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Currency Crises and Monetary Policy in an Economy with Credit Constraints: The Case for Low Interest Rates Restored

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Abstract

This paper revisits the currency crises model of Aghion, Bacchetta and Banerjeee (2000, 2001, 2004), who show that if there exist nominal price rigidities and private sector credit constraints, and the credit multiplier depends on real interest rates, then the optimal monetary policy response to the threat of a currency crisis is restrictive. We demonstrate that this result is primarily due to the uncovered interest parity assumption. Assuming that the exchange rate is a martingale restores the case for expansionary reaction – even with foreign-currency debt in firms' balance sheets. The effect of lower interest rates on output can help restore the value of the currency due to increased money demand.

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1 Introduction

From the viewpoint of economic policy, the central question when a currency crisis is imminent is how should the monetary authorities respond? The monetary policy response followed in most East-Asian countries affected by the 1997-1998 crises, induced by unexpected currency shocks, was to increase interest rates sharply.[1] Despite intense criticism (see Furman and Stiglitz (1998), Krugman (1999)), the reaction was defensible. Domestic borrowers had issued large un-hedged foreign currency liabilities, the domestic currency cost of which rose rapidly as the value of their currencies fell. There was an urgent need to stop the capital outflows and reverse the large depreciations which were leading to default and economic crises. It remains unclear how effective this controversial policy response was. Its logic depends crucially on the effectiveness of interest rate increases as a tool to induce immediate appreciations in the exchange rate. But in all affected countries the interest rate defence was not effective in appreciating the currency (at least in the short term – see Gould and Kamin (2000)), and they all entered severe economic recessions (see Tirole (2002)).

Starting with Krugman (1999) and the sequence of pioneering papers by Aghion, Bacchetta and Banerjee (2000, 2001, 2004), a growing group of researchers have developed a third-generation of

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[1] This was done by Indonesia, Malaysia, South Korea, Thailand and the Philippines. The same stance was adopted by Mexico in the 1994-1995 crises. (See Gould and Kamin (2000).)

currency crises models. Motivated by the facts presented by the East-Asian crisis of 1997-1998, these models depart from the previous generations of theoretic models (see Krugman (1979) and Obstfeld (1994)) by placing the behaviour of the private sector at centre stage, and emphasising the balance sheet effects of foreign currency borrowing as a determinant of crises. The models provide consistent frameworks with which to analyse the optimal monetary response to prevent or resolve currency crises, and have, under certain assumptions, rationalised the high interest rate response referred to above.

A common assumption in third-generation crises models is that uncovered interest parity (henceforth, UIP) holds.[2] This assumption normally serves to ensure a link between current interest rates and current exchange rates.[3] It is naturally important in the subset of the literature which is specifically concerned with the monetary policy response question.

This paper relaxes the UIP assumption within the monetary framework developed in the Aghion, Bacchetta and Banerjee (henceforth, ABB) papers. (See in particular their 2001 paper.) The principal (but not only) motivation for this simple extension is empirical. A slim body of recent evidence gives support to UIP over long horizons and between currencies and long-term bonds traded in deep and fluid international financial markets. Chinn and Meredith (2004) in particular, show strong support for UIP when regressing the ten-year change in the exchange rate on a proxy for the ten-year lagged differential in bond yields for a selection of high-income countries.[4] But when monetary tightening is advocated to prevent or solve crises, it is normally expected that the exchange rate will stabilise or appreciate in response within a short period of time. If not, the benefit of preventing the deterioration of firms' balance sheets due to depreciation will be not enjoyed – output may have already fallen before the currency recovers. As discussed in Chinn (2006), the overwhelming evidence on UIP as a short term relationship (not more than one year) continues to firmly reject the hypothesis.[5]

Two other issues motivate this extension. The first concerns the interest rate defence (i.e. the recourse to tight monetary policy to prevent or reverse large currency depreciations): the evidence on its effectiveness, and its theoretic compatibility with UIP. In ABB(2000, 2001, and 2004), the effect of current domestic interest rates on the current exchange rate, representing the short-term effect, is a consequence of the interest parity assumption. (This is clear from the derivation of the "interest parity-LM" equations.) However, some authors have argued that deviations from UIP are a *necessary* condition for an interest rate defence to succeed. Flood and Rose (2002) note that if UIP holds, and a monetary authority responds to heavy downward pressure on the currency by raising interest rates, the increase in the latter will be exactly offset by an increase in expected

[2]See Aghion, Bacchetta and Banerjee (2000, 2001, 2004), Gertler, Gilchist, and Natalucci (2003), Cespedes, Chang and Velasco (2004), and Devereux, Lane, and Xu (2005). An interesting exception is Christiano, Gust and Raldos (2004). The conclusion we obtain in this simple monetary model regarding the interest rate response is consistent with the latter.

