Currency mismatch and monetary policy in emerging economies

Summer paper

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Abstract

Unable to borrow in their own currency, many emerging markets are faced with liability dollarization and currency mismatch. This leads to adverse balance sheet effects similar to a Fisherian debt-deflation in the event of a sudden stop and exchange rate depreciation. This raises the question whether monetary policy should exhibit fear of floating and limit nominal exchage rate depreciation. Motivated by the experience of Hungary and Romania in 2008, I build a small open economy New Keynesian model where households have currency mismatch. The presence of dollarized debt increases volatility and it makes a sudden stop more harmful for consumption. However, tighter exchange rate management by the central bank, which entails a stricter monetary policy, makes balance sheet effects even worse due to falling nominal incomes. The process of internal devaluation (followed for instance by Southern euro zone members) therefore hurts households more than nominal devaluation even in the presence of currency mismatch. Consequently, in this model free floating and strict inflation targeting remains the preferred monetary strategy.

JEL: E52, F32, F41, F45

1 Introduction

According to the *original sin* theory, put forward by Eichengreen et al. (2005), many small emerging market economies are – to a certain extent – unable to borrow abroad in their own currency. This might be due to poorer institutional setup or worse inflation-fighting track-record which erodes trust in the stability of the domestic currency. As a result, a large portion of the debt of domestic agents is denominated in foreign currency (FCY), a phenomenon called *liability dollarization*, which stands against incomes and assets mainly in local currency (LCY), leading to *currency mismatch* in the balance sheets of these agents. These same countries are also more likely to experience *sudden stops* of capital inflows in case of dropping risk appetite in international financial markets (Calvo et al., 2004) and (Calvo, 2006).

With LCY debt, exchange rate flexibility should ease the adjustment to an external shock (like a sudden stop), especially in the presenece of domestic nominal rigidities. The required real depreciation can be faster with a nominal devaluation than under a fixed exchange rate regime which would require depressing sticky domestic prices (internal devaluation). The latter way is not only slower in stimulting net exports, but leads to higher unemployment and a Fisher type debt-deflation as nominal incomes decline. This causes adverse balance sheet effects for debtors and hurts domestic demand as well. In contrast, nominal devaluation reduces debt in dollar terms, hurting creditors but sparing debtors of the above balance sheet effects.

Against this benchmark, the picture is less clear in the case of currency mismatch. Then even with a floating exchange rate, a country becomes similar to those with a peg in the sense that it does not have control over the currency in which its debt is issued. Therefore, whether it happens through nominal devaluation or domestic deflation, the balance sheet effects of a real depreciation cannot be avoided. By raising the LCY value of dollarized debt, a nominal depreciation has the same effect on FCY-borrowers as a Fisher type debt-deflation: it raises the real burden of debt. This extra mechanism in the exchange rate channel of monetary transmission, which hurts domestic demand, will counteract the usual competitiveness channel which stimulates external demand. Depending on the relative size of these effects, the central bank might want to influence the path of real depreciation by managing the nominal exchange rate more tightly, exhibiting *fear of floating* (Calvo and Reinhart, 2002).

Defending the exchange rate, however, requires a tighter monetary policy stance which, under nominal rigidities, hurts domestic demand in itself (as well as it hinders external adjustment) and might worsen balance sheet effects through rising unemployment and the fall in real incomes. It is therefore not obvious, how tightly monetary policy should manage the exchange rate, so we need a quantitative model to answer that question. [1]

[1] The trade-off here is twofold, which has to be considered by the policymaker. On the one hand, a real depreciation can be expansionary or contractionary depending on whether competitiveness or balance sheet effects dominate. On the other hand, even in the expansionary case, there is a trade-off between protecting consumption (which is unambigously hurt) vs employment.

After the experience of the East-Asian financial crisis in 1997-98 and several Latin American cases like the tequila crisis in 1995, this question has regained relevance during the recent financial crisis in Central and Eastern Europe. This time, however, the situation was different in the sense that it was the households and not the corporate sector with FCY-exposure and that the sudden stop occured in a floating exchange rate environment rather than suddenly breaking through a previously fixed peg. The most illustrative example is Hungary, where in 2008 over 70% of outstanding household debt was denominated in FCY (Krekó and Endrész, 2010), while the country was operating a free floating exchange rate and inflation targeting (IT) monetary policy. Romania was in a similar situation. Yeşin (2013) estimates a currency mismatch index, which was the highest for these two countries among the free floaters in the region. The experience of these emerging economies in response to the sudden stop constituted by the 2008 crisis, were markedly different from other inflation targeters with negligible currency mismatch like the Czech Republic or even the UK. [2] In particular, the fall in their domestic absorbtion was more similar to troubled euro zone members like Spain or Ireland, who also suffered a massive sudden stop as their real estate bubbles went bust.

It is not clear whether this difference can be explained by the presence of currency mismatch. For this we need a model, which could also help answer the question of which monetary policy regime is most beneficial in the case of currency mismatch, depending on the objectives of the policymaker. Hungarian monetary policy, for instance, exhibited fear of floating when in 2008, faced with recessionary forces, it increased interest rates sharply to limit the nominal depreciation, citing financial stability concerns due to the high volume of CHF-mortgages. Would it have been better to totally fix the exchange rate and be already a member of the euro zone, thereby fully shielding FCY-debtors from depreciation? Or would it have helped more to let the currency fall freely which would have allowed a more countercyclical monetary policy and possibly swifter external adjustment? Can the "in-between" managed floating policy of Hungary and Romania be the best of both worlds?

