the effect of an exchange rate depreciation (caused by a monetary expansion) on the balance sheets of a firm that has issued foreign currency debt to finance the purchase of some real capital asset. The depreciation increases the domestic currency value of the debt, but the monetary expansion will inflate the domestic currency value of the real asset. Thus, in the absence of other market imperfections, the monetary expansion has neutral effects on the firms' balance sheets. Conversely, a depreciation will have negative impacts on the balance sheets of a bank whose nominal assets are fixed in domestic currency terms but whose liabilities are not. Modeling the bank balance sheet channel in a small open economy is quite distinct from modeling the balance sheet channel of nonfinancial corporations.

It is a key aspect of our model that banks intermediate the capital flows between a small open economy and global financial markets. Thus, the balance sheets of a country's banks determine the country risk premium (that is, the deviation of exchange adjusted domestic interest rates from world interest rates). An exchange rate depreciation that causes deterioration in the balance sheets of banks will increase the risk premium which a country must pay on its debt. In the absence of a rise in the domestic nominal interest rate, a further depreciation is necessary to maintain interest parity. There is a powerful feedback loop between bank balance sheets and nominal exchange rate changes. A depreciation would lead to deterioration of balance sheets, raise the risk premium, leading to further depreciation, which would lead to further deterioration of balance sheets, further raise the risk premium, leading to further depreciation, and so on. Foreign currency debt exposure can generate large exchange rate and real volatility in the absence of a fixed exchange rate. This may explain why, as Calvo and Reinhart (2000) show, the monetary policies of many developing economies target the nominal exchange rate.

We adapt the financial accelerator model of Bernanke and Gertler (1989) to modeling the borrowing of banks from international capital markets. Antecedents of this model include work on asymmetric information and monitoring costs by Townsend (1979) and Gale and Hellwig (1985). Bernanke and Gertler (1989) developed an overlapping-generations model of financial markets in which lenders pay monitoring costs to observe the outcome of their creditors' investment projects. The interest rate in this model increases with the leverage ratio of borrowers (as high leverage increases the likelihood of default). Carlstrom and Fuerst (1997) incorporate this structure into a representative agent dynamic general equilibrium model of business cycles. Holmstrom and Tirole (1997) construct a model of bank liquidity based on a similar asymmetric information channel. Fuerst (1995) and Bernanke, Gertler, and Gilchrist (2000) incorporate this structure into closed economy models with nominal rigidities to study the effects of this "financial accelerator" channel.

In the wake of the financial crises of the 1990s, a number of papers have considered issues relating to currency mismatches of domestic financial intermediaries. Many of these studies focus on the response of the economy to a financial crisis. Aghion, Bacchetta, and Banerjee (2000, 2001) and Krugman (1998) study models in which the presence of foreign currency debt leads to endogenous currency crises. Burnside, Eichenbaum, and Rebelo (1999) argue that implicit government guarantees to banks reduce the incentive for banks to engage in any currency hedging. They examine some of the real effects of the elimination of such guarantees. Devereux (2001) examines the effects of a depreciation on trade credit when banks that provide such credit have a currency mismatch between assets and liabilities. Chang and Velasco (1999) argue that real exchange rate depreciation systematically leads to more frequent or severe bank runs. Mendoza (2000) shows that when foreign debt is denominated in traded goods, a real exchange rate depreciation can reduce the value of collateral and lead to sudden outflows of capital. Schneider and Tornell (2000) examine a small open economy model with imperfect capital markets in which bailout guarantees lead to endogenous boom-and-bust lending cycles. Chen (2001) studies the impact of asset price declines when the domestic banking system facing collateral constraints.

Comparing the economic performance of small, open economy models under fixed and flexible exchange rates goes back at least as far as Mundell. Taylor (1993) and Clarida, Galí, and Gertler (1998) have observed that the monetary policies of a number of large countries can be described as simple interest rate rules. Subsequently, a large number of papers have examined the business cycle stabilization and welfare properties of simple monetary rules in dynamic, forward-looking models (see, for examples, Woodford, 2001 or the papers in Taylor, 1999). An especially pertinent example is Schmitt-Grohé and Uribe (2001), which examines a sticky-price, dependent-economy model and compares the welfare properties of a number of interventionist monetary policy rules with a fixed or exogenous nominal exchange rate rule. The stabilization properties of each of the interventionist monetary rules considered were superior to a fixed exchange rate rule. In this study, we find that a fixed exchange rate stabilizes the balance sheets of the banking system and leads to greater business cycle stability than an inflation targeting interest rate rule.

The paper proceeds as follows. Section II presents a general equilibrium model of a small open economy. Section III provides calibrations of models with and without the bank balance sheet channel. Section IV explores the contribution of alternative policy rules to business cycle stabilization. Section V provides robustness checks, and Section VI concludes.

II. The Model

A small open economy has a negative financial position relative to the rest of the world. This debt to the rest of the world is intermediated through a domestic banking sector which borrows in foreign currency (dollars) and lends in the domestic currency (baht). Large increases in interest rate risk premium during the financial crisis of 1997–98 were associated with substantial contractions in GDP in Korea, Indonesia, Malaysia, the Philippines and Thailand. We structure our model, following Cook and Devereux (2001), to capture the contractionary effects of interest rate rises.

A. The Banking Sector

The banking sector specializes in borrowing funds from external financial markets and lending those funds to the domestic economy. External financial markets lend only in dollars and domestic banks lend only in baht. The banking sector bears the exchange rate risk. There is a unit measure of bank owners. Banker l begins each period with baht net worth, nw_l. To make a domestic currency loan, d_l, at nominal interest rate, $(1 + i_t)$, the banker borrows additional dollars, $\frac{d_l - nw_l}{S_t}$, from international financial markets which are converted into baht at the spot exchange rate, S_t. Bankers have a stochastic debt collection technology which allow them to collect some fraction, $\omega(1 + i_t)d_l$, next period. This fraction, ω, is distributed uniformly over $[\underline{\omega}, 1]$. Wealth not collected is lost. International lenders observe, ω, only at some monitoring cost, μd_l. The optimal financial contracts between domestic banks and foreign lenders take the form of risky debt. The banks pay a dollar interest rate $1 + i^d$.[2] If the bank defaults, lenders collect the assets of the bank less monitoring costs.

The contract can be described as a quantity of debt and the interest rate. The state dependent minimum technology level, ϖ, at which default is avoided is

$$\varpi(1 + i)\frac{d_l}{S_{t+1}} = (1 + i^d)\frac{(d_l - nw_l)}{S_t}$$

Under the contract, the banker collects the proceeds of the loan minus interest paid to international lenders. Following Bernanke and Gertler (1990), the expected pay-off can be written as a share of the proceeds of the loan, $f(\varpi)(1 + i)d_l$.

