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Capital Flows and the Twin Crises: The Role of Liquidity¹

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Abstract

This paper develops a model that focuses on the interaction of liquidity creation by financial intermediaries with capital flows and exchange rate collapses. The intermediaries' role of transforming maturities is shown to result in larger movements of capital and a higher probability of crisis. These movements resemble the observed cycle in capital flows: large inflows, crisis and abrupt outflows. The model highlights how adverse productivity and international interest rate shocks may trigger a sudden outflow of capital and an exchange collapse. The initial shock is magnified by the behavior of individual foreign investors linked through their deposits in the intermediaries. The expectation of an eventual exchange rate crisis links investors' behavior even further.

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SUMMARY

Balance of payments crises have been found to occur simultaneously with banking crises. The objective of this paper is to highlight the interactions between capital flows and these two crises, providing a consistent framework in which both crises occur together in a fully rational setup. The crises arise as a result of an internal or external shock that is amplified and propagated to the rest of the economy by liquidity-creating financial intermediaries. These intermediaries can generate large capital inflows and, at the same time, increase the risk of large capital outflows. The model is able to replicate the observed cycles in capital flows: increasing inflows, crises, and abrupt outflows. This is done in a context where both investors and financial intermediaries are fully rational and anticipate the possibility of crisis.

The intermediation of capital inflows, an essential explanation of the crises, produces two main effects. On one hand, it can increase capital inflows to the economy. By allowing more flexibility--that is, offering more liquid assets--intermediaries improve the attractiveness of the economy in the eyes of foreign investors. On the other hand, intermediation may generate bank runs and large capital outflows, amplifying initial shocks that otherwise would not have generated crises.

The interaction between exchange rate collapses and runs against the intermediaries is especially interesting. The effects work in both directions. The existence of runs against the intermediaries generates a sudden demand for reserves that may force a devaluation of the currency, independently of the fiscal policy followed by the government. In the other direction, an expected devaluation of the currency will change the return profile of the investment, increasing the benefits of early withdrawals and, therefore, increasing the risk of a collapse.

I. INTRODUCTION

Several balance-of-payment crises occur in the midst of a banking crisis and a sudden capital outflow. Recent examples include Finland (1992), Mexico (1994), Sweden (1992) and Chile (1982). Some features are typical in these episodes. In the external front, capital flows have a definite pattern, increasing steadily up to the crisis and only reversing immediately before the crisis. In the internal front, banking activity increases before the collapse and a banking crisis generally precedes the balance-of-payments crisis leading to what has been dubbed the “twin crises.”

Although there has been productive literature on both balance of payments crises and bank runs, few papers have attempted to integrate them in a coherent story. It is quite difficult to explain major external crises in a context where all agents —investors, intermediaries and policy makers—are rational given the magnitude of the currency crises and the relatively small size of the underlying shocks (internal or external). Surprisingly, it is easier to explain these crises in association with the observed capital swings and banking crises. The latter provides the magnification and propagation effects needed for a complete explanation.

The objective of this paper is to highlight the interactions between capital flows and the twin crises providing a consistent framework where both crises occur together in a fully rational setup. The crises arise as a result of an internal or external shock that is amplified and propagated to the rest of the economy by liquidity creating financial intermediaries. These intermediaries can generate large capital inflows, and at the same time, increase the risk of large capital outflows. The model is able to replicate the observed cycles in capital flows: increasing inflows, crises and abrupt outflows. This is done in a context where both investors and financial intermediaries are fully rational and anticipate the possibility of crisis.

The paper presents a model that focuses on the interaction between liquidity, capital flows and exchange rate crises. Liquidity considerations arise in a world where there are intermediaries transforming maturities, offering liquid assets to their customers and, implicitly, allowing for the possibility of runs on their assets. Thus, the introduction of intermediaries in the model is a synonym for liquidity creation and all its side effects. The model starts from the assumption that there is an asymmetry between the time needed for investment to mature and the timing of investors. The latter are short sighted by necessity. They may demand resources in the short run for their consumption or want to have liquid assets in order to have the flexibility to invest in other places in the short run. The intermediaries, trying to maximize profits, offer these assets to investors and invest the proceeds in production which needs time to mature (early interruptions are not

profitable). In other words, they transform their illiquid assets into liquid ones. It is precisely this transformation that may bring more capital to the economy but it is also the one that introduces the possibility of runs. Ex-post, the good outcome is the one in which the intermediary offers liquid assets, there are no runs and (more) investment occurs. However, the possibility of runs and massive disruption does exist.

