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Monetary policy in a dollarized economy where balance sheets matter ☆

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Abstract

Does the dollarization of liabilites and the resulting balance sheet vulnerability prevent monetary policy from serving its conventional countercyclical role? We study this question in a model of a small open economy in which domestic firms face an imperfect capital market, with risk premia depending on net worth as in Bernanke and Gertler [Am. Econ. Rev. 79 (1989) 14.]. In spite of the financial fragility channels present in the model, the conventional wisdom still holds: under a floating exchange rate, countercyclical monetary policy does help cushion the impact of foreign real shocks. © 2001 Published by Elsevier Science B.V.

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1. Introduction

Monetary and interest rate policy remains the most contentious aspect of the response to the recent crisis in Asia and other emerging markets. Many analysts, led by the IMF's Stanley Fischer, contended that stopping the collapse of national

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currencies was priority number one; confidence, a reversal of capital flows, and growth would follow. Referring to the 1995 example of Mexico, Dornbusch (1998) wrote:

> Mexico fully implemented a stark US-IMF program of tight money to stabilize the currency and restore confidence. Starting in a near-meltdown situation, confidence returned and within a year the country was on the second leg of a V-shaped recovery. The IMF is unqualifiedly right in its insistence on high rates as the front end of stabilization.

Not everyone agreed. The attack on high rates was spearheaded by Joseph Stiglitz, then the Chief Economist at the World Bank, whose objections included the "traditional criticism" of tough policies monetary to defend a fixed exchange rate, namely that they are too costly in terms of output or employment. But the concerns went further, since in East Asia and elsewhere such policies seemed not only to be painful, but also ineffective. Notably, the 1998 Global Economic Prospects published by the World Bank worried that high interest rates had little success in reducing pressure on currencies or stabilizing investor confidence, while at the same time imposing large output costs. This was the case whether the initial package entailed new agreements with the multilateral institutions (Indonesia, Korea and Thailand) or not (Malaysia and Philippines).[2]

That the Chief Economist of the World Bank should be disagreeing with his institution's own policies was peculiar. Even more peculiar was that this debate should be taking place at all. After all, monetary policies are supposed to be used countercyclically: in the Mundell–Fleming world, under flexible rates or an adjustable peg, a monetary expansion is called for to offset an adverse shock to productivity or world demand. But what the IMF and Dornbusch were advocating was a *pro*cyclical monetary policy: tightening in response to adverse shocks.

They were not alone in this advocacy, for procyclical policies are apparently what many policy-makers prefer. Not only did the Asian countries eventually tighten in response to adverse shocks, both internal and external. In response to the 1997–1998 external shocks, most Latin American countries (including those that were nominally floating such as Mexico, Peru, and to a lesser extent Chile) used tight money and high interest rates to prop up their currencies.[3] Gavin et al. (1999) and Calvo and Reinhart (2000) have documented this pattern in a systematic manner for most emerging markets.

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[2] Arguably these problems resulted from policies that were "too little, too late." Corsetti et al. (1998), in particular, maintain that the common perception that high interest rates were the prevalent East Asian response to the crisis is a half-truth at best. The IMF insisted on the policy, but whether countries followed it is a different matter. There is also an issue of timing. Tight money was adopted with much delay in several countries.

[3] Things have changed more recently, with Chile and Colombia relaxing monetary policy and going for a clean float, with the resulting nominal and real depreciation.

Why do policymakers behave the way they do, contravening conventional wisdom? Mostly because of the fear that devaluation would cause financial distress. Suppose that domestic firms have borrowed in dollars, and that at least some of them are in the non-traded goods sector and have earnings in local currency. Then a monetary expansion and the accompanying nominal devaluation can drastically increase the carrying costs of the dollar debt, generating a wave of bank and corporate bankruptcies. This danger has been stressed in some interpretations of the Asian crisis—particularly that of Corsetti et al. (1998) and Krugman (1999). In the coinage of the latter, it is *balance sheet vulnerability* that prevents a more relaxed monetary stance and the accompanying devaluation.

While such balance sheet effects are plausible, economists are far from understanding them and their implications for monetary policy. Accordingly, this paper is an attempt to shed some light on this subject. We study whether, in a small open economy, balance sheet vulnerability can ever cause monetary policies to have the opposite effects than standard models predict. In particular, we ask whether contractionary balance sheet effects can more than offset the conventional Mundell–Fleming expansionary effect of unanticipated monetary growth. And whether, in the presence of balance sheet effects, monetary policy can be used in standard counter-cyclical fashion to cushion the domestic effects of real external shocks.

The short answer is that, in the model we build, monetary policy can still do what it is supposed to do. Unanticipated increases in the money supply increase domestic output both on impact and, through an increase in investment, in the subsequent period. This feature of monetary policy can be used to offset real shocks, though not completely: there is no money supply response that can keep output constant in all periods. These conclusions hold in spite of the fact that devaluation has a harmful effect on the carrying cost of external debt.

We study these issues in the context of a simplified, two-period version of the model in Céspedes et al. (2000, henceforth CCV). The setting is an open economy with home and foreign goods. The former is produced using the labor services supplied by wage-setting, monopolistic, labor suppliers. Capital accumulation is allowed and plays a crucial role in the analysis. To allow for balance sheet effects and related financial distortions, we assume that

- External debt is denominated in terms of foreign goods, and hence a real depreciation increases the debt burden in terms of home goods. This is the analytical equivalent of the “dollarization of liabilities” discussed by Calvo (1999) and others.
- Foreign goods are inputs in domestic investment. As a consequence, a real depreciation makes domestic investment relatively more expensive and, as in Krugman and Taylor (1978) and Lizondo and Montiel (1989), may reduce investment and output.
- Most importantly, domestic firms face an imperfect capital market, with risk premia depending on their net worth along the lines of Bernanke and Gertler

(1989). Hence, a real devaluation could reduce the value of this net worth and thereby increase the risk premia faced by local firms when borrowing abroad.

