Monetary Policy in an International Financial Crisis*

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Abstract

We explore the role of monetary policy in the aftermath of a financial crisis. We develop a small open economy model with limited participation of households in a financial intermediary that provides liquidity to satisfy firms' working capital needs. Firms require two forms of working capital: domestic funds to pay for the wage bill and foreign funds to finance imports of an intermediate good. A shortage of either one of the sources of working capital acts as a drag on economic activity. In normal times, an interest rate cut is expansionary. In a financial crisis collateral constraints bind, and an expansion of domestic liquidity leads to a real exchange rate depreciation that further tightens the collateral constraint and offsets the traditional (expansionary) liquidity channel. In addition, the tightening of collateral constraints places a premium on paying off foreign debt, reinforcing the contractionary effects of an interest rate cut. We study the conditions under such monetary policy action is contractionary and relate them to recent emerging market crises.

*The views reflected in this paper are not necessarily those of the Federal Reserve and/or the International Monetary Fund.

1 Introduction

In recent years there has been considerable controversy over the appropriate monetary policy in the aftermath of a financial crisis. Some argue that interest rates should be raised to defend the currency and halt the flight of capital. Others argue that interest rate reductions are called for. They note that a country that has just experienced a financial crisis is typically sliding into a steep recession. They appeal to the widespread view that in developed economies like the US, central banks typically respond to situations like this by reducing interest rates. These authors urge the same medicine for emerging market economies in the wake of a financial crisis. They argue that to raise interest rates at such a time is a mistake, and is likely to make a bad situation even worse. One expositor of this view, Paul Krugman (1999, pp.103-105), puts it this way:

> "But when financial disaster struck Asia, the policies those countries followed in response were almost exactly the reverse of what the United States does in the face of a slump. Fiscal austerity was the order of the day; interest rates were increased, often to punitive levels....Why did these extremely clever men advocate policies for emerging market economies that would have been regarded as completely perverse if applied at home?"

We describe a framework that allows us to articulate the two views just described. In doing this, we hope to shed light on the controversy. The framework has two fundamental building blocks. First, we assume that to carry out production, firms require domestic working capital to hire labor and international working capital to purchase an imported intermediate input. Second, we adopt the asset market frictions formalized in the limited participation model as analyzed in Lucas (1990), Fuerst (1991) and Christiano and Eichenbaum (1992, 1995). The limited participation assumption has the consequence that an expansionary monetary action makes the domestic banking system relatively liquid and induces firms to hire more labor. To the extent that the imported intermediate input complements labor, the interest rate drop leads to the increased use of this factor too. This is in the spirit of the traditional liquidity channel emphasized in the closed economy literature, which stresses the positive effects of an interest rate cut on output.

In our open economy, an interest rate cut also leads to a real exchange rate depreciation. Under normal conditions, this does not mitigate the positive output effects associated with the traditional liquidity channel. However, during a crisis the real exchange rate depreciation may may lead to very different effects in our model.

We model a crisis as a time when international loans must be collateralized by physical assets such as land and capital, and that this restriction is binding. We suppose that under normal conditions, collateral constraints either do not exist or are not binding. This can occur because output in addition to land and capital is acceptable as collateral in such times or because the government puts up its assets and its tax base as collateral in the form of implicit or explicit loan guarantees. We show that the monetary transmission mechanism can be very different during a crisis. In particular, we show that the real depreciation generated by an expansionary monetary action can tighten the collateral constraints, forcing a cutback in imports of the intermediate inputs. We show that this effect may overwhelm the traditional liquidity channel, and cause an expansionary monetary policy action to produce a fall in output and employment. In addition, the tightening of the collateral constraint places a premium on paying off international debt. This in turn may lead to a further real exchange rate depreciation, reinforcing the contractionary effects of the interest rate cut.

