A corporate balance-sheet approach to currency crises [☆]

Philippe Aghion,[a] Philippe Bacchetta,[b,c,*] and Abhijit Banerjee[d]

[a] *Harvard University, Cambridge, MA 02183, USA*
[b] *Study Center Gerzensee, P.O. Box 21, CH-3115 Gerzensee, Switzerland*
[c] *University of Lausanne, HEC DEEP-BFSH1 CH-1015, Lausanne, Switzerland*
[d] *Massachusetts Institute of Technology, Cambridge, MA 02142, USA*

Abstract

This paper presents a general equilibrium currency crisis model of the 'third generation', in which the possibility of currency crises is driven by the interplay between private firms' credit-constraints and nominal price rigidities. Despite our emphasis on microfoundations, the model remains sufficiently simple that the policy analysis can be conducted graphically. The analysis hinges on four main features (i) ex post deviations from purchasing power parity; (ii) credit constraints a la Bernanke–Gertler; (iii) foreign currency borrowing by domestic firms; (iv) a competitive banking sector lending to firms and holding reserves and a monetary policy conducted either through open market operations or short-term lending facilities. We derive sufficient conditions for the existence of a sunspot equilibrium with currency crises. We show that an interest rate increase intended to support the currency in a crisis may not be effective,

but that a relaxation of short-term lending facilities can make this policy effective by attenuating the rise in interest rates relevant to firms.

1. Introduction

Researchers in recent years have had to grapple with the puzzle of how fast-growing economies with large export surpluses and substantial government surpluses, could end up in the space of months, in a deep and damaging currency crisis. This paper builds on a very simple story of why things fall apart quite so dramatically if domestic prices do not adjust fully to exchange rate changes in the short run, a currency depreciation leads to an increase in the debt burden of domestic firms that borrowed in foreign currency, and consequently a fall in profits.[1] Since lower profits reduce net worth, this may result in reduced investment by credit-constrained firms, and therefore in a lower level of economic activity in the following period. This, in turn, will bring a fall in the demand for money, and thus a currency depreciation in that next period. But arbitrage in the foreign exchange market then implies that the currency must depreciate in the current period as well. Hence the possibility of multiple short run equilibria in the market for foreign exchange. A currency crisis occurs when an expectational shock pushes the economy into the ''bad'' equilibrium with low output and a high nominal exchange rate.

This story is compelling for a number of reasons. First, there is evidence that foreign currency exposure is correlated with the likelihood of a crisis in particular, Hausmann et al. [24] show that the countries most likely to go into a crisis were those in which firms held a lot of foreign currency denominated debt.[2] Second, there is strong evidence that exchange rate changes are incorporated into domestic prices relatively slowly. For example, Goldfajn and Werlang [22] compute the pass-through from exchange rate to prices in a set of 71 countries including both developed and less developed countries. They show that the pass-through is very gradual and tends to be even smaller after currency crises—in the Asian crises, for example, less than 20% of currency depreciation was reflected in inflation after 12 months. Third, it is widely accepted that an important link between the currency crises and the subsequent fall in output was a financial crisis which affected the ability of private firms to finance production—indeed this is why the crises are often described as triple

---

[1] The damaging impact of foreign currency debt is often mentioned in the context of currency crise. See, for example, [19,14,31,32]. While the role of foreign currency *public* debt has received some attention in the theoretical literature on crises [11,33,20] the impact of private foreign currency debt has hardly been analyzed (see, however, [27]).

[2] See also Honkapohja and Koskela [23] for the Finnish case.

(currency, financial, output...) crises.[3] Fourth, the model predicts that such crises are most likely to occur in economies at an intermediate level of financial development (i.e., not in the US and not in Burma) and cannot be ruled out by what are conventionally viewed as prudent government policies, which in turn seems consistent with the facts.

This is not the first paper to tell a story of this kind. Our earlier papers on the subject [4,5] feature the same basic story, as does the related paper by Krugman [30]. In this paper we delve deeper into the story by integrating the monetary side of the economy together with its credit side, through the natural channel of modeling the needs of the banking sector for reserves. This is important because a key question in these papers has been the role of monetary policy in a crisis, and this obviously depends crucially on how monetary policy affects firms' access to credit.[4] Moreover, explicitly modeling the relation between the central bank and the banking sector, naturally leads us to consider a richer menu of monetary policy instruments than is standard in the literature. We are thus able to ask questions about the optimal mix of monetary policy instruments in a crisis. Interestingly, it turns out that it may be optimal to tighten money supply through open market operations but at the same time to ease the supply of emergency credit to banks through the so-called discount window.

There are a number of other recent papers which have studied the issue of monetary policy in related contexts. Apart from our own previous papers already mentioned above, the most closely related literature includes Gertler et al. [21] Céspedes et al. [15] and Christiano et al. [18]. All of these papers share the conclusion that even in a crisis it may be a good idea to let the exchange rate go down further. Gertler et al. and Cespedes et al. interpret this result as supporting the case for flexible exchange rates over fixed exchange rates, while Christiano et al. see it as a case for relaxing monetary controls in a crisis even at the cost of an exchange rate depreciation. The one important difference between these papers and ours is that they operate in an environment where there is a unique equilibrium. In Aghion et al. [5] we had shown that there are circumstances where the equilibrium is always unique and in such cases, the case for taking a relaxed monetary stance and letting the exchange rate float down is much stronger, consistent with the message of these papers. In contrast, our analysis in this paper focuses exclusively on the multiple equilibrium case.

---

[3] Most attempts to make sense of the latest crises have been based on the idea that a crisis affects output through its effect on access to credit in the firm sector. See for example [2,3,29,16,13]. The key difference between these papers and the current paper is these are real models, whereas we stress the monetary elements in our story.

[4] In our previous two papers monetary policy could only have any real effects through changes in the real exchange rate. In Aghion et al. [4] we introduced such a real effect by directly assuming that a tighter monetary policy raises the real costs of lending, which in turn would lead to the conclusion that a tight monetary policy might not always be a good thing. Here, instead, the assumed effect of monetary policy on the real cost of lending is generated from a model where the lending banks optimally choose their cash holdings.

The paper is organized as follows. Section 2 lays out the general framework, including the borrowing and investment decisions of domestic manufacturing firms, and endogenizing their credit constraints. Section 3 describes the monetary side of the economy; in particular, it derives the demand for reserves by banks in relation to the supply of credit to domestic manufacturing firms, thereby generating a reserves market equilibrium equation. Together with interest parity, this equation determines a relationship from future expected output to current nominal exchange rate which we refer to as the "IPLM" (or "interest-parity-LM") curve. Section 4 concentrates on the real side of the economy, which leads to expressing future output as a function of the current nominal exchange rate; we refer to this second relationship between those two variables, as the "W" (or "wealth") curve. Section 5 analyzes the sunspot equilibria of this model; in particular it provides sufficient conditions for the existence of non-deterministic sunspot equilibria, and thus for the occurrence of expectational shocks and the possibility of currency crises. Section 6 uses a simple graphical representation of the model to discuss the stabilization effects of open market operations and of discount window-types of policies. Finally, Section 7 concludes by suggesting potential extensions.

2. General framework

We consider an infinite-horizon, small, open, monetary economy with two production sectors, an import-competing manufacturing and an exporting commodity sector. There are four types of agents in the economy entrepreneurs who produce manufacturing goods; non-entrepreneurs who can either work for the manufacturing sector at a preset wage, or work on their own to produce commodities according to a linear one-for-one technology; commercial banks that lend to the entrepreneurs and hold reserves; and the central bank that runs monetary policy with open market operations or short-term lending facilities.

Entrepreneurs in the manufacturing sector produce differentiated goods, but in a symmetric fashion with the same production function and the same inverse demand function. In addition, all manufacturing firms share the following two characteristics. First, they preset prices for each period before the actual exchange rate is known; to save on menu costs they maintain the price fixed for the entire period. Second, they borrow from banks, but the credit contract is only partially enforceable, which generates a constraint on how much the firm can borrow. Moreover, they prefer borrowing in foreign currency due to moral hazard. Finally, we shall restrict attention to the case where the domestic demand for manufacturing goods is always larger than their domestic production. We assume that for each manufacturing good there are international producers who are ready to sell it in the domestic market. Thus, changes in demand are accommodated by foreign producers who act as a competitive fringe and sell at a constant price equal to one unit of the foreign currency.