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[2] Note that the dollar interest rate, $1 + i^d$, on risky debt is conceptually distinct from the risk free dollar interest rate, $1 + r$, prevailing in international financial markets.

$$f(\varpi) \equiv \int_{\varpi}^{1} \frac{\omega}{1-\underline{\omega}} d\omega - (1 - \int_{\underline{\omega}}^{\varpi} \frac{1}{1-\underline{\omega}} d\omega)\varpi \qquad 0 \leq f(\varpi) \leq 1$$

The expected payoff to foreign lenders is the interest payment in the case of no default plus the value of the bank (less liquidation costs) in the case of default. This pay-off can also be represented as a share of total returns $g(\varpi)(1+i)d_l$.

$$g(\varpi) \equiv (1 - \int_{\underline{\omega}}^{\varpi} \frac{1}{1-\underline{\omega}} d\omega)\varpi + \int_{\underline{\omega}}^{\varpi} \frac{\omega}{1-\underline{\omega}} d\omega - \int_{\underline{\omega}}^{\varpi} \frac{\mu}{1-\underline{\omega}} d\omega$$

The contract will maximize the expected pay-off to bankers subject to the international lenders receiving returns equal to an exogenous dollar interest rate $(1 + r)$:

$$\max E_t[f(\varpi)(1+i_t)d_l]$$

$$\text{subject to } \frac{g(\varpi)(1+i_t)d_l}{S_{t+1}} = (1+r_t)(\frac{d_l - nw_l}{S_t})$$

The only aggregate uncertainty faced by the agent is the exchange rate that will prevail when the dollar loans must be repaid. The optimal $\varpi(S_{t+1})$ is contingent on realizations of the exchange rate so that the constraint holds with equality, ex post. The first order conditions for the optimal contract can be solved to describe a default risk premium, rp_{t+1}, of the domestic lending rate over the exchange rate adjusted foreign interest rate.

$$1 + i_t = E_t\Big[(1+r_t)\frac{S_{t+1}}{S_t} rp(\varpi_{t+1}) \Big] \tag{1}$$

$$rp(x) \equiv \left[\left(\frac{g'(x)\ f(x)}{f'(x)} - g(x) \right)^{-1} \right], \qquad rp'(.) > 0 \tag{2}$$

The risk premium is an increasing function of the expectation of the minimum technology level at which the bank will default.

The implicitly defined ϖ is not dependent on any characteristics of individual l and thus allows (as shown by Carlstrom and Fuerst, 1997) easy aggregation. The banking sector can be described by a set of equations including (1) and the aggregate constraint which holds ex post.

$$\frac{g(\varpi_t)(1+i_{t-1})D_{t-1}}{S_t} = (1+r_{t-1})(\frac{D_{t-1} - NW_{t-1}}{S_{t-1}})$$

The aggregate assets and net worth of the banking system is D_t and NW_t, respectively. Domestic borrowers borrow from banks in perfectly competitive markets. Thus, the size of loans and the onshore rate are determined jointly in equilibrium. The demand for bank assets is determined by the fundamentals of the small open economy described in the next section and the size of the risk premium which is an increasing function of assets relative to bank capital.

Bankers devote a constant share of returns, γ, to accumulating net worth (and the rest to traded goods consumption).

$$NW_t = \gamma f(\varpi_t)(1+i_{t-1})D_{t-1}$$

The share of total domestic currency debt that goes to the banking sector as income is a negative function of unexpected depreciations in the nominal exchange rate. Since aggregate bank capital is a linear function of this income, an exchange rate depreciation reduces bank profits and, thus, bank capital. Local to steady state, the future risk premium is a decreasing function of the current capitalization of the bank: $rp_{t+1} = h(\frac{NW_t}{D_t}),\ h'(.) < 0$. An unexpected depreciation today, will increase the expected country risk premium. Moreover, the modified uncovered interest parity condition (1) says that the current exchange rate is a function of the risk premium. A rise in the risk premium leads to a depreciation given that the domestic interest rate is determined by a policy rule, which will be described later. This implies feedback between the nominal exchange rate and the risk premium. In the subsequent sections, we can examine the quantitative implications of this feedback.

B. Absorption

The domestic economy is populated by a representative working household (referred to throughout as the representative agent) that maximizes lifetime utility from consumption (*C*), labor (*H*), and money (*M*) divided by the consumer price index (*CPI*) The felicity from consumption and leisure is defined as Z_t.

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\varrho} Z_t^{1-\varrho} + \chi \ln\left(\frac{M_t}{CPI_t} \right) \right], \qquad Z_t = C_t - \frac{\Gamma}{1+v} H_t^{1+v} \tag{3}$$

The household earns income, INC_t, from renting labor and capital to a traded goods sector and a non-traded sector. The wage rate is W_t. The capital in the traded goods, K_t^T, and the non-traded goods, K_t^{NT}, are rented at rates, R_t^T and R_t^{NT}, respectively. The household receives lump-sum profits from a non-competitive traded goods sector, Π_t^{NT}.

$$INC_t = W_t H_t + R_t^T K_t^T + R_t^{NT} K_t^{NT} + \Pi_t^{NT} \tag{4}$$

The sum of consumption, investment in traded goods and non-traded capital, I_t^T and I_t^{NT}, and a lump-sum fiscal tax, G_t, is a constant elasticity of substitution combination of traded and non-traded goods, A_t^T and A_t^{NT}, purchased at price, P_t^T and P_t^{NT}, respectively.

$$(C_t + I_t^T + I_t^{NT} + G_t) \equiv A_t = [b^{1-\phi}(A_t^T)^{\phi} + (1-b)^{1-\phi}(A_t^{NT})^{\phi}]^{\frac{1}{\phi}} \tag{5}$$

The consumer price index, CPI_t, is the ratio of nominal absorption to real absorption.

$$CPI_t = \frac{P_t^T A_t^T + P_t^{NT} A_t^{NT}}{A_t}$$

Sectoral capital evolves through investment, assuming that there are costs of adjusting the capital stock within each sector.

$$K_{t+1}^T = (1-\delta)K_t^T + I_t^T - \frac{\zeta}{2}\left(\frac{I_t^T}{K_t^T} - \delta \right)^2 K_t^T \tag{6}$$

$$K_{t+1}^{NT} = (1-\delta)K_t^{NT} + I_t^{NT} - \frac{\zeta}{2}\left(\frac{I_t^{NT}}{K_t^{NT}} - \delta \right)^2 K_t^{NT} \tag{7}$$

The household receives a transfer payment, TR_t, from the central bank in the tradition of the helicopter drop. The households accumulates a level of debt, D_t, at the end of the period. To simplify the notation of the model, we have assumed that the household accumulates capital which is rented to firms. This implies that the net intertemporal borrowing of the household is equal to the net debt of the economy which is, in turn, equal to the assets of the banking system.[3]

[3] A model in which firms directly issue debt to finance capital investment would yield equivalent results, but would be notationally more complicated.

$$D_t = (P_t^T A_t^T + P_t^{NT} A_t^{NT} - INC_t) + (1 + i_{t-1}) D_{t-1} + (M_t - M_{t-1} - TR_t) \tag{8}$$

The maximization of the objective function (3) subject to equations (4)-(8) leads to first order conditions that characterize the solution (see the appendix for the first order conditions).

C. Supply

Production

Traded Goods — Two perfectly competitive sectors produce traded and non-traded goods with a constant returns to scale Cobb-Douglas technology. Firms in the traded goods sector face a convex cost of adjusting their level of employment.

$$Y_t^T = h\left(\frac{H_t^T - H_{t-1}^T}{H_{t-1}^T}\right) X_t (K_t^T)^{\theta} (H_t^T)^{1-\theta}, \qquad h(x) = 1 - \frac{\xi}{2} x^2 \tag{9}$$

where A_t is a stochastic, economy-wide technology term. The traded goods industry sells output at price P_t^T on a world market. The first order conditions characterize the profit maximization function. The shadow value of nominal income at time t is defined as Ω_t.

$$\theta P_t^T \frac{Y_t^T}{K_t^T} = R_t^T \tag{10}$$

$$\frac{W_t H_t^T}{P_t^T Y_t^T} + \xi \frac{H_t^T}{H_{t-1}^T} \frac{H_t^T - H_{t-1}^T}{H_{t-1}^T} - (1 - \theta) = E_t \left[\beta \frac{\Omega_{t+1}}{\Omega_t} \xi \frac{H_{t+1}^T}{H_t^T} \frac{H_t^T - H_{t-1}^T}{H_{t-1}^T} \right] \tag{11}$$

Non-Traded Goods — The non-traded goods industry sells its product to domestic retailers at price MC_t^{NT}.

