Capital Flows and Crisis: the Role of Credit Market Imperfections

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Abstract

This paper builds a model of emerging market crises in which firms are credit constrained and the monetary authorities are limited in their access to foreign currency. The effects of these constraints and their interaction are analyzed in a small open economy that is subject to external shocks and in which capital flows derive out of international investors' lending decisions to firms. A crisis can occur both directly from a shock, or due to a change in market perceptions. The economy, however, is only affected by a change in market perceptions and thus vulnerable to a slowdown in inflows of foreign currency when it has high levels of foreign debt and low holdings of international reserves.

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1 Introduction

Recent crises in emerging market economies have motivated new research in a number of directions in modelling crises. Typical factors at work in earlier crises have been notably absent, particularly in the countries hit by crisis in East Asia. For example, none of the five 'crisis countries' in Asia[1] suffered from large fiscal deficits nor any other large, macro-oriented imbalance. This recognition, that macroeconomic factors may not have been at the core of these crises, has placed emphasis in newer crisis research on more micro-oriented, financial areas.

Two influential strands in newer crisis literature are those emphasizing liquidity shortages and firm balance sheet difficulties. Chang and Velasco (2000) define international illiquidity as "a situation in which a country's consolidated financial system has potential short-term obligations in foreign currency that exceed the amount of foreign currency it can have access to on short notice." Their theoretical framework(Chang and Velasco (1998), Chang and Velasco (2000)) revolves around a maturity mismatch between banks' assets and liabilities, and costly liquidation of investment projects. A bank run creates a liquidity crisis, forcing the liquidation of longer term projects and possibly the bankruptcy of banks.

Balance sheet difficulties, as illustrated by, eg. Krugman (1999), involve constraints on firm borrowing and the effects of changes in the real exchange rate, via capital flows and aggregate demand, on firm balance sheets. An important factor is the presence of a substantial portion of foreign currency denominated debt among firms' liabilities[2]. A decline in capital flows leads to a decline in investment, which causes the real exchange rate to depreciate, hurting firm balance sheets.

This paper builds on the balance sheet approach to modelling emerging market crises. However, I argue that depreciations in the real exchange rate are not solely due to a fall in the demand for domestic goods. They also represent a shortage of foreign currency - a decline in the inflow of foreign exchange that suddenly leaves the country unable to finance capital outflows at the prevailing exchange rate. As a provider of foreign currency for the economy, the central bank's holdings of international reserves play a central

[1] Thailand, Korea, Indonesia, Malaysia and the Phillipines. A comprehensive analysis of the economic conditions in these countries can be found in, eg. Corsetti, Pesenti, and Roubini (1998a), Radelet and Sachs (1998) and IMF (1997).

[2] The motivation for this is the fact that loans to developing and emerging economies are seldom denominated in domestic currency. See eg. Hausmann, Panizza, and Stein (2000). There has been little theoretical research on why this is the case for the private sector. See though Jeanne (2000), Jeanne (1999), and Chamon (2001).

role in this story. This paper is then an analysis of the effects of constraints on firm balance sheets and limits to the central bank's access to foreign currency, and their interaction.

Wealth constraints in this model amplify the effects of shocks along the lines of Bernanke, Gertler, and Gilchrist (1998), which they call the "financial accelerator mechanism". A shock to exports is propagated via adverse effects on firm balance sheets, constraining firm spending in the next period and leading to a decline in prices and output.

Shocks to firm balance sheets, by affecting aggregate levels of capital flows, also magnify effects on the external account. If firms are highly leveraged, this effect can be quite strong and lead to large differences in the behavior of the external account compared to in the absence of credit market imperfections. A temporary shock to exports, for example, that does not affect the expected future returns to investment, would not affect capital inflows in the absence of credit market imperfections. When firms are credit constrained, capital flows may instead fall dramatically; this implies that the size of a real shock necessary to lead to a crisis is much less in this case. Additionally, through their effects on capital flows, firm balance sheet constraints will increase the size of a devaluation should one occur. The negative feedback of a devaluation on balance sheets and back on the exchange rate thus provides an explanation for the large nominal depreciations observed in recent crises.

This analysis is related to a number of papers on crises, in particular those concerned with firm balance sheets, eg. Krugman (1999) and Aghion, Bacchetta, and Banerjee (2000). Krugman (1999) illustrates the role of balance sheets and foreign currency debt in emerging market crises. Firm investment is constrained by end of period wealth, while firm wealth (cash flow) is affected by this same investment, via its effects on aggregate demand and the real exchange rate. The potential for multiple equilibria quickly becomes apparent. If lenders are concerned about firm balance sheets, they reduce lending. This leads to a contraction in investment and aggregate demand. The fall in demand causes a real depreciation, damaging firm balance sheets and thereby justifying lenders' concerns.

While changes in the demand for domestic produced goods provides significant means by which firm balance sheets can be impacted, the large depreciations that we see in many emerging market crises suggest that other forces are at work as well. I will argue in this paper that initial exchange rate depreciations reflect to a large degree a sort of disequilibrium. The real depreciations experienced in these countries in the event of crises has less to do with a decline in the demand for home goods and more to do with a shortage in foreign currency following a sudden decline in capital flows, which then causes the price of foreign currency, the exchange rate, to increase greatly.

Modelling the actual crisis, or devaluation, as a sudden shortage of foreign currency (or a case of "international illiquidity") gives additional insights. It provides a clear role for reserves in affecting the risk of crisis and also the lending decisions of international investors. Also, foreign currency debt adds to the problem in an extra way here. Not only does it lead to a worsening of balance sheets; by adding to the amount of foreign currency that must be financed, it adds to the problem of international illiquidity and the effect on the exchange rate.

The remainder of the paper is as follows. Section 2 gives an outline of the model with its main assumptions and mechanisms. Section 3 presents the basic framework of the model. Section 4 shows how the interest rate and default rate are derived. In section 5 this framework is then used to show how a crisis can occur. Section 6 concludes and discusses some possible extensions.

2 A small open economy with wealth constraints

2.1 An outline of the model

The basic structure behind the model is the following. The authorities maintain a fixed exchange rate[3]. Additionally, the authorities are limited in their access to foreign currency. To be concrete, I assume that the authorities are unable to borrow any funds from abroad[4]. Thus, if total net outflows of foreign currency (ie. the balance of payments deficit) are greater than international reserves, then the authorities will be forced to float the exchange rate.

There are two types of agents in the economy, workers and capitalists. Workers supply labor and their only source of income is wage earnings. Capitalists own firms and do not consume. The firms produce goods using intermediate goods and labor. Goods can then either be used for consumption or as intermediate goods in other firms' production.

It is assumed that firms' wealth is insufficient to finance intermediate goods purchases and they thus must borrow the remainder from abroad.

[3]While this is a monetary model, we maintain very simple assumptions on the monetary side and assume a very passive role for the authorites. They are assumed to change the money supply in accordance with exchange rate commitments, implying that domestic money changes one for one with international reserves.

[4]This will be discussed in more detail later in the paper.

Loans are assumed to be denominated in foreign currency. I assume that firms must secure this external financing for intermediate goods purchases one period in advance.

This assumption on the timing of loans is slightly different from that assumed in Krugman (1999). It reflects the view that a currency crisis is the result of the interaction of firm balance sheets and the authorities limited access to foreign currency. While the source of the crisis may be rooted in balance sheet difficulties, the actual exchange rate depreciation is due to "international illiquidity". Assuming that firms must contract loans one period in advance allows us to separate the effects of capital flows on the external account (same period) and on aggregate demand and the relative price of home goods (next period).

External shocks to the demand for exports affect aggregate demand which in turn impacts firms' cash flow. Balance sheet effects amplify the trade balance effect of shocks on the external account, via their effect on capital flows. The effects of shocks then carry into the next period in two ways. Changes in capital flows affect investment, or the purchase of intermediate goods, in the next period. Additionally, changes in firm balance sheets and the external account affect firm default risk and thus also interest rates.