This sharp difference between the economic effects of an expansionary monetary action in normal and crisis times does not occur in all specifications of our model. One of our objectives is to clarify the conditions under which sharp differences exist. We find that several conditions are necessary. First, the action must act as a relative stimulus to the non-traded good sector. This is what causes the expansion to lead to a real depreciation. In our model this can happen if labor is used relatively heavily in the nontraded good sector, and labor is stimulated by a domestic interest rate cut. Second, the reduction in the value of international collateral associated with the real exchange rate depreciation produces a reduction in the output of the traded good sector if imported goods are relatively important in that sector and substitutability with other factors is limited. Third, if the output of the traded good sector has limited substitutability in production or consumption with that of the nontraded good sector, the reduced output in the traded good sector can actually produce a fall in employment in the non-traded sector. In effect, with limited substitutability the real exchange rate depreciation produced by the expansionary monetary action exerts a negative impact on labor demand which overwhelmes the positive effects of the interest rate reduction.

As noted above, our primary objective in this paper is to present a framework to evaluate the impact on the monetary transmission mechanism of a financial crisis. Still, we suspect that the conditions just described for an interest rate cut to have a perverse negative impact on output during a crisis are not implausible. In future work, we plan to undertake an empirical analysis to evaluate this conjecture. A central issue concerns the plausibility of our way of modeling a crisis, as a time when international collateral constraints are severely tightened. To help motivate our analysis, we present a preliminary discussion of this issue in the first section. A more thorough analysis is beyond the scope of this paper.

The organization of the paper is as follows. In the first section we discuss the collateral constraints. The second section presents a version of our model that is sufficiently simple that analytic results are possible. We begin by focussing on this model to help build intuition into the results. After that we present a more general model which can only be analyzed numerically. We do this to be sure that the results obtained in the simple setting are robust to some of the simplifying assumptions made. The analysis in these first sections assumes all borrowing is short term, and that there is no outstanding international debt. The final section extends the analysis to accomodate the existence of longer term international debt and it shows how this can exacerbate the perverse effects of a monetary expansion in a financial crisis.

2 Evidence on Collateral Constraints

The assumption that the land and capital of the firm is collateral for international loans plays an important role in our analysis. We have not yet compiled the data necessary to substantiate this notion. Still, we understand that it is controversial and wish to clarify the nature of our assumption.

To begin, we emphasize our assumption that collateral constraints become binding *after* the financial crisis. In our analysis we assume they were not binding in the years leading up to the crisis. We take no stand on why this is so. In particular, our analysis is consistent with the widespread idea that, prior to the crisis, a firm's collateral was the willingness of the domestic government and/or the international community to resort to taxation to bail out bad loans. What we assume is that *now*, in the aftermath of the crisis, firms must have collateral to borrow from the international community.

Those who believe that government bailout guarantees are *still* in place may even wish to question the notion that collateral constraints are binding right now. We cannot at this time offer evidence on this. Still, it is important to stress one thing. Even if government bailout guarantees remained a widespread phenomenon today, it might still be that collateral constraints operate in the way emphasized in our model. Governments which understand the risk posed to them of bailout guarantees have an incentive to see to it that collateral exists to back up international loans made to domestic firms. Governments minimize this risk by insisting that international loans only go to firms that possess enough assets to payoff the loan in the event of bankruptcy.

These considerations indicate that to evaluate the plausibility of our notion that collateral constraints are binding in the aftermath of a crisis involves subleties. It is not enough to simply look at loan contracts to see if lenders requested and obtained, liens on assets that can be seized in the event of bankruptcy. From an economic standpoint it would be exactly the same if there were *no* such provision in loan contracts, and instead governments offered bailout guarantees to the lender, which they planned to finance in the event of bankruptcy by liquidating the firm's assets. Such a system might even be efficient, if local court systems were more effective at processing government claims than private claims against bankrupt firms.

These considerations indicate that in our empirical analysis to evaluate the plausibility of collateral constraints, we will investigate not just whether collateral is written directly into loan agreements. We will also investigate wether government authorities review loans, with the right to stop a loan in the event that the land and capital owned by the firm is inadequate to guarantee the loan.

We have done some preliminary research. A database on syndicated loans indicates that frequenly, collateral such as land, equipment and buildings are written into loan agreements. In addition, the work of xxx shows that in Asia it is possible to recover collateral in courts, when bankruptcy occurs. We have not yet compiled evidence on intervention that may exist by governments into loan agreements.

3 A Simple Model

We adopt a standard traded good-non traded good small open economy model. The model has households, firms, a financial intermediary, and a domestic monetary authority.