For this purpose, I build a small open economy New Keynesian DSGE model with incomplete markets, including nominal rigidities and currency mismatch. The balance sheet effects arising from currency mismatch are captured through a debt-elastic risk premium which depends on the ratio of the LCY value of FCY debt and domestic nominal income. The New Keynesian setup allows for analysing a continuum of monetary policy regimes in terms of simple Taylor-rules which are believed to describe central bank behavior well. Comparing impulse responses to a sudden stop shock under differnt policy regimes and with or without FCY debt can help isolate the effect of currency mismatch. It can also advise monetary policymakers on the desired degree of fear of floating (exchange rate management), depending on their desired paths for certain macro variables. With a stochastic simulation we can also quantify the variance of certain variables under different setups, which might be used for welfare evaluation later.

[2] Although the UK is not an emerging economy, it can be argued that the burst of its housing bubble and the ensuing drastic deleveraging constrained credit in a similar way to a sudden stop

2 Literature

This paper is related to the literature along several lines. Mendoza (2002) formalized how economies with currency mismatch react to a real depreciation, describing the similarities with Fisherian debt-deflation as increasing debt values make collateral constraints more binding, thereby endogenously amplifying the sudden stop. This has been widely studied since, although in the form of real models, which do not allow for monetary policy analysis.

Another large branch of the literature studies nominal exchange rate policy during financial crises in emerging markets, with the main contributions being Aghion et al. (2001), Céspedes et al. (2004), Elekdag et al. (2005), Devereux et al. (2006), Gertler et al. (2007) or Magud (2010). In these papers currency mismatch is present in the balance sheet of banks or entrpreneurs who invest in capital. They employ a form of the financial accelerator mechanism whereby access to credit depends on the net worth of the borrower. A depreciation in this framework might hurt output through its adverse impact on investment into capital, which was a main feature of the East Asian crisis of 1997-98. However, most of these studies find that the expansionary effect on net exports dominates the adverse balance sheet effects. As Cook (2004) points out, the contractionary effect of depreciations crucially depends on the form of nominal rigidity: whether using sticky prices (faced by FCY-indebted firms) or sticky wages, can influence how a weaker exchange rate affects the price of capital, asset prices and thereby net worth. This also determines whether fixed or floating exchange rate regimes are more stabilizing. [3]

In the above studies currency mismatches can be financially destabilizing because they cause contractions in *output*. A much smaller branch of the literature argues that even if depreciations are not contractionary, they can cause large adjustment in *consumption* if the currency mismatch is present not in the balance sheets of firms/banks, but of households. This describes the 2008 Central and Eastern European situation much better. In this case it is the change in the *value* of domestic income rather than in asset prices, through which the financial friction operates. Ottonello (2015) and Benczúr and Kónya (2015) both use downward wage rigidity, but the former captures balance sheet effects by an occasionally binding foreign debt constraint (which does not allow for perturbation methods), while the latter uses a highly non-linear debt-elastic risk premium function. Benczúr and Kónya (2015) solve the model deterministically, which prevents stochastic analyses. They both find that during a financial crisis in the presence of currency mismatch it is worth for the monetary authorities to somewhat manage exchange rate depreciation.

In this paper, I build a model where households are indebted in FCY. Nominal rigidity comes not from simple wage, but from Calvo-type price stickiness, which allows for richer effects of monetary policy. Instead of occasionally binding debt constraint I use a linearized version of a risk premium function similar to Benczúr and Kónya (2015) and linearize the model to be able to

[3] More recent papers introduce richer financial frictions in the banking sector to allow for analysis of macro-prudential policies and financial stability aspects as well, like Kiyotaki et al. (2016) or Chang and Velasco (2015).

solve it stochastically. To focus on the household and consumption channel, and to keep things simple, I do not include investment and capital or banking sector. The New Keynesian setup lends itself to derive the model in terms of "gaps" which allows for the analysis of a continuum of monetary policy regimes in terms of simple Taylor rules rather than targeting rules.

3 Model

The model is standard small open economy New Keynesian model with monopolistic competition and Calvo-pricing in the spirit of Galí and Monacelli (2005) (GM), however, with incomplete markets. Under incomplete markets imperfect international risk sharing allows consumption to decouple more from the real exchange rate, which is a crucial for our analysis. The incomplete market version of GM was derived, among others, by De Paoli (2009), Benigno and Thoenissen (2008) and Alonso-Carrera and Kam (2016). I rely on these models and introduce currency mismatch through the risk premium function which, unlike in De Paoli (2009), depends on the ratio of hard currency debt in LCY terms and domestic nominal income.

Incomplete markets kill the isomorphism with the closed economy version of the model and introduce irreducable exchange rate dynamics in equilibrium. This leads to an endogenous trade-off in the New Keynesian Phillips Curve, similar to a cost-push shock. Another interesting feature is that the dependence of the risk premium on nominal income renders monetary policy non-neutral under LCY debt even in the flexible price equilibrium – which is not the case under FCY debt.

3.1 Identities, market clearing

The consumption basket of the household is a CES composite of home-produced C_t^H and imported C_t^F good bundles, both of which, in turn, consist of a continuum $i \in [0,1]$ of differentiated goods. The elasticity of substitution between home and foreign goods is η, while that between goods varieties is ε. Home bias in consumption is denoted by γ.

$$C_t = \left[(1-\gamma)^{\frac{1}{\eta}}(C_t^H)^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}}(C_t^F)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \qquad \text{with } \eta > 1, \gamma \in (0,1)$$

$$C_t^H = \left[\int_0^1 C_t^H(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}} \qquad C_t^F = \left[\int_0^1 C_t^F(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

After solving the standard expenditure minimization problems and applying usual definitions for aggregate price indices, we arrive to the following demand functions: [4]

$$C_t^H = (1-\gamma)\left(\frac{P_t^H}{P_t}\right)^{-\eta} C_t \qquad C_t^F = \gamma\left(\frac{P_t^F}{P_t}\right)^{-\eta} C_t \; = \; \gamma Q_t^{-\eta} C_t$$

$$C_t^{H*} = \gamma\left(\frac{P_t^H}{\mathcal{E}_t P_t^*}\right)^{-\eta} C_t^*$$

