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A simple model of monetary policy and currency crises

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Abstract

This paper analyzes the optimal interest rate policy in currency crises. Firms are credit constrained and have debt in domestic and foreign currency, a situation that may easily lead to a currency crisis. An interest rate increase has an ambiguous effect on firms since it makes more difficult to borrow and may decrease the foreign currency debt burden. In some cases it is actually best to *decrease* the interest rate. We also show how these issues are related to the development of the financial system. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

The recent currency crises have underlined the trade-offs that central banks face when designing appropriate monetary policies for dealing with such crises.

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In particular, central banks in some Asian and Latin American countries have run into strong criticisms for having raised nominal interest rates to an excessive extent. More generally, emerging market economies have differed with regard to both the tightness of their monetary policies in response to the financial crisis[1] and the results in terms of subsequent aggregate output recovery from such policies.

The main debate regarding the optimal conduct of monetary policy in the aftermath of a financial crisis could be broadly summarized as follows: while higher domestic nominal interest rates should generally lead to a stronger exchange rate and therefore improve the finances of domestic firms which have debts denominated in foreign currencies, higher domestic interest rates will also tend to increase the current debt burden of domestic firms, thereby reducing their ability to make further investments (or simply avoid bankruptcy) whenever firms are credit constrained; this, in turn, may feed back negatively on the exchange rate.

Our main purpose in this note is to develop a simple analytical framework to formally assess the relevance and relative importance of these counteracting effects, and thereby to contribute to the ongoing debate on the design of monetary policies in an emerging market economy. The unified model we propose in this paper shows that it might not be desirable to implement a tight monetary policy after a currency crisis either when the proportion of foreign currency debt is not too large or when the economy displays financial fragility in the sense that credit provision and thereby domestic investment and production are highly sensitive to changes in nominal interest rates. We interpret these two features as reflecting the level of financial development of the economy.

2. The model

2.1. General framework

We develop a two-period small open economy monetary model.[2] Goods prices are determined at the beginning of each period and we consider the impact of an unanticipated shock (for example on current sales or productivity) in period one. Hence, during period one, some variables, such as the nominal exchange rate and the nominal interest rate, will adjust while prices are preset

[1] In particular, Korea and Thailand have raised their interest rates more drastically than Malaysia, but perhaps at the cost of triggering deeper recessions.

[2] Strictly speaking, the model has infinite horizon, but we focus here on the first two periods only, with the implicit assumption that the government will adjust its monetary policy from period three onward to maintain a given interest rate.

for the entire period.[3] There is a single tradeable good and purchasing power parity (PPP) holds ex ante, i.e. $P_t = E_t^e$ for $t = 1, 2$, where P_t is the domestic price, E_t^e the expected nominal exchange rate (the price of foreign currency in terms of domestic currency) at the beginning of period t, and the foreign price is constant and equal to one. During period $t = 1$, however, there may be ex-post deviations from PPP as a result of an unanticipated shock.[4] These deviations play a crucial role in the analysis. There is full capital mobility and uncovered interest parity holds.[5]

The economy is populated by identical entrepreneurs who face credit constraints which prevent them from borrowing and investing more than a multiple of their current real wealth (retained earnings or cash-flow) W_t, in the spirit of Bernanke and Gertler (1989).[6] Entrepreneurs' wealth is therefore the fundamental variable that determines investment and output. Entrepreneurs can borrow in domestic currency from domestic consumers or in foreign currency from foreign lenders. Consumers need money for their transactions and there is a central bank that can alter interest rates or the exchange rate by affecting money supply. In this short paper we focus on flexible exchange rates.

The timing of events can be summarized as follows: first the price P_1 is preset and firms invest; then an unanticipated shock occurs followed by a monetary adjustment which determines the current nominal interest rate and the exchange rate; subsequently, period 1's output and profits are generated and firms' debts are repaid. Finally, a fraction $(1 - \alpha)$ of net retained earnings after debt repayment, namely W_2, is saved for investment in period 2.

The remaining part of this section is organized as follows. Section 2.2 describes the monetary side of the economy. We point out that expected real output in period 2, Y_2, influences the nominal exchange rate in period 1, E_1. This relationship is summarized by a curve which we refer to as the IPLM- (or interest parity–LM) curve. Section 2.3 analyzes the entrepreneurs' borrowing and production decisions and shows that output is affected negatively by currency depreciations; this is described by what we refer to as the W- (or wealth) curve. Finally, Section 2.4 analyzes the equilibria of this model, simply defined by the intersection of the IPLM and W curves, and describes cases in which monetary tightening can either facilitate output recovery or instead prevent it.

