# Currency Crises and Monetary Policy in an Economy with Credit Constraints: The No Interest Parity Case

U. Michael Bergman[**]

Shakill Hassan

*University of Copenhagen, Denmark*

*University of Cape Town, South Africa*

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## Abstract

This paper revisits the currency crises model of Aghion, Bacchetta and Banerjee (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

The optimal response of monetary policy to prevent or resolve a currency crisis has attracted a lot of attention in the literature, in particular in the aftermath of the Asian

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[**]Corresponding author: Department of Economics, University of Copenhagen, Studiestræde 6, DK–1455 Copenhagen K, Denmark. Email address: `Michael.Bergman@econ.ku.dk`

crisis 1997–98. According to the IMF, a tighter monetary policy combined with restrictive fiscal policies aiming at restoring credibility and confidence in the currency is the appropriate policy response. The monetary policy response followed in most East–Asian during the 1997–1998 crises was to increase interest rates sharply.[1] Despite intense criticism (see for example Furman and Stiglitz (1998)), this policy can be defended. Domestic borrowers had issued large un–hedged foreign currency liabilities, the domestic currency cost of which was rising 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, however, how effective this policy response was. Its logic depends crucially on the effectiveness of the interest rate as a tool to induce immediate changes in the exchange rate. There is a recent discussion concerning the effectiveness of tight monetary policy where it is often argued that such policy is generally ineffective in reversing large devaluations during crises.[2] To some extent, the developments in the East–Asian countries during and after the crisis of 1997–98 lend support to this view — in each affected country, the interest rate defense was not successful in appreciating the currency, and they all entered severe economic recessions.[3]

The experience during the Asian crisis, therefore, casts doubt on the effectiveness of tight monetary policy in resolving currency crises, and particularly its ability to prevent a severe downturn in output. Moreover, in a recent study of 22 episodes of systemic sudden stops that took place during the Tequila crisis 1994, the East–Asian crisis in 1997 and the

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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.

[2]There is no concensus in the empirical literature. Tight monetary policy may increase, decrease, or may not affect the probability of a successful speculative attack. (See Furman and Stiglitz (1998), Gould and Kamin (2001), Kraay (2003) and Goderis and Ioannidou (2008).) 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 Radelet and Sachs (1998)). Corsetti, Pesenti 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.

[3]The nominal exchange rates fell by more than 20% in Singapore and Taiwan, and more than 40% in Indonesia, Malaysia, Philippines and Thailand during the crisis according to Deutsche Bank Research (dbresearch.com). Output growth also fell sharply and in 1998 all affected countries had a negative growth rate. It is also noteworthy that economic growth did not recover: the average growth rate after the crisis is lower or much lower than the average growth rate before the crisis.

Russian crisis in 1998, Ortiz, Ottonello and Sturzenegger (2007) find that countries that followed the IMF recommendation of raising interest rates and implementing a restrictive fiscal policy experienced larger falls in output than countries implementing a looser policy. It is, of course, difficult to interpret such results, as the authors note, since we do not know if the specific countries that followed tighter policy would have fared better if they had loosened up the policy.

The view that tight monetary policy is the optimal response to emerging currency crises is to a large degree supported by third–generation models focusing on balance–sheet effects and currency mismatches.[4] (See for example Krugman (1999), Aghion, Bacchetta and Banerjee (2000,2001,2004), Cho and Kasa (2007), and Miller, García–Fronti and Zhang (2005,2006).) Motivated by the facts presented by the Asian crisis of 1997–1998, these models depart from the previous generations of theoretic models, for example by placing the behavior of the private sector at center stage, and emphasizing the balance sheet effects of foreign currency borrowing as a determinant of crises. These models provide consistent frameworks with which to analyze the optimal monetary response to prevent or resolve currency crises, and have rationalized the interest rate response referred to above. According to the third–generation models mentioned above, a tight monetary policy will dampen the fall in output by its effect on the exchange rate. An appreciated currency will reduce borrowing costs, increase profits and therefore also increase output, all other things being equal.

A common assumption in most monetary models of exchange rates including the third–generation currency crises models is the uncovered interest rate parity (UIP) condition, which states that the expected rate of depreciation should be equal to the interest rate differential, holds.[5] This assumption serves to ensure a link between current interest rates and current exchange rates which also serves as a link between the monetary policy response to an emerging currency crisis.

It is unfortunate that UIP is used since there is a large body of literature suggesting

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[4]Allen et.al. (2002) surveys the early literature on balance–sheet effects. Blackburn and Sola (1993) provide a survey of first–generation models whereas Rangvid (2001) surveys the second–generation models.