$$Y_t^{NT} = \Theta X_t (K_t^{NT})^{\alpha} (H_t^{NT})^{1-\alpha}$$

$$\alpha MC_t^{NT} \frac{Y_t^{NT}}{K_t^{NT}} = R_t^{NT}, \qquad (1 - \alpha) MC_t^{NT} \frac{Y_t^{NT}}{H_t^{NT}} = W_t \tag{12}$$

Retail

Retailers of non-traded goods are monopolistically competitive and set prices in advance (see Obstfeld and Rogoff, 1995). There is a unit measure of differentiated non-traded firms. Final output is a Dixit-Stiglitz index of the goods produced by a unit measure of sales firms which act as monopolistic competitors.

$$A_t^{NT} = \left[\int_0^1 (y_{i,t}^{NT})^{\varphi} di \right]^{\frac{1}{\varphi}} \tag{13}$$

The price, $p_{i,t}^{NT}$, of good i, $a_{i,t}^{NT}$ is given by the inverse demand curve.

$$\frac{p_{i,t}^{NT}}{P_t^{NT}} = \left(\frac{a_{i,t}^{NT}}{A_t^{NT}} \right)^{\varphi - 1} \Rightarrow P_t^{NT} = \left[\int_0^1 (p_{i,t}^{NT})^{\frac{\varphi}{\varphi - 1}} di \right]^{\frac{\varphi - 1}{\varphi}}$$

Retailers transform non-traded output into non-traded absorption:

$$\int_0^1 y_{i,t}^{NT} di = Y_t^{NT}$$

Marginal cost faced by non-traded goods firms is MC_t^{NT}. Non-traded firms maximize the value of their profit stream to their owners.

$$\max E_t \sum_{j=t}^{\infty} \beta^j \Omega_j (p_{i,j}^{NT} - MC_j^{NT}) y_{i,j}^{NT}$$

Non-traded firms have sticky prices as in Calvo (1983), Rotemberg and Woodford (1997), or Yun (1996). In each period t, a fraction of the firms $1-\kappa$ are able to reset their prices. Prices of the remaining firms are fixed. Define P_t^{NT*} as the price chosen by price setters. Prices evolve according to:

$$P_t^{NT\frac{\varphi}{\varphi-1}} = \kappa(P_{t-1}^{NT})^{\frac{\varphi}{\varphi-1}} + (1-\kappa)(P_t^{NT*})^{\frac{\varphi}{\varphi-1}} \tag{14}$$

Define $Q_t \equiv \Omega_t^{\frac{1}{\varphi-1}} P_t^{NT\frac{\varphi}{\varphi-1}} Y_t^{NT}$, then the optimal price chosen is

$$P_t^{NT*} = \frac{1}{\varphi} \frac{E_{t-1}\sum_{j=t}^{\infty}(\beta\kappa)^{j-t} Q_j MC_j^{NT}}{E_{t-1}\sum_{j=t}^{\infty}(\beta\kappa)^{j-t} Q_j} \tag{15}$$

D. Policy and Shocks

The central bank follows a general inflation targeting interest rate rule allowing the central bank to respond to both traded goods and non-traded goods inflation

$$i_t = \psi_1 i_{t-1} + \psi_2 \pi_t^{NT} + \psi_3 \pi_t^T + \varepsilon_t^M \tag{16}$$

where ε_t^M is an independently and identically distributed (i.i.d.) exogenous shock to the monetary policy process, $\pi_t^{NT} = \frac{P_t^{NT}}{P_{t-1}^{NT}}$ is non-traded goods inflation, and $\pi_t^T = \frac{P_t^T}{P_{t-1}^T}$ is traded goods inflation. The CORE specification of monetary policy is a specialization of this rule setting no weight on traded goods' prices, $\psi_3 = 0$. This monetary policy rule responds to the core inflation in the sticky price non-traded goods sector. Another monetary policy rule puts no weight on this core inflation $\psi_2 = 0$ and adjusts the interest rate so as to keep traded goods' price inflation constant, $\psi_3 \to \infty$. As the traded goods' price is equivalent to the exchange rate, this monetary policy is equivalent to a fixed exchange rate and is referred to as the PEG specification (see Monacelli, 1999).

The external interest rate follows a dynamic process is given by

$$r_t = \rho^r r_{t-1} + \varepsilon_t^r, \qquad \varepsilon_t^r \sim N(0, \sigma_r^2) \tag{17}$$

where ε_t^r is an exogenous real interest rate shock. Technology also follows a first-order autoregressive process as follows:

$$\ln X_t = \rho^X \ln X_{t-1} + \varepsilon_t^X, \qquad \varepsilon_t^X \sim N(0, \sigma_X^2) \tag{18}$$

where ε_t^X is an exogenous technology shock.

III. Calibration

A. Parameters

We solve linearized versions of the above model using the algorithms outlined in King and Watson (1995). Many of the parameters of the model are similar to those used in previous dynamic general equilibrium models of small open economies. Following Backus, Kehoe, and Kydland

(1995), the intertemporal elasticity of substitution $\varrho = 2$. We set the mean quarterly international interest rate equal to $1 + r = 1.01$. The weight on labor, Γ, is normalized so aggregate labor, $H_t = 1$. Following Christiano, Eichenbaum, and Evans (1997), $v = 1$, such that the elasticity of labor with respect to real wages is 1. When the central bank targets inflation in the sticky price sector, the parameters of the CORE policy response function are $\psi_1 = .9$ and $\psi_2 = .11$ (see Bernanke et al., 2000).

Following Cook and Devereux (2001), we set the capital intensity of the traded goods sector, $\theta = .7$ higher than the non-traded sector, $\alpha = .33$. The technology weighting on traded goods, Θ, is such that the real exchange rate between goods is 1 at steady state. Following Cogley and Nason (1995), we set φ so that the marginal cost of adjusting the traded goods workforce by 1 percent is equal to .36 percent of the steady-state level of traded goods output. The percentage of firms changing prices at any given times is $\kappa = .25$. Steady state markups, $\frac{1}{\varphi} = 1.05$. We set the elasticity of substitution between traded goods and non-traded goods, $\frac{1}{1-\phi} = .5$. Zimmerman (1994) reports standard estimates of the elasticity between imports and home goods range between $\frac{1}{1-\phi} = .5$ to 13.5. The weight on each good is such that traded and non-traded goods are equal amounts of consumption when the real exchange rate is equal to 1. The depreciation rate of both capital types is $\delta = .025$. The elasticity of the investment-capital ratio with respect to Tobin's q, ζ^{-1}, is set at 8, which is within the range of standard parameter values.

Some ratios are calibrated using data from East Asia. Average government expenditure as a share of GDP over the period 1980 to 1996 ranges between 9 and 11 percent in Korea, Indonesia, Thailand and the Philippines. We set steady state $\frac{G}{Y} = .1$. The steady-state debt to output ratio is 1.2, as given by the average ratio of Thailand's liabilities to developed country banks over quarterly GDP for the period 1990-1996. The parameters of the banking system $[\underline{\omega}, \mu, \gamma]$ determine the steady state failure rate of banks, the steady state risk premium, and the steady-state capitalization ratio of banks. Over the period, 1986 to 1996, the minimum loan rate of Thai commercial banks on the 3 month treasury bills was 760 annualized basis points over US Treasuries. Over the same period, the ratio of commercial bank capital to total assets was 7 percent. We assume that Thai banks default only rarely with .1 percent default rate per period.

The stochastic process for the world interest rate is parameterized according to a dynamic factor model of large country interest rates. Ex post real interest rates, $r^P_{j,t}$, of j = Germany, Japan, and the United States are assumed to be a function of an unobserved common factor, the world interest rate, and idiosyncratic errors, $e_{j,t}$.