An unexpected currency depreciation has a negative aggregate impact on output in our model through an increase in the foreign currency debt burden. Although

exporters gain from the depreciation, it is the import-competing sector that determines the dynamics of output.

At the heart of the theoretical model is the possibility of multiple expectational equilibria. In other words, a 'sunspot' is realized, causing expectations to shift during the period. The model produces a *non-degenerate* sunspot equilibrium in which the equilibrium exchange rate in period 1, S_1, is randomly distributed and equal to a low value S_1' with probability $1 - q$ and to a high value S_1'' with probability q, with $S_1'' > S_1'$ and q being small. When the exchange rate takes the high value S_1'', manufacturing output is low and firms are unable to meet their debt obligations. We shall refer to this state of nature as a currency crisis.

Purchasing power parity (PPP) will be assumed to hold ex ante at the beginning of every period, and the only deviation from PPP ex post will be in period 1 in the manufacturing sector as a result of the expectational shock not being accommodated at once by domestic price-setting in that sector.

2.1. Sequence of events

The timing of events can be summarized as follows. Manufacturing prices are fixed at the beginning of each period t for the entire period, while the other variables are determined at the end of the period. First, the expectational shock occurs, to which corresponds a realization of the nominal exchange rate S_t. The shock is accompanied by an adjustment in the monetary policy set by the central bank and it also affects the demand for reserves (h_t) from commercial banks. This in turn affects the lending rate i_t^l charged by banks to firms in period $t + 1$. Entrepreneurs then decide whether or not to repay their debt from the previous period and choose the fraction β of their net earnings that they will save. With these savings w_t, entrepreneurs decide how much to borrow for the subsequent period (l_{t+1}) and how much to invest ($w_{t+1} + l_{t+1}$). We will focus on the case where expectational shocks on the nominal exchange rate S_t only occur in the first period and where there is a unique equilibrium exchange rate in all subsequent periods.

2.2. Production technology

All manufacturing firms produce according to the same Cobb–Douglas technology $y_t = A_t k_t^\alpha n_t^{1-\alpha}$, where n_t and k_t denote respectively the labor and capital inputs in period t. k_t is working capital made of manufactured goods that fully depreciates at the end of the period. Since labor supply to manufacturing firms is perfectly elastic at real wage ω, in equilibrium we have

$$y_t = \sigma_t k_t, \quad \text{where } \sigma_t = A_t \left(\frac{(1-\alpha)A_t}{\omega} \right)^{\frac{1-\alpha}{\alpha}} > 1 + r_t,$$

where r_t is the real rate of return on bonds. Note that sales net of wage payments are αy_t, as the optimal demand for labor gives $\omega n_t = (1 - \alpha)y_t$. We will focus on the case where $A_t \equiv A$ (and therefore $\sigma_t \equiv \sigma$) for $t \geqslant 2$, with σ being sufficiently larger than σ_1

so that if expectational shocks and multiple sunspot equilibria can occur in period 1, yet there will be a unique deterministic equilibrium in all subsequent periods.

2.3. Savings and consumption behavior

All individuals in the domestic economy, including the domestic entrepreneurs who produce manufacturing goods, will choose their intertemporal consumption pattern (c_j) and also the fraction of wealth (x_j) they invest in their own manufacturing activity versus investing in bonds to maximize their expected lifetime utility[5]

$$\max_{x_j,c_j} \sum_{j=t}^{\infty} \beta^j E_t \ln(c_j)$$

$$\text{s.t} \quad w_{j+1} = x_j M_j(S_j) w_j + (1 - x_j)(1 + r_j) w_j - c_j,$$

where c_j is an aggregate consumption index for manufactured goods at date j, w_{j+1} is the entrepreneur's savings at the beginning of period $j + 1$, and $M_j(S_j)w_j$ is the ex post revenue in period j.[6]

Using the above budget constraint to substitute for the c_j's, and then taking first order conditions with respect to x_j and w_j for all j, we will show in Section 4 (in particular in footnote 21) that for σ_1 and σ sufficiently large and q sufficiently small, we have[7]

$$x_j \equiv 1.$$

Throughout the paper we shall restrict attention to parameter values such that in equilibrium entrepreneurs do indeed prefer to invest their savings in their own projects rather than in government bonds or in bank deposits.

This, together with the logarithmic preference assumption, implies that entrepreneurs will always consume a constant fraction $1 - \beta$ of the revenues generated by their own projects, namely

$$w_{t+1} = \beta M_t w_t \quad c_t = (1 - \beta) M_t w_t.$$

Within each period t, the consumption index c_t results from an intra-period utility with constant elasticity of substitution between differentiated

---

[5]They could also derive utility from the homogenous commodity, but we assume, without loss of generality, that their optimal consumption of the commodity is equal to zero. Entrepreneurs may also incur some disutility or some private benefits from producing, but this has no bearing on the analysis insofar as the corresponding cost or benefit is fixed.

[6]Since in equilibrium manufacturing output is a linear function of capital investment, $M_j(S_j)$ is independent of w_j. We shall restrict attention to sunspot equilibria in which S_1 can take two values, S_1' and S_1'', respectively with probability $(1 - q)$ and q, such that manufacturing firms may default when $S_1 = S_1''$, whereas the S_j's are deterministic for all $j \geqslant 2$. Thus, $M_j(S_j)$ is also random in period $j = 1$, but not in subsequent periods. Finally, we assume that domestic entrepreneurs can always choose to divert a positive fraction of output, which in turn implies that $M_j(S_j)$ is bounded away from zero.

[7]Consistency with the existence of non-degenerate sunspot equilibria is established in Section 5.

manufacturing goods.

$$c_t = \left[\int_0^1 c_t(i)^{\frac{v-1}{v}} \, di \right]^{\frac{v}{v-1}},$$

where $c_t(i)$ is the individual consumption of manufactured good i in period t and v is the elasticity of substitution between any two manufacturing goods, which in turn we take to be larger than one. A consumer's total nominal consumption at date t is

$$\int_0^1 p_t(i)c_t(i) \, di = \Psi_t,$$

where Ψ_t represents total nominal expenditures and $p_t(i)$ is the price of good i at time t.

The resulting individual demand for manufactured good i is therefore

$$c_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-v} \frac{\Psi_t}{P_t},$$

where P_t is the consumer price index for domestic manufactured goods with

$$P_t = \left[\int_0^1 p_t(i)^{1-v} \, di \right]^{1/(1-v)}.$$

2.4. Price setting

While PPP holds at any time for commodities and ex ante for all goods, it does not hold ex post in period 1 in the manufacturing good sector. This follows, first from the assumption that the price of manufacturing goods is preset in domestic currency for one period to save on menu costs;[8] and, second, from the assumption that consumers cannot arbitrage ex post between domestic and foreign producers. Arbitrage (within an industry) is possible ex ante, so that PPP holds ex ante for all manufacturing goods.

We shall restrict attention to the case where $c_t(i) > y_t(i)$ for all (t, i), so that the manufacturing sector is always import competing and for each good i there is a domestic producer and a set of foreign producers. We assume that consumers first precommit on a quantity and a price with domestic producers. Then, risk-neutral foreign producers compete Bertrand on the residual market segment and set the price in domestic currency.[9] If we normalize their marginal cost (in foreign currency) at 1, their price is S_t^e. The domestic producer has to set the same price to attract consumers (ex ante arbitrage) and sell the quantity determined by their credit constraint. Thus, we simply have $p_t(i) \equiv P_t \equiv S_t^e$. Finally, since the quantity sold by domestic producers is pre-determined, changes in manufacturing goods demand are

---

[8] This is a standard assumption in the 'new-open economy macroeconomics' literature. See for example Obstfeld and Rogoff [34,35] and Bacchetta and van Wincoop [8].

[9] The strategy of pricing to market in domestic currency is taken as given. Bacchetta and van Wincoop [9] provide conditions under which this strategy is optimal.

entirely met by changes in imports, with foreign producers always ready to satisfy domestic demand at the preset price P_t.

While manufacturing prices are sticky, the domestic currency price of commodities is assumed to be flexible in any period t and simply equal to $S_t\omega$, where ω denotes the foreign currency commodity price which we take to be constant and equal to ω. If non-entrepreneurs choose to devote one unit of labor to produce one unit of commodity which they sell on the world markets, they get $S_t^e\omega = P_t\omega$. Thus, they will work in the manufacturing sector if the real wage offered by domestic entrepreneurs is at least equal to ω.