If firms' wealth is less than or equal to zero, then they must default. In determining loan rates, lenders form expectations of default based on the distribution of shocks to exports and on the authorities' ability to sustain the fixed exchange rate.

A balance of payments crisis can occur in one of two ways. A shock to exports, both via a worsening of the trade balance and through adverse effects on capital flows, can lead to a balance of payments deficit so large that the authorities are forced to float the exchange rate. Here it is important to emphasize the amplifying effect that balance sheets have on external shocks.

In some cases there can be multiple equilibria, in which a change in market sentiment can cause a shift to the 'crisis' equilibrium. It will be seen later that there two solutions to the equilibrium interest rate and probability of default; a 'low' or 'normal' equilibrium with a low interest rate and default probability, and a 'high' or 'crisis' equilibrium with a high interest rate and default probability, and possibly also a decline in capital flows. However, the high solution is not always a competitive equilibrium as lenders may be able to increase expected returns by lowering interest rates (which would then push interest rates down to the low equilibrium). The decisive factor in determining whether multiple equilibria are possible is the relative sensitivity of a firm's default rate to the individual firm's interest rate as opposed to aggregate factors that determine the likelihood and potential size of a devaluation. If devaluation expectations' effect on firm default rate is strong, then a decline in 'market sentiment' can be self-validating.

2.2 Production and wealth

There are two countries, Home and Foreign. There are n identical firms in Home, each with the following production function[5]

$$Y_t = K_t^{\beta} L_t^{1-\beta} \quad 0 < \beta < 1 \tag{1}$$

where K_t is capital inputs and L_t is labor.

Both Home and Foreign produce composite goods competitively (home and foreign goods are imperfect substitutes) that can either be used as inputs in production or consumed. Firms must secure financing for nominal intermediate goods purchases, I_t, one period in advance.

Firms purchase both home and foreign capital inputs, $K_{H,t}$ and $K_{F,t}$ according to Cobb Douglas preferences, $K_t = K_{H,t}^{1-\alpha} K_{F,t}^{\alpha}$, and subject to the budget constraint, $I_t = P_{H,t}K_{H,t} + P_{F,t}K_{F,t}$, where I_t is investment (or total input purchases), and $P_{H,t}$ and $P_{F,t}$ are the domestic currency prices of home and foreign capital inputs[6], respectively. α and $1-\alpha$ are the share of foreign and domestic goods, respectively, in firm input purchases (and, as we state later, in domestic consumption). Cost minimization then implies that,

$$I_t = P_t K_{H,t}^{1-\alpha} K_{F,t}^{\alpha}; \qquad P_t = \frac{P_{H,t}^{1-\alpha} P_{F,t}^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} = \kappa P_{H,t}^{1-\alpha} P_{F,t}^{\alpha} \ ; 0 < \alpha < 1 \tag{2}$$

where $P_{H,t}K_{H,t} = (1-\alpha)I_t$ and $P_{F,t}K_{F,t} = \alpha I_t$. P_t is then the producer (and as we will note later, also the consumer) price index for Home. Nominal wages, W_t, are sticky while prices are flexible, and the law of one price holds for both home and foreign goods; $P_{H,t} = S_t P_{H,t}^{*}$and $P_{F,t} = S_t P_{F,t}^{*}$, where S_t is the nominal exchange rate (units of domestic currency per unit of foreign currency). The foreign currency price of foreign goods, $P_{F,t}^{*}$, is assumed constant and is normalized to one. Denote the fixed exchange rate as $\overline{S}$, which is also set equal to one.

Firms end period t with wealth in domestic currency, B_t. Investment in excess of firm wealth is financed by loaning abroad in foreign currency. Assume that internal funds are insufficient to finance investment, so that

[5] These are firm specific values. Aggregate values of these variables will be denoted by a bar, so that, eg. aggregate output is given by $\overline{Y_t} = nY_t$.

[6] Since these are composite goods, these are also the prices of home and foreign final goods.

$I_t > B_{t-1}$. Due to problems of moral hazard, firms are credit constrained, with the maximum amount they can borrow depending on firm wealth;

$$I_t \leq (1+\mu)B_{t-1} \tag{3}$$

where μ is taken as given. The wealth constraint, (3), will be binding when the expected marginal return of capital is greater than the interest rate. We will assume in this paper that this is in general the case, that $I_t = (1+\mu)B_{t-1}$ and $S_{t-1}F_{t-1} = \mu B_{t-1}$. However, if there is a large increase in the interest rate, the wealth constraint may not be binding, so that firms' optimal investment implies $F_{t-1} < \mu B_{t-1}$.

B_t is equal to sales in period t minus wage costs and the repayment of debt taken in t-1. Then we have,

$$B_t = P_{H,t}Y_t - W_tL_t - r_{t-1}S_tF_{t-1} \tag{4}$$

where $P_{H,t}Y_t$ is the home firm's nominal income (or sales proceeds), W_tL_t is wage costs, F_{t-1} is foreign debt denominated in foreign currency, and r_{t-1} is the gross (nominal) loan rate charged on foreign currency loans. As mentioned above, prices in Foreign are assumed constant[7], so that the (risk free) interest rate, r_t^*, is both Foreign's nominal and real (risk free) interest rate. We assume that the exchange rate is fixed at the start of each period. Thus, loans taken the period before are at $S_{t-1} = \overline{S} = 1$. However, due to shocks, there may be a positive probability that a balance of payments crisis will occur. Hence, the domestic currency value of (foreign currency) debt at the time of repayment is written $r_{t-1}S_tF_{t-1}$, as given by (4)[8].

Here I can comment on the timing of the model. As will become clear later, both exports and an eventual devaluation affect input purchases and labor demand. This then implies that the determination of output, prices, exports, capital flows, etc., occurs at the same time. Though, it must be clear that I assume that new loans (and thus aggregate capital flows) are made at time t with the knowledge of export demand, X_t. A balance of payments crisis at time t then, if it occurs, will take place upon the realization of X_t and the determination of capital flows.

[7] Changes in home prices have a negligible effect on the foreign price index, so that the foreign consumer price index is effectively $P_t^* = P_{F,t}^* = 1$.

[8] I assume that the purchase of foreign and domestic goods in Home are done with domestic currency, and thus that F_{t-1} is immediately exchanged (ie. at time t-1) and is in domestic currency at the start of time t.

2.3 Market clearing, wages and exports

Assume that workers spend all their income each period, consuming both home and foreign goods according to Cobb-Douglas preferences (with the same shares as with firms' demand for intermediate goods), while firms do not consume, reinvesting all profits. This assumption is made for simplicity and follows Krugman (1999) and Cespedes, Chang, and Velasco (2000).