[3]More precisely, let i represent the yield, at time t, on a domestic bond maturing at future date $k; i^*$ the yield, at t, on a foreign bond with the same characteristics; and Δ the expected depreciation of the domestic currency (relative to that of the country where the foreign bond is issued) between times t and k. Assuming risk-neutrality, the uncovered interest parity hypothesis states that the interest differential $(i - i^*)$ is approximately equal to Δ, the expected rate of depreciation over the term of the bonds.

[4]The proxies for lagged bond yields were obtained synthetically, by interpolating the yield curve.

[5]This is a well-known result. Other surveys include Froot and Thaler (1990) and Kilian and Taylor (2003). Flood and Rose (2002) look at short horizon UIP using high frequency data during the main crises episodes of the 1990s and indicate an improvement in the empirical performance of UIP. The basis for their claim is fragile: from the sample of 21 countries, the slope coefficient (in regressions of the interest differential on exchange rate depreciation, which is equal to 1 if UIP holds) is negative in twelve cases, essentially zero in two cases, and positive in seven cases. Of the seven positive coefficients, three are statistically significant. None of these three is meaningfully close to 1.

depreciation, making domestic securities unattractive despite the higher yield.[6] There is then an inconsistency in assuming UIP and advocating interest rate rises to prevent or reverse depreciations – as done for example in the ABB papers (applicable under flexible and fixed exchange rate regimes), and much of the literature.

Conversely, the analysis in ABB can be interpreted as implying that UIP is a necessary condition for interest rate increases to cause exchange rate appreciation. In such case, one would expect the lack of empirical support for UIP to cause serious reservations about the effectiveness of the interest rate defence. Although there have been isolated cases where the interest rate defence was effective in countries with strong banking sectors,[7] the existing systematic evidence shows that tight monetary policy is generally ineffective in reversing large devaluations during currency crises. Specifically, there seems to be no systematic association between interest rates (or other measures of monetary policy) and the outcome of speculative currency attacks; and monetary policy responses with the predicted sign on the exchange rate tend to be weak and statistically insignificant.[8] Short-term UIP is an empirical failure; and so it seems is the interest rate defence.

The last motivation is the recent increase in foreign currency borrowing observed in lower income developing countries – which tend to have a heavy dependence on volatile commodity prices and to be exposed to frequent currency shocks.[9] It is common for no distinction to be made between "emerging markets" and lower income developing countries, typically with little exposure to international capital markets.[10] In the currency crises literature it is normally implicit from either the assumptions or the context that motivates the study, that the analysis is applicable to emerging markets only. This focus may be necessary in first- and second-generation crises models, where

[6] Observe that the argument in Flood and Rose (2002) requires that: a) the exchange rate is currently fixed; b) the current peg is not expected to last; and c) the belief that the peg will collapse does not cause an immediate devaluation. It does not apply under flexible exchange rates, nor if the second requirement invalidates the third. Suppose that following an increase in domestic interest rates the exchange rate appreciates, say due to a reversion in the profitability of the carry trade, but expected future exchange rates remain unchanged. The interest rate defence would have succeeded. But the expected rate of depreciation has increased, which is consistent with UIP.

[7] Probably the most vivid case was the Swedish Central Bank's temporary success in repelling heavy krona selling by raising its daily lending rate to 500 percent, during the collapse of the European Monetary System in 1992. (See Bensaid and Jeanne (1997).)