3.1 Households

There is a representative household, which derives utility from consumption of traded goods, c^T, nontraded goods, c^N, and leisure as follows:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, L_t), \tag{1}$$

where

$$c = v(c^N, c^T), \tag{2}$$

and

$$v(c^N, c^T) = \left\{ \gamma \left(c^T\right)^{\frac{\eta-1}{\eta}} + (1-\gamma)\left(c^N\right)^{\frac{\eta-1}{\eta}} \right\}^{\frac{\eta}{\eta-1}}, \ u(c, L) = \frac{\left[c - \frac{\psi_0}{1+\psi} L^{1+\psi}\right]^{1-\sigma}}{1-\sigma}. \tag{3}$$

Here, η is the elasticity of substitution in consumption between traded and non-traded goods.

The household begins the period with a stock of liquid assets, $\tilde{M}_t$. Of this, it deposits D_t with the financial intermediary, and the rest, $\tilde{M}_t - D_t$, is allocated to consumption expenditures. The cash constraint that the household faces on its consumption expenditures is:

$$P_t^T \left(c_t^T + p_t^N c_t^N\right) \leq P_t^T w_t L_t + \tilde{M}_t - D_t, \tag{4}$$

where P_t^T denotes the domestic currency price of tradeable goods, and p_t^N is the relative price of non-tradeables, i.e., the inverse of the real exchange rate. Finally, w_t denotes the wage rate, denominated in units of the tradeable good.

The household also faces a flow budget constraint governing the evolution of its assets:

$$\tilde{M}_{t+1} = R_t(D_t + X_t) + \pi_t + \left[P_t^T w_t L_t + \tilde{M}_t - D_t - P_t^T \left(c_t^T + p_t^N c_t^N\right)\right]. \tag{5}$$

Here, R_t is the gross rate of interest, π_t is profits which derive from household's ownership of firms, and X_t is a liquidity injection from the monetary authority.

The term on the right of the equality reflects the household's sources of liquid assets at the beginning of period $t+1$: interest earnings on deposits and on the liquidity injection, profits and any cash that may be left unspent in the period t goods market.

The household maximizes (1) subject to (4)-(5), and the following timing constraint. A given period's deposit decision is made before that period's liquidity injection is realized, while all other decisions are made afterward. The household Euler equations for consumption and labor are as follows:

$$p^N = \frac{1-\gamma}{\gamma}\left(\frac{c^T}{c^N}\right)^{\frac{1}{\eta}}, \; w = \frac{\psi_0 L^{\psi}}{\gamma \left(v/c^T\right)^{\frac{1}{\eta}}}, \tag{6}$$

where v is the function defined in (3). The first reflects that the household equates the marginal rate of substitution between traded and non-traded goods to their relative price. The second expression equates the real wage, denominated in units of the traded good, to the marginal rate of substitution between leisure and traded good consumption. These two relationships can be combined to yield a labor supply equation as follows:

$$w = \frac{\psi_0 L^{\psi}}{\gamma \left\{\gamma + (1-\gamma)\left(\frac{1}{p^N}\frac{1-\gamma}{\gamma}\right)^{\eta-1}\right\}^{\frac{1}{\eta-1}}}. \tag{7}$$

Note that a fall in p^N shifts the labor supply curve to the right.[1,2]The reason for this is that, for given w, one hour of labor effort buys more nontraded goods the lower is p^N. In effect, leisure becomes more expensive when p^N falls and w is fixed.

3.2 Firms

The representative firm in the economy produces tradeable and non-tradeable goods. The technology for producing these goods is:

$$y^T = A\left(K^T\right)^{\theta} z^{1-\theta}, \; y^N = \left(K^N\right)^{\alpha} L^{1-\alpha}, \tag{8}$$

where y^T denotes gross output of the tradeable good, y^N denotes gross output of the non-tradeable, K^i, $i = N, T$, denotes the stock of land and capital in

[1]This expression is derived as follows:

$$\begin{aligned}\gamma\left(\frac{v}{c^T}\right)^{\frac{1}{\eta}} &= \gamma\left\{\gamma + (1-\gamma)\left(\frac{c^N}{c^T}\right)^{\frac{\eta-1}{\eta}}\right\}^{\frac{1}{\eta-1}} \\ &= \gamma\left\{\gamma + (1-\gamma)\left(\frac{1-\gamma}{\gamma}\frac{1}{p^N}\right)^{\eta-1}\right\}^{\frac{1}{\eta-1}}\end{aligned}$$

[2]We have in mind here the conventional graphical representation of labor demand and supply, with w on the vertical axis and L on the horizontal axis.

the nontraded and trade good sectors, respectively. Finally, z is the imported intermediate input. The stock of land and capital is owned by the firm and is assumed to be fixed in quantity.