In the same way as with firm demand for inputs, we can solve the problem of the consumer, which is to maximize $C_t = C_{H,t}^{1-\alpha} C_{F,t}^{\alpha}$ subject to the budget constraint, $W_t L_t = P_{H,t} C_{H,t} + P_{F,t} C_{F,t}$, where $C_{H,t}, C_{F,t}$ are Home consumption of home and foreign goods, respectively. Then, aggregate consumption is given by[9]

$$\begin{aligned} W_t \overline{L_t} &= P_t \overline{C}_t \text{ where } \overline{C}_t = \overline{C}_{H,t}^{1-\alpha} \overline{C}_{F,t}^{\alpha} \\ \text{and } P_{H,t} \overline{C}_{H,t} &= (1-\alpha) W_t \overline{L_t}, \;\; P_{F,t} \overline{C}_{F,t} = \alpha W_t \overline{L}_t \end{aligned} \tag{5}$$

Total foreign consumption is given by (all Foreign variables in aggregate values) $P_t^* C_t^*$ where $C_t^* = C_{H,t}^{*(1-\alpha^*)} C_{F,t}^{\alpha^*}$ and $P_t^* = \kappa P_{H,t}^{*(1-\alpha^*)} P_{F,t}^{\alpha^*}$. Assume that the share of home goods in foreign consumption is negligible, or $\alpha^* \simeq 1$, which implies that $P_t^* = P_{F,t} = 1$ (since we normalize it to 1) Since $P_{H,t} = S_t P_{H,t}^*$, we have that $P_{H,t}^* = \frac{P_{H,t}}{S_t}$. As with domestic consumption, assume that there is also unitary elasticity of substitution between home and foreign goods in Foreign[10]. This implies that Foreign spends a constant share of its total consumption expenditure on Home and Foreign goods, ie.. $P_{H,t}^* C_{H,t}^* = (1-\alpha^*) P_t^* C_t^*$ and $P_{F,t}^* C_{F,t}^* = \alpha^* P_t^* C_t^*$. The foreign currency value of Foreign consumption of home goods, ie. exports, can then be seen to be $\overline{X}_t = P_{H,t}^* C_{H,t}^* = \frac{P_{H,t}}{S_t} C_{H,t}^*$ and 'real' exports are then $C_{H,t}^* = \frac{S_t}{P_{H,t}} \overline{X}_t$. Aggregate exports, $\overline{X_t}$, are assumed to be exogenous to Home and subject to random shocks.

Market clearing for home goods is then such that output is equal to domestic consumption and investment demand, and export demand;

$$P_{H,t} Y_t = P_{H,t} C_{H,t} + P_{H,t} K_{H,t} + P_{H,t} C_{H,t}^*$$

We can then insert expressions for home consumption, (5), and investment demand, and for export demand;

$$P_{H,t} \overline{Y_t} = (1-\alpha) W_t \overline{L_t} + (1-\alpha) \overline{I_t} + S_t \overline{X_t} \tag{6}$$

[9] P_t is as defined above.

[10] This follows Krugman (1999).

Assume that W_t is set at the end of period t-1[11] and then cannot be changed again until the end of period t. Additionally, assume that labor in each period will then be determined by firms' demand and that firms are always able to employ the amount of labor that maximizes profits, so that $W_t\overline{L_t} = (1-\beta)P_{H,t}\overline{Y_t}$ holds in all periods.

Using this and (6), nominal output is,

$$P_{H,t}\overline{Y_t} = \frac{1}{\alpha + \beta(1-\alpha)}\left[(1-\alpha)\overline{I_t} + S_t\overline{X_t}\right] \tag{7}$$

Since loans are taken prior to the realization of $\overline{X_t}$, $\overline{I_t} = \overline{B}_{t-1} + \overline{F}_{t-1}$ (ie. I_t is determined in t-1).

2.4 Balance of Payments

The domestic value of international reserves is $IR_t = S_tR_t$, where R_t is foreign currency reserves. Reserves at the end of period t, IR_t, will be determined by IR_{t-1} plus the trade balance, $S_t\overline{X_t} - M_t$, (where M_t is total imports) and inflows, $S_t\overline{F_t}$, minus the repayment of loans from period t-1, $r_{t-1}S_t\overline{F}_{t-1}$.

$$IR_t = S_tR_t = S_tR_{t-1} + S_t\overline{F_t} + S_t\overline{X_t} - \overline{M_t} - r_{t-1}S_t\overline{F}_{t-1} \tag{8}$$

Using (5) and (6) we can see that,

$$\begin{aligned}\overline{M_t} &= P_{F,t}\overline{C}_{F,t} + P_{F,t}\overline{K}_{F,t} = \alpha W_t\overline{L_t} + \alpha\overline{I_t} \\ &= \frac{\alpha(1-\beta)}{\alpha+\beta(1-\alpha)}S_t\overline{X_t} + \frac{\alpha}{\alpha+\beta(1-\alpha)}\overline{I_t}\end{aligned} \tag{9}$$

Inserting (9) into (8) we have the following equation for reserves;

$$S_tR_t = S_tR_{t-1} + S_t\overline{F_t} - r_{t-1}S_t\overline{F}_{t-1} + \phi S_t\overline{X_t} - \frac{\alpha}{\beta}\phi\overline{I_t} \tag{10}$$

2.4.1 Condition for a balance of payments crisis to occur

As stated above, the condition for sustaining the fixed exchange rate is (where $\overline{S} = 1$)

$$IR_t \leq 0 \Leftrightarrow R_{t-1} + \overline{F_t} + \overline{X_t} \leq \overline{M_t} + r_{t-1}\overline{F_{t-1}}$$

If $IR_t \leq 0$, then the authorities will be forced to float the exchange rate. This assumption captures in a simple way the idea that emerging markets

[11] And thus also prior to the realization of X_t.

are limited in their access to foreign currency, and that the size of international reserves (in relation to net foreign currency obligations) thus have an important impact on devaluation expectations. By making this assumption we are able to incorporate developments in the balance of payments and reserves into lenders' calculation of the risk of devaluation, and thereby also default risk.

This allows the analysis of lender behavior and the determination of capital flows in an economy where there are both firm credit constraints and an international constraint on access to foreign currency. However, this framework does not allow a more in depth analysis of the problem of the policymaker, in particular the use of the short term interest rate in defense of a currency peg.

2.5 Summary

This then comprises the basic framework of the model. Firms' investment is constrained by their wealth. Capital flows, or aggregate borrowing, are then determined by aggregate firm wealth. The authorities are unable to borrow foreign currency from abroad and if international reserves become negative then the exchange rate is floated. All borrowing is in foreign currency, making firms potentially vulnerable to exchange rate depreciation.

Firms' cash flow is affected by changes in both investment demand and foreign demand. Foreign demand is assumed exogenous and subject to random shocks. The effect of a decrease in export demand is multiplied by its effect on labor demand and wage income. A deterioration in firm balance sheets, brought on by a fall in exports, decreases capital flows and next period investment. The decrease in aggregate investment demand reduces firm cash flow, leading to a decline in investment the following period as well. In this way, temporary shocks are propagated to subsequent periods.

Export shocks affect the balance of payments through a deterioration of the trade balance and are amplified through a decline in capital flows. A balance of payments crisis occurs when net outflows of foreign currency are greater than the authorities' holdings of international reserves.

3 Interest rate and exchange rate determination and the default probability

3.1 Introduction

This section shows how the equilibrium interest rate is determined each period, based on the risk free interest rate and on firm default risk. Default risk depends on three things; the firm specific interest rate, expected aggregate demand, and devaluation expectations. Shocks to exports affect aggregate demand directly, while they affect devaluation expectations both through their effect on firm balance sheets (ie. on aggregate wealth) and on the external account. Central to the analysis is the effect of devaluation expectations on perceived default risk. This 'exchange rate channel' highlights the interaction of balance sheet and external account constraints, in some cases yielding multiple equilibria.

There are two objectives with this section. One is to examine how shocks affect the economy and are propagated, and what major factors are at play. The other is to form a framework to examine how a balance of payments crisis can occur. As a final comment, note that since the focus of this paper is on crises and the role of interest rate determination, we analyze the equilibrium in the short run. Note though, that the long run equilibrium can be easily found, and we include it in the appendix.

3.2 Interest rate determination

Assume that lenders are risk neutral and, due to competition on the loan market, will set interest rates so that the expected return is equal to that of a risk free loan. Lenders, based on the distribution of exports and on beliefs concerning the authorities ability to maintain the exchange rate (ie. whether $IR_t > 0$), form expectations concerning the probability that a firm will default on its loan. In case of default[12], lenders (and firms) receive nothing[13].

In the following subsection we will derive the default rate. For now, the probability that firms will default on their loans is simply denoted as

[12] Note that while the level of reserves will affect expected returns, there are no implicit or explicit guarantees of loans, should a firm default.