Monetary policy has real effects since money wages are set in advance. Assuming flexible exchange rates throughout, we focus on the transmission of unanticipated money supply changes to the rest of the economy in the presence of balance sheet vulnerability. This is in contrast with CCV, whose only concern was the choice between exchange rate regimes.[4] Aside from its policy relevance, the theoretical interest of the exercise is that, in an open economy, the existence of dollarized liabilities means that monetary policy has effects on balance sheets that are absent in the closed economies studied by Bernanke and Gertler (1989) and others. In a closed economy an unanticipated monetary increase, by reducing real interest rates, raises asset prices (including the firm's own value) and boosts current income; both effects are expansionary, as they improve net worth. In an open economy, by contrast, monetary increases can potentially reduce net worth because the associated devaluation may increase the relative burden of extant dollar obligations.

In our model, a temporary monetary expansion causes a temporary real exchange rate depreciation. The depreciation has the standard beneficial effects: it switches demand toward home goods and it reduces the nominal and real interest rate (more precisely, the own-rate of return on home goods), increasing investment and output. On the other hand, it has novel and contractionary effects: it causes financial distress because of the associated fall of net worth and it could potentially bring about an increase of the country risk premium. Nevertheless, these balance sheet effects are not sufficient to overturn the standard effects, and expansionary monetary policy turns out to be expansionary.

We also consider the effects of monetary policy in the face of two kinds of shocks: temporary increases in the world real rate of interest and temporary declines in the rest of the world's demand for the home country's exports. In the absence of countercyclical policy, these shocks induce a persistent fall in investment and home goods output. We show that, in spite of the financial fragility channels present in the model, the conventional wisdom still holds: under a float, countercyclical monetary policy helps cushion the impact of the shocks.

The paper is organized as follows. Section 2 presents the basic model. The model is highly nonlinear, but it is relatively easy to find a loglinear approximation; Section 3 discusses how. Taking advantage of such an approximation, Section 4 analyzes the effects of unanticipated monetary policy, and Section 5 analyzes monetary responses to real external shocks. Section 6 concludes.

[4] A further departure from CCV is that, to be able to discuss the impact of alternative monetary policies, here we model the monetary side of the economy explicitly.

2. The model

Consider a simplified version of the model in CCV. There are two periods indexed by $t = 0, 1$. Our focus is on a small open economy populated by *workers* and *capitalists*. These agents consume and, in the case of capitalists, invest a composite of a home good and a foreign good. The crucial element of the model is that investment is subject to financial frictions, as in the pioneering work of Bernanke and Gertler (1989).

2.1. Domestic production

The home good is produced in a competitive sector. The typical firm in this sector has access to a standard Cobb Douglas production function. Aggregate production then satisfies

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha}, \tag{2.1}$$

where Y denotes home output, K is the aggregate capital input, L is the aggregate labor input, and A is a constant productivity coefficient.

As in Obstfeld and Rogoff (2000), we assume that workers are heterogeneous, and that therefore L_t is a C.E.S. aggregate of the labor of different workers

$$L_t = \left[\int_0^1 L_{it}^{\frac{\sigma-1}{\sigma}} \mathrm{d}i \right]^{\frac{\sigma}{\sigma-1}}, \qquad \sigma > 1, \tag{2.2}$$

where we have indexed workers by i in the unit interval, and L_{it} denotes the services purchased from worker i. Under this specification, σ is the elasticity of demand for worker i's services.

Each firm maximizes profits subject to Eqs. (2.1) and (2.2), and market prices. The solution yields the familiar expressions for capital and labor income

$$R_t K_t = \alpha P_t Y_t, \tag{2.3}$$

$$W_t L_t = (1-\alpha) P_t Y_t, \tag{2.4}$$

where R is the rental rate of capital, expressed in domestic currency (henceforth, the peso), P is the peso price of home output and, if W_i is the price of worker i's labor,

$$W_t = \left[\int_0^1 W_{it}^{1-\sigma} \mathrm{d}i \right]^{\frac{1}{1-\sigma}},$$

is the aggregate wage (the cost of a unit of labor input). Clearly, equilibrium requires that profits be zero.

Finally, the firm's problem implies that the demand for worker i's labor is

$$L_{it} = \left(\frac{W_{it}}{W_t} \right)^{-\sigma} L_t. \tag{2.5}$$

2.2. Workers

Worker i maximizes the expectation, as of time 0, of

$$\sum_{t=0}^{1} \left\{ \log C_{it} - \left(\frac{\sigma - 1}{\sigma} \right) \left(\frac{1}{\upsilon} \right) L_{it}^{\upsilon} + \left(\frac{\kappa}{1-\phi} \right) \left(\frac{M_{it}}{Q_t} \right)^{1-\phi} \right\} \beta^t, \tag{2.6}$$

subject to the budget constraint

$$M_{it} - M_{it-1} + P_t C_{it}^{\mathrm{H}} + S_t C_{it}^{\mathrm{F}} = W_{it} L_{it} + T_t, \tag{2.7}$$

and the demand for his labor services (Eq. (2.5)). The variable T_t is a lump sum peso transfer from the central bank. The consumption quantity C_{it} is an aggregate of home and imported goods

$$C_{it} = \varkappa \left(C_{it}^{\mathrm{H}} \right)^{\gamma} \left(C_{it}^{\mathrm{F}} \right)^{1-\gamma}, \tag{2.8}$$

where C_{it}^{H} denotes i's purchases of the home good, C_{it}^{F} purchases of the foreign good, and $\varkappa = [\gamma^{\gamma}(1-\gamma)^{1-\gamma}]^{-1}$ is an irrelevant constant. We have also assumed that each unit of the imported good costs one unit of a foreign currency or dollar, and that the Law of One Price holds, so that the *peso* price of imports is equal to the *nominal exchange rate* of S_t pesos per dollar. One consequence is that the peso cost of consumption is given by the price index associated with the aggregator (Eq. (2.8)), that is

$$Q_t = P_t^{\gamma} S_t^{1-\gamma}. \tag{2.9}$$

Finally, the market for labor is monopolistically competitive, so that worker i takes L_t and W_t in Eq. (2.5) as given to him.