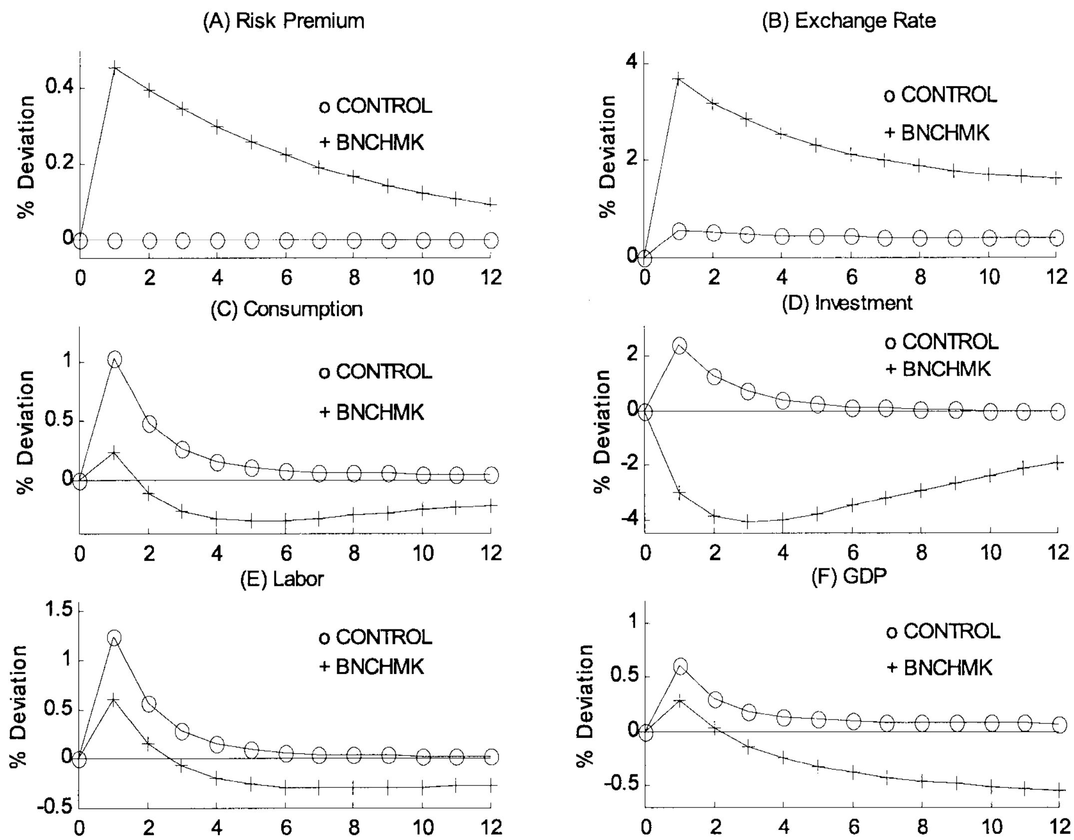
$$r^P_{j,t} = r_t + e_{j,t}, \qquad e_{j,t} \sim N(0, \sigma_j^2)$$
$$r_t = \rho^r r_{t-1} + \varepsilon^r_t, \qquad \varepsilon^r_t \sim N(0, \sigma_r^2)$$

The maximum likelihood estimates are $\rho^r = .96$ and $\sigma_r = .002$. The technology process is calibrated at $\rho^X = .95$ and $\sigma_X = .007$, following Hansen (1985).

B. Monetary Policy Shocks Under A Flexible Exchange Rate

In Figure 1, we show the dynamic response of the Benchmark model to an expansionary monetary policy shock modelled as an annualized 25 basis point decline in ε^M_t. For purposes of comparison, we show the response of a Control model in which the cost of funds does not depend on the state of bank balance sheets, that is, the risk premium rp is constant.

Figure 1. The Dynamic Response to a 25 Annualized Basis Point Interest Rate Cut



Control Model

The monetary policy shock has the standard effects on the small open economy in the Control model. By assumption, the risk premium in the control is unaffected by the shock as shown in Figure 1 (A). Holding *rp* constant, the uncovered interest parity condition (1) shows that a policy shock induced decrease in the nominal interest rate must be accompanied by an expected future appreciation of the nominal exchange rate. Given that the policy shock induces a long run monetary expansion, the nominal exchange rate must appreciate. The nominal exchange rate depreciates by about .5 percent, slightly overshooting the long run level as shown in Figure 1 (B). The cut in the nominal interest rate combined with a rise in expected future inflation implies that the real interest rate declines. Equilibrium consumption rises to nearly 1 percent above steady state before slowly reverting to the mean as shown in Figure 1 (C). Over time, as non-traded goods firms are able to raise their prices, the real interest rate increases and consumption returns to its long run level; consumption is less than .1 percent above steady state by 5 periods following the shock.

The monetary expansion leads to an increase in investment through two channels. First, the decline in the real interest rate reduces the cost of capital in both sectors. Second, the increase in demand for non-traded goods increases the marginal product of capital in that sector. Figure 1 (D) shows that this leads to a sharp rise in aggregate investment; investment spikes to 2 percent above the steady state level and declines back to steady state 5 periods after the shock. The increase in non-traded goods demand also leads to a rise in real wages. Labor supply is a simple (positive) function of the real wage rate. Figure 1 (E) shows that the monetary expansion leads to an initial rise in labor greater than 1 percent above steady state. Once again, by period 5, labor has shifted back to steady state. We define GDP as a weighted average of traded and non-traded production with the weights being the steady state share of each of those sectors in production. In Figure 1 (F), we show that a monetary expansion leads to a brief increase in production levels; GDP rises .5 percent above steady state before declining back to steady state after 5 periods

The Benchmark Model

In the Benchmark model, as in the Control model, the monetary shock leads to an exchange rate depreciation. Unlike the Control model, however, the depreciation will deteriorate the balance sheets of the banking sector and increase the country risk premium. The feedback between the exchange rate and the risk premium combines to produce a quantitatively large rise in the risk premium and a correspondingly large depreciation. This point is illustrated in Figures 1 (A) and 1 (B). A 25 (annualized) basis point decline in the nominal interest rate results in a greater than 100 (annualized) basis point rise in the external risk premium. This large rise in the external cost of capital implies that the exchange rate depreciates by more than 3 percent, sharply over-shooting the long run level.

In the Benchmark model, the rise in the risk premium, which occurs as banks' balance sheets worsen, also affects the real response of the economy to the monetary policy shock. The large rise in the risk premium offsets much of the decline in the real interest rate that occurs owing to the policy shock. In the initial period of the shock, the real interest rate declines slightly. However, in subsequent periods, the persistence of the risk premium causes the real interest rate to rise above its steady-state level. Consumption rises in the initial period owing to the declining interest rate. Figure 1 (C) shows that the initial rise in consumption in the Benchmark model is smaller than in the Control model. Further, in subsequent periods, consumption drops below steady state and remains persistently negative for many periods. The persistent decline in consumption is deeper than the initial rise. Investment is sensitive, not only to the current interest rate, but also to future interest rates owing to capital adjustment costs. Figure 1 (D) shows that the monetary expansion leads to a very sharp and persistent decline in investment.