[13] This is an extreme assumption, which amounts to assuming 100% bankruptcy costs. In relaxing this assumption, one could assume that, in the case of default, the lender receives the firm's remaining assets minus some fraction (ie. less than one) due to bankruptcy costs. However, doing this would not change significantly the analysis and we assume here, for simplicity, 100% bankruptcy costs.

π^d_{t+1}. The loan rate on foreign currency debt is then given by the following equation;

$$r^*_t F_t = r_t F_t (1 - \pi^d_{t+1})$$

Solving for the loan rate gives,

$$r_t = \frac{r^*_t}{(1 - \pi^d_{t+1})} \tag{11}$$

3.3 Deriving the probability of default

In this section I find the threshold value of X_{t+1} that forces firms to default at time t+1, X^d_{t+1}, as a function of the interest rate, r_t. I will call this the 'X^d_{t+1} curve'. Here I will derive an 'equilibrium X^d_{t+1} curve', where an individual firm's interest rate is equal to the aggregate interest rate. Later, in analyzing the sustainability of equilibria, the two interest rates will be allowed to vary from each other.

We first find the value of exports that gives $B_t = 0$, as a function of the exchange rate. The exchange rate can also be expressed as a function of exports, and the two equations are then used to solve for X^d_{t+1}, and the exchange rate that prevails for $X_{t+1} = X^d_{t+1}$, which we denote S^d_{t+1}.

I can start with the wealth equation. Let $\phi \equiv \frac{\beta}{\alpha+\beta(1-\alpha)}$. (4) can then be expressed as

$$\begin{aligned} B_{t+1} &= \beta P_{H,t+1} Y_{t+1} - r_t S_{t+1} F_t \\ &= (1-\alpha)\phi I_{t+1} + \phi S_{t+1} X_{t+1} - r_t S_{t+1} F_t \end{aligned} \tag{12}$$

Then, as mentioned above, shocks to export demand will affect wealth, both directly and, in the case of a balance of payments crisis, via exchange rate depreciation. Setting $B_{t+1} = 0$ in (12) and solving for X^d_{t+1}, we have

$$X^d_{t+1} = \frac{1}{\phi} r_t F_t - (1-\alpha)\frac{I_{t+1}}{S^d_{t+1}} \tag{13}$$

Will this value of X^d_{t+1} lead to a balance of payments crisis *as well as* default? We can also find, and do so later, the critical value of X_{t+1} that leads to a crisis, denoted by X^c_{t+1}. Since firms default for any $X_{t+1} \leq X^d_{t+1}$, clearly if $X^c_{t+1} \geq X^d_{t+1}$ then 'default' will always be accompanied by 'crisis' (though the opposite will not always hold - ie. there can be a crisis that does not result in default). The conditions for which $X^c_{t+1} > X^d_{t+1}$ will in general depend on the size of aggregate wealth relative to international reserves[14]. Here, we simply note that if there is 'no crisis' then $S^d_{t+1} = \overline{S} = 1$, and if there is 'crisis' then $S^d_{t+1} > 1$ and we can then find S^d_{t+1} in the following way.

Consider (10) (where aggregate values are substituted by '$nZ = \overline{Z}$');

$$S_{t+1}R_{t+1} = S_{t+1}R_t + S_{t+1}nF_{t+1} - r_tS_{t+1}nF_t + \phi S_{t+1}nX_{t+1} - \frac{\alpha}{\beta}\phi nI_{t+1} \quad (14)$$

For $R_{t+1} \leq 0$, the exchange rate is floated, and the exchange rate adjusts so that the external account is in balance. Note that for $X_{t+1} = X^d_{t+1}$, $B_{t+1} = 0$. Thus in this case capital flows, F_{t+1}, are zero as well. (14) then reduces to

$$S_{t+1}R_{t+1} = S_{t+1}R_t - r_tS_{t+1}nF_t + \phi S_{t+1}nX_{t+1} - \frac{\alpha}{\beta}\phi nI_{t+1}$$

and for $R_{t+1} \leq 0$ (and $X_{t+1} = X^d_{t+1}$) the exchange rate is

$$S^d_{t+1} = \frac{\frac{\alpha}{\beta}\phi I_{t+1}}{\frac{1}{n}R_t - r_tF_t + \phi X^d_{t+1}} \quad (15)$$

where we can see, unsurprisingly, that the exchange rate is increasing in foreign debt and decreasing in exports and international reserves.

Inserting this into (13) and rearranging, we find that (for $X^d \leq X^c$)[15]

$$X^d_{t+1} = \frac{1}{\phi}r_tF_t - (1-\alpha)\frac{1}{n}R_t \quad (16)$$

and the exchange rate in this case is[16];

$$S^d_{t+1} = \frac{I_{t+1}}{\frac{1}{n}R_t} > 1 \quad (17)$$

[14] When is $X^d_t < X^c_t$? In answering this question, we want to look at both equations under the fixed exchange rate (X^c_t is derived later in the paper), $X^c_t = \frac{1}{\phi}r_{t-1}F_{t-1} - \frac{1}{\phi}F_t + \frac{\alpha}{\beta}I_t - \frac{1}{\phi}\frac{1}{n}R_{t-1}$ and $X^d_t = \frac{1}{\phi}r_{t-1}F_{t-1} - (1-\alpha)I_t$. $X^d_t < X^c_t$ implies that $X^c_t - X^d_t > 0$ or, $\frac{1}{\phi}r_{t-1}F_{t-1} - \frac{1}{\phi}F_t + \frac{\alpha}{\beta}I_t - \frac{1}{\phi}\frac{1}{n}R_{t-1} - \frac{1}{\phi}r_{t-1}F_{t-1} + (1-\alpha)I_t > 0$.

Simplifying, this gives $I_t > F_t + \frac{1}{n}R_{t-1}$. And, as a point of reference, for $F_{t-1} = F_t$, we have (noting that $I_t = F_{t-1} + B_{t-1}$) $B_{t-1} > \frac{1}{n}R_{t-1}$. Then, the probability of a currency crisis will be greater than the probability of default if aggregate wealth is greater than reserves.

[15] And in the case where default is not accompanied by crisis, we have, $X^d_{t+1} = \frac{1}{\phi}r_tF_t - (1-\alpha)I_{t+1}$ *for "no crisis"*

[16] It can be shown that, for $R_{t+1} = 0$, $X_{t+1} = X^d_{t+1}$ (ie. $F_{t+1} = 0$), I_{t+1} is larger than R_t, implying that the exchange rate does in fact depreciate.

The probability that firms will default is then $\pi^d_{t+1} = \Pr(X_{t+1} \leq X^d_{t+1})$, or $F(X^d_{t+1})$, where $F(\cdot)$ is the cdf of X.

The fairly simple result in (16) and (17) reflects the fact that, with capital flows equal to zero at $X_{t+1} = X^d_{t+1}$, balance sheets and reserves are affected in much the same way. The effect of X^d_{t+1} and $r_t F_t$ on reserves and balance sheets are exactly equal in this case, and the effect of investment on reserves is $\frac{\alpha}{\beta}\phi = \frac{\alpha}{\alpha+\beta(1-\alpha)}$ and on balance sheets is $\frac{1-\alpha}{\alpha+\beta(1-\alpha)}$.

$\frac{1}{\phi} r_t F_t$ represents both the effect of firms own holdings of debt, and that of aggregate debt levels on the exchange rate. The higher interest rates and the ratio of debt to exports are, the greater the default rate. The default rate is also declining in reserves since the greater reserves are, the lower the likelihood and size of a devaluation.