Assume that the aggregate supply of pesos changes can only be due to the lump sum transfers T, that is

$$M_t - M_{t-1} = T_t.$$

This assumption and Eq. (2.7) ensure that, in a symmetric equilibrium,

$$P_t C_{it}^{\mathrm{H}} + S_t C_{it}^{\mathrm{F}} = Q_t C_t = W_t L_t. \tag{2.10}$$

The resulting demand for pesos is then given by

$$\kappa \left(\frac{M_0}{Q_0} \right)^{-\phi} + \beta \frac{1}{C_1} \frac{Q_0}{Q_1} = \frac{1}{C_0}, \tag{2.11}$$

$$\kappa \left(\frac{M_1}{Q_1} \right)^{-\phi} = \frac{1}{C_1}. \tag{2.12}$$

Note also that the Cobb Douglas consumption aggregator (Eq. (2.8)) implies that a fraction γ of the wage bill, $WL = QC$, will be spent on home goods.

To allow for a meaningful discussion of monetary policy, we assume that each worker sets a peso wage one period in advance, and commits to supply as much of his labor as it is demanded at that wage. One can then show that, in a symmetric equilibrium, all workers will choose the same contractual wage, W_t, equal to the expected value of $(1-\alpha)P_tY_t$ conditional on information available at the end of period $t-1$. Given this wage, L_t is determined by Eq. (2.4). One important consequence, as we shall see, is that unexpected increases in employment can only be due to unexpected changes in P. In the remainder of the paper, we focus on the effect of period 0 shocks only; consequently, our previous assumptions imply that $L_1 = 1$ always, but that L_0 may differ from one if P_0 increases unexpectedly.

2.3. Capitalists

Capital accumulation plays a key role. Capitalists start period 0 with some inherited amount of capital K_0 and some foreign debt repayment due. After receiving the income from capital and repaying the foreign debt, capitalists can borrow dollars in the world market which, together with their *net worth*, finance purchases of new capital. Crucially, we assume that foreign borrowing is subject to frictions similar to those emphasized by Townsend (1979), Williamson (1987), and Bernanke and Gertler (1989). In addition, our specification implies that liabilities are dollarized, as emphasized in Calvo (1999).

For simplicity, we assume that capitalists only consume in period 1, and that they only consume imported goods. Their *net worth* in period 0, in pesos, is therefore given by

$$P_0 N_0 = R_0 K_0 - S_0 D_0 = \alpha P_0 Y_0 - S_0 D_0, \tag{2.13}$$

where D_0 denotes the *total* dollar debt repayment due in period 0.[5]

Again for simplicity, we assume that capital depreciates completely in production. New capital, available in period 1, can be obtained by aggregating home and foreign goods in the same fashion as Eq. (2.8). Correspondingly, the price of investment is Q_0; and aggregate investment must satisfy the flow constraint

$$Q_0 K_1 = P_0 N_0 + S_0 D_1,$$

where K_1 denotes capital available in period 1, and D_1 denotes foreign borrowing in period 0.

[5] Note that D_0 is therefore exogenous and represents inherited debt. The size of this debt will play an important role in what follows.

Home capitalists can borrow in the world market, where the gross *safe* dollar interest rate is given by $1+\rho$. However, and crucially, we assume that they are required to pay a *risk premium* on top of the safe rate, which is given by

$$1+\eta=\left(\frac{Q_0 K_1}{P_0 N_0}\right)^{\mu}. \tag{2.14}$$

That is, the risk premium is increasing in the ratio of the value of investment to net worth, as in Bernanke and Gertler (1989). This assumption is supposed to capture the effects of financial imperfections caused by informational or enforcement problems, and in fact, it can be derived from first principles.[6]

This specification has the potential for devaluation to have contractionary effects, which are ignored in conventional literature but have been emphasized recently by Calvo (1999), Krugman (1999), and others. To see this, use the definition of net worth to express the risk premium as

$$1+\eta=\left(\frac{(Q_0/P_0)K_1}{\alpha Y_0 - E_0 D_0}\right)^{\mu}, \tag{2.15}$$

where $E_0 = S_0/P_0$ is the *real* exchange rate. This expression makes it clear that a real devaluation (an increase in E_0) must, ceteris paribus, reduce net worth, expressed in terms of home output, and increase the risk premium. It will become clear, however, that the ceteris paribus proviso is indeed crucial, since real devaluation will, in general, affect the other determinants of η.

Aggregate investment is such that the expected return on capital is equalized to the cost of borrowing, inclusive of the risk premium. If we allow for shocks only in period 0, this condition requires

$$\frac{R_1}{Q_0}=\frac{\alpha P_1 Y_1}{Q_0 K_1}=(1+\rho)(1+\eta)\frac{S_1}{S_0}. \tag{2.16}$$

The interpretation is obvious. A unit of capital costs Q_0 pesos in period 0 and yields R_1 pesos in period 1, so that the first term is the return on capital; the first equality follows from Eq. (2.3). The last term is the cost of borrowing pesos, inclusive of the risk premium: to borrow one peso, capitalists must borrow $1/S_0$ dollars in period zero, and hence will have to return $(1+\rho)(1+\eta)/S_0$ dollars in period one which, in pesos, becomes $(1+\rho)(1+\eta)S_1/S_0$.