[5]See Aghion, Bacchetta and Banerjee (2000, 2001, 2004), Gertler, Gilchrist, and Natalucci (2006), Céspedes, Chang and Velasco (2004), and Devereux, Lane, and Xu (2005). An interesting exception is Christiano, Gust and Raldos (2004) who find that tight monetary policy is not the appropriate policy recommendation in a model relaxing UIP.

that the condition does not hold in the short–run.[6] In particular, the empirical literature suggests that in the short–run, exchange rates very often move in the opposite direction to the UIP prediction: higher domestic interest rates (relative to foreign) are associated with appreciation, not depreciation. Flood and Rose (2002) find that the slope coefficient in regressions of the interest differential on exchange rate depreciation (which is equal to 1 if UIP holds) is negative for twelve out of 21 currencies, essentially zero in two cases, and positive in seven cases (only three of these are statistically significantly different from zero but different from unity) using monthly data. When monetary tightening is advocated to prevent or resolve crises, it is normally expected that the exchange rate will stabilize 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 not be enjoyed — output may have already fallen before the currency recovers. The empirical evidence suggests that this link between interest rates and exchange rates through the UIP relation is not very strong. Therefore, it is of import to investigate whether theoretical models which justify or rationalize the sort of action recommended by the IMF (in response to the 1997–98 South East Asian crisis) rest on the UIP assumption.

The purpose of this paper is to modify the monetary framework developed in the Aghion, Bacchetta and Banerjee (2000,2001,2004) (henceforth ABB) papers by relaxing the UIP assumption. We replace the UIP relation with the assumption that the nominal exchange rate is a martingale process. We demonstrate that the case for tight monetary policy primarily is due to the assumption that UIP holds, not due to the dependence of the credit multiplier on real interest rates. Relaxing UIP, holding everything else in the original ABB model unchanged, restores the case for loose monetary policy.[7] Moreover, it is shown that an expansionary monetary response need not lead to further depreciations.

The remainder of the paper is organized as follows. In section 2 we first present the essential features of the real sector following the ABB (2001) model. We then introduce and motivate the martingale assumption as an alternative to UIP; and discuss its implications for monetary equilibrium, which allow us to derive an associated LM curve. Section 3 contains our analysis of the appropriate monetary response to a negative supply shock

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[6]This is a well–known result, see for example Chinn (2006), Froot and Thaler (1990) and Kilian and Taylor (2003). However, empirical evidence suggests that UIP holds in the long–run, see for example Chinn and Meredith (2004).

[7]Christiano, Gust and Raldos (2004) show, in a different setup which does not assume UIP, that allowing further depreciation may be an effective response to crises.

under different specifications for the credit multiplier. Section 4 concludes.

# 2    Aghion–Bacchetta–Banerjee setup without interest parity

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 government 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.

## 2.1    The real sector

Consider a simple infinite–horizon small open economy monetary model with the common features in ABB (2000,2001), except that uncovered interest parity does not hold.[8] Following Obstfeld and Rogoff (1995), prices are assumed preset for one period. Purchasing power parity holds *ex ante*, so $p_t = E_{t-1}(s_t)$ at any $t$, where $p_t$ is the domestic price for period $t$ 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 level is constant and equal to one. The central bank targets inflation in all periods except in period 1 when there is a supply shock affecting the economy. This implies that the interest rate $i_t$ for $t \geq 2$ is predetermined. The credit market is assumed to be imperfect such that firms

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[8]For micro–foundations see Aghion, Bacchetta and Banerjee (2004).

are credit constrained; they can borrow only a certain fraction of their wealth or cash flow and the domestic credit market cannot supply enough funds implying that firms are forced to borrow abroad.

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. $d_t \leq \mu_t w_t$.[9]

Output, $y_t$, is assumed to be produced using working capital $k_t$ according to the concave production function $y_t = \sigma f(k_t)$ where $\sigma$ is technology.[10] As in the original ABB model, we assume that there is a supply shock in period 1 which will affect production. In all subsequent periods, there are no shocks. This implies that there will be a unique deterministic equilibrium in all other subsequent periods. Working capital is assumed to fully depreciate every period implying that working capital at time $t$ is equal to the sum of cash flow from the earlier period and debt issued in the earlier period, or $k_t = w_t + d_t$. If the credit constraint binds, we then have that

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

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 $i^*$. At the end of period $t$, nominal operating profits net of financing costs are given by

$$\Pi_t = p_t y_t - (1 + i_{t-1}) p_{t-1} d_t^c - (1 + i^*) \frac{s_t}{s_{t-1}} p_{t-1} d_t^f \tag{2}$$

where $d_t^c$ is debt issued in domestic currency and $d_t^f = d_t - d_t^c$ is debt issued in foreign currency. The first term on the right hand side of this equation represents operating profits, the second term is the cost of domestic currency debt, and the third term represents the cost of foreign–currency debt expressed in domestic currency units.