The firm chooses L and z after the current period realization of the liquidity injection, subject to working capital constraints. In particular, it must acquire domestic currency to hire L and foreign currency to purchase z. We assume that all loans are short-term and are repaid at the end of the period. The working capital requirement for labor is WL units of the domestic currency, which is obtained from the domestic financial intermediary. The firm repays RWL at the end of the period. Here, R is the gross nominal rate of interest in the domestic currency, which the firm takes as exogenous. The working capital requirement for the intermediate good is $P^{T*}z$ units of the foreign currency. The gross nominal rate of interest in the foreign currency is R^*, which is also taken as exogenous by the firm. Thus, international borrowing in the beginning of the period generates an obligation of $R^*P^{T*}z$ units of the foreign currency at the end of the period. In our analysis we adopt the convention of valuing goods in units of the traded good. The end-of period foreign financial obligation of domestic firms, valued in units of the traded good, is $SR^*P^{T*}z/P^T$, where S is the nominal exchange rate. Imposing purchasing power parity, this reduces to R^*z.

The firm's collateral constraint on international borrowing is:

$$\tau^N q^N K^N + \tau^T q^T K^T \geq R^* z. \tag{9}$$

Here, q^i, $i = N, T$ denotes the value of a unit of capital in the nontraded and traded good sectors, respectively.[3] Also, τ^i denotes the fraction of these stocks accepted as collateral by international creditors.[4] We define 'a crisis' as a time when this constraint is imposed and is binding. We define 'normal times' as a time when the constraint is not imposed. Loosely, we think of normal times as a time when physical assets and cash flow serve as collateral on borrowing, where these restrictions are nonbinding. In a crisis, international lenders no longer accept cash flow, and only accept physical assets like land and capital, because these, as practioners put it, 'cannot walk'.

The formal statement, in Lagrangian form, of the firm problem in a crisis is:

$$\begin{aligned}&\max_{L,z}\{p^N y^N + y^T - wRL - R^* z \\ &+\lambda\left[\tau^N q^N K^N + \tau^T q^T K^T - R^* z\right]\}.\end{aligned} \tag{10}$$

[3]We have not explicitly imposed a collateral constraint on domestic working capital. Implicitly, we assume that the output of the nontraded sector can be used as collateral against these loans. Since the working capital needed to fund the wage bill is only a fraction of output, this constraint is non-binding and so can be ignored in the analysis. In later drafts of this paper, we plan to incorporate a more elaborate discussion of this asymmetric treatment of domestic and international borrowing in the aftermath of a crisis.

[4]For now we abstract from long-term debt. This will play an important role in our analysis below.

In addition, there are the complementary slackness conditions, $\lambda \geq 0$, (9) and:

$$\lambda \left[\tau^N q^N K^N + \tau^T q^T K^T - R^* z\right] = 0.$$

The firm Euler conditions are:

$$\begin{aligned} \frac{p^N}{R}(1-\alpha)\left(K^N\right)^{\alpha} L^{-\alpha} &= w \\ (1-\theta)A\left(K^T\right)^{\theta} z^{-\theta} &= (1+\lambda)R^*. \end{aligned} \tag{11}$$

The first Euler equation is the firm's demand for labor. Note that it shifts right with an increase in P^N and with a decrease in R. The latter reflects that, for a given w, a lower R represents a lower marginal cost of employing labor. The Euler equation for z indicates that when $\lambda > 0$, the marginal cost of the intermediate good exceeds the direct purchase and financing price. The Euler equations in normal times is just the previous expression without λ.