[4] For details of derivations and log-linearizations a separate appendix is available upon request.

where we have used the assumption that purchasing power parity (PPP) holds for imported goods, i.e. $P_t^F = \mathcal{E}_t P_t^*$. For export, we have local currency pricing in P_t^H, which will be sticky. The real exchange rate is defined as $Q_t = \frac{\mathcal{E}_t P_t^*}{P_t}$. Plugging these into the definition of the CPI, $P_t = \left[(1-\gamma)(P_t^H)^{1-\eta} + \gamma(P_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}}$, we see that imports ($\gamma > 0$) will drive a wedge between the CPI and the PPI (P_t^H), dependent on the real exchange rate:

$$\frac{P_t}{P_t^H} = \left[\frac{1-\gamma}{1-\gamma\, Q_t^{1-\eta}}\right]^{\frac{1}{1-\eta}} \equiv h(Q_t) \tag{1}$$

Goods market clearing is given by $Y_t(i) = C_t^H(i) + C_t^{H*}(i)$ in which we can plug in the usual demand functions and then apply the definition $Y_t = \left[\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}$. Then we arrive at

$$\begin{aligned} Y_t &= \underbrace{(1-\gamma)\left(\frac{P_t^H}{P_t}\right)^{-\eta} C_t}_{C_t^H} + \underbrace{\gamma\left(\frac{P_t^H}{\mathcal{E}_t P_t^*}\right)^{-\eta} Y_t^*}_{C_t^{H*}} = \\ &= [h(Q_t)]^\eta\ \left[(1-\gamma)C_t + \gamma Y_t^* Q_t^\eta\right] \end{aligned} \tag{2}$$

3.2 Households

Risk averse households maximize lifetime expected utility which depends on consumption and leisure. They have access to a domestic asset denominated in LCY (B_t), which cannot be traded internationally. They also have access to a non-state-contingent international asset B_t^* which is denominated in FCY and which pays a gross premium Ψ_t on top of the foreign interest rate $1 + i_t^*$. This describes the incomplete markets setup of the model.

$$\max_{C_t, B_t, B_t^*, N_t} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{N_t^{1+\varphi}}{1+\varphi}\right]$$

$$\text{s.t.} \qquad P_t C_t + \frac{B_t}{1+i_t} + \frac{\mathcal{E}_t B_t^*}{(1+i_t^*)\Psi_t} = \underbrace{W_t N_t + \Pi_t}_{P_t^H Y_t} + B_{t-1} + \mathcal{E}_t B_{t-1}^* \tag{3}$$

The first order conditions are standard:

$$\text{LCY Euler:} \qquad 1 = \beta\, \mathrm{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \underbrace{\frac{1+i_t}{1+\mathrm{E}_t \pi_{t+1}}}_{1+r_t} \tag{4}$$

$$\begin{aligned} \text{FCY Euler:} \qquad 1 &= \beta\, \mathrm{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{(1+i_t^*)\Psi_t}{1+\mathrm{E}_t \pi_{t+1}} \frac{\mathrm{E}_t \mathcal{E}_{t+1}}{\mathcal{E}_t} = \\ &= \beta\, \mathrm{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} (1+r_t^*)\Psi_t \frac{\mathrm{E}_t Q_{t+1}}{Q_t} \end{aligned} \tag{5}$$

$$\text{labor supply:} \qquad N_t^\varphi C_t^\sigma = \frac{W_t}{P_t} \tag{6}$$

Combining (4) and (5) gives us the UIP condition (no-arbitrage between foreign and domestic assets, even under incomplete markets) in nominal or real terms: $1 + i_t = (1+i_t^*)\Psi_t \frac{\mathrm{E}_t \mathcal{E}_{t+1}}{\mathcal{E}_t}$ and $1 + r_t = (1+r_t^*)\Psi_t \frac{\mathrm{E}_t Q_{t+1}}{Q_t}$

Assuming a symmetric foreign Euler-equation and combining it with the real UIP, we get in log-linearized terms that under imperfect international risk sharing $\sigma(\mathrm{E_t}c_{t+1}-c_t) = \sigma(\mathrm{E_t}y^*_{t+1}-y^*_t)+\psi_t + \mathrm{E_t}\Delta q_{t+1}$. This gives us a much less tight link between consumption and the real exchange rate than under the complete markets version of Galí and Monacelli (2005) with $\sigma c_t = \sigma y^*_t + q_t$.

From the budget constraint of the household (3) and using that in equilibrium $B_t = 0$ must hold, we can derive the external balance of payments equation in terms of domestic output:

$$\frac{\mathcal{E}_t}{P_t^H}\left[\frac{B_t^*}{(1+i_t^*)\Psi_t} - B_{t-1}^*\right] = Y_t - \frac{P_t}{P_t^H}C_t \tag{7}$$

With B_t^* being the net foreign asset (NFA) position of country, this shows that the financial account balance (change in NFA) must be equal to the current account balance (net exports plus net interest income). If a country has net external debt in FCY ($B_t^* < 0$), then a real depreciation or a rise in the risk premium will raise interest payments on debt which will require some combination of current account adjustment and/or extra foreign borrowing. This will depend on the size and persistence of these shocks and the intertemporal elasticity of substitution of the household.