The rise in the external risk premium also affects the dynamic response of aggregate production to the monetary shock. The Control model shows that a monetary expansion will lead to a rise in real wages owing to price stickiness in the non-traded goods sector. As a result, the monetary expansion will, on its own, lead to a rise in employment and output. Conversely, in the Benchmark model, a rise in the external risk premium will on its own lead to a decline in real wages, employment and output. A rise in the external risk premium reduces the optimal amount of debt held by the representative agent. In order to pay down the debt, the agent switches production away from non-traded goods for domestic consumption and toward the production of traded goods for export. Capital cannot be rapidly switched across sectors due to capital adjustment costs. Labor adjustment costs and the relatively higher capital intensity in the traded sector implies that the demand for labor does not rise as quickly in the traded sector as the demand for labor falls in the non-traded sector. Further, sticky prices in the non-traded sector exacerbate the decline in demand in that sector. The response of output and employment to a monetary expansion in the Benchmark model is a combination of the expansionary effects of monetary policy in a model with sticky prices and the contractionary effects of a rise in the external risk premium. In the short-run, the expansionary effects of the monetary shock owing to sticky prices are stronger than the contractionary effects of the risk premium, producing a mild expansion in employment and output. However, the effect of sticky prices on markups is much more transitory than the effect of bank balance sheets on the external risk premium. Figures 1 (E) and 1 (F) show that after 2 periods equilibrium labor moves and remains persistently below the steady state level.

C. Policy Rules and Exogenous Shocks

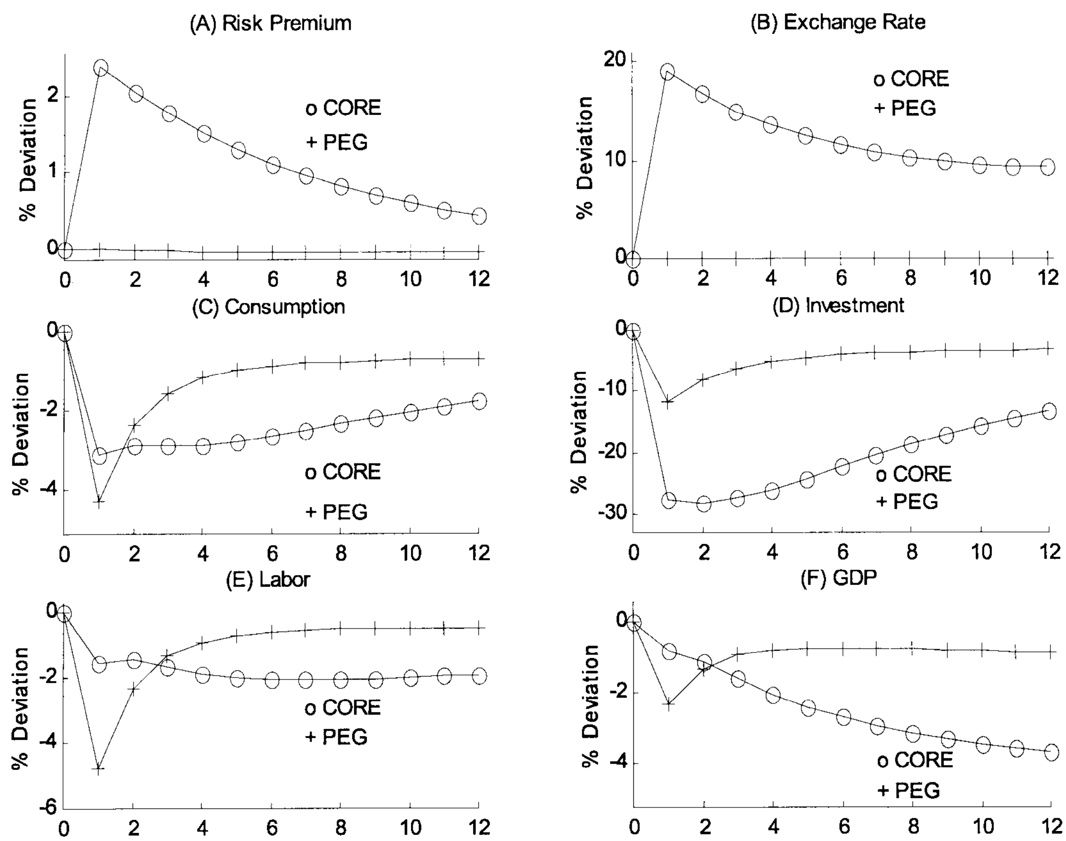
The above results suggest that in a country with the characteristics of the Benchmark model, counter-cyclical monetary policy may not be a useful tool for stabilizing the economy. In this section, we compare the response of the Benchmark economy to a contractionary shock to the external real interest rate and a contractionary shock to the internal level of technology under the CORE and PEG policy specifications. Although these two shocks affect the economy through very different channels, there are conceptual similarities in thinking about monetary policy responses to both shocks. In each case, price stickiness in the non-traded goods sector makes the economy's short-term response to the shock temporarily inefficient; an interest rate rule that targets non-traded goods prices ameliorates some of these inefficiencies, stabilizing the economy in the short run. However, each of these shocks results in an exchange rate depreciation under the CORE rule. In the absence of a pegged exchange rate, each of these shocks damage banks' balance sheets, persistently raising the external cost of capital.

External: World interest rate shocks

The rate, r, at which the domestic banking sector borrows external funds is subject to foreign shocks. It may be useful to consider the effect of a rise in the world interest rate on the small economy, abstracting, for a moment, from both the banking channel and sticky prices in the non-traded sector. Uncovered interest rate parity implies that a persistent rise in the world interest rate requires a large initial depreciation followed by an appreciation back to the mean. The rise in the world interest rate (which owing to covered interest parity and purchasing power parity might be thought of as the real interest rate in the traded goods sector) will lead the representative agent to postpone consumption and reduce investment in order to pay back some of the outstanding debt. The reduction in spending leads to a reduction in absorption of both traded and non-traded goods. However, traded goods can be exported. The rise in price of traded goods will cause a shift in production factors (primarily labor, as adjustment costs prevent capital from shifting quickly) away from the non-traded sector toward the traded sector. This leads to deflation in the non-traded sector. Because of the labor adjustment costs and the high capital intensity in the traded sector, shifting a marginal hour of labor from the non-traded sector to the traded sector results in the marginal physical product of labor falling more in the traded sector than it rises in the non-traded sector. As a result, there will be a decline in average productivity, a decline in the real wage rate, and thus a decline in the equilibrium aggregate labor.

Now, consider how the market imperfections in the Benchmark model exacerbate the effects of the interest rate shock. First, sticky prices in the non-traded sector prevent deflation in that sector from occurring immediately. A decline in nominal demand for non-traded goods coupled with sticky prices implies a larger contraction in real demand for non-traded goods and a larger contraction in productivity and employment than would occur in an efficient economy. Second, the imperfect external capital market and foreign liability dollarization imply that the country risk premium can be increased by unexpected changes in the nominal exchange rate. A rise in the foreign interest rate would cause an exchange rate depreciation, deterioration in bank balance sheets and a rise in the risk premium on foreign loans. The effect of a rise in the risk premium is parallel to the effect of

Figure 2. The Response to a World Interest Rate Shock



a rise in the foreign interest rate, exacerbating the effect of the shock. Moreover, a rise in the risk premium leads to further depreciation and further deterioration in bank balance sheets.

A monetary policy response to the interest rate shock can ameliorate the effects of one of the two market imperfections, sticky prices and foreign currency debt obligations, but only at the cost of exacerbating the effects of the other. An interest rate rule that targets non-traded inflation, such as the CORE rule, can ameliorate the effects of sticky prices in the non-traded section. Under the CORE rule, a foreign interest rate shock which leads to non-traded deflation would lead to a cut in domestic interest rates and a nominal expansion. The larger is the nominal expansion, the milder will be non-traded deflation and the milder will be the real impact of nominal price stickiness. However, a nominal expansion will lead to a sharper nominal exchange rate depreciation, increasing the deterioration in bank balance sheets and increasing the effect of the interest rate shock on the risk premium. A fixed exchange rate policy such as the PEG rule requires that a rise in the foreign interest rate be accompanied by an equal rise in the domestic interest rate. The rise in the domestic interest rate leads to a nominal contraction and a larger contraction in demand for non-traded goods.