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[3] The assumption that prices are preset for one period is commonly made in monetary models of an open economy, following Obstfeld and Rogoff (1995).

[4] Producers set prices in domestic currency by taking the foreign price (adjusted by the expected exchange rate) as given.

[5] Our analysis can be easily extended to the case where interest rate parity does not hold strictly.

[6] Aghion et al. (1999b) and Aghion et al. (1999a) use a similar formulation, although these two papers focus on the real side of the economy.

2.2. The monetary sector

The interaction between consumers and the central bank gives us a money market equilibrium and an interest parity condition. Since these two components are standard in open macroeconomics, we shall not expand on their microfoundations, but rather derive them in a reduced form way. Arbitrage by consumers between domestic and foreign bonds yields the following interest parity (IP) condition:

$$1 + i_t = (1 + i^*)\,\frac{E_{t+1}}{E_t} \tag{1}$$

where i^* is the foreign interest rate which we assume to be constant.

In addition, consumers have a standard money demand $L(Y_t, i_t)$.[7] We assume that the function L has the usual properties of being increasing in Y_t and decreasing in i_t and that $L(0, i_t) > 0$.[8] Thus money market equilibrium at dates $t = 1, 2$ can be expressed by the $(\mathrm{LM})_t$ equations:

$$M_t^{\mathrm{S}} = P_t L(Y_t, i_t) \tag{2}$$

where M_t^{S} is the nominal money supply at date t.

Combining equations (IP), $(\mathrm{LM})_2$ in which the second-period interest rate i_2 is exogenously fixed[9] and the PPP assumption $P_2 = E_2$, we get

$$E_1 = \frac{1 + i^*}{1 + i_1}\,\frac{M_2^{\mathrm{S}}}{L(Y_2, i_2)} \tag{3}$$

which provides a negative relationship between E_1 and Y_2. This relationship can be represented graphically in the (E_1, Y_2) space and is shown in Fig. 1a; we call it the IPLM curve (interest parity–LM).[10] The negative slope of the IPLM curve reflects the fact that an increase in Y_2 increases the demand for money in period 2, which in turn produces an exchange rate appreciation in that period, i.e., a reduction in $E_2 = P_2$. The anticipation of an exchange rate appreciation tomorrow in turn increases the attractiveness of domestic currency today, thereby producing an exchange rate appreciation today, i.e., E_1 also goes down.

[7] The dependence of money demand on output can be derived under some restrictive conditions. Alternatively money demand could depend on consumption. This would not change our results as long as real consumption is not substantially affected by unexpected depreciations.

[8] The latter assumption is needed in our context since output only depends on past profits and therefore can be equal to zero. It could be dropped in a more general context.

[9] We implicitly assume that monetary policy from period three onward is such that the nominal interest rates i_t for $t \geq 2$ are brought back to their pre-shock steady-state level.

[10] Note that our curve differs from the AA curve in Krugman and Obstfeld (1997) which relates E_1 with Y_1 by keeping period 2 variables constant.

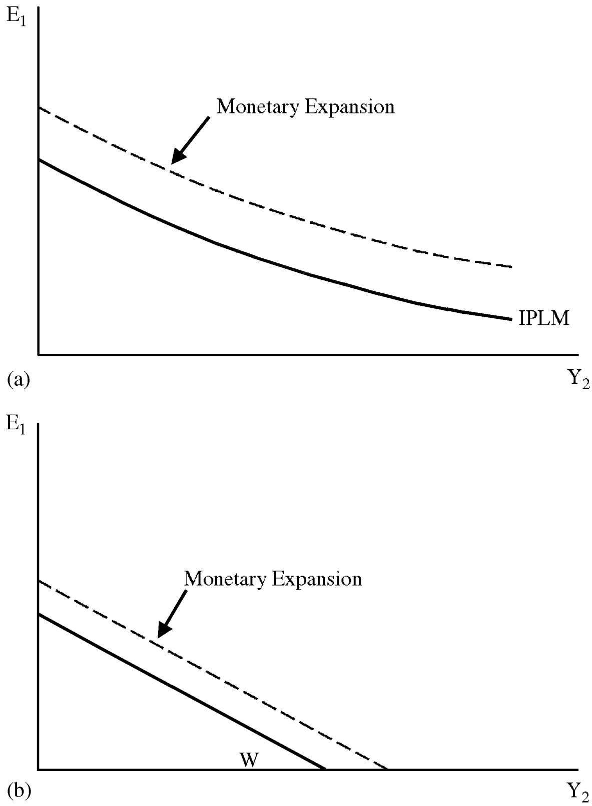

Fig. 1.