3.3 Risk premium

The balance sheet effects of currency mismatch are captured through the risk premium function Ψ_t. This is the most significant departure from De Paoli (2009) who does not account for this effect. A depreciation causes problems for FCY-indebted households mainly by increasing the LCY value of dollarized debt relative to their nominal income in LCY. This makes monthly debt payments harder which increases non-performing loan ratios. Therefore, instead of making the premium dependent explicitly on net worth which makes more sense in the case of firms, here we will use the ratio of FCY debt (in LCY terms) and nominal income – an approach similar to Benczúr and Kónya (2015) except for the less non-linear specification.

$$\Psi_t = e^{-\delta\left(\frac{\mathcal{E}_t B_t^*}{P_t^H Y_t} - \chi_t\right)} \tag{8}$$

$$\chi_t = (1-\rho_\chi)\chi + \rho_\chi \chi_{t-1} + \varepsilon_t^\chi \tag{9}$$

where χ captures some level of NFA to GDP ratio which is tolareted by international markets by a zero risk premium. ε_t^χ can act as a sudden stop shock when this tolerance changes and markets are less willing to lend. Note that the first-order effects of a real depreciation crucially depend on whether the curency mismatch occurs due to liability or asset dollarization (in this setup, whether the country is a net debtor $B_t^* < 0$ or creditor $B_t^* > 0$ in FCY).

To construct a benchmark case without currency mismatch we assume that external debt can be issued in LCY, so $\mathcal{E}_t B_t^* = B_t^*$. This yields the following premium function:

$$\Psi_t^D = e^{-\delta\left(\frac{B_t^*}{P_t^H Y_t} - \chi_t\right)} \tag{10}$$

Note that in the benchamrk case monetary policy is not neutral even under flexible prices: the evolution of P_t^H clearly influences the risk premium which affects other real variables. With nominal (non-indexed) LCY debt the real value of debt depends on prices. This is not the case with FCY debt, the real value of which depends on the real exchange rate (and exogenous foreign prices), which is independent of monetary policy under flexible prices.

3.4 Firms

Monopolistically competitive firms produce differentiated products, which gives them pricing power but profit maximization is subject to the demand functions of households. Calvo-type nominal rigidities mean that each period only a fraction θ of firms is able to adjust prices P_t^H. The production technology is a CRS, using only labor. The problem is therefore entirely analogous to the baseline closed economy New Keynesian model, except for the definition of marginal costs.

$$Y_t(i) = A_t N_t(i) \qquad\qquad N_t = \int_0^1 N_t(i)\mathrm{d}i \tag{11}$$

Under flexible prices we obtain the usual pricing condition that real wages are a constant markup below marginal product, depending on the substitutability of the firm's product ε and a tax rate τ. Equivalently, real marginal costs are constant

$$RMC_t^n = \frac{W_t}{A_t\, P_t^H} = \frac{\varepsilon - 1}{\varepsilon}\frac{1}{1-\tau} \equiv \frac{1}{\mathcal{M}} \tag{12}$$

Under sticky prices markups will be time-varying. Log-linearizing (12) and plugging in the log-linear versions of (6), (1), (11) and (2), then subtracting the steady state version of the equation we get that the log deviation of real marginal costs from their steady state is:

$$-(\mu_t - \mu) = \widehat{rmc_t} = \underbrace{\frac{\sigma + \varphi(1-\gamma)(1+aa)}{(1-\gamma)(1+aa)}}_{\kappa_1}\widetilde{y}_t + \underbrace{\left[\frac{\gamma}{1-\gamma} - \sigma\eta\left(\frac{1}{(1-\gamma)^2(1+aa)} - 1\right)\right]}_{\kappa_2<0}\widetilde{q}_t \tag{13}$$

where $\widetilde{y}_t$ and $\widetilde{q}_t$ are the output gap and real exchange rate gap, respectively, and $aa = \frac{\gamma(C-Y^*)}{Y} < 0$ is a parameter which is a result of linearizing around the non-symmetic steady state with $B^* < 0$. The open economy channel is captured by κ_2: a depreciation raises import prices which makes workers demand higher wages, pushing up real marginal costs by $\frac{\gamma}{1-\gamma}$. By incomplete markets, however, households cannot fully insure against the drop in their purchasing power, which prompts them to work more, depressing wages and real marginal costs by the second term in κ_2. The overall effect is negative under reasonable parameter values.

The optimal pricing decision of the firm under sticky prices is given by the same formula as in Galí and Monacelli (2005) which, after substituting (13), yields the New Keynesian Phillips Curve:

$$\pi_t^H = \beta\,\mathrm{E_t}\pi_{t+1}^H + \underbrace{\frac{(1-\beta\theta)(1-\theta)}{\theta}}_{\lambda}\widehat{rmc_t} = \beta\,\mathrm{E_t}\pi_{t+1}^H + \lambda(\kappa_1\widetilde{y}_t + \kappa_2\widetilde{q}_t) \tag{14}$$

(14) demonstrates that, as in Alonso-Carrera and Kam (2016), the exchange rate is no longer a reducable variable in the incomplete markets equilibrium, hence the model is not isomorphic to the closed economy version. We can also see the endogenous trade-off arising in the NKPC.

3.5 Monetary policy

Monetary policy is characterized in terms of the widely used Taylor-rule.

$$i_t = \rho + \phi_\pi \pi_t^H + \phi_x \widetilde{y}_t + \phi_e \Delta e_t + v_t \tag{15}$$

We can explore different policy regimes by different values for the reaction parameters. In a fully domestic focused PPI inflation targeting regime $\phi_e = 0$. The most widely used CPI inflation targeting rule has $\phi_e = \frac{\gamma}{1-\gamma}\phi_\pi$ which follows from using the linearized and rearranged version of (1).[5] In other words, a CPI inflation targeting central bank has to react to exchange rate movements insofar as the pass through to import prices affects the CPI, but otherwise they have freely floating exchange rates. Increasing ϕ_e above this value leads us to a managed floating exchange rate regime where monetary policy reacts to a nominal depreciation *over and above* its direct inflationary effect. As $\phi_e \to \infty$, we get the fully fixed exchange rate regime.