2.4. Equilibrium

To close the model, consider the market for home goods. In addition to the domestic demand for home goods, we assume that there is some exogenous

[6] See CCV for a derivation based on Bernanke et al. (1998) and Céspedes (2000).

foreign demand of X_t dollars. Hence, recalling that domestic demand is a fraction γ of workers' consumption and investment, market clearing is given by

$$P_t Y_t = \gamma Q_t (C_t + K_{t+1}) + S_t X_t, \tag{2.17}$$

noting that

$$K_2 = 0.$$

3. Solving the model

The model is highly nonlinear, but a log-linear approximation is easy to derive. In this section, we show how to achieve such an approximation, and derive an important property of the risk premium. As noted, we restrict attention to the effects of shocks in the first period. In addition, and for brevity, we consider only i.i.d. shocks.

3.1. The economy with no shocks

If we assume that shocks are identically equal to zero, an associated equilibrium can be computed easily. The no-shock outcome, which will be marked with overbars, will be the reference point for the approximation.

If shocks are zero, there are no unexpected movements in P, and hence $\bar{L}_t = 1$, $t = 0, 1$: Using this fact together with Eqs. (2.1), (2.4), (2.9), and (2.10) in Eq. (2.17), one obtains

$$[1 - (1-\alpha)\gamma] A \bar{K}_t^{\alpha} = \gamma \bar{E}_t^{1-\gamma} \bar{K}_{t+1} + \bar{E}_t \bar{X}, \tag{3.1}$$

where $\bar{X}$ is the no shock dollar value of exports. Eq. (3.1) holds for $t = 0, 1$, with $\bar{K}_0 = K_0$ given and $\bar{K}_2 = 0$, and so it furnishes two equations in the three unknowns $\bar{K}_1$, $\bar{E}_0$, and $\bar{E}_1$.

To obtain a last equation, take the last equality in Eq. (2.16), multiply both sides by P_0/P_1, and use Eqs. (2.1), (2.4), (2.13) and (2.15) to get

$$\frac{\alpha A}{\bar{E}_0^{1-\gamma} \bar{K}_1^{1-\alpha}} = (1+\bar{\rho}) \frac{\bar{E}_1}{\bar{E}_0} \left\{ \frac{\bar{E}_0^{1-\gamma} \bar{K}_1}{\left[\alpha A K_0^{\alpha} - \bar{E}_0 D_0\right]} \right\}^{\mu}. \tag{3.2}$$

Now one can solve for $\bar{K}_1$, $\bar{E}_0$, and $\bar{E}_1$, and all the real variables and relative prices of the model. Finally, the supply of pesos has no real effects and only determines the price level, through Eqs. (2.11) and (2.12).

3.2. Linear approximation

In order to illustrate our approximation procedure, consider the market clearing condition (Eq. (2.17)) for period 1. Since $Q_t C_t = W_t L_t = (1-\alpha) P_t Y_t$ and $K_2 = 0$; that condition reduces to

$$[1-(1-\alpha)\gamma]\, Y_1 = E_1 X_1.$$

The corresponding no-shock expression is

$$[1-(1-\alpha)\gamma]\, \bar{Y}_1 = \bar{E}_1 \bar{X}_1.$$

Taking logs of both and subtracting the second from the first yields

$$y_1 = e_1 + x_1 = e_1, \tag{3.3}$$

where lowercase letters now refer to log deviations (or, approximately, percentage deviations) from the no-shock equilibrium. In addition, since our focus is on temporary first period shocks, we can take $x_1 = 0$. Note that Eq. (3.3) implies that, in equilibrium, the *dollar* value of home output in period 1, $P_1 Y_1 / S_1 = Y_1 / E_1$, is a constant regardless of any period 0 shocks and of monetary policy. This simplifies our analysis greatly and is the consequence of three aspects of the model: consumption is equal to the wage bill, which in turn is a constant share of the value of home output; investment is zero in the last period; and dollar exports are exogenous.

In period 0; and after substituting $Q_0 C_0 = W_0 L_0 = (1-\alpha) P_0 Y_0$ and $Q_0 / P_0 = E_0^{1-\gamma}$ (from Eq. (2.9)), Eq. (2.17) becomes

$$[1-(1-\alpha)\gamma]\, Y_0 = \gamma E_0^{1-\gamma} K_1 + E_0 X_0.$$

Obtaining a linear expression in the log deviations is more involved, since the right hand side is not linear in logs. But after a Taylor expansion of the right hand side, it is easy to show that

$$y_0 = \lambda k_1 + (1-\lambda\gamma)\, e_0 + (1-\lambda)\, x_0, \tag{3.4}$$

where

$$\lambda = \frac{\gamma}{1-(1-\alpha)\gamma}\left(\frac{\bar{Q}_0 \bar{K}_1}{\bar{P}_0 \bar{Y}_0}\right) = \frac{\gamma\alpha}{(\alpha\gamma + 1 - \gamma)(1+\rho)(1+\eta)}\, \frac{\bar{Y}_1 \bar{E}_0}{\bar{Y}_0 \bar{E}_1},$$

where the last equality follows from Eq. (2.16). Note that λ is smaller than one as long as $\bar{Y}_1 / \bar{E}_1$ is not too different from $\bar{Y}_0 / \bar{E}_0$, that is, as long as the growth in dollar home output is not too large; we shall maintain that assumption from now on.