Furthermore, the IPLM curve is shifted by changes in monetary policy in each period. For example, an increase in M_1^S implies a decline in i_1 (from $(LM)_1$), which clearly shifts the IPLM curve upwards. The same occurs with an increase in M_2^S. These effects are standard: for a given output level, the domestic currency depreciates after a monetary expansion in the first period due to an excess of liquidity and it depreciates after a monetary expansion in the second period due to an expected increase in inflation. This, however, takes output Y_2 as given. But monetary policy itself can affect output in a way we now describe.

2.3. Output and entrepreneurs' debt

Our analysis in this section rests on two basic assumptions on the real side of the economy. First, due to the existence of credit constraints, entrepreneurs can at most borrow an amount D_t proportional to their cash flow W_t, $D_t = \mu_t W_t$. They can borrow either in domestic currency at interest rate i_{t-1} or in foreign currency at i^*. Since capital is the only production input and it fully depreciates within one period, entrepreneurs' capital stock at the beginning of each period t is $K_t = W_t + D_t$. If we assume a linear production technology, $Y_t = \sigma K_t$, current output becomes a linear function of current entrepreneurs' wealth:

$$Y_t = \sigma(1 + \mu_t)W_t.$$

We also assume that the proportionality factor μ_t is a negative function of the nominal interest rate: $\mu_t = \mu(i_{t-1})$.[11]

The second basic assumption is that, for reasons which reflect the level of financial development in the domestic country, domestic consumers are unwilling to lend more than a real amount D^c in domestic currency to domestic firms at each period.[12] The rest of the funding, $D_t - D^c$, comes from foreigners and is in foreign currency.[13]

Aggregate nominal profits net of debt repayments in period t, are simply given by

$$\Pi_t = P_t Y_t - (1 + i_{t-1})P_{t-1}D^c - (1 + i^*)\frac{E_t}{E_{t-1}}P_{t-1}(D_t - D^c).$$

When profits are positive, entrepreneurs use a proportion $(1 - \alpha)$ of these profits as their own retained earnings for production in the following period (a proportion α of profits is distributed or consumed). Total net wealth available for next period production is thus either equal to zero, when net profits are not positive, or otherwise equal to

$$W_{t+1} = (1 - \alpha)\frac{\Pi_t}{P_t}.$$

[11] This can be justified, e.g. using similar considerations as in Aghion et al. (1999a). Namely, suppose that entrepreneurs can either produce transparently and fully repay their loan or instead can hide their production in order to default on their debt repayment obligations. There is a cost to hiding proportional to the funds invested: $cP_{t-1}K_t$. Yet, whenever the entrepreneur chooses to default, the lender can still collect his due repayment with probability p. Thus the borrower will decide not to default if and only if: $P_tY_t - (1 + i_{t-1})P_{t-1}D_t \geq P_tY_t - cP_{t-1}K_t - p(1 + i_{t-1})P_{t-1}D_t$. This is equivalent to $D_t \leq \mu(i_{t-1})W_t$ with $\mu = c/[(1 - p)(1 + i_{t-1}) - c]$, which is indeed decreasing in i_{t-1}. The foreign interest rate does not affect μ when both PPP and the interest parity hold.

[12] Whether D^c is large or small, that is the extent to which domestic lenders are willing to lend (short-term) on the domestic market, in turn reflects such things as the information costs of lending to domestic firms, the 'thickness' and 'completeness' of the domestic credit market and the domestic lenders' attitude toward risk. A precise analysis of the determinants of D^c and of how D^c may vary for example with the size of period 1's shock, goes beyond the scope of this note.

[13] To lend in domestic currency, foreigners would ask a positive premium to compensate for transactions costs. Thus, they would require an interest rate higher than i_t. Thus if domestic entrepreneurs borrow more than D^c, they borrow the difference from foreigners in foreign currency.

If we focus on second-period output Y_2, which is a multiple of the wealth W_2 available at the beginning of period 2, we have

$$Y_2 = \sigma(1+\mu(i_1))(1-\alpha)\left[Y_1 - (1+r_0)D^c - (1+i^*)\frac{E_1}{P_1}(D_1 - D^c)\right] \quad (4)$$

or $Y_2 = 0$, if the above expression is negative; r_0 is the real interest rate on domestic debt.