The prices, q^N and q^T are what a firm would pay for one unit of the capital good in the nontrated and traded good sectors, respectively. We adopt the following formulas for these:

$$q^i = MP_K^i + \lambda q^i + f^i,\ i = N, T, \tag{12}$$

where MP_K^i is the marginal product of capital, in units of the traded good, in industry i. Also, f^i is the present discounted value of future marginal productivities, and λ is the multiplier in (10). There is a variety of more elaborate specifications of the firm problem which would allow us to formally derive the above pricing formulas. We do not display these in order to conserve on notation. In the formula, $MP_K^i + f^i$ is just the standard present discounted value of current and future marginal productivities. The term involving λ captures the fact that the acquisition of an additional unit of physical assets relaxes the international collateral constraint, when $\lambda > 0$.

3.3 Financial Intermediary

The financial intermediary takes domestic currency deposits, D, from the household at the beginning of the period. In addition, it receives the liquidity transfer, X, from the monetary authority.[5] It then lends all its domestic funds to firms to finance their employment working capital requirements. The sources and uses of domestic funds for the financial intermediary are:

$$D + X = WL. \tag{13}$$

This is the domestic money market clearing condition. Although the logic of the model does not require it, we are free to assume that the financial intermediary also handles firms' international borrowing.

[5] In practice, injections of liquidity do not occur in the form of lump sum transfers, as they do here. It is easy to show that our formulation is equivalent to an alternative, in which the injection occurs as a result of an open market purchase of government bonds which are owned by the household, but held by the financial intermediary. We do not adopt this interpretation in our formal model in order to conserve on notation.

3.4 Monetary Authority and Equilibrium

The monetary authority in our model simply injects funds into the financial intermediary. We abstract from other aspects of government finance. The aggregate stock of money evolves according to the following equation:

$$M_{t+1} = M_t + X_t.$$

We consider a perfect foresight, sequence-of-market equilibrium concept. In particular, it is a sequence of prices and quantities having the properties: (i) for each date, the quantities solve the household and firm problems, given the prices, and (ii) the labor, goods and domestic money markets clear.

Clearing in the money market requires that (13) hold and that actual money balances, M_t, equal desired money balances, $\tilde{M}_t$. In addition, goods market clearing requires:

$$c^N = y^N, \; c^T = y^T - R^* z. \tag{14}$$

The traded goods sector imports z at the beginning of the period and then at the end of the period it exports $R^* z$ and sells c^T to the household sector.

We note that although we model v in (2) as being part of the utility function, we can equivalently interpret v as a production function used by a perfectly competive domestic final goods producing firm to produce c using c^T and c^N as inputs. We do not adopt this interpretation formally, in order to conserve on notation. Still, in discussing some of our results below, we will find it useful to adopt this interpretation.

3.5 Analysis of the Equilibrium

We imagine that the economy is in a perfect foresight equilibrium. In one particular period, after the household has made its deposit decision, D, the monetary authority undertakes a one-time deviation from the expected money path. The deviation has no effect on future allocations or money growth.

It is a feature of our model that the impact of the monetary disturbance on the current allocations is characterized by a system of static equations. This is because the only dynamic equation in the model, the household's intertemporal Euler equation, has no impact on the analysis, due to the fact that the D decision has already been taken. We refer to the current period prices and quantities which solve the static equations as a 'temporary equilibrium'. Since only current period variables matter for our analysis, we do not use the time subscript, t.

We find it convenient to characterize the policy of the monetary authority in the temporary equilibrium by the nominal rate of interest, R. We consider a given drop in this variable and analyze its consequences in this order. First, we determine the impact on quantities and on relative prices in the temporary equilibrium. Then, we determine how much liquidity the monetary authority must inject into the domestic financial market in order to bring about the given fall in R. Finally, we compute the change in the nominal exchange rate associated with the policy change.

To study the real effects of a cut in R, we divide the equations of the real economy into two sets: those that characterize the labor market, and those that characterize the market for assets.