The rest of the model can be approximated in a similar fashion. The linearized version of Eq. (2.9) is

$$q_t - p_t = (1-\gamma)\, e_t. \tag{3.5}$$

In turn, the linearization of the production function (Eq. (2.1)) yields

$$y_0 = (1-\alpha) l_0,$$

and

$$y_1 = \alpha k_1. \tag{3.6}$$

The reason for the asymmetry between these two expressions is straightforward. In period 0, capital is predetermined, and home output can only expand if more labor is employed. Investment in period 0 increases home output in period 1, while L_1 must equal one because there are no surprises in period 1:

The arbitrage condition (Eq. (2.16)) can be linearized to yield

$$y_1 - (q_0 - p_0) - k_1 = p' + \eta' + e_1 - e_0, \tag{3.7}$$

where η_0' and ρ' denote the differences between η and ρ and their values in the no-shock equilibrium. Note that this expression, from Eq. (3.5) and the fact that dollar output in period 1 is a constant, reduces to

$$k_1 - \gamma e_0 = -(\rho' + \eta'). \tag{3.8}$$

This expression is naturally interpreted as an investment schedule. Importantly, the left hand side is (the percentage change of) investment in period zero, measured *in dollars*.[7] Hence, Eq. (3.8) states that the dollar value of investment falls with the world interest rate and the risk premium.

In turn, the linearization of the risk premium Eq. (2.14) reduces to

$$\eta' = \mu\left(\frac{1-\lambda}{\lambda} - \psi\right)(y_0 - e_0) - \mu\left(\frac{1-\lambda}{\lambda}\right)x_0, \tag{3.9}$$

where $\psi \equiv \bar{S}_0/\bar{D}_0/\bar{P}_{0\bar{N}0}$ indicates how large the initial debt burden is relative to capitalists' net worth. Expression (3.9) reveals that the risk premium depends only on the dollar value of period 0 home output and on the export shock. While a favorable export shock reduces the risk premium, changes in dollar output have ambiguous effects on the risk premium. The reason is apparent from rewriting the risk premium in yet another way, using Eqs. (2.14) and (2.13)

$$1 + \eta = \left(\frac{Q_0 K_1/S_0}{[\alpha Y_0/E_0 - D_0]}\right)^{\mu}. \tag{3.10}$$

This expresses the risk premium as the ratio of the *dollar* value of investment to the *dollar* value of net worth, both of which increase if the dollar value of home output in period 0 increases. The net effect depends on the parameters of the model, and in particular on the initial ratio of foreign debt of net worth.

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[7] The dollar value of investment is $Q_0 K_1 / S_0 = K_1 / E_0^{\gamma}$ by Eq. (2.9). Hence, its percentage change is $k_1 - \gamma e_0$.

Under our assumption of nominal wage stickiness, it is easy to show that employment changes are given by

$$l_0 = \left(\frac{1}{\alpha}\right) p_0, \tag{3.11}$$

which is an elementary Phillips curve.

Finally, we can approximate the money demand Eqs. (2.11) and (2.12) by

$$\phi\theta(m_0 - q_0) + (1-\theta)(c_1 + q_1 - q_0) = c_0, \tag{3.12}$$

$$c_1 = \phi(m_1 - q_1), \tag{3.13}$$

where $1-\theta = \beta\overline{Q}_0\overline{C}_0/\overline{Q}_1\overline{C}_1 = \beta\overline{P}_0\overline{Y}_0/\overline{P}_1\overline{Y}_1$. Note that θ is between 0 and 1 as long as the growth rate of nominal consumption and nominal home income is not too negative, which we henceforth assume.

3.3. *A useful result*

The analysis is greatly simplified by a somewhat surprising property of this model. Rewrite Eq. (3.4) as

$$y_0 - e_0 = \lambda(k_1 - \gamma e_0) + (1-\lambda)x_0. \tag{3.14}$$

Using this expression and Eq. (3.8) to eliminate $y_0 - e_0$ and k_1 from Eq. (3.9) and simplifying, one obtains

$$\{1 + \mu[1 - \lambda(1+\psi)]\}\eta' = -(1-\lambda)(1+\psi)\mu x_0 - \mu[1-\lambda(1+\psi)]\,\rho'. \tag{3.15}$$

Hence, in equilibrium, the risk premium depends *only* on x_0 and ρ—that is, on the exogenous foreign shocks exclusively. In particular, the risk premium does not respond to either monetary or exchange rate policy.

This can be explained as follows. From the discussion of Eq. (3.10), we know that movements in the risk premium can be caused only by movements in the dollar value of home output or the dollar value of investment. The latter, however, depends only on changes in the world safe rate and the risk premium itself (recall Eq. (3.8)). And Eq. (3.14) implies that the dollar value of output depends only on the dollar value of investment and shocks to exports. It follows that the risk premium, the dollar value of output, and the dollar value of investment can be solved for as functions of the exogenous shocks ρ' and x, independently of the rest of the system.

While it must be the case that the *dollar values* of output and investment in period zero can only depend on the foreign shocks, monetary policy will be able to influence how these values are split between quantities and prices. We now turn to this issue.

4. The effects of monetary policy

In order to analyze monetary policy, it is useful to reduce the linearized model to a system of three equations. Recall that the value of consumption must equal the wage bill. Hence, $q_t + c_t = w_t + l_t = p_t + y_t$, or

$$c_t = y_t + p_t - q_t = y_t - (1-\gamma)e_t, \tag{4.1}$$

for $t = 0, 1$. The second equality follows from Eq. (3.5).