2.5. Credit

2.5.1. Interest parity
The exchange rate is determined by investors arbitraging between domestic and foreign currency bonds; we assume full capital mobility, so that uncovered interest parity (IP) is assumed to hold perfectly[10]

$$1 + i_t = (1 + i^*)\frac{S_{t+1}^e}{S_t}. \tag{1}$$

2.5.2. The debt contract
A firm's capital investment in any period t is made of the entrepreneur's own wealth w_t and of additional funds borrowed from a bank l_t. Our model will rely heavily on balance-sheet effects in the spirit of Bernanke–Gertler [10], which in our framework shows up as a positive relation between l_t and w_t. We now derive some properties of this relationship and other properties pertaining to the currency composition of debt, based on the model of ex post moral hazard in the credit market developed by Aghion et al. [7].

We imagine a world where credit contracts are only partially enforceable. First, the borrower is protected by a kind of limited liability he always retains at least a fraction φ of his revenue *from production* in all states, including the ones where there is involuntary default, i.e., when he does not have enough money to meet his debt obligation. This is the amount he can simply divert without being found out afterwards.

Second, the borrower has the option of voluntarily defaulting on any specific loan even if he has the money to repay. In other words, he can refuse to repay the loan. When this happens, the lender can collect any collateral that the borrower has pledged to her in lieu of the interest payment. However we assume that future output from production cannot be pledged the borrower can always hide the proceeds from production, though in the process a fraction τ is lost. Yet the lender can still try to get her money back by putting effort into debt collection. Specifically, by incurring a nonmonetary effort cost $l \cdot C(\psi)$, where $C(\psi) = -c\ln(1 - \psi)$ and l is the size of the

---

loan, the lender can appropriate a fraction ψ of her due repayment (as long as the borrower has the money).

Finally, loan contracts are short-term and there is perfect competition among lenders, so that entrepreneurs have full bargaining power upon contracting their loans.

These assumptions together determine the structure of the loan contract in equilibrium. This is what we investigate in the remaining part of this sub-section.

The credit multiplier. Consider first the strategic default decision on a loan that is invested in production. The entrepreneurs' real income after wage and debt repayment in a particular state of the world is $\alpha y_{t+1} - R_t l_{t+1}$, where $R_t l_{t+1}$ is the real interest rate obligation in that state of the world. He will not choose strategic default in period $t + 1$ if and only if

$$\alpha y_{t+1} - R_t l_{t+1} \geqslant \alpha(1 - \tau)y_{t+1} - \psi R_t l_{t+1},^{[11]} \tag{2}$$

or equivalently

$$\alpha\tau \geqslant (1 - \psi)R_t \frac{l_{t+1}}{y_{t+1}}.$$

Now, turning to the choice of the optimal monitoring policy ψ, the lender will choose ψ to maximize

$$\psi R_t + c\ln(1 - \psi),$$

so her optimal choice of ψ is given by the first order condition

$$(1 - \psi)R_t = c.$$

Substituting for $(1 - \psi)R_t$ in the borrower's incentive constraint, we immediately obtain

$$\frac{l_{t+1}}{y_{t+1}} \leqslant \frac{\tau\alpha}{c}.$$

This gives us a relation between the borrower's predicted future income and the amount he can borrow on the strength of it. To see how this translates into a borrowing constraint, we make use of the fact that the loan is invested in production so that $y_{t+1} = \sigma_{t+1}(l_{t+1} + w_{t+1})$. In this case, we immediately see that

$$\frac{l_{t+1}}{w_{t+1}} = \frac{\tau\alpha\sigma_{t+1}}{c - \tau\alpha\sigma_{t+1}} = \mu_{t+1}.$$

Notice that the credit multiplier μ_t depends only on σ_t and since σ_t is known when the loan is being allocated, μ_t is independent of what happens within the period. As a result, a borrower who is lent more than $\mu_t w_t$ will strategically default *in every state of the world where he has anything to repay* (what he does when he generates no revenues, is irrelevant). We now assume that c is sufficiently large that the lender would never consider lending to a borrower who is planning to refuse to repay.

---

[11] The LHS (resp. RHS) is the borrower's net revenue if he repays (resp. if he refuses to repay) his debt. The RHS assumes that the borrower does hide the proceeds from production.

Therefore a borrower who is planning to invest only in production will be lent at most $\mu_t w_t$.

Foreign versus domestic currency borrowing. The fact that firms borrow in foreign currency plays a crucial role in our analysis. While this accords well with what we observe in many emerging market economies, it does require a justification. In Burnside et al. [12] or Schneider and Tornell [36], foreign currency borrowing follows from the assumption that domestic banks are bailed out by the government in case of default, so that firms will want to increase their risk exposure by borrowing in foreign currency. Jeanne [25–27] develops models in which foreign currency borrowing serves as a signaling or as a commitment device. In Chamon [17] foreign currency borrowing follows directly from the extrinsic exchange rate uncertainty together with the assumption that the currency composition of a borrower's portfolio is not contractible. In Aghion–Bacchetta–Banerjee [6] we generalize Chamon's result to the case of credit-constrained firms. The basic intuition there is that firms prefer borrowing in foreign currency due to the following moral hazard consideration foreign currency debt implies a lower interest rate in the good state of the world, but a much larger repayment in the bad state; however, in the bad state firms default and only partially repay their debt.

3. The monetary sector

3.1. The demand for reserves

Domestic banks play a crucial role in this economy since they both channel credit to firms and hold reserves, and are therefore at the center of the monetary transmission mechanism. There is perfect competition in the banking sector. Furthermore, we assume that banks have enough assets not to fall into insolvency in case a currency crisis occurs.

Banks receive deposits d_t from non-entrepreneurs and possibly foreigners, lend l_t to firms and hold an amount of reserves h_{t-1} in the central bank at the beginning of period t.[12] Thus, $d_t = h_{t-1} + l_t$. Deposits in period t yield the risk-free nominal domestic interest rate i_t. We assume that banks only take deposits to cover their lending and reserves needs.[13]

We assume that banks' demand for reserves is linked to the supply of credit to the manufacturing sector more specifically, suppose that with probability λ a manufacturing firm faces an aggregate liquidity shock (e.g., due to the fact that its workers need to be paid in cash early in the period instead of waiting until the end of the production period). We assume that the liquidity need is proportional to the

---

[12] The difference in timing notation between monetary and real-sector variables is imposed by consistency with the interest parity condition (the nominal interest rate determined at the end of $t-1$, but valid for period t, is i_{t-1}).

[13] We abstract from liquidity needs from depositors so that they are indifferent between holding bank deposits or domestic bonds. There is also no transaction cost for banks to receive deposits. Alternatively, banks could also hold bonds and raise more deposits.

amount l_t borrowed by the firm at the beginning of the period, γl_t. Thus, with each loan l_t a bank needs to provide liquidity γl_t to the borrowing firm with probability λ. If the lending bank does not fulfil this liquidity need, the firm cannot produce nor repay its outstanding debt.[14]

Banks can get liquidity by holding reserve deposits at the central bank in quantity h_t. However, these reserves do not bear interest and thus have an opportunity cost of i_t. Alternatively, banks can borrow at the discount window at a penalty rate $\tilde{\theta}_t$. The optimal holdings of reserves by banks in period t for period $(t+1)$ is determined by the following cost minimization program in which banks weigh the cost of holding reserves against that of borrowing at the discount window

$$\min_{h_t} \{i_t h_t + \lambda(\gamma l_{t+1} - h_t)\tilde{\theta}_t\}.$$

We assume that this rate increases with the proportion of liquidity which is borrowed. For analytical convenience, we assume a linear relationship $\tilde{\theta}_t = \theta_t \cdot ((\gamma l_{t+1} - h_t)/\gamma l_{t+1})$, where θ_t is what we call the discount window rate and can be changed by the central bank to modify monetary policy.[15] The optimal *demand* for reserves is then simply given by[16]

$$h_t = \gamma l_{t+1}\left(1 - \frac{i_t}{2\lambda\theta_t}\right) = y_{t+1}\frac{\gamma\mu}{\sigma_t(1+\mu)}\left(1 - \frac{i_t}{2\lambda\theta_t}\right). \tag{3}$$

If now the central bank *supplies* a nominal quantity of reserves H_t^S, then the reserve or "money" market equilibrium, is characterized by the (LM) relationship

$$\frac{H_t^S}{P_t} = h_t. \tag{4}$$

3.2. Monetary policy

In most of the paper, we assume that the central bank sets i_t and θ_t. However, there is still a degree of freedom to set the level of the nominal money stock. For convenience, we assume that the central bank sets H_2^S, while H_t^S is endogenous in the other periods. We could have alternatively set H_3^S or H_4^S, or any single future value of H_t^S: The important assumption is not that H^S is set in a particular period, but that this level is not state contingent.