Under "strict" inflation targeting monetary policy $\phi_\pi \to \infty$, which fully stabilizes prices (CPI or PPI). Flexible inflation targeting rules (believed to be used by most central banks) are captured by a lower value for ϕ_π while assigning some positive weight ϕ_x to output gap stabilization.

3.6 Equilibrium

The equilibrium conditions are log-linearized around the non-symmetric steady state with net external debt $B^* < 0$. The steady state real exchange rate is normalized to $Q = 1$.[6] Then, the first-order approximated equilibrium dynamics in the neighborhood of this steady state are described by the linear versions of equations (1), (2), (4), (5), (6), (7), (8), (9), (11), (14) and (15) plus exogenous AR1 processes for $a_t, v_t, y_t^*, r_t^*, \pi_t^*$. To be able to derive "gaps" in the NKPC, we also solve the flexible price equilibrium with the same equations but (12) instead of (14). The benchmark case of no currency mismatch uses (10) instead of (8). Definitions of the real exchange rate and inflation are also needed.

This completes the description of the model.

[5] This is $\pi_t = \pi_t^H + \frac{\gamma}{1-\gamma}\Delta q_t = (1-\gamma)\pi_t^H + \gamma\Delta e_t + \gamma\pi_t^*$. Then the CPI-targeting rule would be like $i_t = \rho + \underbrace{\phi_\pi^{CPI}(1-\gamma)}_{\phi_\pi} \pi_t^H + \phi_x\widetilde{y}_t + \underbrace{(\phi_e^{CPI} + \phi_\pi^{CPI}\gamma)}_{\phi_e} \Delta e_t + \phi_\pi^{CPI}\gamma\pi_t^* + v_t$ with $\phi_e^{CPI} = 0$ (i.e. not reacting to the exchange rate over and above its direct inflationary impact) and assuming $\pi_t^* = 0$.

[6] This is just to make log-linear approximations simpler as in De Paoli (2009). This normalization prohibits to choose freely either the steady state foreign demand Y^* or the domestic tax rate τ, but those cause less trouble and do not affect the dynamics of the system anyway.

4 Results

4.1 Parametrization

The parameters are from Galí and Monacelli (2005) and De Paoli (2009) with the exception of δ, χ, ρ_χ and the policy parameters. The large persistence of the sudden stop shock helps mimic a binding borrowing constraint, as forward-looking agents see that funding will stay scarce long ahead, so they rather start deleveraging than smooth consumption.

β	0.99	φ	0.47	δ	0.1	θ	0.75	ϕ_e	$\frac{\gamma}{1-\gamma}\phi_\pi$	ρ_y	0.86	ρ_π	0.5
ρ	$\frac{1}{\beta}-1$	γ	0.25	χ	-1.5	ϕ_π	1.5	ρ_a	0.66	ρ_r	0.5	aa	$(1-\beta)\chi$
σ	2	η	1.5	ε	6	ϕ_x	0.1	ρ_v	0.5	ρ_χ	0.95		

Table 1: Baseline Parameters under flexible CPI targeting

4.2 Impulse responses

In our baseline scenario we explore the economy's reaction with currency mismatch to a sudden stop shock under flexible CPI inflation targeting monetary policy. The shock raises the risk premium which leads to a nominal and real depreciation. The central bank reacts to the inflationary impact of a weaker exchange rate and positive future output gaps by increasing the real interest rate which in turn drags down consumption. Real depreciation boosts exports while the fall in consumption drags down imports, and the resulting trade balance improvement dominates falling domestic demand, so GDP increases. Hence, depreciation is still expansionary, as Figure 1 shows.