In particular, since dollar output is constant in period 1, $y_1 = e_1$ and Eq. (4.1) implies

$$c_1 = \gamma y_1 = \gamma e_1.$$

Using this and Eq. (3.13),

$$c_1 + q_1 - q_0 = \gamma(1 - 1/\phi) y_1 + m_1 - q_0.$$

This expression, Eqs. (4.1) and (3.5) in Eq. (3.12) then yield

$$\phi\theta(m_0 - p_0 - (1-\gamma)e_0) + (1-\theta)[\gamma(1-1/\phi)y_1 + m_1 - p_0 - (1-\gamma)e_0] = y_0 - (1-\gamma)e_0. \tag{4.2}$$

Finally, use $\alpha y_0 = (1-\alpha)p_0$ to substitute out p_0. After rearrangement, we have

$$\phi\theta m_0 + (1-\theta)m_1 = (1-\gamma)(\phi-1)\theta e_0 + \left[1 + \frac{\alpha(\phi\theta + 1 - \theta)}{1-\alpha}\right] y_0 - \gamma(1-\theta)(1-1/\phi) y_1. \tag{4.3}$$

Given m_0 and m_1, this is a linear equation in e_0, y_0, and y_1.

A second equation in the same variables follows from using Eqs. (3.3) and (3.6) in Eq. (3.4), and recalling that $y_1 = e_1$ to get

$$\alpha y_0 = \alpha(1-\gamma\lambda)e_0 + \alpha(1-\lambda)x_0 + \lambda y_1. \tag{4.4}$$

Finally, a third relation is derived from Eq. (3.7), by substituting out k_1 and η', using Eqs. (3.4) and (3.9)

$$\alpha\gamma e_0 - y_1 = \alpha\rho' - \alpha\mu\left(\frac{1-\lambda}{\lambda}\right)x_0 + \alpha\mu\left(\frac{1-\lambda}{\lambda} - \psi\right)(y_0 - e_0). \tag{4.5}$$

Eqs. (4.3), (4.4) and (4.5) can be solved for e_0, y_0 and y_1 as functions of the shocks ρ' and x_0, once monetary policy has been specified.

In order to analyze the effects of monetary policy, in this section we assume that the money supply is exogenous, and ask what is the effect, in the absence of any other shocks, of a temporary money shock; $m_0 > 0$ and $m_1 = 0$. The first and striking result in this case is that the risk premium does *not* move: $\eta' = 0$. This follows directly from the finding, discussed at the end of last section, that the risk premium can only react to foreign shocks.

Since, from the discussion just mentioned, dollar output cannot react to money shocks, $y_0 - e_0 = 0$. Then, taking $\rho' = x_0 = 0$ to focus on the money shock, both Eqs. (4.4) and (4.5) reduce to

$$e_1 = y_1 = \alpha\gamma e_0. \tag{4.6}$$

Inserting this expression into Eq. (4.3), we get

$$\phi\theta m_0 = \left[(1-\gamma)\theta(\phi-1) + 1 + \frac{\alpha}{1-\alpha}(\theta\phi + 1 - \theta) - \alpha\gamma^2(1-\theta)\frac{\phi-1}{\phi}\right]e_0.$$

The expression in brackets in the right hand side is positive if $0 < \theta < 1$, as we have assumed.[8] Hence, an unanticipated monetary expansion ($m_0 > 0$) induces a depreciation of the real exchange rate in period 0; by Eq. (4.6), this depreciation is persistent. And given that $y_t = e_t$, $t = 0, 1$, output and consumption increase in both periods. The increase in output in period 0 reflects unanticipated inflation: $p_0 = (\alpha/(1-\alpha))y_0 > 0$. Finally, recall that $k_1 = y_1/\alpha = e_1/\alpha > 0$, and hence investment increases.

In short, the unanticipated monetary expansion is clearly expansionary, in line with the standard Mundell–Fleming results. It causes a persistent expansion in output, unanticipated inflation, a persistent real devaluation, and overshooting of the nominal rate.

Notably, these results hold regardless of the presence and strength of the "balance sheet" effects stressed in recent literature. Because the foreign debt is denominated in dollars, the real devaluation engineered by the monetary shock *does* increase the real burden of foreign debt. In the absence of other effects, this would imply that the devaluation is contractionary. However, the other, conventional expansionary effects of devaluation push the risk premium in the opposite direction. These opposite forces cancel out in this model, and monetary shocks have no impact on the risk premium.

5. Countering foreign shocks

This section expands our policy discussion by asking whether and how monetary management can soften the impact of shocks to the economy.

[8] If $\phi > 1$, the first term of the sum inside the bracket is positive, and $\alpha\gamma^2(1-\theta)(\phi-1)/\phi < 1$. If $0 < \phi < 1$, the last term of the sum is positive, while $(1-\gamma)\theta(\sigma-1) < 1$.

5.1. Shocks to export demand

Consider first a shock to the value of exports, $x_0 \neq 0$, keeping $\rho' = 0$. This and Eq. (3.15) imply that the risk premium changes according to

$$\eta' = -(1+\psi)\mu\chi(1-\lambda)x_0, \tag{5.1}$$

where $\chi^{-1} \equiv 1 + \mu[1 - \lambda(1+\psi)]$. If there is an unexpected increase in exports, therefore, the risk premium falls provided that χ is positive. We shall assume that indeed $\chi > 0$, which in turn requires that ψ not be too large. The alternative case of a positive χ is both quantitatively improbable[9] and theoretically implausible, since it causes domestic output to rise and the risk premium to fall in response to adverse external shocks.

Using $y_1 = \alpha k_1$, Eq. (3.14) reduces to

$$y_0 - e_0 = \frac{\lambda}{\alpha} y_1 - \lambda\gamma e_0 + (1-\lambda)x_0, \tag{5.2}$$

and Eq. (3.8) becomes

$$y_1 = \alpha\{\gamma e_0 + \chi(1+\psi)\mu(1-\lambda)x_0\}, \tag{5.3}$$

where we have used Eq. (5.1) to substitute out η'. Combining the two to eliminate y_1 yields

$$y_0 = e_0 + [1 + \lambda\chi(1+\psi)\mu](1-\lambda)x_0. \tag{5.4}$$

The previous two expressions give the response of home output, conditional on the real devaluation implied by monetary policy. In particular, it follows that, given that $x_0 \neq 0$, there is no e_0 that can set $y_0 = 0$ and $y_1 = 0$ simultaneously. Monetary policy can affect the real exchange rate e_0, but it cannot simultaneously isolate current and future income from responding to the export shock. This follows from the asymmetric way such a shock affects these two variables.