[8] For the empirical evidence see Furman and Stiglitz (1998), Gould and Kamin (2000), and Kraay (2003). A number of studies have attempted to explain precisely why interest rate defences may fail. Bensaid and Jeanne (1997) develop a theoretic model where the anticipation that the authorities will try to protect the value of the currency by raising interest rates can lead to self-fulfilling currency crisis. See also the discussions in Furman and Stiglitz (1998) and Radelet and Sachs (1998). Corsetti, Presenti and Roubini (2001) discuss evidence of "double play" strategies where investors take short positions in the target currency and bond markets, so an interest rate defense permits the speculator to gain from either (or both) the currency depreciation or a fall in bond prices brought about by the interest rate rise. In such cases the possibility of an interest rate defense may stimulate further the incentive for large traders to sell the currency.

[9] See Nicoló, Honohan and Ize (2003) for data on foreign currency liabilities in developing country banking sectors. Of course, if banks also lend in foreign currency they are not directly exposed to currency shocks. But the currency exposure simply moves to borrower balance sheets, so currency shocks affect non-bank balance sheets directly, and banks' loan portfolios indirectly (through increased default rates). Consider Mozambique as a specific example. According to an IMF Country Report (04/52 of March 2004), foreign exchange liabilities reached 63% of total liabilities in the banking sector by 2001. But a similar ratio of bank loans was denominated in foreign currency and statistics from the Mozambican central bank show that foreign currency debt reached 60% of total debt for the non-bank sector in 2004 – with the latter group of borrowers rarely hedging their foreign currency debt.

[10] To be more specific consider the distinction adopted by Husain, Mody and Rogoff (2005). Take the set of countries which are not classified as upper income countries by the World Bank. Of these, the Emerging Market countries are those classified as such by the Morgan Stanley Capital International classification according to a number of factors related to international capital market access. The remaining countries are what we refer to in this note as "less developed countries".

movements in international portfolio capital flows play a central role.

In third-generation models however, the combination of a large depreciation with credit constraints and domestic borrowing in foreign-currency, is sufficient to cause a currency crises. Portfolio capital outflows can either cause or aggravate depreciations. But the latter can just as well be caused by shocks to a country's terms of trade or sudden reductions in foreign aid. And although a theoretic case for uncovered interest parity remains valid for advanced economies and some emerging markets with globally integrated capital markets, this is not the case for LDCs. In these countries interest parity has neither empirical nor theoretic support. Due to their rudimentary financial markets and isolation from international portfolio investment flows, the arbitrage-based theoretic motivation for interest parity conditions is inapplicable.[11] The focus on credit market imperfections in contributions such as Aghion, Bacchetta and Banerjee (2001) however, is certainly relevant.

2 Present paper's contribution

A key result in ABB(2001) is that, if some proportion of firms' liabilities is denominated in foreign currency (so that crises are possible), and the credit multiplier depends only on the real interest rate, then prevention or resolution of crises requires tight monetary policy (lower money supply or higher interest rates). We demonstrate that this result is primarily due, not to the dependence of the credit multiplier on real interest rates, but to the uncovered interest parity assumption. Relaxing the latter restores the case for monetary relaxation to prevent or resolve currency crises – consistent with conventional wisdom and the result in ABB(2000) where the same policy implication is a consequence of assuming the credit multiplier depends (only) on nominal interest rates. Moreover, it is shown that an expansionary monetary response need not lead to further depreciations, and may in fact contribute to currency appreciation.

The analysis illustrates how monetary tightening in response to a contractionary currency depreciation may prolong or accentuate a crisis through two channels: first it reduces the availability of external financing and increases the cost of domestic currency debt (without reducing the domestic currency cost of foreign currency debt), unambiguously weakening corporate balance sheets and reducing output; second, the anticipation of the consequent economic recession can lead to further exchange rate depreciation through the expected effect of lower output on demand for domestic currency. Conversely, reducing interest rates increases the availability of external funds and lowers the cost of debt denominated in domestic currency without inducing further depreciation (and therefore not increasing the cost of foreign currency liabilities). If its effect on output is sufficiently strong to raise output despite a currency shock, lower interest rates can also exert upward pressure on the value of the currency, through standard money market equilibrium effects, thus helping to defend the value of the currency.