3.4 Short run equilibrium for r and X^d

Hence, (11) and (16) determine the equilibrium values of r_t and X^d_{t+1}, provided that $X^d \leq X^c$. For the remainder of this analysis, we assume that this is the case. If we solve (16) for r_t then we have two curves that can be graphed in (r, X^d) space.

$$RP\ curve : r_t = \frac{r^*_t}{(1 - F(X^d_{t+1}))} \tag{18}$$

$$X^d\ curve : r_t = \frac{\phi}{F_t} X^d_{t+1} + (1-\alpha)\phi \frac{\frac{1}{n} R_t}{F_t} \tag{19}$$

The slope of the RP curve is increasing in X^d_{t+1} and approaches 0 at the lower bound of X, and approaches ∞ at the upper bound of X. For values of r_t where the wealth constraint is binding, the X^d_{t+1} curve is linear with slope equal to $\frac{\phi}{F_t} = \frac{\phi}{\mu B_t}$. When it is not binding, firms will choose F_t (or $I_{t+1} = F_t + B_t$) such that the expected marginal product of K_{t+1} equals r_t. Denote as $\widetilde{r}_t$ the critical value of r_t for which both the wealth constraint is binding and the expected marginal product of K_{t+1} equals r_t. Then for $r_t > \widetilde{r}_t$, F_t is decreasing in r_t, implying that the slope of the X^d_{t+1} curve is increasing.

Figure (1) shows the two curves. They are drawn under the assumption that at the low solution, the wealth constraint is binding while at the high solution, it is not. Then, for $r_t \leq \widetilde{r}_t$, the X^d_{t+1} curve is linear, and for $r_t > \widetilde{r}_t$ it is concave.

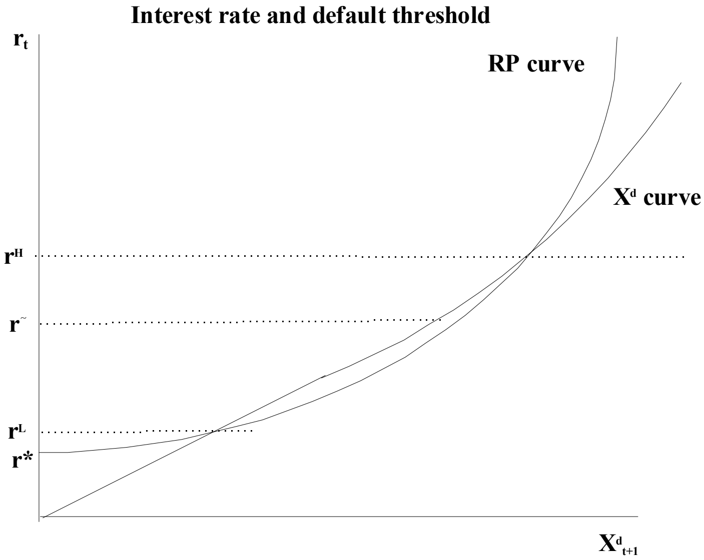

Figure 1

Here we can examine how the curves are affected by a (temporary) negative shock to exports[17], which we depict in figure (2). Since the RP curve only depends on r^*, it is not affected. A shock to X_t will affect the X_{t+1}^d curve in two ways. A negative shock to exports reduces wealth, thus leading to a decline in inflows, F_t. Additionally, the shock, both through its effect on inflows and its effect on the trade balance, reduces reserves. Since F_t falls, the slope of the X_{t+1}^d curve increases. What happens to the intercept depends on the size of reserves relative to foreign debt. To see whether the intercept increases or decreases in response to a negative shock to exports, note that $\frac{\partial F_t}{\partial X_t} = \mu \frac{\partial B_t}{\partial X_t} = \mu\phi$ and $\frac{\partial R_t}{\partial X_t} = \frac{\partial F_t}{\partial X_t} + \phi = (1+\mu)\phi$. Then $\frac{\partial \frac{R_t}{F_t}}{\partial X_t} = \frac{F_t(1+\mu)\phi - R_t\mu\phi}{F_t^2} > 0$ if $F_t > \frac{\mu}{1+\mu} R_t$. Thus, if $F_t > \frac{\mu}{1+\mu} R_t$ then the intercept will decrease in response to a negative shock. Then, a negative shock at time t will cause the X_{t+1}^d curve to rotate upwards, and it can either shift upwards or downwards depending on the ratio of reserves to debt (and on the wealth multiplier).

[17]By a negative shock, we mean that X_t falls below its mean value.

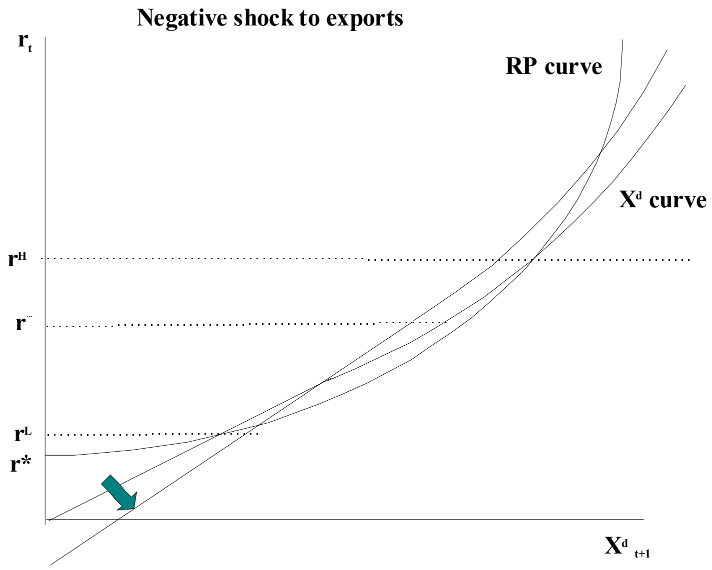

Figure2

4 Crisis

As we have noted in the introduction, a crisis can occur in one of two ways in this model[18]. A crisis can be the unique outcome, ie. regardless of which equilibrium results for the interest rate a balance of payments crisis occurs at time t. Here, the combined effect of a fall in exports and a decline in capital flows depletes reserves and forces the authorities to float the currency.

We will argue here that a crisis can occur in an additional way, due to the existence of multiple equilibria. We will use the analysis of interest rate equilibrium to examine under what conditions these can occur. We will see that there can either be one or two (sustainable) equilibrium values of the interest rate. We characterize the low equilibrium as the 'normal' equilibrium (no crisis at time t, low interest rate and default probability, binding wealth constraint) and the high equilibrium as the 'crisis' equilibrium (high interest rate and default probability, possibly a decline in capital flows and balance of payments crisis). At the high equilibrium it may well be the case that the wealth constraint is no longer binding. At the high interest rate, a single firm's investment demand may be so low that the firm does not loan up to

[18] Additionally, a 'sudden stop' in inflows can occur (in which there is no solution to the interest rate). In this case, lenders are not able to gain the required return for any interest rate, and stop lending. While it is potentially interesting, we will abstract from this possibility in this paper.

the maximum. The abrupt increase in interest rates and decline in capital flows will have adverse effects on wealth and aggregate demand in t+1 and following periods. Importantly, the extent of the damage from a switch to the high equilibrium will depend greatly on whether the decline in capital flows results in a crisis at time t.

As an additional comment, note here that while we are deriving the probability of default at *time t+1,* our interest is also in how the determination of (r_t, X^d_{t+1}) affects the outcome at *time t.*

4.1 Crisis as the unique outcome

Here we examine the case where a crisis occurs for *any* $F_t \leq \mu B_t$. Here we can find the threshold value of exports that leads to crisis (denoted by X^c_t) much in the same way as for X^d. While the derivation of X^d is central to the determination of the interest rate, X^c_t is more for illustrative purposes. In determining the probability of a balance of payments crisis, we can highlight the 'multiplier effect' of balance sheet effects. Given the constructs of the model, this effect is perhaps unsurprising. However, the basic story is not without relevance.

In the period leading up to the crisis in East Asia, capital flows and investment reached their highest level[19]. Shortly thereafter, these countries experienced a large fall in demand for their exports[20]. This had a substantial (negative) impact on firm (and bank) balance sheets. In this situation, international lenders may have been very reluctant to maintain previous levels of lending, with a large decline in inflows putting pressure on currency arrangements.