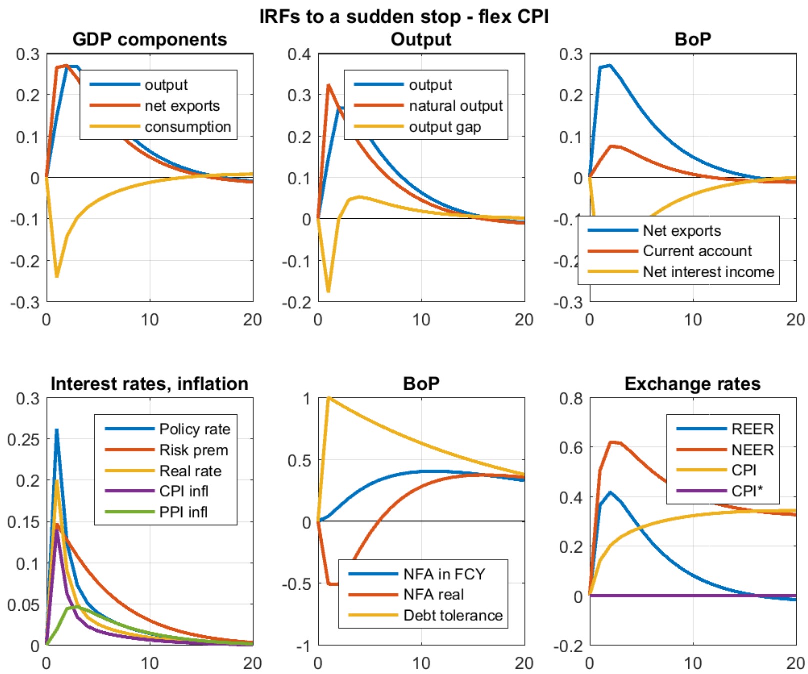

Figure 1: Impulse responses to a sudden stop under flexible CPI targeting

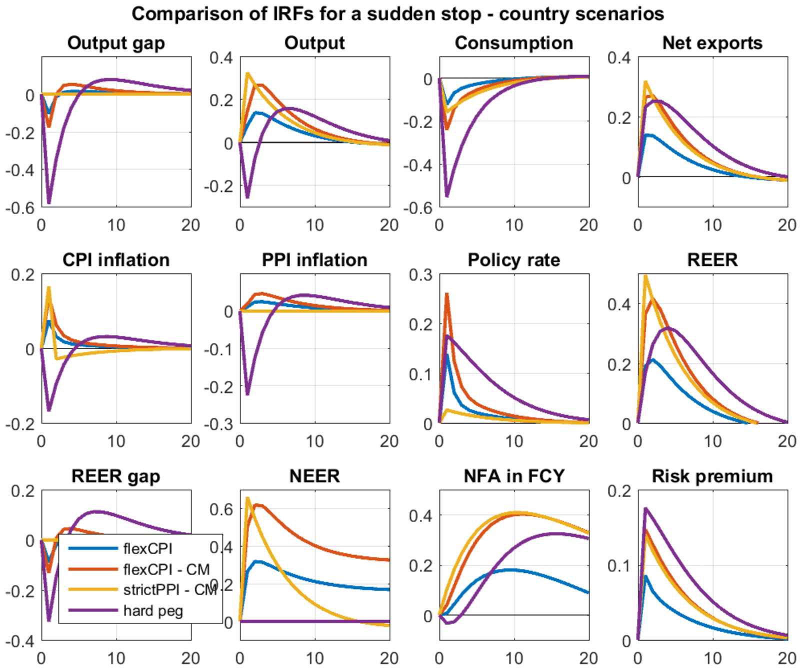

Figure 2: Impulse responses to a sudden stop for different settings

Even with higher debt interest payments we see a current account adjustment which leads to gradually improving NFA position (i.e. deleveraging) as foreign markets now tolarate lower debt levels. The real burden of external debt, however, is increasing due to the real depreciation. [7]

Figure 2 compares different monetary strategies and market settings. First, we see that without currency mismatch (blue lines) the weaker nominal exchange rate does not feed back to the premium function which makes the depreciation pressure smaller in the first place. This requires a less strict monetary stance which hurts consumption less than under currency mismatch (red lines). The external adjustment is also less sharp as with a smaller risk premium households can afford to smooth their consumption more.

This might suggest that stabilizing the nominal exchange rate could spare the economy of these adverse balance sheet effects stemming from currency mismatch, since in that case there is no difference between LCY and FCY debt. However, Figure 2 also shows that with currency mismatch tighter exchange rate management (from the fully domestic-focused strict PPI targeting through flexible CPI targeting to a fixed exchange rate) leads to worst outcomes in consumption and output, while stimulating exports similarly. The stickier process of internal devaluation (through domestic deflation) makes the real depreciation less sharp, but defending the nominal exchange rate and forcing sticky domestic prices down instead requires such a strict monetary policy which will depress domestic demand much more, actually causing a recession.

Despite the similar trade balance improvement (which is achieved by importing less rather than by more competitive exports) the external adjustment is more gradual under a fixed exchange rate because much higher debt interest payments weigh on the current account. This is because

[7] Note that even as real consumption falls, import becomes more expensive in terms of domestic output due to real depreciation, so the *value* of consumption does not necessarily fall by much, making net exports drive GDP.

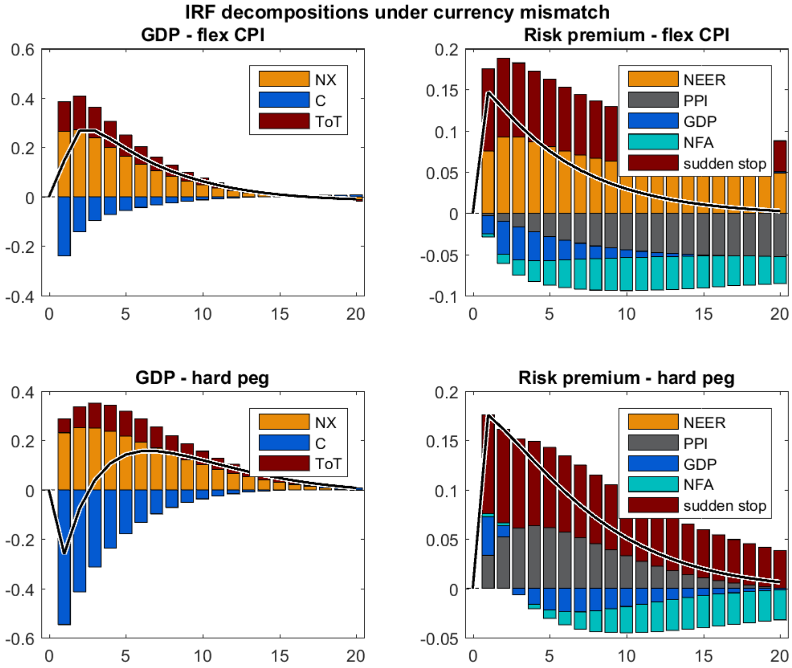

Figure 3: IRF decompositions for different policies

the risk premium increased more, which also illustrates the narrative of the euro zone crisis that a sudden stop can manifest itself not only in a currency crisis but also by driving up interest rates drastically. Figure 3 explains the dynamics behind this. Even though a currency peg eliminates adverse balance sheet effects coming from nominal depreciation, the fall in nominal incomes (and the slower NFA adjustment) will more than offset this gain, thereby yielding a higher premium. This further depresses consumption and nominal incomes, feeding back to higher premium. It can also be seen in the left panels of Figure 3 how the similar improvement in net exports under a peg is dominated by the more drastic fall in domestic demand leading to falling real incomes and falling employment.