---

[14] The liquidity need is assumed to be ex ante the same in all periods. An interesting extension would be to model this liquidity need and relate it to crises.

[15] An alternative interpretation of the parameter θ is that it reflects a quantity restriction imposed by the central bank to the commercial banks. For example suppose that the central bank commits itself to refinancing up to a fraction δ of a bank's liquidity need γl_t, where δ is uniformly distributed between 0 and D. And let b denote the private loss incurred by the bank or the bank's manager if the liquidity need is not fully met. Then, the cost minimization problem will be identical to that stated above, but with $\theta = \frac{b}{D}$; in particular a tighter quantity restriction on refinancing, that is a lower D, amounts to increasing θ.

[16] See Agénor et al. [1] for a recent estimation of a similar demand of reserves by commercial banks in Thailand.

When changes in monetary policy, that is in θ_t, i_t and/or H_t^S are anticipated, then the equilibrium price P_t fully adjusts to such changes. In particular, P_2 adjusts to the anticipated monetary policy (H_2^S, i_2, θ_2) according to Eq. (4). For all $t \geqslant 3$, given a sequence of monetary policies (i_t, θ_t), equilibrium prices P_t are sequentially pinned down by the Interest Parity conditions $1 + i_t = (1 + i^*)P_{t+1}/P_t$, since $P_t = S_t^e = S_t$ for all $t \geqslant 2$.

However, when changes in monetary policy are unanticipated, as we assume to be the case in period 1, the price level is fixed and from (3) policy variables are linked by

$$i_1 = 2\lambda\theta_1 \left(1 - \frac{H_1^S}{\gamma P_1 l_2} \right). \tag{5}$$

In the equilibrium analysis of Section 5 we take (i_1, θ_1) as given, so that H_1^S is determined by (5). However, in the policy analysis of Section 6, (H_1^S, θ_1) are the primary policy variables. Thus, the central bank can increase the nominal risk-free interest rate i_1 in two ways either by decreasing the monetary base H_1^S or by increasing the discount window rate θ_1 (or equivalently by tightening its limits to refinancing).

3.3. The cost of lending

Banks lend to manufacturing firms at a nominal interest rate i_t^{*l} in foreign currency units. Suppose that with probability $1 - q_t$ the bank gets back its full loan plus interest and with probability q_t the firm defaults, in which case the bank gets a proportion $1 - \varphi$ of the firm's profits net of wage payments. The bank's net expected nominal earnings in domestic currency units, are therefore

$$(1 - q_t)(1 + i_t^{*l})P_t l_{t+1}\frac{S_{t+1}'}{S_t} + q_t(1 - \varphi)P_{t+1}y_{t+1}.$$

Under perfect competition this should be equal to the cost of the loan. This cost, in turn, is the sum of the deposit rate paid by the bank (which, by competition, should be equal to i_t) and its intermediation costs. That is

$$(1 + i_t)P_t l_{t+1} + i_t P_t h_t + \lambda P_t(\gamma l_{t+1} - h_t)\tilde{\theta}_t.$$

Equating the two above expressions, and letting π_t and r_t denote respectively the inflation rate and the real interest rate at date t, we get[17]

$$(1 - q_t)(1 + i_t^{*l})\frac{S_{t+1}'}{S_t} = (1 + i_t) - q_t(1 - \varphi)(1 + \pi_{t+1})\frac{y_{t+1}}{l_{t+1}}$$

$$+ i_t\frac{h_t}{l_{t+1}} + \lambda\left(\gamma - \frac{h_t}{l_{t+1}} \right)\tilde{\theta}_t. \tag{6}$$

---

[17] Here we are using the fact that the inflation rate π_t is determined by

$$1 + \pi_t = (1 + z_t)\frac{h(l_t, i_{t-1})}{h(l_{t+1}, i_t)},$$

in which z_t denotes the growth rate of reserves supply at date t, which in turn follows directly from (4).

By using (3), interest parity and the definition of $\tilde{\theta}_t$, we then find

$$(1 + i_t^{*l}) = \frac{1 + i^*}{1 - q_t}\left[1 - q_t(1 - \varphi)\frac{\sigma(1 + \mu)}{(1 + r_t)\mu} + \gamma\frac{i_t}{1 + i_t}\left(1 - \frac{i_t}{4\lambda\theta_t}\right)\right]. \tag{7}$$

In particular, inflation targeting or any other policy that maintains i_t constant throughout all periods $t \geqslant 2$, will also result in the lending rate remaining invariant throughout these periods.

Note that the lending rate i_t^{*l} is influenced both by the risk-free rate i_t, and therefore indirectly by the supply of reserves H_t^s, and directly by the discount window rate θ_t. As we shall see in Section 6 below, tightening the money supply by increasing θ_t and by reducing H_t^s, not only have different effects on the overall equilibrium outcome, but also may end up being mutually offsetting.

3.4. The IPLM curve

Using the fact that PPP holds at the beginning of every period and in particular in period 2, so that $P_2 = S_2^e$, and thereby eliminating P_2 between the two Eqs. (3) and (4), we obtain the following "IPLM" relationship between S_1 and y_3

$$S_1 = \frac{1 + i^*}{1 + i_1}\frac{H_2^s}{y_3\frac{\gamma\mu}{\sigma(1 + \mu)}(1 - \frac{i_2}{2\lambda\theta_2})}. \tag{8}$$

For given i_2, S_1 is a decreasing function of y_3. This can be simply explained as follows an anticipated increase in output amounts to an anticipated increase in the demand for reserves by the banking system in order to meet the liquidity needs of the manufacturing sector. This in turn will lead to an expected appreciation of the domestic currency in the future, that is to a reduction of S_2^e. But the anticipation of a currency appreciation in the future increases the attractiveness of holding domestic currency bonds today, which in turn induces a reduction in S_1, that is a currency appreciation today.

The negative relationship is illustrated in Fig. 1. From the IPLM equation, we see that a restrictive monetary policy at time 1 shifts the curve downwards through an increase in i_1 for a given future output, a restrictive monetary policy implies a currency appreciation.

4. The real sector

In this section we determine the dynamics of output and provide a graphical representation between third period output and period one nominal exchange rate.

4.1. Net profits and wealth dynamics

Let i_{t-1}^{*l} denote the lending rate charged at time t by banks to domestic manufacturing firms which borrow in foreign currency. Using the interest parity
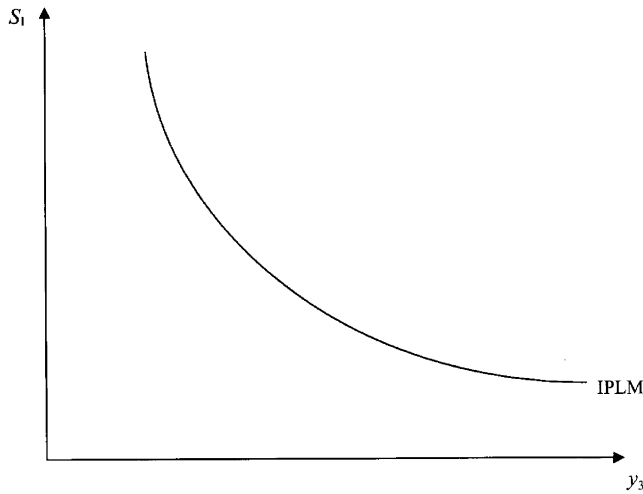
Fig. 1.

condition to express the debt obligation of firms in units of the domestic currency, assuming that in case of default a positive fraction φ of a firm's output cannot be appropriated by its lenders,[18] and allowing for strategic default, nominal profits are

$$\Pi_t = \max\left\{\alpha P_t y_t - (1 + i_{t-1}^{*l})\frac{S_t}{S_{t-1}}P_{t-1}l_t, \alpha\varphi P_t y_t\right\},$$

or equivalently

$$\Pi_t = P_t M_t w_t, \tag{9}$$

where M_t is the real rate of return on investment

$$M_t = \max\left\{\alpha\sigma_t(1 + \mu) - (1 + i_{t-1}^l)\frac{S_t}{S_{t-1}}\frac{P_{t-1}}{P_t}\mu, \alpha\varphi\sigma_t(1 + \mu)\right\}.$$

The second term in the curly bracket is what accrues to the firm in case of default, under the assumption that entrepreneurs first pay workers and then lenders can seize a proportion $1 - \varphi$ of the remaining funds. Thus, entrepreneurs are left with $\varphi\alpha y_t$.[19] We shall be particularly interested in non-deterministic sunspot equilibria where strategic default occurs in period 1, whenever the domestic currency experiences a large depreciation with an exchange rate realization S_1'' becoming correspondingly high.