Intermediation, therefore, produces two main effects. On one hand, it can increase the capital inflows to the economy. By allowing more flexibility, offering more liquid assets, intermediaries improve the attractiveness of the economy in the eyes of foreign investors. On the other hand, it may generate runs and large capital outflows, amplifying initial shocks that otherwise would not have generated crises.

The interaction between exchange rate collapses and runs against the intermediaries is especially interesting. The effects work in both directions. The existence of runs against the intermediaries generates a sudden demand for reserves that may force a devaluation of the currency, independently of the fiscal policy followed by the government. On the other hand, an expected devaluation of the currency will change the return profile of the investment, increasing the benefits of early withdrawals, and, therefore, increasing the chances of a collapse.

The paper is organized as follows. Section II presents some stylized facts associated with exchange collapses and discusses how our model differs from traditional ones. Section III presents the basic model of intermediation, capital flows and exchange collapses. Section IV discusses two extensions of the model. Finally, Section V presents some concluding remarks.

II. STYLIZED FACTS AND EXPLANATIONS

There are three different features of exchange collapses that we want to explain. First, banking crises are highly correlated with exchange crises. Second, capital inflows increase steadily before the crisis and fall sharply during the crisis. Third, banking activity (intermediation) increases some time before the collapse. In what follows we review some evidence of these features and discuss how our explanation differs from the traditional balance-of-payments crises models.

The simultaneous occurrence of balance of payments and banking crises has been documented extensively in Kaminsky and Reinhart (1996).¹ They study a sample of 76 balance-of-payment crises and 26 banking crises and show that more than 25 percent of

¹Their work differs from this paper in that it is purely an empirical exercise.

the banking crises happen within one year of the balance of payment crises (33 percent within 3 years).

The swings of capital flows pre- and post- crisis are a phenomenon that is present in most crises. For example, analyzing devaluations in industrial countries, Eichengreen, Rose and Wyplosz (1994) show that devaluations are preceeded by large external deficits. Simple inspection of the behavior of capital flows in the experiences mentioned in the introduction shows that flows increase steadily up to the crisis and fall sharply in the year of the crisis (Figure 1).²

Finally, there is the less known fact that banking activity increases steadily prior to the crises. This increase can be induced by a previous financial liberalization and manifest itself through higher growth rates in deposits and credits of the banking system. As Kaminsky and Reinhart conclude:³ *"In 18 of the 26 banking crises studied here the financial sector had been liberalized during the preceding five years, or usually less. This suggest that the twin crises may have their common origins in the deregulation of the financial system..."* Further, they show that:

- Financial liberalizations accurately signal 71 percent of balance of payment crisis and 67 percent of banking crisis.
- The M2 multiplier rises steadily into the onset of the banking crisis. Its growth rate is 20 percent higher than in tranquil times.
- The growth in the ratio of domestic credit/nominal GDP accelerates steadily and markedly as the crisis approaches, peaking at the time the crisis erupts at about 15 percent above growth rates observed during tranquil periods.

This same pattern is confirmed in the four episodes mentioned before. Figure 2 shows credit claims by the banking sector as a proportion of GDP in these experiences. In all of them we observe a surge in intermediation in the years preceding the crises.

The traditional theoretical framework on balance of payment crises is based on the vast literature on speculative attacks that followed the seminal article by Krugman (1979). The key starting point of these *first generation models* is that the government follows an inconsistent policy combined with a fixed exchange rate regime, which would eventually have to collapse. The major contribution, then, is to use rational investors to

²For a description of 3 of these 4 crises see Dornbusch, Goldfajn and Valdés (1995).

³Kaminsky and Reinhart (1996) page 8.