Figure 2 demonstrates the response of the Benchmark economy to a one-standard deviation foreign interest rate shock. Under the PEG rule, the shock has no effect on nominal exchange rates and little effect on the country risk premium. Under the CORE rule, allowing for a monetary easing following the interest rate shock, the interaction between the nominal exchange rate and the country risk premium causes large movements in both. Figures 2 (A) and 2 (B) show that the country risk premium increases by more than 2 percentage points (a 9 percent rise at annualize rates) and a greater than 18 percent depreciation of the currency. The shock causes the real interest rate to rise under either policy. However, the rise in the country risk premium under the CORE rule induces a larger and more persistent rise in the real interest rate than under the PEG rule. Figure 2 (C) shows a more persistent decline in consumption under the CORE rule than the PEG rule. Sticky prices in the non-traded sector are a direct cause of the short-run decline in employment and output following the shock. Figure 2 (D) also shows a far larger and more persistent decline in investment under the CORE rule. Figures 2 (E) and 2 (F) show that, in the immediate period of the shock, employment and output decline much less severely under the CORE rule (which offsets the effects of sticky prices) than under the PEG rule (which exacerbates the effects of sticky prices). However, movements in bank balance sheets have far more persistent effects than do sticky prices. After several periods, employment and output under the CORE rule are lower than those under the PEG rule.

Internal: Technology shocks

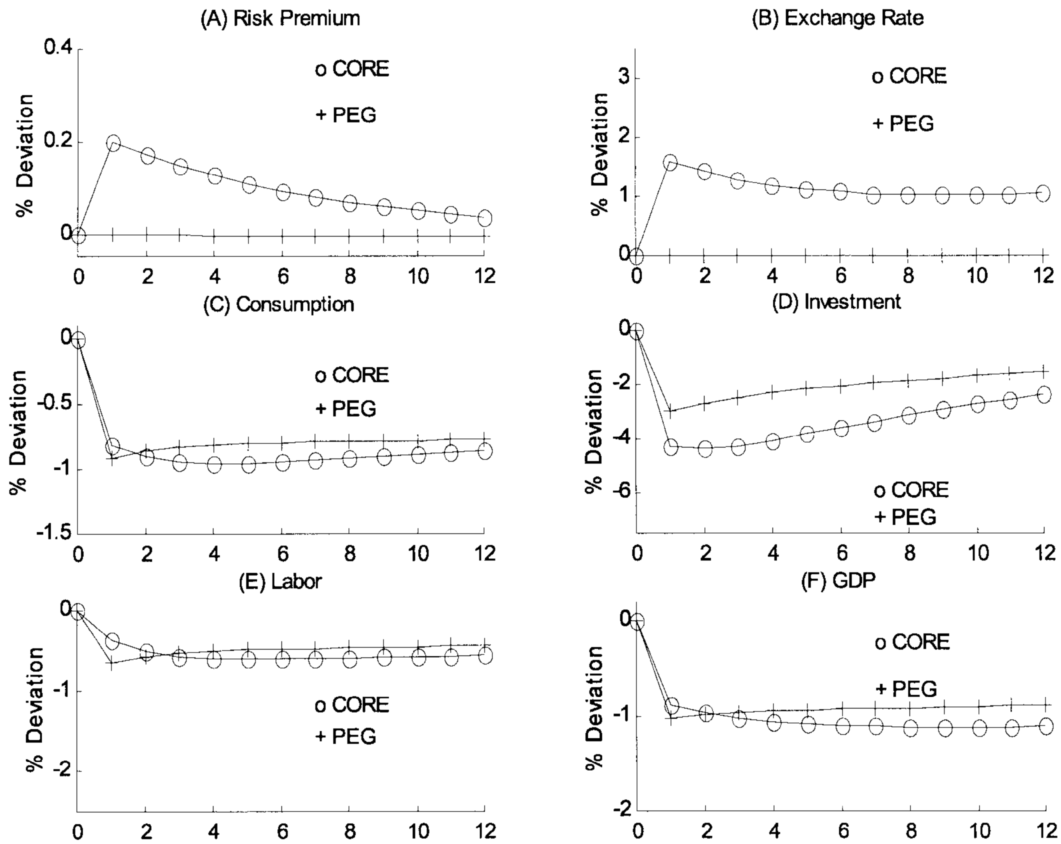
A second type of shock to consider is a persistent contraction in domestic technology, X_t, the effect of which we might again consider, abstracting from the market imperfections. A reduction in technology would lead to a decline in productivity of both labor and capital reducing equilibrium labor and investment. The resulting decline in income would lead to a decline in consumption. The decline in goods relative to money will lead to inflation and, thus, a depreciation of the nominal exchange rate. The efficient outcome with a fixed money stock will require inflation in the non-traded goods sector, an outcome prevented in the short run by sticky prices. Monetary policy could offset the effects of sticky prices by reducing the money supply. Both monetary policy rules considered would implement a monetary tightening in response to a negative technology shock. The PEG rule would require a monetary tightening to prevent an exchange rate depreciation. The CORE rule would raise nominal interest rates in response to non-traded goods inflation.

Figure 3 shows the response of the Benchmark economy to a domestic technology shock. Under the PEG rule, neither the exchange rate nor the country risk premium is much affected by the shock. The CORE rule, which tightens monetary policy by less than the PEG rule, leads to a mild depreciation and a mild increase in the country risk premium. The negative technology shock leads to a persistent contraction in consumption, investment, employment and output under each policy. Again, the immediate impact of the shock on output, employment and consumption is milder under the CORE rule than the PEG rule. However, the persistent rise in the country risk premium under the CORE rule implies a more persistent downturn in consumption, investment, employment and output. Investment, which is relatively sensitive to the real interest rate (and, thus, the risk premium), falls significantly more under the CORE rule than under the PEG rule.

IV. Stability: Business Cycle Volatility

In this section, we will explore the contribution of each monetary policy rule to business cycle stabilization. For each economy and policy studied, we draw random shocks and simulate the economy 1000 times, constructing band-pass filtered (see Baxter and King, forthcoming) time series of 120 periods each. The filter admits cycles between 8 and 32 quarters in frequency.

Figure 3. The Response to a Technology Shock



We compare business cycle stability in the Control and Benchmark models under both the inflation targeting CORE rule and the exchange rate stabilizing PEG rule. For each economy and policy, we report the business cycle volatility of the nominal variables (the exchange rate, inflation and the nominal interest rate) as well as real variables (output, consumption, investment, and employment). Abstracting from the benefits of holding real balances, the period by period utility function is monotonically increasing in a weighted average of consumption and labor, Z_t, which we refer to as felicity. Following Schmitt-Grohé and Uribe (2001), we might measure business cycle instability as proportional to the second moments of percentage deviations of the felicity term Z_t (in equation 3) from steady state. The concavity of the utility functions suggests that, all else equal, volatility in the flow felicity reduces expected utility. Near the optimum non-stochastic steady state, a second order approximation of the utility function is proportional to the volatility of felicity, Z_t (see Lucas, 1987). As Schmitt-Grohé and Uribe (2001) note, however, a caveat is in order. In a model with multiple market distortions, as here, the volatility of felicity near steady state remains an incomplete measure of welfare.