Our results are obtained through a simple extension of the analysis developed in Aghion, Bacchetta and Banerjee (2001).[12] Specifically, we focus on the monetary policy implications of replacing uncovered interest parity with a martingale process for the exchange-rate. The martingale assumption is consistent with the classical empirical demonstration by Meese and Rogoff (1983) showing that the out-of-sample forecasting accuracy of a simple martingale (predicting the exchange rate to remain unchanged) is generally greater than that of a variety of standard exchange-rate determi-

[11] See for example Aron and Ayogu (1997).

[12] This monetary model was introduced in simpler form in Aghion, Bacchetta and Banerjee (2000).

nation models.[13] Theoretically, the assumption can be justified by recent research (see Engel and West (2005)) showing that, provided the discount factor (used to discount future fundamentals in a rational expectations present value model) is close to one, the exchange rate will follow a process arbitrarily close to a random walk if at least one of its fundamental determinants (which may include unobservable fundamentals) has a unit root.[14] Assuming that the exchange rate process satisfies the martingale property does not therefore imply the absence of equilibrating forces pushing the exchange-rate towards an equilibrium fundamental value. Merely that at least one of these forces is I(1) – a very plausible assumption.

The parsimonious setup in ABB (2001) is appealing for the purpose of this study for a number of reasons. Despite its simplicity the model is based on facts which are known to have contributed to recent crises. First, it is consistent with the high level of foreign-currency borrowing in the private sector of countries affected by the Asian crisis in 1997-1998. Second, it reflects the substantial deviations from purchasing power parity commonly observed after the occurrence of currency shocks. Third, it captures the relationship between decline in output during crises and financial sector under-development, in the form of credit market imperfections. Fourth, although we concentrate here on the case of flexible exchange rates, the framework is applicable under flexible and fixed exchange rate regimes. Fifth, it predicts the occurrence of crises despite sound fiscal management and macroeconomic stability. And lastly, the clearly laid-out monetary side is, by design, particularly well-suited for the analysis of monetary policy during crises. Given our specific interest in this issue, the ABB (2001) setup lends itself easily to analytic clarity, without imposing the need for any more assumptions than what is necessary to reflect the essential stylised facts.

Other studies that analyse monetary policy in crises include Krugman (1999) and Cespedes, Chang and Velasco (2004), who require specific assumptions on the role of tradable and non-tradables, and Gertler, Gilchist, and Natalucci (2003), who focus on the choice of the exchange rate regime in considering the optimal response to crises. Christiano, Gust and Raldos (2004) argue, in contrast to ABB (2001) and in a different setup which does not assume uncovered interest parity, that allowing further depreciation may be an appropriate response to crises.

The next section presents the essential features of the ABB model without assuming interest parity. This is followed by the introduction of the alternative martingale assumption and the simple derivation of an associated LM curve. An analysis of the monetary response to a currency shock under different specifications for the credit multiplier follows, and the paper is concluded.

3 Aghion-Bacchetta-Banerjee setup without interest parity

3.1 The setup

Consider a simple infinite-horizon small open economy monetary model with the common features in ABB (2000) and ABB (2001), except that uncovered interest parity does not hold.[15] Following Obstfeld and Rogoff (1995), prices are assumed preset for one period. Purchasing power parity holds ex-ante, so $p_{t+1} = E_t(s_{t+1})$ at any t, where p_{t+1} is the domestic price for period $t+1$,

[13] For subsequent evidence documenting the persistence of this result see for example Froot and Thaler (1990), Taylor (1995), and Kilian and Taylor (2003).

[14] The assumption is also consistent with the result in Manuelli and Peck (1990), who show precisely that under certain conditions the martingale property is the *only* restriction that equilibrium exchange rates have to satisfy.

[15] For micro-foundations see Aghion, Bacchetta and Banerjee (2004).

pre-set at t, and $E_t(s_{t+1})$ denotes the expectation at t, of the spot exchange rate (units of domestic currency per unit of foreign currency) at $t+1$. The foreign price is constant and equal to one.

The monetary setting is standard. Consumers have a real money demand function given by $m_t^d = m^d(y_t, i_t)$, where it is assumed that m^d is increasing in y_t and decreasing in i_t, and $m^d(0, i_t) > 0$. Let m_t^s denote nominal money supply at t. Then money market equilibrium, at time t, is described by the $(LM)_t$ equation:

$$\frac{m_t^s}{p_t} = m^d(y_t, i_t) \tag{1}$$

Under these conditions it is evident that there is an unambiguously negative contemporaneous relationship between money supply and the rate of interest. This obviates the need to distinguish between money supply and the rate of interest as the monetary policy instrument.