Figure 1: Capital Flows in Crisis Experiences
(Percentage of GDP)

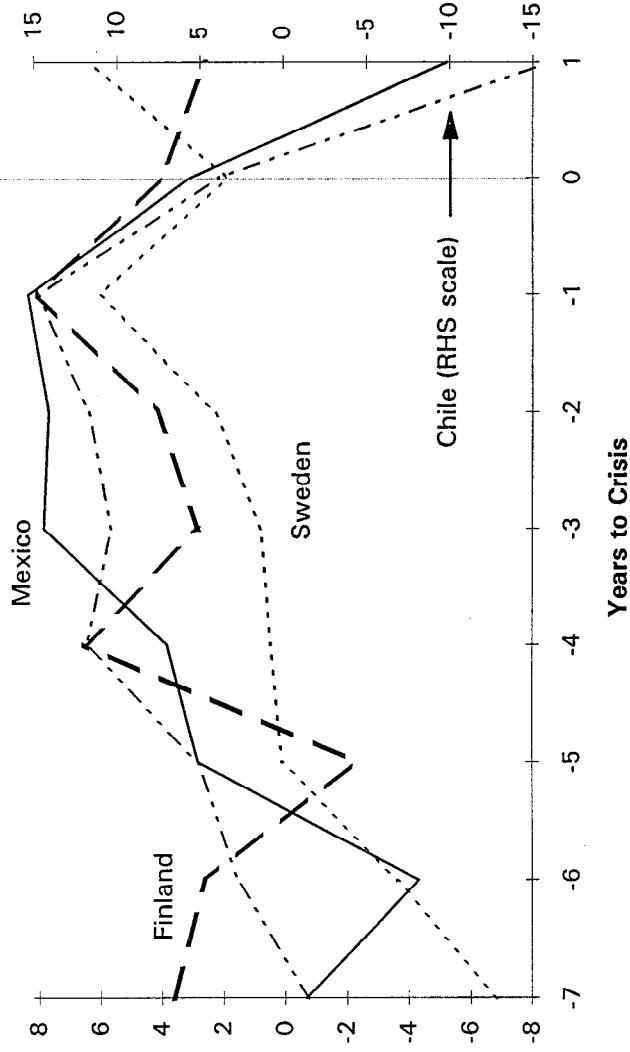
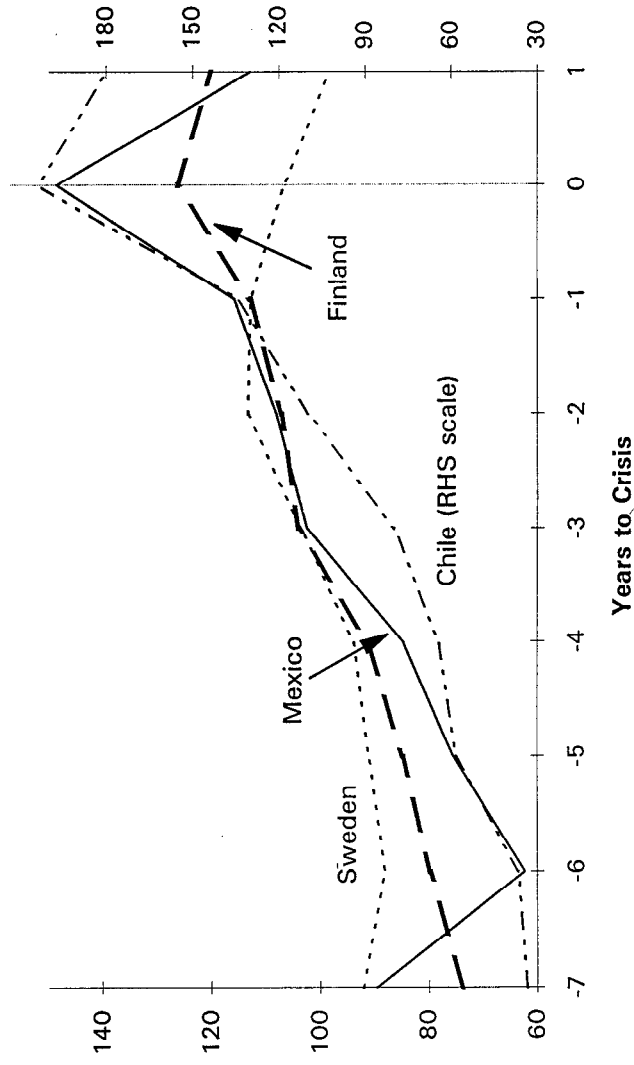


Figure 2: Intermediation-Credit Claims of the Banking System
(Ratio to GDP - Average of Period = 100)



Source: IMF

define exactly when and how the collapse occurs.⁴ They do not link the banking sector to the crisis.