The effects on consumption are similar. Recall that $c_t = y_t - (1-\gamma)e_t$, and hence

$$c_0 = \gamma e_0 + [1 + \lambda\chi(1+\psi)\mu](1-\lambda)x_0. \tag{5.5}$$

That is, period 0 consumption increases with a real devaluation in period 0, and moves in the same direction as x_0. Likewise,

$$c_1 = \alpha\gamma[\gamma e_0 + \chi(1+\psi)\mu(1-\lambda)]x_0], \tag{5.6}$$

so consumption in period 1 increases with a real devaluation and with x_0 through the risk premium. Again, if $x_0 \neq 0$, there is no e_0 that can set $c_0 = 0$ and $c_1 = 0$ simultaneously.

[9] See CCV.

To see what monetary policy *can* accomplish, consider two questions. First, can the effects of the shocks be ameliorated in both periods? The answer is yes: since e_0 enters with the same sign in the reduced-form expressions for y_0 and y_1, a real devaluation increases both outputs. If output levels are being pushed down by the export shock, then an expansionary monetary policy can help moderate the effects of the shock. In this sense, there exists no real trade-off in the use of monetary policy.

The second question is: by focusing on output stabilization in one period (say the first one), does monetary policy cause output in the next period to undershoot $(y_1 < 0)$ or to undershoot $(y_1 > 0)$? Suppose the real exchange rate is targeted to ensure $y_0 = 0$. From Eq. (5.4), this implies

$$e_0 = -(1 + \lambda\chi(1+\psi)\mu)(1-\lambda)x_0. \tag{5.7}$$

Using this in Eq. (5.3), we obtain

$$y_1 = \alpha[\chi(1+\psi)\mu - \gamma(1+\lambda\chi(1+\psi)\mu)](1-\lambda)x_0, \tag{5.8}$$

$$y_1 = \alpha\left[\gamma - \frac{\mu}{1+\mu}(1+\psi)\right]e_0, \tag{5.9}$$

where the last equality follows, after tedious but straightforward manipulation, from Eq. (5.7) and the definition of χ. It is clear, then, that a monetary policy that initially isolates the economy from a negative export shock in period 0 may or may not cause an output fall in period 1; depending on the sign of the term in brackets in Eq. (5.9). The intuition is easy. Output in period 1 will fall if investment falls in period 0. From Eq. (3.8), $k_1 = \gamma e_0 - \eta'$, so that the devaluation needed to keep $y_0 = 0$ has a direct expansionary effect on investment. However, the same devaluation increases the risk premium; in fact, one can show that $\mu(1+\psi)/(1+\mu)$ is the elasticity of the risk premium with respect to the real devaluation under our policy assumption. So there may or may not be a policy tradeoff (in the sense that targeting policy to prevent a recession in period 0 allows a recession in period 1), depending of the relative strengths of the direct effect of the devaluation and its indirect effects via the risk premium.

Finally, consider the change in the money supply that would be required to implement this required real devaluation. To find it, rewrite the money demand Eq. (2.11) as

$$\phi\theta m_0 = \phi\theta q_0 + c_0 - (1-\theta)c_1 - (1-\theta)(q_1 - q_0), \tag{5.10}$$

$$\phi\theta m_0 = (\phi - 1)[\theta(1-\gamma)e_0 - (1-\theta)\gamma y_1/\phi]. \tag{5.11}$$

The first equality expresses that, in response to $x_0 \neq 0$, the money supply may need to be increased or decreased, depending on the relative strength of four terms. The first, $\phi\theta q_0 = \phi\theta(1-\gamma)e_0$, reflects the necessary change in money to compensate for the direct effect of a devaluation on the price of consumption. This component is negative if $x_0 > 0$, since a positive shock to exports is followed by a real appreciation, which pushes q_0 down. The second component, $c_0 = -(1-$

$\gamma)e_0$, is positive if $x_0 > 0$: this implies a real appreciation, higher wage income, and higher consumption in period 0, which increases the demand for pesos. The third component $-(1-\theta)c_1 = -(1-\theta)\gamma y_1$ may be positive or negative, depending on whether period 1 output falls or not. This term reflects that a shock to exports affects income and consumption in period 1, which determine the marginal value to workers of saving pesos. Finally, the last component, $-(1-\theta)(q_1 - q_0) = -(\gamma y_1/\theta) - (1-\gamma)e_0$, reflects the change of the inflation rate on money demand. This term is also of ambiguous sign. After some tedious substitutions and simplifications, all these terms reduce to Eq. (5.11), which makes it clear that the necessary change in the money supply is ambiguous and depends on several parameters.

Two remarks are in order. First, the case in which monetary policy is such that $y_0 = 0$ is also worth emphasizing because it replicates the outcomes of an economy without nominal wage rigidity. If nominal wages were free to adjust to the shock in period 0, equilibrium in the labor market would imply $L_0 = 1$ always and, since K_0 is given and productivity shocks are absent, $Y_0 = \bar{Y}_0$ for any value of x_0. Hence, by suitably adjusting monetary policy, the central bank can "undo" the effects of nominal wage rigidity. It does not follow, however, that this is necessarily a desirable policy, because the central bank has *other* options that imply different intertemporal distributions of the impact of the export shock.