The representation of credit market imperfections follows Bernanke and Gertler (1989) in assuming that an entrepreneur's borrowing capacity is a function of its internal funds (the accumulation of retained earnings). In specific, letting w_t represent current real wealth, the total amount (identical) entrepreneurs are able to borrow, d_t, is limited to a multiple of wealth, i.e. $d_t \leq \mu_t w_t$.[16]

Output, y_t, is produced using (working) capital, k_t, according to a concave production function $y_t = f(k_t)$. Working capital depreciates within one period so at the beginning of each period we have $k_t = w_t + d_t$, implying that whenever the credit constraint is binding we have

$$y_t = f((1+\mu_t) w_t) \tag{2}$$

For period t, entrepreneurs can borrow in domestic currency at interest rate i_{t-1} or in foreign currency at the constant foreign rate of interest i^*. Interest rates are set one period ahead. At the end of period t, nominal operating profits net of financing costs are given by

$$\pi_t = p_t y_t - (1+i_{t-1}) p_{t-1} d_t^c - (1+i^*) \frac{s_t}{s_{t-1}} p_{t-1} (d_t - d_t^c) \tag{3}$$

The first term on the right hand side of this equation represents operating profits; the second is the cost of domestic currency debt (where d_t^c is the stock of domestic currency debt); and the third term represents the cost of foreign currency debt, determined by the foreign interest rate and the loss in value of domestic currency relative to that in which the foreign currency loan is issued, expressed in domestic currency units.

Let α denote the fraction of profits distributed as dividends. Assuming positive profits, the remaining share of $(1-\alpha)$ is retained and used to finance future investment (directly, and by determining the amount of external funds which can be borrowed), giving total net real wealth available for financing production in any period after start-up as

$$w_t = (1-\alpha) \frac{\pi_{t-1}}{p_{t-1}} \tag{4}$$

from which it follows (by substituting equation (3) into (4), and the result into equation (2)):

$$y_t = f\left((1+\mu_t)(1-\alpha)\left[y_{t-1} - (1+i_{t-2}) \frac{p_{t-2}}{pt-1} d_{t-1}^c - (1+i^*) \frac{s_{t-1}}{s_{t-2}} \frac{p_{t-2}}{p_{t-1}} \left(d_{t-1} - d_{t-1}^c\right)\right]\right) \tag{5}$$

[16] We will concentrate on the case where the constraint is binding, i.e. $d_t = \mu_t w_t$. The credit multiplier is specified in section 4. Until then it will be treated as a constant.

This real-sector equation (the "W" curve) is particularly instructive as a description of the output response of credit-constrained entrepreneurs, in period $t+1$, to changes in the exchange rate in period t. Equilibrium requires that equation (5) as well as the condition for money market equilibrium be met. (See remark below and section 3.)

The timing of events is as follows. Start in period 1. First the price level is set for one period, and firms invest. An unanticipated (once-off) shock then occurs. The monetary authorities respond to this shock using the money supply or (equivalently) the interest rate. The monetary response determines the cost of domestic currency debt maturing at the end of the second period, but has no effect on period 1 profits. The change in the period 1 exchange rate due to the unanticipated shock does however affect profits realized in period 1. These, in turn, determine the amount available for investment in period 2, and hence, period 2 output.

3.2 Remarks

In ABB (2000, 2001, 2004), interest parity (IP) combined with the standard LM relationship leads to an "IPLM" equation, relating the current exchange rate to current interest rates and next-period output and interest rates. Short-run equilibrium is then defined, for a given path of prices and interest rates, by the values of s_t and y_{t+1} that satisfy both the IPLM and W equations – essentially a standard textbook intersection of the IPLM and W curves, in (y_{t+1}, s_t) space.[17] In the absence of interest parity we do not have an IPLM curve. We will derive, in section 4, an alternative relationship between the exchange rate and next period interest rates and output. The short-run equilibrium of the model is defined analogously. The economy is understood to be in a currency crisis state when the values of $s_t$and y_{t+1} that simultaneously satisfy both the W and LM equations consist of the combination of a high (depreciated) exchange rate with output arbitrarily close to zero.