Second generation models of balance of payment do not assume an inconsistency in policy making and explain the crises as self-fulfilling bad outcomes.⁵ In these models the central bank decides to abandon its peg once the the benefits of maintaining the exchange regime are outweighed by the costs of higher domestic debt or lower domestic output. The selffulfilling nature of the crises arise since both costs depend largely on the expectation of devaluation by the agents. In these models, there is no role for a banking system or the cycle of capital flows actually observed.

This paper departs from both the Krugman tradition and the second generation models. It does not assume an inconsistency in policy making, but it gives an active role to the banking system in magnifying shocks to fundamentals. Intermediation, together with its creation of liquid assets, *allows* for the possibility of runs and crises but it does not generate crises by itself. With our model one can analyze two types of shocks to fundamentals: productivity and international interest rates. For each type of fundamental, there is a threshold such that for shocks large enough, runs against the intermediary is the equilibrium outcome. This threshold is determined by foreign investors, who decide whether or not to accelerate the timing of their withdrawals. With this region defined one can explicitly determine the probability of crises. In this sense we also depart from the standard “bank run” literature in which the outcome of the models are multiple self-fulfilling equilibria whose likelihood is not determined endogenously.

III. THE MODEL

A. Set-Up

Time is discrete and there are three periods: 0, 1, and 2. There are three types of agents: a continuum of international investors of mass 1 who have initial wealth equal to 1, domestic financial intermediaries, and the central bank. Initially, there are two assets: a safe and liquid international asset and a risky and illiquid country investment (*home* from the perspective of the receiving country).⁶

International investors are risk averse agents who maximize their expected utility of

⁴See, e.g., Agénor et al. (1992), Dornbusch (1987) and Flood and Garber (1984).

⁵See Obstfeld (1986, 1994).

⁶All that we need for the final result is that the international technology is safer than the country's.

wealth, choosing their optimal portfolio allocation between the two assets. These agents may have liquidity needs in the form of a random probability of requiring the resources invested. At time zero each investor does not know whether he will need the money in the next period, although the total number of people requiring the money is known. As in Diamond and Dybvig (1983), investors are divided in two types:

1. Early Consumers

Their utility function is $U[W_1]$, where W_1 is wealth in period 1, and they are a proportion θ (fixed and known) of the total population. These investors always interrupt their investments in period 1.

2. Late Consumers

Their utility function is $U[W_2]$, where W_2 is wealth in period 2, and they are a proportion $1 - \theta$. These investors have the option to maintain their resources invested in the technology but may choose to withdraw in period 1 depending upon convenience.

We assume that the discount rate is equal to 1 and that agents' type is private information.

The return of the international asset is constant and equal to r^* per period. The return on the country investment is ultimately tied to a risky constant-return-to-scale technology. It is relatively irreversible, requiring some time to generate profits. The gross return on a unit invested in this technology is given by:

$$\text{Return} = \begin{cases} \tilde{R} & \text{if } t = 2 \\ q & \text{if } t = 1, \end{cases} \quad (1)$$

where \tilde{R} is known only in period 1, has a publicly known distribution $\mathcal{G}(\tilde{R})$, and q is a known constant. We assume that the support of \tilde{R} has a lower bound $\underline{R} = q$ and an upper bound $\bar{R} > r^{*2}$. Moreover, we assume that $q < r^*$. This captures the fact that investment is irreversible or illiquid and that the country does not (absolutely) dominate the safe asset. Illiquidity is defined as the cost to liquidate an asset in the short run. This cost is the difference between the return in the short run and the per-period-return of the technology in the long run.

When there are intermediaries, investors use their services instead of investing directly in the technology. The intermediaries compete à la Bertrand and their role is

to transform the illiquid technology into liquid assets, providing liquidity to potentially illiquid investors. Their liabilities may be composed of demand deposits (as in the case of banks), other fixed income assets (investment banks or government bonds) or simple quotas (as in mutual funds). Here we will simply assume that they offer investors the following return \tilde{r} :

$$\tilde{r} = \begin{cases} \tilde{r}_2 & \text{in } t = 2 \\ r_1 & \text{in } t = 1, \end{cases} \quad (2)$$

where r_1 is fixed and \tilde{r}_2 is a function of the return on the technology.