All these results show us that although a smaller nominal depreciation protects FCY-indebted households in itself, balance sheet effects are actually worse due to the much lower path of nominal incomes brought about by tighter monetary policies required to manage the exchange rate. Therefore, even in the presence of currency mismatch, letting the nominal exchange rate depreciate in the face of a sudden stop is more beneficial for consumption than fixing it and forcing the economy to go through the painful experience of internal devaluation. In this sense, the policy prescription given by this simple linear model (under the current parametrization) is the same as without currency mismatch, i.e. that flexible exchange rates are more desirable than currency pegs in the case of external shocks. The potential trade-off between protecting consumption vs employment does not materialize since the balance sheet effects of nominal depreciation are smaller than those of falling nominal incomes in the case of a currency peg. This is why defending the exchange rate does not help in protecting consumption, while it definitely makes the employment situation worse.

On the other hand, the model highlights how, under a *given* inflation targeting regime, the presence of currency mismatch makes the shock more harmful to consumption relative to the case with LCY-debt.

4.3 Simulation

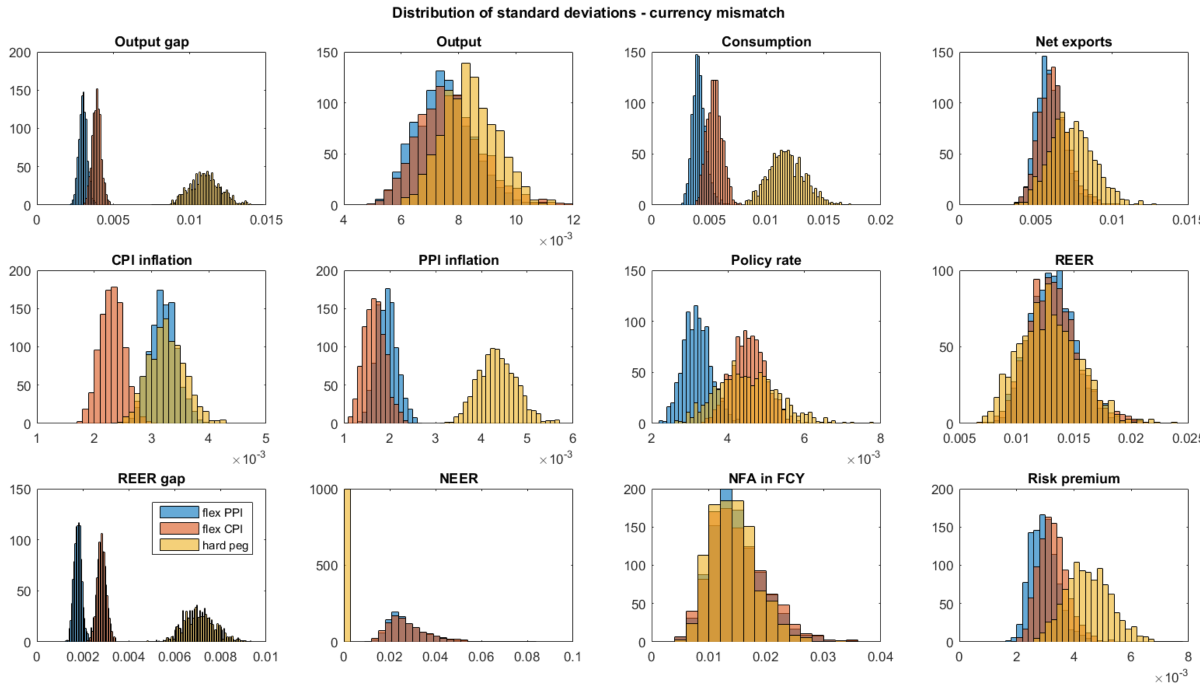

Figure 4: Distribution of standard deviations

In order to assess welfare properties of different policy regimes, we need to look at second moments of variables. Absent a second-order approximation to the model, a Monte Carlo simulation with our linearized system will also produce variances which are informative in the neighborhood of the steady state.[8] $N = 1000$ simulations are made for 120 quarters by drawing from a distribution of TFP, foreign demand and sudden stop shocks with standard deviations $\sigma_a = 0.0071, \sigma_y = 0.0078$ and $\sigma_\chi = 0.01$, respectively, the first two being from GM2005.

Compared to the case of LCY-debt, the presence of currency mismatch creates higher volatility in most of the variables under all policy regimes, except the fixed exchange rate. The feedback of the nominal exchange rate into balance sheet effects explains this phenomenon. Figure 4 compares different policy regimes under currency mismatch. It can be seen that, in line with the suggestions from the IRF analysis, PPI inflation targeting stabilizes consumption, output gap and real exchange rate gap the most, while a currency peg causes the highest volatility. CPI inflation targeting performs the best in stabilizing both CPI and PPI inflation.

[8] These variances could be evaluated with a welfare loss function, which is usually a second order approximation to the utility of the household. It is, however, beyond the scope of this paper to derive such a second-order approximation which is why, for now, we only compare variances.