Observe that the third term in the right-hand side of equation (3) represents the cost of foreign-currency debt in terms of domestic-currency irrespective of whether UIP holds. This simple fact drives the negative relationship between output and the exchange rate in the previous period in equation (5). It captures the balance-sheet effect of currency depreciations.

4 Occurrence of crisis and monetary policy in the no interest parity case

4.1 The LM equation

Assume the only restriction imposed on equilibrium exchange rate determination is that the exchange rate process is a martingale.[18] Thus, at any t and for any $j \geq 1$ we have $E_t s_{t+j} = s_t$. In words, the expectation at time t of the exchange-rate at a future date, conditional on information available up to t, is simply the time-t exchange-rate.

[17] See ABB(2000, 2001) for simple graphical illustrations.

[18] More precisely: Consider a probability space (Ω, F, P), where Ω denotes the sample space (the set of possible exchange rate paths); F_t the σ-algebra generated by $(s_1, s_2, \ldots, s_t)$, representing the flow of information generated by the exchange rate history and events up to time t; and P is a probability measure on (Ω, F) – to be understood as an objective probability distribution, with respect to which all expectations in this paper are taken. We are assuming the exchange rate process is an F_t-martingale with respect to P, and the expectations operator E_t in $E_t s_{t+j}$ above really means $E^P(\bullet|F_t)$

Now, from ex-ante purchasing power parity (and not depending on the absence of a shock in period 2) we have that $p_{t+1} = E_t(s_{t+1})$. Thus the LM curve (1) can be re-written as $\left(m^s_{t+1}/E_t(s_{t+1})\right) = m^d(y_{t+1}, i_{t+1})$. Using the martingale assumption we have $E_t(s_{t+1}) = s_t$. It follows that

$$\frac{m^s_{t+1}}{m^d(y_{t+1}, i_{t+1})} \tag{6}$$

This equation describes an LM curve consistent with a martingale process for the exchange rate, when purchasing power parity holds ex-ante. In the current setup, equation (6) replaces the IPLM equation in ABB (2000, 2001, 2004), with which it coincides only if domestic and foreign interest rates are equal. It shows how changes in the exchange rate affect money market equilibrium in the following period. Alternatively, it can be interpreted as showing how expected monetary conditions in period 2 affect the period-1 exchange rate. The reasoning is as follows. Consider an anticipated increase in output over period 2. This causes increased demand for money for that period. Money market equilibrium would then require a reduction in period-2 prices. But these are set in period 1, according to the period-1 expectation of the period-2 exchange rate. This expectation is equal to the actual exchange rate in period 1. Thus the period-1 exchange rate has to decrease. Intuitively, the anticipation of increased demand for domestic currency causes the latter to appreciate immediately.

4.2 Occurrence of currency crises

Suppose the economy is hit by an unexpected shock leading to currency depreciation in period 1.[19] Using equation (5), the effect on period-2 output can be read from the equation below:

$$y_2 = f\left((1+\mu_2)(1-\alpha)\left[y_1 - (1+i_0)\frac{P_0}{p_1}d_1^c - (1+i^*)\frac{s_1}{p_1}(d_1 - d_1^c)\right]\right) \tag{7}$$

Treat the credit multiplier as a constant. Then, since all period-1 variables in the right-hand side of this equation, other than the exchange and interest rates, are fixed at the beginning of the period, the increase in $s_1$has an unambiguously negative effect on y_2. This is reflected by the ratio of s_1 to p_1 inside the square brackets in equation (7). The economic story is simple. Currency depreciation raises the cost of servicing foreign-currency liabilities contracted in period-1. Since p_1 is fixed at the beginning of the period (so the depreciation causes an ex-post deviation from purchasing power parity), the increase in the domestic-currency cost of foreign-currency liabilities is not hedged by an increase in revenues. This reduces period-1 profits which in turn reduces the capacity to borrow and invest in the second period. Hence there is a reduction in period-2 output. We refer to this outcome as a currency crisis if it occurs at point where the value of y_2 is arbitrarily close to zero – in practical terms the combination of a "very high" depreciated exchange rate with "very low" output. How should the monetary authorities react?