The transformation of liquidity is done by investing the proceeds in the technology and offering the international investors a contract that pays a fixed rate of return $r_1 \geq q$ in period 1. In this way, the intermediary will be effectively reducing the liquidity costs to the investors, which in case of necessity will obtain a better rate. Of course, this contract is feasible only because the intermediaries, constrained by the technology, will pay a rate $\tilde{r}_2 \leq R$ in the second period. This reduction of the spread between returns increases utility for risk averse consumers.

The link between the rates \tilde{r}_2 and r_1 is given by the resource constraint and how many investors withdraw in period 1. Because the intermediary cannot distinguish between types she will have to honor the withdrawals of every investor. If f_1 investors withdraw in period 1, the resource constraint reads:⁷

$$\frac{r_1 f_1}{q} + \frac{r_2(1 - f_1)}{\tilde{R}} = 1, \quad (3)$$

so that the return promised in period 2 is given by:

$$\tilde{r}_2 = \frac{\tilde{R}(1 - \frac{r_1 f_1}{q})}{1 - f_1}. \quad (4)$$

It is immediately apparent from (4) that $r_1 \geq q$ implies $\tilde{r}_2 \leq R$.

The transformation of liquidity makes the intermediary vulnerable to runs. There is always the possibility that the expectation of a high number of withdrawals in period

⁷Equation (3) is derived as follows. a is the amount invested in the country and $ar_1 f_1$ is what is paid to investors who withdraw in period 1. Since the return of the technology in period 1 is q per unit invested, the intermediary needs to retire $\frac{r_1 f_1}{q}a$ from the technology and keep $(a - \frac{r_1 f_1}{q}a)$ in the technology to generate $\tilde{R}(a - \frac{r_1 f_1}{q}a)$ in period 2. This amount has to equal the amount distributed in period 2 $r_2(1 - f_1)a$.

1 (in particular, higher than the proportion of early consumers θ) will drain the resources available to continue investing in the technology and the return promised to investors in period 2 may turn unprofitable. In this case late consumers will have an incentive to withdraw early and this may generate a self-fulfilling run on the intermediary. Moreover, if the return promised in period 1 plus the return of investing in the international asset for one period ends up being higher than the realized r_2 (under a normal proportion of withdrawals $f_1 = \theta$), it is optimal for everybody to withdraw in period 1 and the run is the unique equilibrium outcome.

In order to formally analyze the possibility of runs, the behavior of the intermediary under a run must be precisely defined. We assume that in the case of a run the intermediary will distribute all its assets equally among the investors.⁸ Since the intermediary will have to interrupt all her investment in technology to pay for the withdrawals, every investor will get q . Thus, the actual return profile offered is:

$$\tilde{r} = \begin{cases} q & \text{in the case of run} \\ r_1 & \text{in } t = 1 \text{ if there is no run} \\ \tilde{r}_2 & \text{in } t = 2 \text{ if there is no run.} \end{cases} \quad (5)$$

Finally, we model the central bank with two key assumptions. First, the central bank will try to maintain the exchange rate fixed whenever it is possible. Denoting the exchange rate of period t by e_t , in the model this condition translates to $e_0 = e_1 = e_2$ when the central bank is successful in fixing the peg and $e_0 \leq e_1 = e_2$ if the central bank is forced to devalue in period 1. Second, in the case of a run, the central bank fixes a limit to the amount of reserves it is willing to sell at the original exchange rate (RX_{lim}). When the selling reaches this limit, the rest of the reserves are publicly auctioned so as to clear the market (at a higher exchange rate).

These assumptions portray the central bank as an agent that fixes the exchange rate and has some reserves to defend the peg, in line with most of the literature on balance-of-payment crises. The central bank may want to fix the exchange rate for inflation stabilization or credibility purposes (which are exogenous to the model).⁹ Also, the central bank has an upper limit to the amount of reserves it can use to defend the peg since it cannot borrow in the short run against future reserves. This will typically be the case if there is risk of repudiation and credit rationing in international markets.¹⁰ The

⁸This can also be done as a “first come first serve basis,” where the last investors in line do not get anything, as in Diamond and Dybvig (1983).