4.4 Data

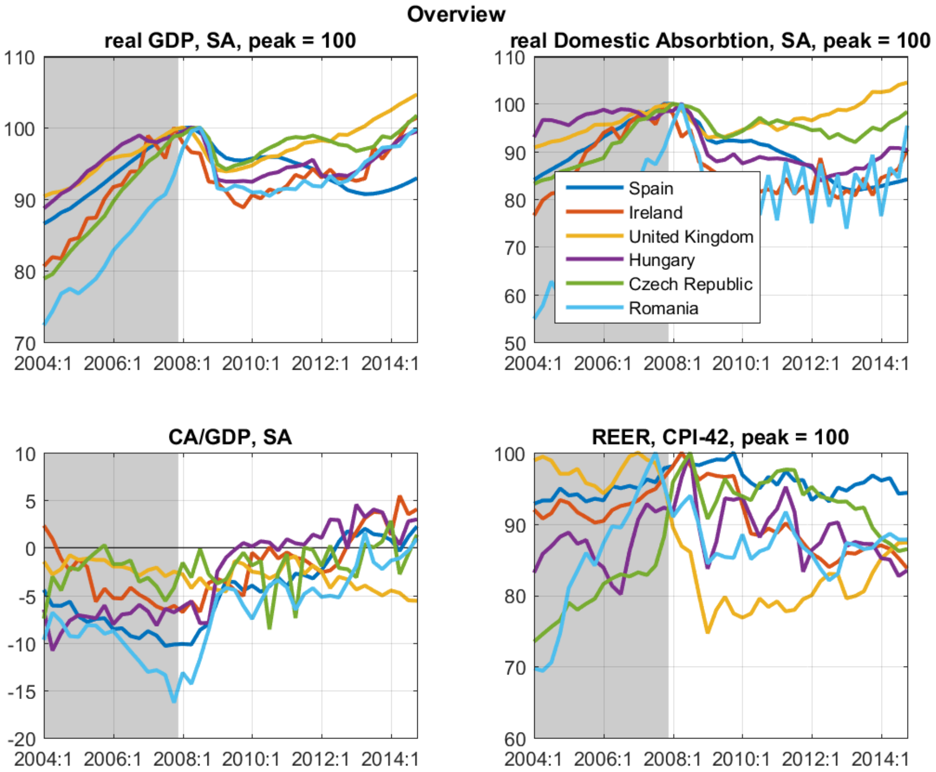

Figure 5: Data (source: Eurostat)

Following the motivation from the Introduction we look at macro time series of Hungary and Romania as countries with substantial currency mismatch under a flexible CPI targeting monetary regime. The Czech Republic and the UK illustrate the benchmark inflation targeting economy without a currency mismatch. Spain and Ireland are examples of currency peggers experiencing a large sudden stop as the 2008 crisis broke out. [9]

For euro zone members the sudden stop generated a less sharp real depreciation than for IT countries, but the internal devaluation caused adverse balance sheet effects through debt-deflation, hurting domestic demand very much. The sudden stop manifested itself in higher risk premiums rather than in a currency crisis and the relative tightness of monetary policy (required to remain in the euro) also weighed on demand. Free floater CZ and UK, on the other hand, went through a much smaller drop in their domestic absorbtion. The Central and Eastern European inflation targeters with currency mismatch performed much more similarly to euro zone members in this respect: the adjustment of Hungarian and Romanian consumption was larger than in the Czech Republic as depreciation hurt the balance sheet of housholds with CHF and EUR mortgages.

The current account adjustment was sharpest in Hungary and Romania, as currency mismatch adversely affected demestic demand. Even though domestic absorbtion dropped similarly in euro members, their CA-adjustment was more gradual due to a bigger increase in interest payments. For inflation targeters without currency mismatch no significant external adjustment is observed,

[9] The UK, Spain and Ireland are not emerging economies, but the busts of their housing bubbles also prompted a severe deleveraging process and credit tightening.

which is line with previous arguments that with LCY-debt a nominal depreciation erodes the dollar value of external debt which is why real savings do not need to be increased that much.

If we compare Figure 5 with impulse responses in Figure 2, we can see that the model replicates some important features of the time series. In particular, we have that fall in consumption with currency mismatch (HU) is between that of no currency mismatch (UK, CZ) and fixed exchange rate (IE). The real depreciation is also sharper for inflation targeters than for currency peggers (inside the euro). The degree of CA-adjustments (change in NFA) also decreases from currency mismatch countries (HU, RO) through fixed exchange rate (ES, IE) to economies with LCY-debt (CZ, UK). The pattern of output responses in the data, however, is not captured correctly by the model, which predicts better outcomes with currency mismatch than without. This is because the larger real depreciation stimulates net exports much more in this case. These results are robust to a change in the REER-elasticity of net exports (η) as well as including a foreign demand shock ε_t^y. Of course, these time series are meant only as an illustration of the model, and in reality many aspects of these economies (parameter values, sizes and nature of the shocks) can be different. Another explanation can be that Hungary and Romania were managing the exchange rate more tightly than what would have followd from a flexible IT rule. However, some future improvements in the model might also improve fit for output paths such as inclusion of imported inputs in production, wage rigidities or investment in capital.

5 Conclusion

In this paper I have built a small open economy New Keynesian model where the presence of currency mismatch in the balance sheets of households introduces Fisherian debt-deflation dynamics in the event of a real depreciation. Currency mismatch increases the volatility of most variables and in response to a sudden stop it leads to higher risk premiums and a larger fall in consumption than with LCY debt. These adverse balance sheet effects are, however, dominated by the usual competitiveness effects in the exchange rate channel of monetary transmission, so a depreciation is still expansionary even though consumption is hurt.

The potential urge for monetary policy to exhibit fear of floating under currency mismatch does not arise here. This is in contrast to the results of Benczúr and Kónya (2015) and Ottonello (2015) where a small degree of exchange rate management is desirable if policymakers care about defending consumption. In the present model, under currency mismatch the central bank is not faced with a trade-off between protecting employment vs consumption (or financial stability due to FCY-indebted households). This is because even though a more rigid nominal exchange rate limits balance sheet effects arising from nominal depreciation, it makes them much worse "through the back door" by tighter monetary policy and falling nominal incomes. Hence, even under currency mismatch consumption is best protected by a free floating exchange rate regime, which also leads to the best employment outcomes in this model.

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