The second remark is that balance sheet considerations play a role in the discussion of monetary policy because of, and only because of, the impact of the export shock on the risk premium, as given by Eq. (5.1). Monetary policy cannot affect that impact; instead, the appropriate stance of monetary policy is affected by the change in the risk premium because it affects the cost of borrowing and the growth rates of income and/or consumption.

5.2. Shocks to world interest rates

Suppose now that $x_0 = 0$ but that $\rho' \neq 0$—that is, that there is an unexpected and temporary change in the world interest rate. The effects of such a shock under alternative exchange rate regimes are analyzed in great detail in CCV, so our discussion here can be brief.

From Eq. (3.15), the response of the risk premium is

$$\eta' = -\mu[1 - \lambda(1+\psi)]\,\chi\rho'. \tag{5.12}$$

The term in square brackets can be positive or negative. The case in which $[1-\lambda(1+\psi)] < 0$ is what CCV termed *financial vulnerability*.[10] Here, financial vulnerability in the CCV sense is necessary but not sufficient for the risk premium

[10] In CCV, an economy is *financially vulnerable* if, in the absence of nominal wage rigidities, the risk premium increases with a real devaluation. That such a condition is equivalent to $1 - \lambda(1+\psi) < 0$ follows from Eq. (5.17) below and the fact that, when $y_0 = 0$, there cannot be unexpected inflation, and hence our economy behaves as if there were no wage rigidities.

to increase if there is an increase in the world interest rate. Sufficiency requires—in addition to financial vulnerability—that χ be positive as we have assumed.

Now, from Eq. (3.8) one obtains

$$\gamma e_0 - k_1 = \chi \rho', \tag{5.13}$$

while Eq. (3.7) becomes

$$y_0 - e_0 = \lambda(k_1 - \gamma e_0). \tag{5.14}$$

Combining the two yields

$$y_0 - e_0 = -\lambda \chi \rho'. \tag{5.15}$$

As expected, dollar output depends inversely on the interest rate shock. Moreover,

$$y_1 = \alpha k_1 = \alpha[\gamma e_0 - \chi \rho']. \tag{5.16}$$

As in the case of export shocks, an unexpected interest rate increase depresses output in both periods. The central bank can reduce the output fluctuations by allowing the real exchange rate to depreciate on impact. The analysis in terms of consumption is the same, since

$$c_0 = y_0 - (1-\gamma) e_0,$$

and

$$c_1 = \gamma y_1.$$

We can ask again: what is the effect of a policy that eliminates completely the impact effect of the shock? From Eq. (5.15), with $y_0 = 0$, we get the necessary real devaluation

$$e_0 = \lambda \chi \rho', \tag{5.17}$$

which implies that

$$y_1 = -\alpha(1 - \gamma\chi\lambda)\rho'.$$

That is, the central bank can postpone the output loss but not eliminate it completely. Note that there is a difference with the case of an export shock, in that there is no ambiguity about whether output falls in period 1.

Finally, to identify the necessary response of the money supply, note that both Eqs. (3.12) and (3.13) must hold in this case also.[11] Hence, since $e_0 > 0$ and $y_1 < 0$; an expansion of the money supply is called for. Again in contrast with the case of a shock in exports, there is no ambiguity in the monetary response needed to achieve $y_0 = 0$.

To close this section, note that the two remarks at the end of the previous subsection apply here too. A monetary policy that achieves $y_0 = 0$ in effect replicates a flexible wage economy. And a shock to the world interest rate may

[11] The proof is tedious but straightforward and left to the reader.

call for a monetary response, but not because that response can affect the impact on risk premia. Instead, the central bank may want to moderate the output effects associated with the change in the risk premium and the cost of borrowing.

6. Final remarks

We have studied the role of monetary policy in an economy in which dollarization of liabilities implies that devaluations have detrimental effects on balance sheets. In our model, financial frictions are important for the behavior of the economy. In particular, the behavior of risk premia is a crucial transmission channel from changes in net worth to aggregate investment and output.

In spite of the presence of potentially strong effects of devaluation on net worth, monetary policy turns out to be largely impotent to affect the dynamics of risk premia. Instead, its effects work essentially through conventional channels. This implies, in particular, that it is futile to gear the money response to foreign shocks towards the amelioration of the impact on risk premia. The only thing that the central bank can do is to counter the effects on output associated with that impact.

Admittedly, these are strong implications of a particular, simple model with strong assumptions. But it should be noted that weakening many of our assumptions would likely reinforce our conclusions. For instance, we assumed that *all* foreign liabilities are dollarized. This obviously tends to overstate the balance sheet effect relative to the more realistic assumption in which some liabilities are dollarized and some are not.

As noted, our specification of financial frictions followed CCV and Bernanke et al. (1998), which in turn is based on the costly state verification model of Townsend (1979) and Williamson (1987). A possible avenue for future research would be to check the robustness of our analysis to alternative assumptions on financial imperfections.

Perhaps more importantly, our analysis here entirely abstracts from issues of credibility. This is not because we believe that credibility considerations should be ignored. In fact, one important reason why in practice central banks are reluctant to use monetary policy to offset real shocks is that they worry about the effects that a monetary expansion today may have on expectations of monetary expansions in the future. And, if the credibility problem is large enough, countercyclical monetary policy could well be counterproductive, as Calvo (1999, 2000) and others have argued. But that does not invalidate the conclusions of the analysis here. It simply means that, in the presence of imperfect credibility, there may be additional factors affecting the transmission of monetary policy that would have to be taken into account when crafting real-world policies.[12]

[12] For an exploration in that direction, see Céspedes et al. (2001).

Finally, we did not derive the implications of our analysis for individual welfare. This is possible but complicated and delicate, given that our model features different classes of agents and several, simultaneous distortions. We leave this extension for future research.

7. Uncited reference

Krugman, 2000

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