4.3 The case for expansionary monetary policy

To evaluate the effects of monetary policy on output we have to be specific about the credit multiplier. In ABB(2000) the multiplier is assumed to depend only on the nominal interest rate. In ABB (2001), it depends uniquely on the real interest rate, which stands in one to one correspondence to the real exchange rate. ABB (2001) observe that either extreme might be inappropriate, as there

[19] Examples include productivity and terms of trade shocks, causing the W curve to shift down.

are reasons to expect both real and nominal interest rates to affect credit supply. They obtain sharply different policy implications from merely varying this assumption: restrictive monetary policy is the optimal response to the threat of a currency crisis when the credit multiplier depends on the real interest rate, but not when the multiplier depends (only) on the nominal rate. This is seen below not to be the case in the present paper, where: first, the multiplier's dependence on the real interest rate is consistent with dependence also on the nominal rate; and second, changing the setting so that the credit multiplier depends only on the nominal interest rate does not reverse the monetary policy implications.

Since from the analytic viewpoint this paper differs from ABB (2001) only in replacing interest parity by a martingale for the exchange rate, it follows that the sensitivity of the model to the distinction between nominal and real interest rates as credit supply determinants is due to the interest parity assumption. This argument is now made more precise.

4.3.1 Case 1: the credit multiplier depends on real (and nominal) interest rates

Following ABB (2001) let credit depend negatively on the real interest rate, so $\mu_t = \mu(r_{t-1})$ with $\mu' < 0$, and define the real interest rate by $1 + r_t = (1 + i_t)\, p_t/p_{t+1}$. Since purchasing-power parity holds ex-ante we have $p_2 = E_1 s_2$, implying (from the definition of the real interest rate) that $1 + r_1 = (1 + i_1)\, p_1/E_1 s_2$. Since $E_1 s_2 = s_1$ (from the martingale assumption) we have $1 + r_1 = (1 + i_1)\, p_1/s_1$. Hence the credit multiplier can be re-written as $\mu_t = \mu(i_{t-1}, s_{t-1}/p_{t-1})$, where μ is decreasing in the nominal interest rate i, and increasing in the nominal exchange-rate to price ratio s/p, here the real exchange rate.[20] The equation for period-2 output becomes:

$$y_2 = f\left([1 + \mu(i_1, s_1/p_1)]\,(1-\alpha) \left[y_1 - (1 + i_0)\,\frac{p_0}{p_1} d_1^c - (1 + i^*)\,\frac{s_1}{p_1}\,(d_1 - d_1^c) \right] \right) \tag{8}$$

Now an increase in the exchange rate has two effects on output. It raises the cost of foreign-currency debt (the balance sheet effect), with a negative impact on output – as can be seen from the second square brackets in (8); but it also increases the ratio of the exchange-rate to price, which relaxes the credit constraint (an increase in μ_2) and impacts positively on y_2 , reflecting increased availability of external funds for period-2. (This can be loosely interpreted as a competitiveness effect in the sense that there is an increase in output following the currency depreciation for a given level of foreign currency debt.) In the absence of some form of policy response, the effect of the shock becomes ambiguous. There is a (negative) foreign-currency debt effect, and a (positive) credit market effect.

Consider the case where the effect on the cost of foreign currency debt dominates, so that in the absence of some form of policy intervention the economy will experience a contraction due to the currency shock. Suppose that the monetary authorities react to the shock by tightening money supply or (equivalently) raising the interest rate. From the expression for the credit multiplier one sees that an increase in i_1 leads to a reduction in μ_2, causing y_2 to fall further. Because the interest rate increase is ineffective in appreciating or restoring the initial value of the currency, it does not prevent the increase in the cost of foreign-currency debt. Yet, it tightens the credit constraint, with the unambiguous consequence of exacerbating the reduction in output caused by the currency shock.

[20] In ABB (2001) the real interest rate is uniquely determined by the s/p ratio. Real and nominal interest rates are disconnected.

In addition, the contraction in period-2 output (originally caused by the unanticipated shock but amplified by the tight monetary policy reaction) reduces period-2 money demand. From the LM equation (6), and holding period-2 money supply (or its expectation) unchanged, the anticipation of lower period-2 money demand leads to an increase in the exchange-rate in period-1. As suggested by Furman and Stiglitz (1998), monetary tightening can *increase* the upward pressure on the exchange rate, pushing the economy further to the currency crisis situation.