Given the optimal savings behavior of entrepreneurs as described in Section 2.3, if productivity σ_t is sufficiently high and the probability of default q is sufficiently

---

[18] This fraction is naturally interpreted as reflecting monitoring imperfections on the lending side.

[19] Here we allow for both genuine and strategic default. Genuine default occurs when the first term in the curly bracket is negative, while strategic default will occur whenever the first term in the curly bracket is less than the second term.

small,[20] entrepreneurs will invest all their savings in their own manufacturing projects and total net wealth available for the next production period $t + 1$ will then be given by

$$w_{t+1} = \beta \frac{\Pi_t}{P_t}.$$

Focusing on a potential crisis occurring at time 1, let us look at entrepreneurs' wealth at time 2

$$w_2 = \beta \max\left\{\alpha\sigma_1(1 + \mu) - (1 + i_0^{*l})\frac{S_1}{P_1}\mu, \alpha\varphi\sigma_1(1 + \mu)\right\}w_1. \tag{10}$$

A currency depreciation clearly has a negative impact on w_2 as it increases entrepreneurs' debt burden.[21] Given our assumption that in subsequent periods $t \geqslant 2$, the productivity parameter $\sigma_t \equiv \sigma$ is sufficiently large that no expectational shocks can occur, interest parity will hold throughout these periods and firms will not find it profitable to default on their debt obligations. Thus, for period 3 we have

$$w_3 = \beta\left(\alpha\sigma(1 + \mu) - (1 + i_1^{*l})\frac{P_1}{S_1}\mu\right)w_2. \tag{11}$$

The positive effect of S_1 on w_3 for given w_2, stems from the fact that a devaluation in period 1 predicts a real appreciation in the following period. This, in turn, has the effect of lowering the real interest rates on bonds and investments in period 2, thereby increasing the retained earnings that firms can invest at the beginning of period 3.

For all subsequent periods $(t > 2)$ we have

$$w_{t+1} = \beta(\alpha\sigma(1 + \mu) - (1 + i^{*l})\mu)w_t = \beta M w_t, \tag{12}$$

where the lending rate i^{*l} remains also constant under inflation targeting or any other policy that will maintain i_t constant for $t \geqslant 2$. This equation shows that output in subsequent periods is unaffected by the nominal exchange rate (a natural

---

[20] A sufficient condition for domestic entrepreneurs to invest all their savings in their own project instead of investing them in government bonds, is that q be sufficiently small and

$$\alpha P_t \sigma_t(1 + \mu) - (1 + i_{t-1}^{l*})\frac{S_t}{S_{t-1}}P_{t-1}\mu > (1 + i)P_{t-1},$$

where i_{t-1}^{l*} is determined by Eq. (7). For q sufficiently small, this condition is implied by the stronger condition.

$$\alpha\sigma_t(1 + \mu) > (1 + i^*)(1 + \mu + \gamma),$$

or equivalently

$$(C_0) \qquad \alpha\sigma_t > (1 + i^*)\left(1 + \frac{\gamma}{1 + \mu}\right).$$

[21] The model could be extended by introducing stronger competitiveness effects, for example with an exporting sector that has characteristics similar to those of the import-competing sector. Since competitiveness effects are well understood, we do not incorporate them in our model and focus instead on foreign currency debt effects.

consequence of the fact that there is no deviation from PPP throughout these periods).

4.2. The W curve

Combining (10), (11), and the fact that $y_3 = \sigma(1 + \mu)w_3$, we obtain

$$y_3 = \beta^2 \sigma(1 + \mu)\left(\alpha\sigma(1 + \mu) - (1 + i_1^{*l})\frac{P_1}{S_1}\mu\right)$$

$$\times \max\left\{\alpha\sigma_1(1 + \mu) - (1 + i_0^{*l})\frac{S_1}{P_1}\mu, \varphi\alpha\sigma_1(1 + \mu)\right\}w_1. \tag{13}$$

This gives a second relation between S_1 and y_3, which we will call the W curve. It is depicted in Fig. 2. We see that it is composed of three segments. The upper segment is upward sloping and starts at the exchange rate level $\hat{S}_1$, which is the level from which strategic default occurs. Larger values of S_1 have only a positive impact on output by lowering the period-two real interest rate. The second segment is downward sloping. This is the case where a currency depreciation lowers period-two wealth, which lowers period-three wealth and output. When $i_1^{*l} = i_0^{*l}$, this segment will be for S_1 between P_1 and $\hat{S}_1$. When S_1 is below this point, which is the case where the currency appreciates compared to its expected level, the curve is upward sloping since the real interest effect dominates. Notice that without sunspots, the W curve is vertical. There is an impact of the exchange rate on future output only when there are deviations from ex post PPP, which in this case only occurs with sunspots.

The W curve shifts with changes in the lending rate in period one i_1^{*l}. For example, an increase in i_1^{*l} shifts the curve downward, since it implies a higher cost of debt in period two and thus a lower output.
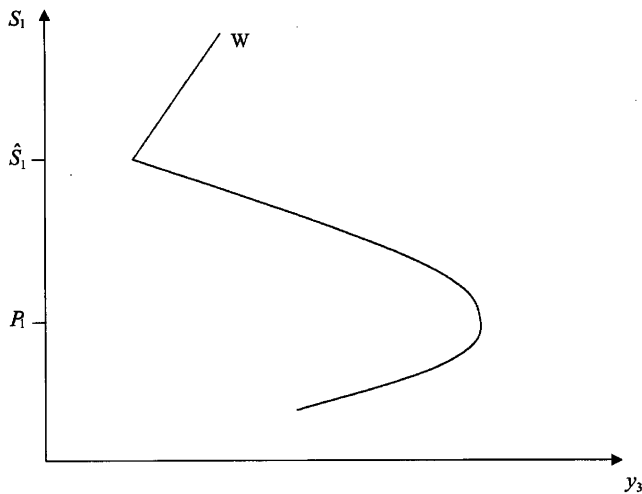

Fig. 2.

5. Sunspots equilibria

In this section, we show under what conditions multiple equilibria including an equilibrium with currency crisis occur. Since prices cannot move within a period, an expectational shock has to be absorbed by the nominal exchange rate, which explains why it has output effects and can be self-confirming. We focus on the case where this expectation shift can only occur in the first period. To ensure this, we assume that the productivity parameter σ_t in all but the first period is constant equal to σ, with σ sufficiently high that there exists only one deterministic equilibrium at each period $t \geqslant 3$. Moreover, we shall assume that the central bank's policy consists in setting the nominal money supply H_2^s in period 2, and the interest rate i_t and the discount window rates θ_t in all periods.

For a given choice of H_2^s and a given sequence of policy variables $(i_t, \theta_t), t \geqslant 0$, we define an equilibrium as a sequence of allocations $w_t, y_t, l_t, t \geqslant 2$; a sequence of prices, exchange rates, and lending rates $P_t, S_t, i_t^{*l}, t \geqslant 1$; and a sequence of endogenous money supplies $H_t^s, t = 1, t \geqslant 3$, such that the following conditions hold (i) the transition equations for the firm net worth (10)–(l2) given the paths of P_t, S_t and i_t^{*l} and the initial values i_0^{*l}, w_1; (ii) $y_t = \sigma_t(1 + \mu)w_t$ and $l_t = \mu w_t$; (iii) the ex ante PPP condition $P_t = E(S_t)$ for all t; (iv) the interest parity condition (1), the money demand (3) and money market clearing (4) equation, and the banks zero-profit condition (6) for all t.