4.1.1 Deriving X^c_t

Let us here derive X^c_t, under the condition that $F_t = \mu B_t$. Then, inserting $F_t = \mu B_t = \mu\left[(1-\alpha)\phi I_t + \phi S_t X_t - r_{t-1} S_t F_{t-1}\right]$ into (10) and rearranging,

[19] See eg. IMF (1997). Additionally, some recent data (1993-1997) on exports, short term debt and international reserves, which we will discuss below, are included in the appendix.

[20] See again, IMF (1997). Among the 'shocks' noted at this time were: i) a decline in export demand; ii) the appreciation of the US dollar, to which most of these economies were either explicity or implicitly pegged; iii) a decline in the price of electronics; iv) the devaluation in China.

we have

$$S_t \frac{1}{n} R_t = S_t \frac{1}{n} R_{t-1} - (1+\mu) r_{t-1} S_t F_{t-1} + (1+\mu)\phi S_t X_t - \left(\frac{\alpha}{\beta} - \mu(1-\alpha)\right) \phi I_t \tag{20}$$

A shock to exports, through its adverse effects on output and prices, reduces firm revenues. $(1+\mu)$ indicates the multiplier effect of exports on the external account via balance sheets, while ϕ indicates the impact of exports on the trade balance.

Setting $R_t = 0$ (under $S_t = \overline{S} = 1$) and solving (20) for X_t^c we have

$$X_t^c = \frac{1}{\phi} r_{t-1} F_{t-1} + \frac{1}{1+\mu}\left(\frac{\alpha}{\beta} - \mu(1-\alpha)\right) I_t - \frac{1}{(1+\mu)\phi} R_{t-1} \tag{21}$$

A devaluation then occurs for $X_t \leq X_t^c$ and the crisis probability is Pr($IR_t \leq 0) = F(X_t^c)$, where $F(\cdot)$ is the cdf of X_t. Clearly, important factors affecting the risk of crisis in this case are the ratio of foreign debt to exports, the interest rate, and reserves. If foreign debt is high relative to exports, then the maintenance of the currency peg will depend to a large extent on the continued inflow of capital, and on exports. A fall in either can lead to a large decline in reserves. Here, we have a fall in both. In the absence of credit market imperfections, the shock to exports at time t would have no effect on the expected return to K_{t+1}. Yet, due to credit market imperfections, it results in a decline in capital flows. Reserves provide a cushion, or extra 'liquidity', against temporary shocks, reducing to some extent dependence on continued inflows.

What happens then, if capital flows are insufficient to sustain the currency peg? The devaluation means that capital flows will fall even more[21]. Take (20), and setting $R_t = 0$ and solving for the exchange rate, we have in this case (where, as opposed to earlier with S_t^d, capital flows are not zero);

$$S_t = \frac{\left(\frac{\alpha}{\beta} - \mu(1-\alpha)\right)\phi I_t}{\frac{1}{n} R_{t-1} - (1+\mu)\left[r_{t-1} F_{t-1} - \phi X_t\right]} \tag{22}$$

$[r_{t-1} F_{t-1} - \phi X_t]$ indicates the effect of the devaluation on firm balance sheets and $(1+\mu)$ the multiplier effect on the exchange rate. The greater the exchange rate depreciation, the larger the fall in wealth and thus also capital flows. And the larger the decline in capital flows, the greater the exchange rate depreciation.

[21] ie. in addition to the decline caused by the fall in exports.

The initial effect of the crisis will depend on the offsetting effects of the shock to exports and on the resulting devaluation. The shock to exports depresses both output and prices. The initial effect of a devaluation is an increase in the price of the home good and in output, through increases in both S_t and $P_{H,t}$.

The main costs of the crisis are incurred in period t+1. The decline in balance sheets, B_t, severely restricts intermediate goods purchases in period t+1, depressing aggregate demand. Thus, B_{t+1} is also below pre-crisis levels and gradually recovers thereafter.

4.2 The existence of multiple equilibria

We have found that there are in general[22] two solutions to r_t and X_{t+1}^d. Are both solutions sustainable equilibria? As a starting point, take the two solutions depicted in figure (1). Suppose that the economy consists of only one firm. It is clear in this case that the high solution is not a competitive equilibrium. The decline in the interest rate, both by reducing the firm's debt burden and by reducing the risk of crisis, lowers the default rate to such an extent that the lender's expected return increases (ie. the X_{t+1}^d curve is above the RP curve). Competition will then drive the interest rate down to the point where the expected return equals the foreign interest rate, ie. to the low equilibrium.

In considering the problem of an individual firm, aggregate values of the interest rate, debt and reserves are taken as given. Changes in the firm's own interest rate now have a much smaller effect on the firm's default rate, since they affect only the firm's own debt burden and not exchange rate expectations. To analyze this further, consider the problem of an individual firm, taking average levels of r_t and F_t (denoted by r_t^H, F_t^H) as given[23]. This implies an 'aggregate' default threshold of $X_{t+1}^{d,H}$, as in (16) and also that for any $X_{t+1} < X_{t+1}^{d,H}$, aggregate capital flows at t+1 are still zero and[24] for $X_{t+1} < X_{t+1}^{d,H}$, $S_{t+1} = \frac{\frac{\alpha}{\beta}\phi I_{t+1}}{\frac{1}{n}R_t^H - r_t^H F_t^H + \phi X_{t+1}}$. The lender can then calculate the single firm's default rate (or X_{t+1}^d curve) which will depend both on the firm specific interest rate and on average levels. From the wealth equation we

[22] Either two solutions or no solution, in which case firms are rationed from the loan market.

[23] Ie. the individual lender believes that aggregate levels of r_t and F_t (and R_t) are at the high equilibrium.

[24] This will be the most important case to examine in checking the sustainability of the high equilibrium. To be more precise, we are interested in whether lowering the firm specific interest rate and thus also the default rate (ie. so that $X_{t+1} < X_{t+1}^{d,H}$), the lender can increase expected returns.

have, $X^d_{t+1} = \frac{\alpha+\beta(1-\alpha)}{\beta} r_t F_t - (1-\alpha)\frac{\overline{I}_{t+1}}{S_{t+1}}$. Inserting S_{t+1} and rearranging, we then find the firm specific default rate;

$$X^d_{t+1} = \frac{\alpha}{\beta} r_t F_t - (1-\alpha)\frac{1}{n} R^H_t + (1-\alpha) r^H_t F^H_t \tag{23}$$

The firm specific default rate is dependent on average values, $r^H_t F^H_t$, and is less sensitive to changes in the firm specific interest rate as opposed to both interest rates (ie. both the firm specific and aggregate interest rates). Solving for the 'firm specific interest rate' we have[25]

$$r_t = \frac{\frac{\beta}{\alpha}}{F_t} X^d_{t+1} + (1-\alpha)\frac{\beta}{\alpha}\frac{\frac{1}{n}R^H_t}{F_t} - (1-\alpha)\frac{\beta}{\alpha}\frac{r^H_t F^H_t}{F_t} \tag{24}$$

(24) then forms a '*firm specific X^d_{t+1} curve*'. Since the firm specific X^d_{t+1} curve is steeper than the equilibrium X^d_{t+1} curve[26], it is 'less sensitive' to changes in the firm specific interest rate. The question of sustainability of the high equilibrium boils down to - 'how steep'? The high equilibrium is sustainable if a decline in the firm specific interest rate reduces the lenders expected return. This will be the case if, at the high equilibrium, the slope of the firm specific X^d_{t+1} curve is steeper than that of the RP curve[27]. Otherwise, if the slope of the firm specific X^d_{t+1} curve is *not* steeper than that of the RP curve at the high equilibrium, then the high equilibrium is *not sustainable*. The two cases are depicted in figures (3) and (4). In figure (3), the equilibrium is not sustainable; in figure (4), it is, and there are multiple equilibria.