Let $\alpha$ denote the fraction of profits distributed as dividends. Assuming positive profits,

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[9]We will concentrate on the case where the constraint is binding, i.e. $d_t = \mu_t w_t$. The credit multiplier will be specified in section 3.

[10]This assumption can be motivated using a technology–augmented Cobb–Douglas production function — see ABB (2004).

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 wealth available for financing production in any period after start–up as

$$w_t = (1 - \alpha)\frac{\Pi_{t-1}}{p_{t-1}} \tag{3}$$

from which it follows:

$$y_t = \sigma f\left((1 + \mu_t)(1 - \alpha)\left[y_{t-1} - (1 + i_{t-1})\frac{p_{t-2}}{p_{t-1}}d_{t-1}^c - (1 + i*)\frac{s_{t-1}}{p_{t-1}}d_{t-1}^f\right]\right). \tag{4}$$

This real–sector equation (the W–curve) shows how credit constrained entrepreneurs respond to changes in the exchange rate. Observe that the third term on the right–hand side of equation (4) 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 as it is illustrated in equation (4). It captures the balance–sheet effect of currency depreciations.

The slope of the W–curve in the exchange rate–output plane is given by

$$\frac{\partial s_1}{\partial y_2} = \frac{p_1}{\sigma f'(k_2)(1 - \alpha)(1 + \mu)\left[\frac{\mu'}{1 + \mu} - (1 + i*)d_1^f\right]}. \tag{5}$$

If we, for the moment, assume that the credit multiplier is constant, we find that the slope is always negative. This is the base case considered in ABB (2000,2001). A change in the exchange rate in period 1 has a negative effect on output in the next period, through its effect on foreign–currency debt, the balance sheet effect.

So far, the model is identical to the ABB (2000,2001) setting. In the next two sections we first introduce the assumption we make regarding the behavior of the nominal exchange rate and then we discuss the credit multiplier and the monetary sector when UIP is not assumed to hold.

## 2.2   The credit multiplier

Assume that the only restriction imposed on equilibrium exchange rate determination is that the nominal exchange rate is a martingale, i.e., $E_t\left(s_{t+j}\right) = s_t$ for any $t$ and $j \geq 1$.[11] This assumption replaces the UIP relation in the original ABB (2000,2001,2004) model.[12] 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 determination models.[13]  Theoretically, the assumption can be justified by recent research (see Engel and West (2005)) showing that, provided the discount factor 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 next step is to specify the credit multiplier $\mu_t$. As our base case, we assume that the credit multiplier is a function of the real interest rate. Following ABB (2001) we assume that domestic firms or entrepreneurs either can produce transparently and fully repay their loans or hide the production value so that they default. It is also assumed that there is a cost associated with hiding proportional to the amount invested ($cp_t k_t$) where $c$ is the cost. Even if the firm defaults, the lender is assumed to be able to collect repayments with probability $q$. The firm decides not to default if the net expected revenue

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[11]More precisely: consider a probability space $(\Omega, \mathcal{F}, \mathcal{P})$ where $\Omega$ denotes the sample space representing the set of possible exchange rate paths, $\mathcal{F}$ is the $\sigma$–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 $\mathcal{P}$ is the probability measure on $(\Omega, \mathcal{F})$ — to be understood as an objective probability distribution, with respect to which all expectations are taken. We are assuming that the exchange rate process is an $\mathcal{F}_t$–martingale with respect to $\mathcal{P}$, and the expectations operator $E_t$ used throughout the paper is in fact $E^{\mathcal{P}}\left(\cdot \mid \mathcal{F}_t\right)$.

[12]Note that the martingale assumption does not preclude uncovered interest parity. The latter can still hold, but it is not assumed.