The recursive nature of the above system of equations implies that solving for the set of equilibria boils down to characterizing the equilibrium sequences $(y_{t+2}, S_t), t \geqslant 1$, defined by the relationships "IPLM" and "W" between S_t and y_{t+2} for all t. For $t \geqslant 2$, we are taking the productivity parameter $\sigma_t = \sigma$ to be sufficiently large that no expectational equilibrium can occur. This, in turn, means that we can solve recursively for a unique deterministic sunspot equilibrium $(y_{t+2}, S_t)_{t \geqslant 2}$. This is given by

$$y_{t+2} = \sigma(1 + \mu)w_{t+2}, \quad w_{t+2} = \beta M_{t+1}w_{t+1} \quad \text{and}$$

$$S_t = \frac{1 + i^*}{1 + i_t} \frac{H_{t+1}^s}{y_{t+2}\frac{\gamma\mu}{\sigma(1+\mu)}(1 - \frac{i_{t+1}}{2\lambda\theta_{t+1}})},$$

for $t \geqslant 2$, where $M_t = \beta(\alpha\sigma(1 + \mu) - (1 + i_t^{*l})\mu)$.

More interesting is the equilibrium analysis in period 1 where we allow for extrinsic uncertainty and expectational multiplicity. More specifically, we shall now derive sufficient conditions for the existence of non-degenerate sunspots equilibria $\{(y_3', S_1'), (y_3'', S_1''), q\}$ such that

(1) $q = pr(S_1 = S_1'')$ lies strictly between 0 and 1, and in fact must be allowed to be arbitrarily small;

(2) the pairs (y_3', S_1') and (y_3'', S_1'') satisfy

$$(IPLM) \quad S_1 = \frac{1 + i^*}{1 + i_1} \frac{H_2^s}{y_3\frac{\gamma\mu}{\sigma(1+\mu)}(1 - \frac{i_2}{2\lambda\theta_2})} = \frac{K}{y_3},$$

where K is fixed by the choice of monetary policy (H_2^s, i_2, θ_2), and

$$(W) \quad y_3 = \beta^2 \sigma (1 + \mu) \left(\alpha \sigma (1 + \mu) - (1 + i_1^{*l}) \frac{P_1}{S_1} \mu \right)$$

$$\times \max \left\{ \alpha \sigma_1 (1 + \mu) - (1 + i_0^{*l}) \frac{S_1}{P_1} \mu, \varphi \alpha \sigma_1 (1 + \mu) \right\} w_1,$$

where the first (resp. second) term in the curly bracket corresponds to the no-default equilibrium (y_3', S_1') (resp. to the default equilibrium (y_3'', S_1'')).

(3) the initial price P_1 satisfies PPP, so that

$$P_1 = q S_1'' + (1 - q) S_1'.$$

(4) [strategic] default occurs whenever the firm's default payoff—the second term in the above curly bracket for y_3—is greater than its no-default payoff-the first term in same bracket. Using the IPLM equation, this is equivalent to

$$(1 - \varphi) \alpha \sigma_1 (1 + \mu) - (1 + i_0^{*l}) \frac{K}{P_1 y_3''} \mu \leqslant 0. \tag{14}$$

If we define $a = (1 + i_0^{*l}) \mu$ and $b = (1 - \varphi) \alpha \sigma_1 (1 + \mu)$, (14) can be written as

$$P_1 \leqslant \frac{a}{b} S_1''. \tag{15}$$

Condition (3) imply that sufficient condition for (15) to hold for arbitrarily small q is

$$S_1' < \frac{a}{b} S_1'' \quad \text{and} \quad \frac{a}{b} < 1.$$

Using again the IPLM equation, the above condition becomes

$$\frac{y_3'}{y_3''} > \frac{b}{a} \quad \text{and} \quad \frac{a}{b} < 1.$$

We can reexpress y_3' as

$$y_3' = \beta^2 \sigma (1 + \mu) w_1 \left\{ \Omega - \mu (1 + \mu) \alpha \left[\sigma_1 (1 + i_1^{*l}) \frac{P_1}{S_1'} + \sigma (1 + i_0^{*l}) \frac{S_1'}{P_1} \right] \right\},$$

where

$$\Omega = \alpha^2 \sigma_1 \sigma (1 + \mu)^2 + \mu^2 (1 + i_0^{*l})(1 + i_1^{*l});$$

Then, using PPP, the IPLM equation, and the fact that

$$y_3'' = \beta^2 \sigma (1 + \mu) \sigma_1 (1 + \mu) w_1 \alpha \varphi \left(\alpha \sigma (1 + \mu) - (1 + i_1^{*l}) \frac{P_1}{S_1''} \mu \right),$$

we can solve for $\chi = \frac{y_3'}{y_3''} = \frac{S_1''}{S_1'}$. The equation for χ is quadratic, and by solving it we find that when q tends to zero, the ratio χ becomes approximately equal to

$$\chi = \frac{\alpha^2 \sigma_1 \sigma (1 + \mu)^2 + \mu^2 (1 + i_0^{*l})(1 + i_1^{*l}) - \mu (1 + \mu) \alpha [\sigma_1 (1 + i_1^{*l}) + \sigma (1 + i_0^{*l})]}{\alpha \varphi \sigma_1 (1 + \mu)(\alpha \sigma (1 + \mu) - (1 + i_1^{*l}) \mu)}.$$

For a non-degenerate sunspot equilibrium with q sufficiently small to exist, it suffices that

$$(C_1) \qquad \chi > \frac{b}{a} > 1.$$

In particular, φ cannot be too large, otherwise $\frac{b}{a} < 1$, or μ cannot be too small otherwise $\chi < \frac{b}{a}$. This implies that countries with very low levels of financial development, i.e., with a very low μ and a high φ, are unlikely to experience expectational shocks and currency crises. Only those countries at an intermediate level of financial development, that is where μ is not too small or φ is not too large but where firms are still credit-constrained, may experience currency crises. Finally, to the extent that a high value of σ_1 (and therefore of b) will also result in $\chi < \frac{b}{a}$, we can indeed rule out expectational shocks in periods $t \geq 2$ by assuming that for $t \geq 2$, firms' productivity $\sigma_t \equiv \sigma$ in all these periods is sufficiently high.

To complete our analysis we need to check that condition (C_1) is consistent with condition (C_0) (see footnote 21 above) guaranteeing that domestic entrepreneurs invest all their savings in their own projects. To see that these two conditions define a non-empty set of parameter values, assume condition (C_0) and let $\varphi \to 0$ while keeping $\mu \leq 1$; then $\chi \to \infty$, whereas condition (C_0) together with $\mu \leq 1$ implies that $\frac{b}{a} > 1$, so that (C_1) ends up being also satisfied.

6. Policy analysis

The appropriate monetary policy response to the recent crises has been a hotly debated question. Our framework, to the extent that it explicitly models the monetary side of the economy, appears to be well-suited for discussing these issues. Consider our monetary economy in period 1, and suppose that the sufficient conditions derived in the previous section for expectational shocks and currency crises to occur in period 1, are met. This implies that this economy can be described by Fig. 3. The IPLM curve intersects the W curve at three points. Since the intersection in the middle is not a stable equilibrium, only the other two intersections are considered. They represent the crisis equilibrium at (S_1', y_3'') and the non-crisis equilibrium at (S_1', y_3').