Table 1. Moments and Welfare Comparisons

	Control Model		Benchmark Model	
	A. CORE	B. PEG	C. CORE	D. PEG
Nominal Prices				
Nominal Exchange Rate: S	4.29	0.00	19.08	0.00
Nominal Interest Rate: i	0.16	0.21	0.41	0.17
CPI Inflation: π^{CPI}	0.96	0.34	4.01	0.21
Real Aggregates				
Output: Y	1.47	2.44	2.52	1.82
Consumption: C	1.51	4.49	3.81	3.06
Investment: I	6.52	14.34	35.45	9.71
Employment: H	1.69	4.74	2.16	3.19
Felicity: Z	1.06	1.89	3.78	1.38

Though we are most interested in the properties of the Benchmark model, it may be useful, for purposes of comparison, to examine the more traditional Control model under the CORE rule (see Table 1 Column A) and the PEG rule (see Table 1 Column B). Under the PEG rule, the volatility of the nominal exchange rate is zero at all frequencies. Under the CORE rule, we observe volatility in spot exchange rates above 4 percent. As non-traded goods' prices are sticky and move slowly in response to shocks, much of the movement in the CPI is from the volatility of the traded goods' price which is equivalent to the exchange rate. Inflation is thus more volatile under the CORE rule than the fixed exchange rate policy. In the Control model, there is a trade-off between nominal price stability and real stability. There is only one nominal rigidity: non-traded goods' price stickiness. The CORE rule is explicitly devoted to offsetting the inefficient effects of this rigidity. Output, employment, consumption and investment are substantially more stable under CORE rule than under the PEG rule. As a result, felicity, Z_t, is much more stable under an inflation target than a fixed exchange rate. The measure of business cycle instability under the PEG rule is nearly twice as large as under the CORE rule. Thus, the Control model upholds the traditional logic that activist counter-cyclical monetary policy stabilizes the economy more than an exchange rate target.

Compare this with the results under the Benchmark model. In the Benchmark model, the PEG rule leads to greater nominal price stability. The PEG rule, of course, eliminates all exchange rate volatility at all frequencies (see Table 1 Column D). Under the CORE rule, nominal exchange rate volatility in the Benchmark model is far greater than in the Control model (see Table 1 Column C). Because of the feedback between the country risk premium and the spot exchange rate, exchange volatility is greater than 19 percent. The volatility of traded goods' prices leads to greater volatility in overall inflation, which has a standard deviation of 4 percent. However, in the Benchmark model, there is no trade-off between nominal stability and real stability. A fixed nominal exchange rate stabilizes the country risk premium, and, thus, the real interest rate. Output and consumption are substantially more stable under the PEG rule than under the CORE rule. The volatility of investment exceeds 35 percent under an inflation targeting rule but is less than 10 percent under an exchange rate peg. Although employment is more volatile, consumption is much less volatile under the PEG rule. As a result, felicity, a function of business cycle movements in employment and consumption, is substantially less volatile under the exchange rate peg. The measure of business cycle instability under the CORE rule is close to 3 times the cost under the PEG rule.

It is worth noting that the Benchmark model under the PEG rule is more stable than is the Control model under the PEG rule. When exchange rates are fixed, the time varying country risk is a channel that stabilizes the economy. A rise in the world interest rate leads the small open economy to reduce its future external debt. Given a fixed exchange rate, bank capital is a function of lagged debt. Thus, movements in bank capital tend to lag movements in bank liabilities. In an economy with shrinking debt levels, the bank capitalization ratio will be rising and the country risk premium will fall. The fall in the country risk premium offsets the rise in the world interest rate, stabilizing the economy.

V. Robustness: Alternative Parameterizations

Calibrating a model as elaborate as this one involves a number of choices in terms of specifying the economy and choosing parameter values. In this section, we check the robustness of the results against a number of alternative choices. Given the large number of robustness checks that we make, it is useful to select one number to represent the business cycle stability of the economy under either monetary policy rule, CORE or PEG. We report the stability of the felicity term, Z_t, in Table 2 as this might most closely approximate the welfare results of the different policies. Recall that in the Benchmark specification, the volatility of Z_t under the CORE rule is nearly three times the volatility under the PEG rule. Most of the instability in the felicity term under the CORE rule is owing to the external interest rate shocks.

In Table 2 Rows A and B report the volatility when interest rate shocks or technology shocks, respectively, affect the economy. When interest rate shocks are the only source of volatility, the standard deviation of Z_t under the CORE rule is more than three times that under the PEG rule. As shown in Figure 3, the dynamic response of the macroeconomic aggregates to technology shocks is quite similar under both policies. Similarly, the volatility of Z_t is similar under both policies when the only shocks are technology shocks. We also construct a specification in which workers are monopolistic competitors, changing their nominal wages only with some lag (see Cho et al., 1997). Firms in the non-traded sector have flexible and competitive prices in this Sticky Wages specification. The location of this nominal rigidity seems to have little impact on the business cycle stability effects of the various policies. The standard deviation of felicity under the CORE rule is nearly three times that under the PEG rule in the Sticky Wages model as shown in Row C. A second alternative specification eliminates all nominal price rigidities. In the Flexible Price model, only the foreign dollar value of foreign currency debt is fixed. The relative benefits of following inflation targeting rather than fixing the exchange rates are reduced when non-traded goods' prices are flexible. The standard deviation of felicity under the CORE rule is more than 3 times that under the PEG rule in the Flexible Price specification as shown in Row D.

Table 2. Alternative Moments and Welfare Comparisons

	σ_Z		$\frac{\sigma_Z^{CORE}}{\sigma_Z^{PEG}}$
	CORE	PEG	
A. Interest Shocks Only	3.65	1.15	3.17
B. Technology Shocks Only	0.96	0.76	1.26
C. Sticky Wages	3.64	1.25	2.91
D. Flexible Prices	3.76	1.19	3.16
E. High Capital Adjustment Costs	5.17	1.57	3.29
F. Low Capital Adjustment Costs	2.68	1.23	2.18
G. High Intertemporal Elasticity	5.68	2.04	2.79
H. Low Intertemporal Elasticity	1.90	0.98	1.94
I. High Technology Persistence	3.87	2.01	1.93
J. Low Technology Persistence	3.71	1.20	3.09
K. High Elasticity of Substitution	3.64	1.37	2.66
L. Zero Labor Adjustment Costs	3.81	1.38	2.76
M. Equal Capital Intensity	4.98	1.54	3.23
N. Low Debt Levels	0.96	0.80	1.20
O. CPI Targeting	3.39	1.38	2.46

We have chosen parameter values within the range of parameters used in the open economy DGE literature. For a number of parameters, this range may be considered broad. In Table 2 Rows E-J report the relative volatility of felicity in calibrations from nearer the extremes of the range of potential parameters. Rows E and F, respectively, report results from specifications in which capital adjustment costs are very large (the elasticity of the investment-capital ratio with respect to Tobin's q is 2) and very small (the elasticity is 50). Consumption is more volatile when investment is less volatile. Thus, the volatility of felicity is greater when capital adjustment costs are large than when they are small. However, under any of these capital adjustment costs, the standard deviation of felicity under the CORE rule is more than twice the volatility under the PEG rule. Rows G and H report the standard deviation under different specifications of the intertemporal elasticity of substitution. When the intertemporal elasticity of substitution is high, $\psi = 1$, consumption and felicity are more volatile than the Benchmark case; when the intertemporal elasticity is low, $\psi = 5$, consumption and felicity are less volatile. However, under either case felicity is substantially more volatile under a CORE rule than under the PEG rule. The persistence of technology shocks can have important impacts on the dynamic behavior of the economy. However, Rows I and J that felicity is much more volatile under the CORE rule than the PEG rule when the persistence of the technology shock ranges from a low of $\rho^X = .8$ to a high of $\rho^X = 1.0$.