[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.

exceeds the net expected revenue under default, i.e.,

$$p_t y_t - (1 + i_t) p_{t-1} d_t \geq p_t y_t - c p_t k_t - q (1 + i_{t-1}) p_{t-1} d_t.$$

Simplifying this, we obtain

$$d_t \leq \mu w_t$$

where

$$\mu = \frac{c}{(1 - q)(1 + r_{t-1}) - c}.$$

The credit multiplier $\mu_t$, thus, depends negatively on the real interest rate $r_{t-1}$ and positively on the probability $q$ reflecting monitoring or the degree of financial development.

The real interest rate is defined as

$$(1 + r_{t-1}) = (1 + i_t) \frac{p_t}{p_{t+1}}$$

implying that we can rewrite the credit multiplier as

$$\mu_t = \frac{c}{(1 - q)(1 + i_t) \frac{p_t}{p_{t+1}} - c}.$$

Since PPP holds *ex ante* we have that $p_{t+1} = E_t [s_{t+1}]$ and since the exchange rate is a martingale we finally obtain

$$\mu_t = \frac{c}{(1 - q)(1 + i_t) \frac{p_t}{s_t} - c}. \tag{6}$$

For $t = 1$ we then have

$$\mu_1 = \frac{c}{(1 - q)(1 + i_1) \frac{p_1}{s_1} - c}$$

and

$$\frac{\partial \mu_1}{\partial s_1} = -\frac{c(q - 1)(1 + i_1) p_1}{(cs_1 + p_1 q (i_1 + 1) - p_1 (i_1 - 1))^2} > 0 \tag{7}$$

and

$$\frac{\partial \mu_1}{\partial i_1} = \frac{c(q - 1) p_1 s_1}{(cs_1 + p_1 q (i_1 + 1) - p_1 (i_1 - 1))^2} < 0. \tag{8}$$

We can now use these results to discuss the slope of the W–curve in the exchange rate–output plane. The slope was given in equation (5). From this equation, and using our

results above, we find that the slope is ambiguous, it can be positive, zero or negative. The reason is that an increase in the nominal 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 (4); but it also relaxes the credit constraint — as is shown in equation (7); 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.) Hence, in the absence of some form of policy response, the effect of a change in the nominal exchange rate becomes ambiguous. There is a (negative) foreign–currency debt effect, and a (positive) credit constraint effect.

We can distinguish between the following cases. The first case is when the foreign currency debt effect dominates, $\frac{\mu'}{1+\mu} < (1+i^*)\,d_1^f$. In this case the slope of the W–curve is always negative. The limit is when $d_1^c = 0$. This case also corresponds to the case when the credit multiplier is constant. The second case is when the credit constraint is not binding corresponding to very large values of the credit multiplier $\mu$ in which case the W–curve is vertical. This is also the case if credit markets are absent, $\mu = 0$, and $d_1 = d_1^c = 0$. The third case is when there is no foreign debt, $d_1^f = 0$, implying that the slope of the W–curve is positive. As a fourth possibility, we have that the slope can be positive when the exchange rate is low (an appreciated currency) and negative for higher values of the exchange rate. All these cases are discussed by ABB (2000,2001). After defining the monetary equilibrium and deriving the LM–curve, we will return to these four cases below when discussing the possibility of a currency crisis.

## 2.3   The LM curve

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 implies that

$$\frac{m_t^s}{p_t} = m^d(y_t, i_t). \tag{9}$$

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.

Now, from *ex ante* purchasing power parity we have that $p_{t+1} = E_t(s_{t+1})$. Thus the LM curve (1) can be re–written as $(m^s_{t+1}/E_t(s_{t+1})) = m^d(y_{t+1}, i_{t+1})$. Using the martingale assumption, we have that $E_t(s_{t+1}) = s_t$ and it then follows that

$$s_t = \frac{m^s_{t+1}}{m^d(y_{t+1}, i_{t+1})}. \tag{10}$$

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 (10) 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 (expected) monetary conditions in period–2 affect the period–1 exchange rate, and indicates a negative relationship between output and the previous period spot exchange rate. Intuitively, the expectation of an increase in output over period 2 causes increased demand for money for that period, leading to nominal currency appreciation. The anticipation of this future appreciation increases the attractiveness of holding domestic currency in period 1, causing the latter to appreciate.

## 2.4   Occurrence of currency crises

Starting in period 1, the timing of events is as follows: first the price level is set for one period, and firms invest. An unanticipated shock then occurs. This shock takes the form of an unanticipated shock to technology (unexpectedly lower $\sigma$), leading to lower output and a depreciated currency. The monetary authorities respond 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 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.