What makes the potential for multiple equilibria more likely? From the above discussion, the lower the slope of the RP curve at the 'high' solution, the greater the scope for multiple equilibria. Important determinants are then levels of foreign debt and reserves. The greater foreign debt relative to (the mean value of) exports, the lower the slope of the X^d_{t+1} curve, and the lesser international reserves, the lower is the intercept. Both these factors tend toward a lower high solution, making it more likely that it is a sustainable equilibrium.

[25] We can observe that for $r_t < r^H_t$, $F_t > F^H_t$. For r_t close to r^H_t, the difference is negligible and we will ignore the effect on r_t of $F_t \neq F^H_t$.

[26] We can note that the slope of a 'equilibrium X^d_{t+1} curve', $\overline{r_t} = \frac{\phi}{\overline{F_t}} \overline{X^d_{t+1}} + (1-\alpha)\phi\frac{R_t}{\overline{F_t}}$, is $\frac{\frac{\beta}{\alpha+\beta(1-\alpha)}}{F^H_t}$ which is less than $\frac{\frac{\beta}{\alpha}}{F_t}$.

[27] ie. $r_t = \frac{r^*_t}{(1-F(X^d_{t+1}))}$

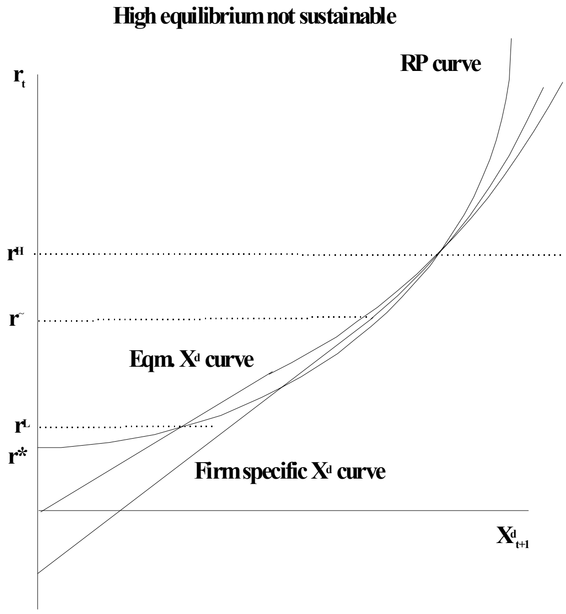

Figure 3

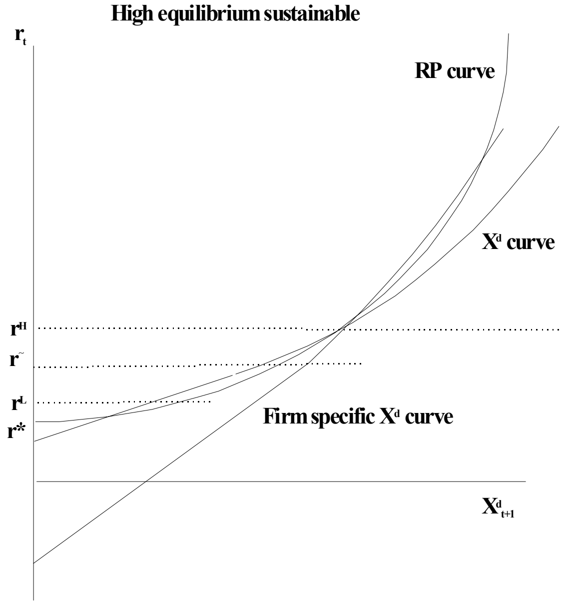

Figure 4

This seems intuitively reasonable, since with high levels of foreign debt, both the size and probability of devaluation become greater, increasing the influence of aggregate factors on firm balance sheets. The external account's role is then central here in determining whether there are multiple equilibria. For low values of F_t relative to exports (or high R_t), the external account is not very vulnerable, either to external shocks or to sudden increases in the interest rate. The risk of devaluation is diminished in this case and the 'exchange rate channel', which is the way in which the external account influences firm balance sheets, is reduced. Then, the economy is not vulnerable to multiple equilibria and changes in market expectations.

For high levels of foreign debt, the exchange rate channel is much stronger. High aggregate values of foreign debt increase both the risk of devaluation and the size of the depreciation for a given level of exports. This both results in an increase in the firm specific default rate (compared to that with no exchange rate effect) and means that the firm specific default rate is more sensitive to aggregate variables than to the firm specific interest rate.

We see then that the existence of multiple equilibria depends on fundamental factors, namely the ratio of foreign debt to exports and foreign debt to reserves. In the presence of high levels of foreign debt, a change in market sentiment can result in an abrupt rise in the interest rate.

The outcome of a change in equilibria will also depend crucially on fundamental factors, namely whether the level of exports and reserves are sufficient to sustain the exchange rate in the face of a decline in inflows. Suppose first that there is a fall in market sentiment and it results in the high equilibrium, with (r_t^H, F_t^H), and that the authorities are still able to maintain the exchange rate ($S_t = \overline{S} = 1$). The increase in interest rates reduces lending which results in lower I_{t+1}. The decline in demand for inputs combined with large interest costs hurts firm balance sheets, B_{t+1}, implying that investment and output will be depressed in the following periods as well.

Now suppose the decline in inflows (F_t^H) leads to a crisis at time t[28]. The devaluation increases the domestic currency value of debt ($r_{t-1}S_tF_{t-1}$), damaging firm balance sheets at time t, B_t. Since $I_{t+1} = B_t + F_t^H$, I_{t+1} falls further as a result of the devaluation. Furthermore, the exchange rate depreciation and resulting increase in $P_{H,t}$ mean that real input purchases fall even more. Saddled with debt and a deeper contraction in demand, wealth falls further as a result of the devaluation.

4.3 Discussion

What are the main implications of the model? First, ignoring balance sheet effects may lead to a significant underestimation of the adverse effects of external shocks such as those that hit East Asian economies. While surges in capital flows and enhanced access to global capital markets may have benefits in terms of output growth, they also generate an acute need for the sustenance of those inflows. With balance sheet effects, an external shock will not only impact the trade balance, it may also lead to a substantial decline in capital flows. Currency mismatches between firm revenues and liabilities can result in negative effects of a devaluation, and further increase the size of the exchange rate depreciation.

This is particularly the case when a country is limited in its access to foreign currency[29]. Low levels of international reserves then make the economy

[28] Does the high solution imply a crisis at time t? Can F_t fall enough to precipitate a crisis? To examine this, take the equation for reserves, set $R_t = 0$, and solve for F_t (call it F_t^c).

$$\overline{F}_t^c = r_{t-1}\overline{F}_{t-1} - \phi\overline{X}_t + \frac{\alpha}{\beta}\phi\overline{I}_t - R_{t-1}$$

This F_t^c is the minimum amount of capital flows needed to sustain the fixed exchange rate. F_t^c may be negative; ie. reserves and exports are high enough that no crisis is possible at time t, even for a complete stop in inflows. However, with low reserves relative to foreign debt and a negative shock to exports (ie. less than mean), it can very well be that the high solution will result in a crisis at time t.

[29] Hausmann, Panizza, and Stein (2000) note the widespread inablility of emerging and developing countries to loan abroad in their own currency (with the notable exception of South Africa).

vulnerable to crises. While there is in general some disagreement over the role of reserves in terms of maintaining a fixed exchange rate, they have been found to be strong indicators of financial crises[30].

Finally, high levels of foreign currency debt create vulnerability to changes in market sentiment that can lead to a sudden increase in the interest rate, a decline in capital flows and possibly, crisis.