Can the monetary authorities react to the expectational shock in period 1 so as to move the IPLM and/or W curves in such a way that a currency crisis with $y = y_3''$ and a correspondingly high nominal exchange rate $S = S_1''$, can be avoided? More precisely, keeping future monetary policy H_2^s and (i_t, θ_t) for all $t \geq 2$ fixed, can a crisis by avoided by choosing (i_1, θ_1) or (H_1^s, θ_1)?[22] In particular suppose that in period 1 the monetary authorities use the supply of reserves H_1^s and the discount window

---

[22] Again, we assume that future monetary policies in all periods $t \geq 2$ are fully anticipated by all agents in the economy, whereas monetary policy in period 1 is allowed to adjust in an unanticipated way to the expectational shock occurring during that period.
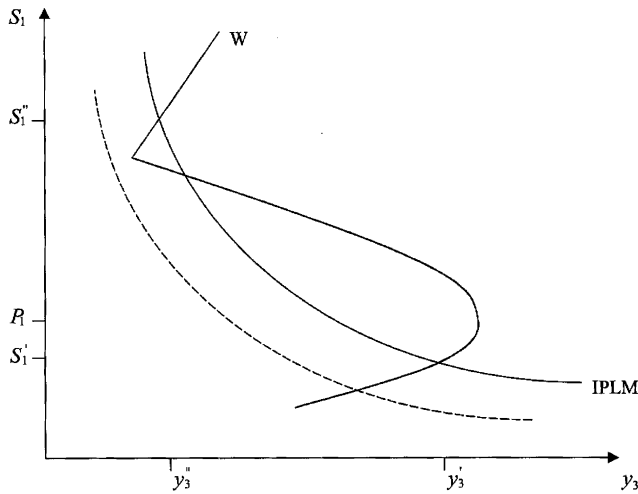
Fig. 3.

parameter θ_1 to try and stabilize the economy, with the interest rate i_1 being endogenously determined by Eq. (5). Let us rewrite the equations for the IPLM and the W curve in period 1, namely[23]

$$(IPLM) \quad S_1 = \frac{1+i^*}{1+i_1} \frac{H_2^s}{y_3 \frac{\gamma\mu}{\sigma(1+\mu)}(1-\frac{i_2}{2\lambda\theta_2})} = \frac{1+i^*}{1+i_1} \frac{\widetilde{K}}{y_3},$$

---

[23] As mentioned above, we take i_2 as given. However, one can show that the impact of monetary policy in period one is not significantly affected by having i_2 endogenous. Thus, suppose that instead of stabilizing i_2, the monetary authority targets money growth. Then second-period interest rate will depend on the entire dynamics of money supply. Let z_t be the growth rate of the monetary base, such that $H_t^s = (1+z_t)H_{t-1}^s$.

For example to see what happens when i_2 is endogenized, suppose the monetary authority sets z_3 and let i_2 vary endogenously, but still keeping i_t fixed for $t \geqslant 3$ (the reasoning can then be extended for any number of period, as long as the nominal interest rate is stabilized at some date before infinity).

The second-period interest rate is now determined by the equation $1+i_2 = (1+i^*)(1+\pi_3)$, which is derived from the interest rate parity condition $1+i_2 = (1+i^*)S_3/S_2$, using the fact that PPP holds after the first period. Then the inflation rate π_3 is determined by the money market equilibrium condition

$$1+\pi_3 = (1+z_3)\frac{h_2(y_3,i_2)}{h_3(y_4,i_3)}, \tag{16}$$

and i_3 is determined by the equation $1+i_3 = (1+i^*)(1+\pi_4)$. These equations jointly determine i_2 and π_3 as functions of z_3 for given values of y_3, y_4, and $\overline{\pi}_4$.

Note that i_2 depends on π_3 which in turn depends on y_3 and y_4. From (12) we see that i_1 has no direct impact on y_4 (for any fixed value of y_3). Thus, changing i_1 keeping y_3 fixed, leaves π_3 and therefore i_2 unaffected. This implies that movements in the IPLM curve are not affected by the endogeneity of i_2.

where $\widetilde{K}$ is fixed by future monetary policy and

$$(W) \quad y_3 = \beta^2 \sigma(1+\mu)\left(\alpha\sigma(1+\mu) - (1+i_1^{*l})\frac{P_1}{S_1}\mu\right)$$
$$\times \max\left\{\alpha\sigma_1(1+\mu) - (1+i_0^{*l})\frac{S_1}{P_1}\mu, \varphi\alpha\sigma_1(1+\mu)\right\}w.$$

For a small probability of default q, the lending rate i_1^{*l} is approximately equal to

$$1 + i_1^{*l} = (1+i^*)\left[1 + \gamma\frac{i_1}{1+i_1}\left(1 - \frac{i_1}{4\lambda\theta_1}\right)\right]. \tag{17}$$

Consider first the effects of a reduction in the supply of reserves H_1^s in period 1, keeping the discount window rate θ_1 fixed. As already explained in Section 3, this unanticipated monetary change will be fully absorbed by an increase in the nominal risk-free interest rate i_1, according to Eq. (5). This interest rate increase rate will in turn shift the IPLM curve downward. If the W curve remained fixed, this would help stabilize the economy, in the sense of getting rid of the multiplicity of expectational equilibria. However, the W curve also shifts downward when i_1, and thereby also i_1^{*l}, increases. This in turn may prevent the monetary authority from avoiding multiple equilibria and a currency crisis. The reason is that the rise in interest rates may have a significant negative effect on future output, which in turn exerts a downward pressure on the currency value.

However H_1^S is not the only instrument available for stabilization. We see in Eq. (17) that lowering θ_1 lowers i_1^{*l} for given interest rate i_1. This suggests the possibility of combining the increase in i_1 with a reduction in θ_1, so as to keep the W curve unchanged while shifting the IPLM curve downward. Intuitively, in this model, there is a wedge between the rate paid to depositors (i_1) and the rate charged to borrowers (i_1^{*l}). Making it easier for banks to borrow from the central bank reduces this wedge, which in turn shifts the W curve up. The optimal policy in a crisis may therefore be to use the discount window to partially (or totally) offset the effect of the open market operations on the lending rate.

This argument, however, is not quite complete. We have not said anything about what influences the central bank's choice of θ when there is no crisis. In particular, it is not clear why θ should not be equal to zero to start with, given that a non-zero θ imposes an extra cost on borrowers. One way to justify an initial non-zero θ is to observe that in our model setting $\theta = 0$ causes the central bank to lose control of the money supply, since banks can generate as much credit as they want. It is not hard to think of reasons why the central bank may want to have some control on the volume of credit that is being generated. Introducing this motive into our model introduces a trade-off between the gains to the economy of a lower θ through its effect on investors, and the costs of reduced control over credit. The optimal monetary policy in 'normal' times balances these two objectives Facing a crisis shifts this trade-off, since the potential gains from lowering θ are much bigger (if it allows the economy to avoid the crisis). Therefore the central bank may find optimal to lower θ in a crisis.

The discussion so far assumes that the central bank cannot use a policy rule which makes future monetary policy a function of the exchange rate in the first period. If the central bank could commit to shrinking the money supply at the right rate in the event of a crisis, then, somewhat paradoxically, there would be no crisis. Essentially the shrinking of the money supply can guarantee that the price level in the second period becomes independent of the realization of the exchange rate in the first period, which effectively pins down the first period exchange rate. Therefore the sunspot cannot affect the exchange rate. It is however unclear that the central bank can commit to this type of policy rule. In particular, in the real world there is no such thing as a well defined second period, whereas in our model the second period is a discrete instant when the price level once again becomes free to adjust. In reality prices adjust at different times and the central bank probably does not know precisely when they are being adjusted.

7. Conclusion

This paper has concentrated on developing a full-fledged "third generation" model of currency crises. Whilst we have focused our attention on microfoundations, we have left out a number of interesting implications and extensions of this type of model. A first extension is to analyze the post-crisis dynamics of output. In the simple benchmark case considered in the above graphical analysis, there is a progressive recovery after a crisis, as firms build up their net worth. While the recovery is influenced by the policy at the time of the crisis, it is also influenced by monetary policy in the aftermath of the crisis. Thus, it would be of interest to examine the dynamics of output under various policy rules, such as inflation, monetary or exchange rate targeting. Longer lags of price stickiness and issues of credibility could also be introduced in the analysis.

The precise mechanics of exchange rate policy have also been left out from the analysis, but in Aghion et al. [5] we show that assuming a fixed exchange rate does not affect the analysis in any substantial way. If the nominal exchange rate is fixed, the central bank has to change its money supply, e.g., through interventions in the foreign exchange market. If we assume that there is a lower limit to money supply, e.g., through a lower limit on international reserves as in Krugman [28], the central bank will not be able to defend the currency when large shocks occur. Alternatively, the nominal exchange rate described in this paper can then be reinterpreted as the 'shadow' exchange rate typically used in the currency crisis literature. If the shadow exchange rate is depreciated enough, the fixed exchange rate has to be abandoned and a large depreciation occurs. In that case, the analysis derived from the IPLM-W graph in the above policy section, carries through at the 'good' equilibrium the fixed exchange rate is sustained, while at the 'crisis' equilibrium the fixed rate is abandoned. While the mechanism leading to a crisis is similar under a floating or fixed exchange rate, there may be differences between the two regimes that are not considered in the model. For example, a fixed exchange rate could lead to a stronger

real appreciation which makes more likely that a large depreciation with default can happen.