Equilibrium is defined as the intersection of the W–curve and the LM–equations above (which can be illustrated graphically in the $s_1$–$y_2$ plane). As is also discussed at some length by ABB (2000,2001), the model can produce both "good equilibrium" (normal times with no currency crisis) and "bad equilibrium" (currency crisis). There are multiple

equilibria if the W–curve intersects the $s_1$–axis below the point where the LM–curve intersects the same axis. 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.

In ABB (2000, 2001, 2004), interest parity (UIP) combined with the monetary equilibrium leads to an IPLM–curve, 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 $(s_t, y_{t+1})$ space.[15] In the absence of interest parity we do not have an IPLM curve, only an LM–curve.

The slope of the W–curve determines whether there can be a currency crisis or not. As discussed above, we have several possibilities. However, only two cases are of interest when discussing currency crises: when the slope of the W–curve is negative; and when it is positive for small values of the exchange rate, but negative for large values. In case the slope of the W–curve is vertical, there can be no currency crisis since there is no equilibrium with high nominal exchange rate and output arbitrarily close to zero. The same holds for the case when the slope is positive, i.e., when foreign debt is zero.

Let us first consider the case when the slope of the W–curve is negative, the foreign currency debt effect dominates.[16] Suppose the economy is hit by an unexpected negative supply shock. This will lead to a shift of the W–curve to the left such that for given exchange rate, output will be lower. The new equilibrium, since the LM–curve is not affected, implies therefore a depreciated currency and lower output. If the new W–curve intersects the y–axis below the point where the LM–curve intersects the y–axis, there will be a new equilibrium with output close to zero or zero. This holds regardless of whether the exchange rate is fixed or flexible. The economic story is simple. Currency depreciation raises the cost of servicing foreign–currency liabilities contracted in period–1. Since $p_1$ is pre–determined, a depreciation causes an *ex post* deviation from purchasing power parity and 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

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

[16]This also corresponds to the case when the credit multiplier is constant.

the capacity to borrow and invest in the second period. Hence we have 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 depreciated exchange rate with very low output.

The predictions of the model when the slope of the W–curve is first positive and then turns negative for large values of the exchange rate $s_1$ is very similar to the case when the slope is only negative. If a negative supply shock affects production, the W–curve will shift to the left leading to a fall in output and a depreciated currency as above and there will be a currency crisis if the new W–curve intersects the y–axis below the point where the LM–curve intersects the same axis.

# 3  The effects of monetary policy

In the present setting, changes in $i_1$ need not lead to a reduction in $s_1$. Hence, an increase in the rate of interest cannot be relied upon to appreciate or restore the value of the currency and prevent the reduction in period–2 output due to an increase in the cost of foreign–currency debt (which in turn reduces profits and wealth and therefore borrowing capacity).

In ABB (2000) the multiplier is assumed to depend only on the nominal interest rate whereas 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 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 setup, where the multiplier's dependence on the real interest rate is consistent with dependence also on the nominal rate. Since from the analytic viewpoint this paper differs from ABB (2001) only in replacing interest parity by a martingale for the exchange rate, it must be 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.[17] This argument is now made more precise.

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[17]In ABB (2001) the real interest rate is uniquely determined by the $s/p$ ratio. Real and nominal

## 3.1 Credit multiplier depends on both real and nominal interest rates

Consider, first, the case where the effect on the cost of foreign currency debt dominates (the slope of the W–curve is always negative), 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 $\mu$, causing $y_2$ to fall further. The result is intuitive and straightforward: 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.

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 (10), and holding period–2 money supply (or the expectation thereof) 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 $\mu$ 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 (4)) 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 (10), the stimulus to output raises period–2 demand for money, the expectation of which exerts downward

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interest rates are disconnected.

pressure on the exchange rate in period–1.[18] Thus, *reducing* interest rates can (at least partly) restore the value of the currency and prevent a crisis.

Let us now consider the case when the slope of the W–curve is first positive for low values of the nominal exchange rate and negative for large values, corresponding to Figure 9(b) in ABB (2001). Suppose the economy once again is affected by an unexpected negative supply shock. As above, the W–curve will shift to the left leading to a depreciated currency and lower output since the the LM–curve is not affected. If the negative supply shock is large enough such that the W–curve intersects with the y–axis at a point below the point where the LM–curve intersects the same axis, there will be a currency crisis. The effects of monetary policy are the same as in the case above when the slope of the W–curve is always negative. A contractionary monetary policy will lead to further falls in output since a higher interest rate tightens the credit constraint whereas an expansionary policy leads to a loosening of the credit constraint which will reduce the effect of the depreciated currency on output.