Some anecdotal support can be gained for the relevance of this approach by examining developments in some of the variables highlighted in this analysis. The tables in the appendix list some stylized facts for the East Asian countries hit by crisis. The general picture shows strong growth in exports that suddenly comes to a halt in 1996 and 1997. At the same time, short term external debt more than doubles in this short period, also increasing relative to international reserves[31]. This then suggests that these countries were hit by significant external shocks, at a time when they had greatly increased their dependence on capital flows.

The model here shows how both the existence of multiple equilibria and the effects of a change in market sentiment depend on fundamentals, and have done so from the perspective of an individual lender. However, as in many other models with multiple equilibria, we do not incorporate into the model how this change in expectations occurs. A potential source for this change may lie in information problems[32]. In addition to sharing a number of other common characteristics, East Asian countries may also borrow from the same lenders. In the presence of incomplete information, a deterioration of conditions in, eg. Thailand, may cause a reassessment of expectations concerning other economies in the region[33].

5 Extensions and conclusion

A main task of crisis theories is in explaining how small shocks can have large effects. In this paper I have focussed on two factors that magnify the effect of shocks: balance sheet difficulties under imperfect credit markets, and the interaction of external and balance sheet constraints to produce multiple equilibria. In an economy where firms are credit constrained, capital flows

[30] See, in particular, Kaminsky and Reinhart (1999).

[31] As an additional comment, due to forward market interventions, the level of international reserves may overstate the amount of funds the central banks had with which to defend their currencies. For example, Corsetti, Pesenti, and Roubini (1998b) report that Thailand effectively had only 2 billion out of its 30 billion dollars of reserves available to defend the currency.

[32] See, eg. Morris and Shin (2000), Morris and Shin (1998).

[33] For an empirical analysis on this, see Kaminsky and Reinhart (2000).

will be influenced by the state of firm balance sheets. A shock to export demand is magnified by this balance sheet effect through a decline in capital flows. Additionally, this balance sheet effect will increase the size of a devaluation in a crisis, as the exchange rate depreciation worsens firm balance sheets further.

When firms borrow in foreign currency, devaluation expectations are an important factor in determining the riskiness of loans. In this model, where the authorities are unable to borrow foreign currency to support the exchange rate, exchange rate expectations are affected greatly by aggregate levels of foreign debt due for repayment. When foreign debt is high relative to exports, then changes in market expectations can be self sustaining - if an individual lender is concerned that average interest rates will increase, raising the aggregate foreign debt burden, then the lender will also raise interest rates, validating the lenders' concerns.

This analysis can be extended in a number of ways. Here I briefly discuss two. In the paper I have assumed a fixed wealth constraint. What would happen if it instead had been derived within the model? For example, we can pose an ex post moral hazard problem as in work by Aghion, Bacchetta and Banerjee[34], and extend it to account for uncertainty and default risk. This would then imply that μ is decreasing in the interest rate and risk of default. The basic results of the analysis would not be affected significantly. However, the analysis of default risk becomes more interesting. The effect of a shock on capital flows then is not a simple multiple of the change in firm wealth. Changes in default risk also affect the amount of capital flows. For example, if a negative shock to exports increases default risk, then capital flows will not only fall due to a decline in firm wealth, but also due to an increase in interest rates.

This model can also be used to discuss the effects of a financial liberalization. Suppose that taxes on foreign investment are removed, resulting in a decline in interest rates. What are the effects? The drop in interest rates results in an increase in both firm wealth and international reserves, which in turn implies a lower default risk. The sum result would be greater firm wealth, capital flows, investment, reserves - overall, very positive effects. Though, there is one exception, however. There is a danger to this 'liberalization' despite the fact that reserves increase. The increase in capital flows, and hence also the ratio of foreign debt to exports, makes the economy more vulnerable to changes in market sentiment, and multiple equilibria.

[34]eg. Aghion, Bacchetta, and Banerjee (1999), Aghion, Bacchetta, and Banerjee (2000).

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1 Tables on Exports, External Debt and Reserves

Exports[35]	1993	1994	1995	1996	1997
Thailand	46940	56132	69440	70625	47903
Korea	94572	114094	147118	146254	92869
Philippines	16692	23450	26438	33464	29724
Malaysia	50194	67879	82165	91842	67535
Indonesia	42274	46897	53185	58717	60106

Short Term Debt	1993	1994	1995	1996	1997
Thailand	22437	32184	47569	49115	42946
Korea	31266	43008	55818	69181	61356
Philippines	4736	4465	5743	9109	13300
Malaysia	9508	8732	13948	19361	22282
Indonesia	21306	23817	30470	37180	38103

Debt/Reserves[36]	1993	1994	1995	1996	1997
Thailand	0.92	1.10	1.32	1.30	1.64
Korea	1.55	1.68	1.71	2.03	3.01
Philippines	1.01	0.74	0.90	0.91	1.83
Malaysia	0.34	0.34	0.59	0.72	1.07
Indonesia	1.89	1.96	2.22	2.04	2.30

2 Solving for the steady state under the fixed exchange rate

Here we find the steady state under the following assumptions: the exchange rate is fixed, the wealth constraint is binding, the interest rate is determined by the low equilibrium as given above, and realized exports are equal to their mean value.

We can start with firm wealth. Solving for B_{t+1} in terms of B_t and X_{t+1}, we have

$$B_{t+1} = [\phi(1-\alpha)(1+\mu) - \mu r_t] B_t + \phi X_{t+1} \tag{25}$$

Then, using $F_{t+1} = \mu B_{t+1}$ and (25), R_{t+1} can then be expressed in terms

[35] Exports from IFS. Short term debt (under 1 year) to BIS banks, from joint BIS-IMF-OECD-World Bank External Debt Statistics. All values in millions of US dollars. Availability for debt statistics determined time period used here.

[36] Ratio of short term debt (above) to International Reserves. Reserves from joint BIS-IMF-OECD-World Bank External Debt Statistics.

of R_t, B_t and X_{t+1};

$$\begin{aligned} R_{t+1} &= R_t - (1+\mu) r_t F_t + (1+\mu)\phi X_{t+1} - \left(\frac{\alpha}{\beta} - \mu(1-\alpha)\right)\phi I_{t+1} \\ &= R_t - \left[(1+\mu) r_t \mu + \left(\frac{\alpha}{\beta} - \mu(1-\alpha)\right)\phi(1+\mu)\right] B_t + (1+\mu)\phi X_{t+1} \end{aligned} \tag{26}$$

(25) and (26) form the dynamic system for the model, after having inserted the solution for the equilibrium interest rate. Using the RP and X^d_{t+1}curves, and using $F_t = \mu B_t$, we can see that the equilibrium interest rate can be expressed as $r_t = r_t(r^*, X_t, B_t, R_t, \alpha, \beta, \mu)$. In steady state it becomes $r = r(r^*, X, B, R, \alpha, \beta, \mu)$. To solve for the steady state, set $B_{t+1} = B_t = B$ and then in the absence of shocks to X_t we have, $B = \frac{\phi}{[1-\phi(1+\mu)+\mu r]} X$. Note that $1 - \phi\left(1+\mu\right) = \frac{\alpha+\beta(1-\alpha)-\beta(1-\alpha)-\mu\beta(1-\alpha)}{\alpha+\beta(1-\alpha)} = \frac{\alpha-\mu\beta(1-\alpha)}{\alpha+\beta(1-\alpha)}$. Setting this in, we get

$$B = \frac{\beta}{\mu r(\alpha + \beta(1-\alpha)) + \alpha - \mu\beta(1-\alpha)} X \tag{27}$$

Setting $R_{t+1} = R_t = R$ we have in the absence of shocks to X_t,

$$(1+\mu)\phi X = \left[(1+\mu) r \mu + \left(\frac{\alpha - \mu\beta(1-\alpha)}{\beta}\right)\phi(1+\mu)\right] B$$

After inserting the solution for B we have, $\phi X = \phi X$. Thus, the value of B that solves (25) for $B_{t+1} = B_t$, gives also $R_{t+1} = R_t$.