At the beginning of period 1, all variables on the right-hand side of (4) are fixed except for E_1 and i_1 (P_1 is given since prices are preset). Increases in both variables reduce Y_2: an increase in E_1 reduces profits Π_1, while an increase in i_1 reduces the availability of funds D_2 at the beginning of period 2. The nominal exchange rate E_1, however, has an impact on W_2 only if there are deviations from PPP in period 1, i.e., if there is an unanticipated shock such that $E_1 \neq P_1$. We can represent Eq. (4) and the non-negativity constraint $Y_2 \geq 0$ graphically in the (E_1, Y_2) space. This corresponds to our (W) curve in Fig. 1b. For positive levels of Y_2, the (W) curve is linear and downward sloping, since a depreciation of the domestic currency increases entrepreneurs' cost of reimbursing the foreign-denominated debt.

A major factor influencing the slope of the (W) curve is the proportion of foreign currency debt. With no foreign currency debt, i.e., when $D^c = D_1$, the (W) curve is vertical. As the proportion of foreign currency debt increases the slope of the (W) curve decreases, the limit being achieved for $D^c = 0$.

Monetary policy shifts the (W) curve through changes in i_1. An expansionary monetary policy implies an upward shift in (W). The reason is simply that a decrease in i_1 increases the availability of external funds D_2 (for a given exchange rate E_1).

2.4. Equilibrium

Equilibrium is simply defined by the intersection of the (IPLM) and (W) curves. As shown in Fig. 2, there are three possible outcomes. Fig. 2a shows the 'good' case, with positive output and a single exchange rate value. This case occurs, in particular, when foreign currency debt is small. Fig. 2b shows the 'bad' case, where the exchange rate depreciation is so large that it drives profits to zero.[14] Finally, Fig. 2c shows an intermediate case with multiple equilibria, where only the two extreme equilibria are stable. The reason for multiple

[14] A zero level of output is obviously an extreme simplification. In a more general framework, firms would gain competitiveness through a currency depreciation. Moreover, output would still be positive for firms which do not have foreign currency debt.

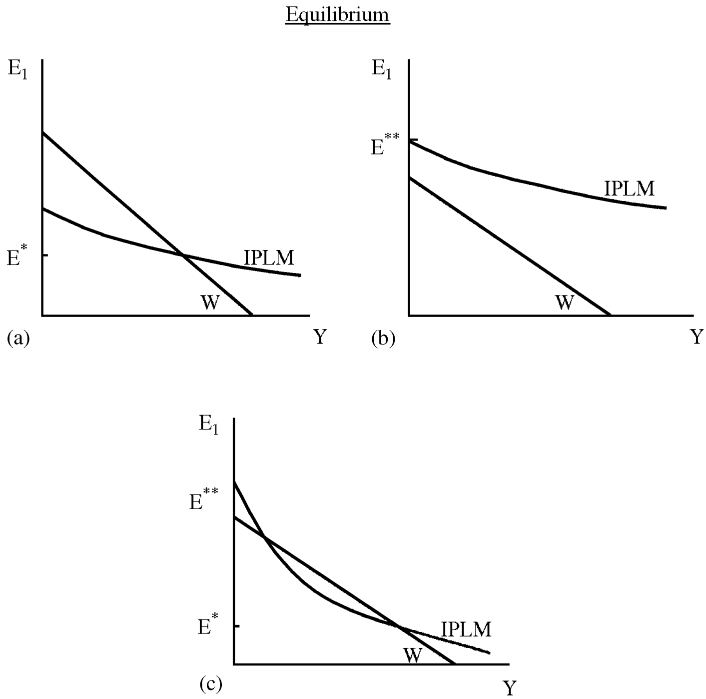

Fig. 2.

equilibria is simple:[15] if a large depreciation is expected, consumers will reduce their money demand because expected output is lower. This leads to a currency depreciation, confirming the consumers' expectations. On the other hand, if no large depreciation is expected, it will not occur in equilibrium. Notice that a currency crisis may occur either as a switch between equilibria or because a fundamental shock moves curves so that we go from Fig. 2a to Fig. 2b.

3. Currency crisis and monetary policy

Suppose that the economy is hit by an unexpected negative productivity shock, i.e., σ goes down.[16] This shock shifts the (W) curve down and can lead to

[15] The scope for multiple equilibria in open economies with credit-constrained firms, has already been pointed out by Stiglitz (1998) and Krugman (1999). However, as our analysis in this section shows, this multiplicity is *not* what matters fundamentally when evaluating the costs and benefits of a tight monetary policy in the aftermath of a financial crisis.

[16] A decline in σ can also capture the terms of trade shock.