In the Benchmark specification, we have chosen a number of parameters such that a rise in the external interest rate will lead to a decline in the level of output through a shift of resources from the non-traded sector to the traded sector. Because the traded sector is more capital intensive and because of labor adjustment costs, labor demand in the traded sector does not rise as quickly as it falls in the non-traded sector as the equilibrium wage and equilibrium labor decreases. We parameterize the elasticity of substitution between traded and non-traded goods to be relatively low. At this parameterization, an interest rate rise leads to a relatively large contraction in demand for non-traded goods. In Rows K-M, we show that these parametric choices have little effect on our chief result. When the elasticity of substitution is parameterized at $\frac{1}{1-\phi}$ =1.5, the standard deviation of felicity under the CORE rule is nearly three times that under the PEG rule. When we parameterize the model so that labor adjustment costs are zero, the standard deviation of felicity under the CORE rule is nearly three times that under the PEG rule. When we parameterize the model so that both sectors have equal capital intensity, $\theta_T = \theta_{NT} = \frac{1}{3}$, the standard deviation of felicity under the CORE rule is still nearly three times that under the PEG rule. Though the substitutability of traded and non-traded goods, labor adjustment costs, and sectoral capital intensity are important determinants of the response of output to interest rate shocks, they have little impact on consumption, the chief component of felicity.

The Benchmark specification is parameterized such that international debt relative to GDP is at a level similar to that seen in Thailand in the mid-1990's. Thailand and other East Asian economies in the mid-90's had high levels of debt relative to other developing economies and other eras. We examine the stability of felicity when initial debt levels are set at a lower level. In the Low Debt specification, initial external debt is only 20 percent of quarterly GDP or 5 percent of annual GDP. The volatility of felicity in this specification is far lower under both monetary policies. Under the PEG rule, a world interest rate rise that leads to a decline in future debt levels will also raise the bank capitalization ratio and reduce the country risk premium (see Row N). When debt levels are small, a given change in the interest rate will cause large percentage changes in debt. Under the CORE rule, an interest rate rise affects future bank capitalization through two channels. First, both the income and substitution effects of an interest rate rise cause domestic borrowers to reduce their debt levels. The consequent reduction in bank assets relative to net worth, increases the capitalization of banks. Second, through a balance sheet channel, the exchange rate depreciations leads to deterioration in balance sheets and reduce capitalization, which is absent under the PEG rule. When debt levels are large, as in the Benchmark specification, an interest rate change leads to small percentage changes in debt levels, and the second channel dominates. When debt levels are small, an interest rate rise leads to large percentage changes in debt levels, and the first channel dominates.

We also examine the case when the central bank targets the CPI inflation rate.

$$i_t = \psi_1 i_{t-1} + \psi_4 \pi_t^{CPI}, \qquad \pi_t^{CPI} = \frac{CPI_t}{CPI_{t-1}} \tag{19}$$

The parameterization is $\psi_1 = .9$ and $\psi_4 = .11$. In a model in which a single sticky price is the only distortion, an inflation targeting interest rate rule is likely to be most effective when it targets that sticky price. In this model, the non-traded price is sticky. However, we have shown that stabilizing the exchange rate offers benefits owing to the currency mismatch of the banking system. Exchange rate depreciation is equivalent to traded goods' price inflation, an element of CPI inflation. Thus, an interest rate rule that stabilizes CPI inflation will stabilize the nominal exchange rate to a greater degree than will a non-traded inflation targeting policy such as the CORE rule. In Row O, we report the volatility of felicity under the CPI inflation target rule in the first column. The volatility of felicity under the fixed exchange rate is reported in the second column. Implementing a CPI inflation target offers greater stability than the CORE rule. Quantitatively, however, the business cycle volatility under the CPI inflation target is much larger than under the PEG rule.

VI. Conclusion

There has been a long-established understanding in open economy macroeconomics of the advantages of flexible exchange rates in response to external shocks when prices are sticky. A monetary policy that targets inflation can ameliorate the destabilizing effects of sticky prices in a small open economy. Inflation targeting is inconsistent with fixed nominal exchange rates. In an economy in which sticky prices are the only nominal rigidity, an activist monetary rule leads to greater real stability than would a fixed exchange rate.

Many developing economies, however, have a large negative debt position, much of which is denominated in foreign currencies. Using a macroeconomic model with two nominal rigidities (sticky prices and the currency mismatch), we attempt to address an interesting quantitative question about which sort of monetary policy to follow. This paper shows that a pegged exchange rate can offer greater stabilization benefits to such an economy than does a more activist policy, despite the presence of sticky prices. In our model, an exchange rate devaluation causes a deterioration of bank balance sheets, which, in turn, induces a macroeconomic effect that will lead to further exchange rate depreciation under a Taylor-type policy rule. This feedback between the banking system and the macroeconomy leads to an interestingly large exchange rate volatility. An important caveat is that our analysis applies only to a permanent, credible fixed exchange rate. A noncredible exchange rate policy may be prone to speculative attacks.

The model economy in this paper has implications for emerging markets in Asia, in which inflation is moderate, so that offshore debts are dollarized whereas onshore debts are denominated in domestic currency. For economies with high and/or highly volatile inflation, financial intermediation tends to be dollarized through hedging decisions on both sides of a bank's balance sheet (see, for example, Ize and Levy-Yeyati, 1998). Burnside, Eichenbaum, and Rebelo (1999) argue that implicit government guarantees reduce the incentive for banks to engage in any currency hedging. Eliminating such a distortionary policy would reduce the incentive for banks to accept destabilizing currency mismatches. This view stands in contrast to the "original sin" view of liability dollarization expressed by Eichengreen and Hausmann (1999). The latter argue that the lack of opportunities to issue external debt denominated in domestic currency or to hedge foreign currency debt is due to the undeveloped state of financial markets in developing economies.

A. Data Appendix

The data on international debt for Korea and Thailand are taken from the IFR Platinum database. Data on Thailand's debt to developed country banks is taken from the BIS-IMF-OECD High Frequency Debt statistics. Data on National Income accounts for Korea, the Philippines, and Thailand are from the CEIC database. Data on Thai loan rates and Thai bank balance sheets are also from the CEIC database. Data on short-term interest rates and consumer prices for Germany, Japan, and the United States are from International Financial Statistics.

B. The First Order Conditions for the Household

The first order conditions of the household are

$$CPI_t \; \Omega_t \equiv Z_t^{\varrho}$$

$$b\left(\frac{A_t^T}{A_t}\right)^{\phi-1} = \frac{P_t^T}{CPI_t}, \qquad (1-b)\left(\frac{A_t^{NT}}{A_t}\right)^{\phi-1} = \frac{P_t^{NT}}{CPI_t} \tag{A.1}$$

$$\frac{W_t}{CPI_t} = \Gamma H_t^{\gamma}, \qquad \Omega_t \frac{i_t}{1+i_t} = \frac{\chi}{M_t} \tag{A.2}$$

$$1 = \beta E_t\left[(1+i_t)\frac{CPI_t}{CPI_{t+1}}\frac{\Omega_{t+1}}{\Omega_t}\right] \tag{A.3}$$

$$CPI_t \; \Omega_t = \eta_t^T\left(1-\zeta\left(\frac{I_t^T}{K_t^T}-\delta\right)\right) = \eta_t^{NT}\left(1-\zeta\left(\frac{I_t^{NT}}{K_t^{NT}}-\delta\right)\right) \tag{A.4}$$

$$1 = \beta E_t\left[\frac{\left(1-\delta+\frac{I_t^T}{K_t^T}\zeta\left(\frac{I_t^T}{K_t^T}-\delta\right)\eta_{t+1}^T + R_{t+1}^T\Omega_{t+1}\right)}{\eta_t^T}\right] \tag{A.5}$$

$$1 = \beta E_t\left[\frac{\left(1-\delta+\frac{I_t^{NT}}{K_t^{NT}}\zeta\left(\frac{I_t^T}{K_t^T}-\delta\right)\eta_{t+1}^{NT} + R_{t+1}^{NT}\Omega_{t+1}\right)}{\eta_t^{NT}}\right] \tag{A.6}$$

The parameter η_t^T is the shadow value of installed traded goods capital, and η_t^{NT} is the shadow value of installed non-traded goods capital.

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