This result stresses the central role played by corporate balance sheets and the potentially minor role played by exchange rate policies. Obviously, a deterioration of public finance can also contribute to a financial crisis (as argued in first and second generation models of currency crises), in particular through potential crowding-out effects on the balance sheet of private firms. The role of public finance and public debt and its interaction with the private sector are examined in some detail in Aghion et al. [5]. In particular, a public debt in foreign currency can increase the likelihood of a currency crisis as the public sector's loss from a devaluation may increase the interest payment and/or tax burden of firms.

A critical simplification has been to assume a constant credit multiplier μ. This assumption simplifies the analysis and allows a better exposition of the main mechanisms at work. However, in a more general framework, the credit multiplier is influenced by other variables such as the real interest rate (see Aghion et al. [5,6] for a model where μ, depends negatively on the real interest rate). In this case, output may be more sensitive to monetary policy and the W curve is more likely to shift downward with a restrictive monetary policy. Thus, a currency crisis may be more difficult to avoid. Moreover, we should also try to understand better how the credit multiplier evolves during crises.

The paper has focused on the foreign currency exposure of *firms*, but the exposure of *banks* is also an important characteristic of recent financial crises. In the current setting, banks fully lend in foreign currency, but have enough assets not to go bankrupt after a depreciation. An interesting extension of the analysis is to incorporate explicitly currency exposure at the banking level. If currency depreciations entail significant losses for banks, the lending process may be disrupted (the credit-multiplier μ may be reduced) so that firms will again suffer from a currency depreciation. Introducing the possibility of a currency mismatch at both the bank and the firm levels, can provide new interesting insights.

Finally, we have focused attention on currency crises induced by expectational shocks, that is on the existence of non-degenerate sunspot equilibria. A natural extension is to introduce exogenous shocks, for example on firms' productivity. In particular, a (small) negative shock on productivity may have substantial effects on output and the nominal exchange rate if firms are highly indebted in foreign currency, to the extent that such a shock may result in the IPLM and W curves intersecting more than once.

References

[1] P.R. Agénor, J. Aizenman, A. Hoffmaister, The credit crunch in East Asia what can bank excess liquid assets tell us? NBER Working Paper No. 7951, October 2000.
[2] Ph. Aghion, Ph. Bacchetta, A. Banerjee, Financial liberalization and volatility in emerging market economies, in: P.R. Agénor, M. Miller, D. Vines, A. Weber (Eds.), The Asian Financial Crises Causes, Contagion and Consequences, Cambridge University Press, 1999, pp. 167–190. (Published under the wrong title "Capital Markets and the Instability of Open Economies").

[3] Ph. Aghion, Ph. Bacchetta, A. Banerjee, Capital markets and the instability of open economies, CEPR Discussion Paper No. 2083, March 1999.

[4] Ph. Aghion, Ph. Bacchetta, A. Banerjee, A simple model of monetary policy and currency crises, Europ. Econ. Rev. 44 (2000) 728–738.

[5] Ph. Aghion, Ph. Bacchetta, A. Banerjee, Currency crises and monetary policy in an economy with credit constraints, Europ. Econ. Rev. 45 (2001) 1121–1150.

[6] Ph. Aghion, Ph. Bacchetta, A. Banerjee, A corporate balance-sheet approach to currency crises, CEPR Discussion Paper No. 3092, December 2001.

[7] Ph. Aghion, A. Banerjee, T. Piketty, Dualism and macroeconomic volatility, Quart. J. Econ. 114 (1999) 1357–1397.

[8] Ph. Bacchetta, E. van Wincoop, Does exchange rate stability increase trade and welfare, Amer. Econ. Rev. 90 (2000) 1093–1109.

[9] Ph. Bacchetta, E. van Wincoop, A theory of the currency denomination of international trade, NBER Working Paper No. 9039, July 2002.

[10] B. Bernanke, M. Gertler, Agency costs, net worth, and business fluctuations, Amer. Econ. Rev. 79 (1989) 14–31.

[11] H. Bohn, A positive theory of foreign currency debt, J. Int. Econ. 29 (1990) 273–292.

[12] C. Burnside, M. Eichenbaum, S. Rebelo, On the fundamentals of self-fulfilling speculative attacks, NBER Working Paper No. 7554, February 2000.

[13] R.J. Caballero, A. Krishnamurthy, International and domestic collateral constraint in a model of emerging market crises, J. Monet. Econ. 48 (2001) 513–548.

[14] G.A. Calvo, Balance of payments crises in emerging markets large capital inflows and sovereign government, in: Paul Krugman (Ed.), Currency Crises, NBER and University of Chicago Press, Chicago, 2000.

[15] L.F. Céspedes, R. Chang, A. Velasco, Balance sheets and exchange rate policy, NBER Working Paper 7840, August 2000.

[16] R. Chang, A. Velasco, Liquidity crises in emerging markets theory and policy, in: B.S. Bernanke, J.J. Rotemberg (Eds.), NBER Macroeconomics Annual, MIT Press, Cambridge, MA, 2000, pp. 11–58.

[17] M. Chamon, Foreign currency denomination of Foreign currency debt: has the 'original sin' been forgiven but not forgotten? Mimeo, 2001.

[18] L.J. Christiano, C. Gust, J. Roldos, Monetary policy in a financial crisis, Working Paper No. 204, Federal Reserve Bank of Cleveland, 2002.

[19] R. Cooper, Currency devaluation in developing countries, Princeton's Essays in International Finance, Reproduced in: P.B. Kenen (Ed.), The International Monetary System Highlights from Fifty Years of Princeton's Essays in International Finance, Boulder and Oxford Westview Press, Colorado, 1971.

[20] E. Falcetti, A. Missale, The currency denomination of public debt and the choice of the monetary regime, Mimeo, 1999.

[21] M. Gertler, S. Gilchrist, F. Natalucci, External constrains on monetary policy and the financial accelerator, Mimeo, 2000.

[22] I. Goldfajn, S.R. Werlang, The pass-through from depreciation to inflation a panel study, Mimeo, 2000.

[23] S. Honkapohja, E. Koskela, The economic crisis of the 1990's in Finland, Econ. Pol. 14 (1999) 401–436.

[24] R. Hausmann, U. Panizza, E. Stein, Why do countries float the way they float? Mimeo, Inter-American Development Bank, 2000.

[25] O. Jeanne, Foreign currency debt and signaling, Mimeo, September, IMF, 1999.

[26] O. Jeanne, Foreign currency debt, moral hazard and the global financial architecture, Mimeo, September, IMF, 1999.

[27] O. Jeanne, Foreign currency debt and the global financial architecture, Europ. Econ. Rev. 44 (2000) 719–727.

[28] P. Krugman, A model of balance of payments crises, J. Money, Credit, Banking 11 (1979) 311–325.

[29] P. Krugman, Balance sheets, the transfer problem, and financial crises, in: P. Isard, A. Razin, A. Rose (Eds.), International Finance and Financial Crises, Essays in Honor of Robert P. Flood, Kluwer, Dordrecht, 1999.

[30] P. Krugman, Analytical Afterthoughts on the Asian Crisis, Mimeo, MIT, Cambridge, MA, 1999.

[31] F.S. Mishkin, Understanding financial crises a developing country perspective, Annual World Bank Conference on Development Economics, Washington, 1999, pp. 29–62.

[32] F.S. Mishkin, Global financial instability framework, events, issues, J. Econ. Perspect. 13 (1999) 3–20.

[33] M. Obstfeld, The logic of currency crises, Cah. Econ. et Monétaires, Banque de France 43 (1994) 189–213.

[34] M. Obstfeld, K. Rogoff, Exchange rate dynamics redux, J. Polit. Economy 103 (1995) 624–660.

[35] M. Obstfeld, K. Rogoff, Foundations of International Macroeconomics, MIT Press, Cambridge, MA, 1996.

[36] M. Schneider, A. Tornell, Balance sheet effects, bailout guarantees and financial crises, NBER Working Paper 8060, December 2000.