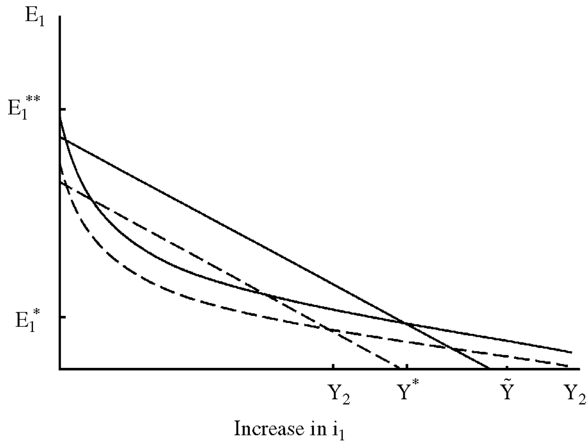

Fig. 3.

the multiple equilibrium case (this is not crucial for our story). This is illustrated in Fig. 3. The initial equilibrium is at $(\tilde{Y}, \tilde{E})$. The negative shock leads to a currency depreciation, either to (Y^*, E^*) or in the worst case to $(0, E^{**})$. The latter case corresponds to a currency crisis situation.

What is the best monetary policy response to such a shock, if the objective is to limit the output decline and more importantly, to avoid a currency crisis? A standard recommendation (the IMF position) is to increase the interest rate i_1 (through a decrease in M_1^S). From (3), this shifts down the (IPLM) curve. If the (W) curve remained unchanged, this might eliminate the currency crisis situation and lead to an appreciation and to a subsequent increase in Y_2 in the good equilibrium. However, the (W) curve also shifts down as an increase in i_1 reduces Y_2 through a decline in lending. This downward shift reduces the positive impact of an interest rate increase on Y_2. Moreover, the (W) curve may shift more than the (IPLM) curve, in which case an increase in the nominal interest rate i_1 will have an overall negative impact on equilibrium output Y_2. In this case it would be best to *decrease* the interest rate through increasing money supply M_1^s.

Whether the nominal interest rate should increase or decrease will depend on the relative shifts of the IPLM and W curves, i.e., on $\mathrm{d}E_1/\mathrm{d}i_1$ in Eqs. (3) and (4). One can show that it is optimal to increase i_1 when

$$-\frac{\mu'(i_1)P_1[Y_1 - (1 + r_0)D^c - (1 + i^*)(E_1/P_1)(D_1 - D^c)]}{(1 + \mu(i_1))(1 + i^*)(D_1 - D^c)} < \frac{E_1}{1 + i_1}.$$

This condition holds, in particular, when $\mu'(i_1)$ is small and when $(D_1 - D^c)$ is large: it makes sense to increase interest rates only when the proportion of foreign currency debt is sufficiently enough and when the sensitivity of credit supply to interest rates is small.

How does the level of financial development affect the optimal policy response to a financial crisis? The answer is somewhat ambiguous. First, to the extent that a more developed financial system corresponds to a higher value of μ, the more developed the credit market the more likely it is that monetary tightening will be the right policy to follow. On the other hand, whilst credit supply should not be very sensitive to interest rates in both an economy with no credit market and an economy with perfect credit markets, at intermediate levels of financial development high interest rates may lead to a contraction or collapse of the financial system, that is to a sharp reduction in $\mu(i_1)$.[17] In this case, increasing i_1 becomes undesirable. However, a higher degree of financial development has an ambiguous impact on the proportion of foreign currency debt: indeed both μ (i.e., D_1) and D^c should increase with financial development, hence an ambiguous effect on the LHS of the above inequality. Consequently, it is necessary to look more closely at the financial structure of domestic firms before drawing definite conclusions.

In the above analysis, monetary policy in period 2 has been maintained constant, i.e., restrictive monetary policy was assumed to be temporary. Now, if monetary policy is expected to be more permanent with a decline in M_2^S, there will be a larger exchange rate effect, making an interest rate increase more desirable. More generally, credibility considerations – the analysis of which would require a multi-period extension of our model – should obviously affect the analysis of the medium- and long-term effects of the monetary responses to financial crises.

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[17] For example, as we argue in Aghion et al. (ABB) (1999a), signaling considerations in a financially fragile economy may lead to a high (negative) interest sensitivity of the credit multiplier μ (e.g. through the effects on creditors' confidence in the credit market). Also, if we introduce uncertainty and the risk of insolvency and liquidity defaults as in ABB, then a higher interest rate will increase the fraction of defaulting firms. This in turn increases the per-project cost of monitoring (or the monitoring probability p on each individual project) if, as in Diamond (1984), the monitoring of projects by financial intermediaries involves positive fixed costs. The thinner the credit market, the greater the reduction in p resulting from an increase in the nominal interest rate.

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