3.5.1 Labor Market

Equating labor supply, (7), and labor demand, (11):

$$\frac{\psi_0 L^{\psi}}{\gamma\left\{\gamma+(1-\gamma)\left(\frac{1}{p^N}\frac{1-\gamma}{\gamma}\right)^{\eta-1}\right\}^{\frac{1}{\eta-1}}}=\frac{p^N(1-\alpha)\left(K^N\right)^{\alpha}L^{-\alpha}}{R}.$$

Rearranging:

$$R\frac{\psi_0}{\gamma}L^{\psi+\alpha}=(1-\alpha)\left(K^N\right)^{\alpha}\left\{\gamma\left(p^N\right)^{\eta-1}+(1-\gamma)\left(\frac{1-\gamma}{\gamma}\right)^{\eta-1}\right\}^{\frac{1}{\eta-1}}.$$

For the moment, we think of R as an exogenous variable. So, this expression characterizes the relationship between L and p^N imposed by equilibrium in the labor market. A higher p^N is consistent with a higher L because it shifts the labor demand curve to the right. It also shifts labor supply to the left, but this latter effect is overwhelmed by the labor demand effect. We can represent this relationship in a figure with p^N on the vertical axis and L on the horizontal axis (see Figure 1). The relationship is positively sloped and a fall in R shifts it to the right. This effect on the curve reflects that a fall in R shifts labor demand to the right and this results in an increase in equilibrium L for a fixed level of p^N. Because it summarizes the implications of equililbrium in the labor market, we refer to this curve as the LM curve.

3.5.2 Asset Market

We now consider the asset markets. To convey the basic intuition of the version of the model with collateral constraints, it is useful to first consider the special case, $\theta=0$.[6] In this case, $q^T=0$. Also, we assume $A>R^*$, so that the collateral constraint is binding, and (11) indicates that the multiplier is constant, e.g.,

$$A=(1+\lambda)R^*.$$

Combining (9) with (12) for $i=N$:

$$\frac{zR^*\tau^N}{K^N}=q^N=\frac{1}{1-\lambda}\left[\alpha\left(\frac{L}{K^N}\right)^{1-\alpha}p^N+f^N\right]. \tag{15}$$

[6]With $\theta=0$ the unconstrained version of the model is not interesting. In this case there is no equilibrium since the demand for z would be infinite.

To get this into an expression involving p^N and L only, we substitute out for z using the following expression for p^N :

$$p^N = \frac{1-\gamma}{\gamma}\left[\frac{(A-R^*)z}{(K^N)^{\alpha}L^{1-\alpha}}\right]^{\frac{1}{\eta}}. \tag{16}$$

After rearranging, we obtain:

$$\left(\frac{L}{K^N}\right)^{1-\alpha}\left\{\left(p^N\right)^{\eta}\frac{R^*}{A-R^*}\left(\frac{\gamma}{1-\gamma}\right)^{\eta}-\frac{\alpha}{1-\lambda}p^N\right\}=\frac{f^N}{1-\lambda}. \tag{17}$$

To understand this relationship, note first that for η near unity, (17) represents a negative relationship between p^N and L, while the relationship is positive for η close to zero. So, in developing intuition into this relationship, it is clear that the elasticity of substitution between consumption of the nontradable and tradable goods plays a central role. To obtain this intuition, we consider an increase in L and ask what sort of change in p^N is required to restore equilibrium in goods and asset markets. Consider two extreme cases. In the first, the elasticity of substitution in consumption between the two goods is unity, so that expenditures on the two goods are proportional in value terms, i.e., $p^N L^{1-\alpha}$ is proportional to z. From this it is evident note that if p^N falls by enough to keep $p^N L^{1-\alpha}$ unchanged when L rises, then (16) and (17) continue to hold. This explains why the AM curve has a negative slope when η is large. Now suppose η is very small, say zero. In this case, quantities of the nontraded and traded goods are proportional in physical terms. Hence, an increase in L requires that z increase in the same proportion as $L^{1-\alpha}$. For this to be consistent with the collateral constraint requires a proportional increase in the entire present discounted value that defines q^N. Since L only operates on the first term in this expression, a very large increase in p^N is required to satisfy the collateral constraint. This establishes why the AM curve is positively sloped when η is small. In additonal analysis of this curve, we have also found that as η falls from unity towards zero, the AM curve rotates in a clockwise direction.

We now turn to the general equilibrium analysis of the real effects of a fall on R, using the AM and the LM curves. Consider first the case in which η is sufficiently large that the AM curve is downward sloped. Recall that a drop in R has no impact on the location of the AM curve, but shifts the LM curve down (see Figure 1). As a result, the drop in R produces a real exchange rate depreciation, ie., a fall in p^N, and a rise in L. As noted in the previous paragraph, when $\eta = 1$ $p^N y^N$ does not change, so that (16) implies that z does not change either. Thus, with $\eta = 1$, L rises, y^N rises, and $p^N y^N$, q^N, z, y^T remain unchanged.