## 3.2 Credit multiplier depends only on nominal interest rates

Our assumption that the credit multiplier is a function of the real interest rate may be critical for our results. Therefore we now assume that the credit multiplier depends only on nominal interest rates: $\mu_t = \mu(i_{t-1})$, where $\mu' < 0$. In this case the equation for period-2 output is simply given by

$$y_2 = \sigma f\left([1 + \mu(i_1)](1 - \alpha)\left[y_1 - (1 + i_0)\frac{p_0}{p_1}d_1^c - (1 + i*)\frac{s_1}{p_1}(d_1 - d_1^c)\right]\right) \quad (11)$$

which differs from equation (4) only in the specification of the credit multiplier as $\mu = \mu(i_1)$. An unexpected increase in the exchange rate $s_1$ now has no effect on the supply of credit. Its effect on output, through an increase in the nominal exchange rate $s_1$, i.e., 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

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[18]By reducing the cost of borrowing in domestic currency without inducing further depreciation, loose monetary policy 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. Moreover, there is no incompatibility between third–generation models and previous models based on government mismanagement. 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.

reduction in external funding for period 2. Since the increase in interest rates does not appreciate the currency, the reduction in $\mu$ 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 (10), 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 reversing the effect of the unanticipated depreciation. As in the case when the credit multiplier was a function of the real interest rate, the appropriate or least harmful monetary policy response is expansionary, and aimed at preventing a reduction in output.

## 3.3  Remarks

These results stand in contrast to the results from the original ABB (2000,2001,2004) models unless the credit multiplier is a function only of the nominal interest rate. In our setting where UIP is not assumed, the dependence of the credit multiplier on real and nominal interest rates is not important. We reach the same conclusions regarding the appropriate policy response in both cases. An interesting question is whether this result applies to other extensions of the ABB(2000,2001) model.

Bouvatier (2004) extends the ABB (2000,2001) model by allowing for a risk premium in the UIP relation. This reduces the efficiency of monetary policy but the main policy recommendation is still to raise the interest rate to prevent or resolve a currency crisis. Relaxing the UIP relation and introducing our martingale assumption in Bouvatiers setting we again find that tighter monetary policy leads to a fall in output since the credit multiplier is tightened and that expansionary monetary policy has the opposite effect.

Miller, García–Fronti and Zhang (2005,2006) extend the ABB (2000,2001) model by introducing demand–side effects. In particular, they assume that output in period 1 is demand determined instead of supply determined as in the ABB model. This implies that there will be an additional negative effect on output in period 2. While there are still

arguments that restrictive monetary policy should be used, their model suggest that the fall in output could be reduced using an expansionary fiscal policy. It is straightforward to replace the UIP relation with our preferred martingale assumption. In such a case, the positive effects on output caused by the expansionary fiscal policy could be further strengthened if it is combined with an expansionary monetary policy.

The main conclusion seems to be that the UIP assumption is critical. The result that tight monetary policy is the appropriate way to prevent and resolve currency crises depends solely on the UIP assumption. It is also noteworthy that Christiano, Gust and Roldos (2004) reach the same result as we do in a model where UIP is not assumed to hold. In their model, the degree of flexibility is critical. If there is not enough short–term flexibility, then a restrictive monetary policy is optimal and the opposite holds when there is a high degree of short–term flexibility.

# 4  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 summarized as follows. Consider an economy characterized 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.

The intuition is straightforward: if interest parity fails, there is no reason to expect (in the ABB setting) that an increase in policy interest rates will be successful in preventing further depreciation in the short–run. Hence the exchange–rate stabilization benefit of monetary tightening is lost, but the standard negative output effect is not. 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 short–term depreciations through the expected effect of lower output on money demand. Conversely, reducing interest rates increases the availability of external funds and lowers the cost of debt denominated in domestic currency without inducing further depreciation. 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.

A caveat is in order. From a practical policy viewpoint, the idea of reducing interest rates when a crisis seems imminent is admittedly vertiginous. The analysis ought to be interpreted primarily as showing a specific set of conditions under which raising the interest rate may worsen the effect of an initial shock. To the extent that the ABB setup without uncovered interest parity as an assumption is a reasonable approximation of reality, our analysis points to the importance of ensuring that raising the interest rate will be an effective tool in stabilizing the currency in the very short term. If it is not (and as discussed, this is not a settled issue), it may be better to, at a minimum, leave it unchanged.

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