In contrast, consider an expansionary monetary response. Reducing interest rates in period-1 lowers the period-2 cost of domestic-currency debt without increasing the cost of foreign-currency denominated debt (since it does not provoke further currency depreciation). Since μ is decreasing in the nominal interest rate, lower interest rates lead to an expansion in external debt funding in period-2. This stimulates investment capacity and (from the first square brackets in equation (8)) period-2 output – at least partly compensating for the negative effect of the unexpected depreciation on profitability. In the extreme scenario where the credit channel boost to output exceeds the contractionary balance-sheet effect of the depreciation (net of the positive effect of depreciation on the credit multiplier), period-2 output will increase. From LM equation (6), the stimulus to output raises period-2 demand for money, the expectation of which exerts downward pressure on the exchange rate in period-1.[21] Thus, *reducing* interest rates can (at least partly) restore the value of the currency and prevent a crisis.

4.3.2 Case 2: credit multiplier depends only on nominal interest rates

Lastly, we also examine the simple case in ABB(2000) where the credit multiplier depends only on nominal interest rates: $\mu_t = \mu\left(i_{t-1}\right)$,where $\mu' < 0$. In this case the equation for period-2 output is simply given by

$$y_2 = f\left(\left[1+\mu\left(i_1\right)\right](1-\alpha)\left[y_1-\left(1+i_0\right)\frac{p_0}{p_1}d_1^c-\left(1+i^*\right)\frac{s_1}{p_1}\left(d_1-d_1^c\right)\right]\right) \tag{9}$$

which differs from equation (8) only in the specification of the credit multiplier as $\mu_2 = \mu\left(i_1\right)$. An unexpected increase in the exchange rate $s1$ now has no effect on the supply of credit. Its effect on output, through an increase in the cost of foreign currency debt, is unambiguously negative. Consider an increase in interest rates i_1 as the monetary response. From $\mu' < 0$ this leads to a reduction in external funding for period 2. Since the increase in interest rates does not appreciate the currency, the reduction in $\mu\left(i_1\right)$ amplifies the negative effect of the currency shock on period-2 output. Moreover, the decline in period-2 output causes a decrease in period-2 demand for money, the anticipation of which exerts further upward pressure on the period-1 exchange rate. This follows from the LM equation (6), and presumes that no increases are expected in period-2 money supply.

In contrast, responding by reducing i_1 may prevent the decline in period-2 output. The channels are the same. The lower interest rate expands the availability of credit in period-2, which has a positive effect on output. If this effect is larger than the negative effect of the currency depreciation, period-2 output may increase. Such an increase would raise period-2 money demand, the anticipation of which puts upward pressure on the value of the currency in period-1, at least partly

[21] By reducing the cost of borrowing in domestic currency without inducing further depreciation, lower interest rates could in practice also reduce the cost of refinancing foreign-currency liabilities with domestic currency loans. This would prevent or at least reduce defaults on foreign-currency debt, and therefore alleviate the contraction in credit following a large depreciation. In cases where private sector foreign currency borrowing is coupled by large domestic currency public debt, the contractionary consequences of raising interest rates would be magnified.

reversing the effect of the unanticipated depreciation. As in case 1, the appropriate or least harmful monetary policy response is expansionary, if aimed at preventing a reduction in output.

5 Conclusion

This paper adds to the insights on the monetary policy response to prevent or resolve currency crises caused by balance sheet effects, presented in the sequence of papers by Aghion, Bacchetta and Banerjee (2000, 2001, 2004). Put together, these insights can be summarised as follows. Consider an economy characterised by private sector credit constraints and the existence of nominal price rigidities. Then restrictive monetary policy is the optimal response to the threat of a currency crisis if uncovered interest parity holds and the credit multiplier depends only on real interest rates – the case in ABB(2001). In contrast, lower interest rates (or money supply expansion) is the appropriate response if: a) interest parity holds and the credit multiplier depends only on nominal interest rates – the ABB(2000) case; or, b) the exchange rate is a martingale and the credit multiplier can depend on real or nominal interest rates, or both – the case presented in this paper.

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