Now suppose $\eta < 1$, but sufficiently large that the AM curve is still downward sloping. Then, the fall in R produces a fall in p^N and a rise in L, as before. According to (17), the fall in p^N results in a fall in $p^N y^N$. Then, according to (12), $q^N K^N$ falls, producing a fall in z via the collateral constraint.

Now suppose that η is very close to zero. According to (17), with $\eta = 0$, the AM curve is positively sloped. Moreover, if $A > R^*$ but close to R^*, then

AM curve cuts the LM curve from below. In this case, a drop in R produces a fall in L, y^N, and p^N. The reduction $p^N y^N$ results in a fall in q^N, causing a contraction in z. Thus, in this case there is a real depreciation and output in both sectors declines.

We summarize the results in this and the previous paragraph as follows:

Proposition 1 *Suppose $\theta = 0$, and $A > R^*$. Then, a cut in R leads to:*
(i) when $\eta = 1$, L rises, p^N falls, and q^N, $p^N y^N$, y^T remain unchanged.
(ii) when $\eta < 1$, but large enough, L rises, and p^N, $p^N y^N$, q^N, y^T fall.
(iii) when $\eta = 0$ and A is small enough, then L, y^N, p^N, $p^N y^N$, q^N, y^T fall.

3.5.3 Domestic Financial Market

We now determine the increase in X that is required to sustain the drop in R whose effects on the temporary equilibrium have just been analyzed. Combining the household's cash constraint, (4), with the money market clearing condition, (13), and making use of (6), we obtain:

$$\frac{wL}{\left[\left(p^N \frac{\gamma}{1-\gamma}\right)^{\eta} + p^N\right] c^N} = \frac{D+X}{M+X} = \Gamma.$$

Here, Γ measures the amount of domestic liquidity flowing through the financial sector relative to the total amount of liquidity in the economy. Recall that the monetary action occurs after D is selected so that, since $D < M$, Γ is increasing in X. We now impose the nontraded good firm's Euler equation for labor:

$$\frac{1-\alpha}{R\left[\left(\frac{\gamma}{1-\gamma}\right)^{\eta} (p^N)^{\eta-1} + 1\right]} = \frac{D+X}{M+X} = \Gamma.$$

From this expression we can determine the X that is required to produce any given fall in R. Unless the fall in R produces a very large real exchange rate depreciation, to effect a fall in R the monetary authority must increase X.

3.5.4 The Nominal Exchange Rate

We can determine the nominal exchange rate, S, by combining the household's cash constraint, and the money market clearing condition:

$$P^T \left[c^T + p^N c^N\right] = M + X.$$

Applying purchasing power parity in the tradeable good, we

$$SP^{T^*} \left[c^T + p^N c^N\right] = M + X.$$

This expression determines S since everything else has been determined elsewhere. When η is less than unity, but sufficiently large, we know that $c^T + p^N c^N$ falls with a drop in R and that this requires a positive injection of the domestic currency. In this case there is a nominal depreciation.

3.5.5 Numerical Example

The following numerical example illustrates the discussion in the previous paragraphs. The preferences of the representative household are: $\sum_{t=0}^{\infty}\beta^t u\left(c_t - 0.32L_t^2\right)$, where $\beta = 1/1.05$, $c = \min\left[c^T, c^N\right]$, and c^T and c^N denote traded and nontraded goods, respectively. The lack of substitutability between c^T and c^N in utility is consistent with assumption (iii), and L_t denotes time worked. We specify the technology for producing traded goods as $y^T = Az$, where $A = 1.21$ and z is an intermediate good that must be imported from abroad at the beginning of the period. Also, $y^N = \left(k^N\right)^{0.25} L^{0.75}$, where k^N is capital which is fixed exogenously, with $k^N = 1$.

To finance beginning of period purchases of the intermediate good, z, the firm must borrow foreign currency. This gives rise to an end-of-period obligation, denominated in units of the domestic traded good, of R^*z, where $R^* = 1.06$ is the foreign currency nominal rate of interest, which we take as given. At the end of the period, the firm exports zR^* to pay off its international debt. The collateral constraint on foreign loans is $0.1q^N k^N \geq R^*z$. In the example, no more than 10 percent of the capital in the nontraded good sector can be used as collateral. Also, q^N is how much a domestic resident would be willing to pay, in units of the traded good, to acquire a unit of k^N and become a firm. It is the present discounted value of the marginal contribution to firm profits of an increment in k^N, inclusive of the shadow value of k^N in relaxing the collateral constraint.[7]

The financial intermediary accepts deposits, D and (on behalf of households) a monetary transfer, X, from the monetary authority. These are loaned on to the firms, who seek funding in local currency for their wage bill. This leads to the following clearing condition in the domestic money market: $P^T wL = D + X$. Clearing in the domestic goods markets implies $c^N = y^N$ and $c^T = y^T - R^*z$. We define a stationary equilibrium in crisis times as an equilibrium in which all variables are constant and the collateral constraint is binding. There is only one such equilibrium, and it has the properties, $p^N = 9.45$, $q^N = 70.7$, $z = 6.7$, $L = c^N = c^T = 1$, $D/M = 0.058$, $X/M = 0.01$, and $R = 1.06$ (all variables have been rounded).

We now investigate what happens if the monetary authority engineers a one-time, never-to-be-repeated, unexpected increase in the money supply in the first period designed to reduce the domestic rate of interest, R, by 1 percentage point. We contemplate that this action is taken after the current period D choice by the household (this is the 'limited participation' assumption). The consequences of this intervention are easy to work out, since the only real effects of this change are limited to the current period, and they are characterized by

[7] In particular, $q^N = p^N MP_k^N + \lambda\tau^N q^N +$ future terms, where MP_k^N is the physical marginal product of capital in the nontraded good sector and p^N is the price of nontraded goods, deflated by the traded good price. Also, λ is the multiplier on the collateral constraint, and τ^N is the fraction of k^N that is collateralizable. In the example, $\lambda = (A/R^*) - 1$. The 'future terms' in the expression corresponds to the future values of $p^N MP_k^N + \lambda\tau^N q^N$, appropriately discounted. In an equilibrium where all variables are constant, this is just βq^N.

a small system of static equations. The only dynamic equation in the model of the example, the one that determines D, has been momentarily put aside by the assumption that the cash injection occurs after D has been chosen. In the version of our model with long term debt held by firms, there is another dynamic equation, but we have suppressed that to keep the example simple.

To get the rate of interest down by one percentage point by increasing the money growth rate requires that X/M be increased to 0.024. We find that q^N, z, L, c^N and c^T all fall by (roughly) one percent, while p^N falls by 17 percent. Finally, the nominal exchange rate, S, depreciates by 20 percent. The example illustrates how a monetary expansion that leads to a fall in the domestic rate of interest and a nominal depreciation of the currency, can produce an economic contraction.[8]

At an intuitive level, the idea is this. The economy is one in which foreign and domestic liquidity are both required to undertake production. We model a financial crisis as a time when the binding constraint on economic activity is a shortage of foreign liquidity. Actions designed to expand domestic liquidity at a time like this may paradoxically just serve to further tighten the constraint on foreign liquidity.

4 Long-term foreign debt and external adjustment

[To be completed]

5 Conclusion

We analyzed a small open economy model in which firms require two types of working capital: domestic currency to hire domestic inputs and foreign currency to finance imports of intermediate inputs. A shortage of either one of these sources of working capital can act as a drag on economic activity. Which of these shortages exists can have a drastic impact on the monetary transmission mechanism. If there is a shortage of domestic liquidity, an expansionary monetary policy expansion can lead to a rise in the level of economic activity. If there is a shortage of foreign liquidity, induced say by a tightening of international collateral requirements, then an expansionary monetary action could exacerbate the shortage and lead to a further fall in and the level of economic activity.

[8] For other discussions of the potential contractionary effects of an exchange rate depreciation, see Edwards (1989, Chapter 8), Krugman and Taylor (1978), Lizondo and Montiel (1989), and Sachs and Larrain (1993, Chapter 21).

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