⁹See Krugman (1978), Flood and Garber (1984) and the survey in Agénor et al. (1992).

¹⁰See Eaton et al. (1986).

innovation here is to introduce the more realistic assumption that the central bank sells a specific amount of reserves at the original exchange rate before giving up the peg.

With these assumptions, for a given stock of net reserves in period 1, RX , and a given demand for reserves in period 1, F/e , where F is capital outflows measured in local currency and e is in units of local currency per unit of foreign currency, the investor will face the following exchange rate values in period 1 (normalizing $e_0 = 1$):

$$e_1 = \begin{cases} 1 & \text{if } F \leq RX \\ 1 & \text{with prob. } \beta \quad \text{if } F > RX \\ 1 + \frac{F-RX}{RX-RX_{lim}} & \text{with prob. } 1 - \beta \quad \text{if } F > RX, \end{cases} \quad (6)$$

where $\beta = RX_{lim}/F$.¹¹ Given that $RX > RX_{lim}$, and in the case of a run $F > RX$, the exchange rate will be higher for a proportion β of the investors. Also, the larger RX_{lim} , the higher the devaluation.

In order to clearly depart from the first generation exchange rate collapse literature, we assume that the government is *not* following an inconsistent policy: the treasury has a balanced budget and the central bank is not increasing domestic credit.

B. Solution Without Exchange Rate Risk

We *initially* assume that the authority has enough reserves RX to maintain the exchange rate fixed regardless of the capital outflows resulting from a liquidity crisis. Therefore, in this section, the returns to investment can be thought of as being denominated in the international currency. The case where reserves are not sufficient to overcome a liquidity crisis is analyzed in subsection C.

Absence of intermediation

This section starts assuming there are no intermediaries. This case provides a benchmark for the amount of capital inflows and outflows that occur without the effect of the liquidity creation by intermediaries and the interaction between the returns of the investors. This is useful to later analyze the impact of intermediation on the probability of runs and capital flows. The no intermediation case is also a benchmark where no crisis occurs, a helpful device to understand when is that negative shocks generate crisis.

¹¹In period 1, if there are not enough reserves, the exchange rate will increase so that the excess demand for reserves $(F - RX_{lim})$ will match the remaining supply: $\frac{F-RX_{lim}}{e} = RX - RX_{lim}$. Rearranging, we obtain the last expression above.

In the absence of intermediation, foreign investors still have the option to invest directly in the technology. The returns are given by the technology in (1) and the return on the safe asset r^* .

Since the proportion of early consumers is fixed at θ , each investor knows the probability that he will need to withdraw in period 1. Denoting by a the proportion (and amount) of wealth invested in the country, the maximization problem is:

$$\text{Max}_a E[U[\tilde{W}]] = \theta U(aq + (1-a)r^*) + (1-\theta) \int_q^{\tilde{R}} U(a\tilde{R} + (1-a)r^{*2}) dG(\tilde{R}). \quad (7)$$

With probability θ , the return of the portfolio is $(aq + (1-a)r^*)$ and with probability $(1-\theta)$ the return is $(a\tilde{R} + (1-a)r^{*2})$. Each investor needs to worry only about his idiosyncratic shock (being a late or early consumer) and the macroeconomic shock \tilde{R} . There is no need to worry about the possibility of exchange rate crises (which will generally affect the returns in the international currency) because the central bank has enough reserves RX to sell to all the early consumers. Moreover, there is no possibility of runs against domestic assets. There are no intermediaries to link the returns of the investors (here \tilde{R} and q do not depend on the behavior of the other investors).

The maximization in (7) implies an optimal amount invested in the country given by:¹²

$$a_{ni}^* = a_{ni}^*(q, \tilde{R}, \theta, r^*), \quad (8)$$

where the subscript ni stands for no intermediation. The flow of capital, in turn, will be given by:

$$\begin{aligned} t = 0 & \quad a_{ni}^* \\ t = 1 & \quad -\theta q a_{ni}^* \\ t = 2 & \quad -(1-\theta)\tilde{R}a_{ni}^*, \end{aligned} \quad (9)$$

where the outflows in periods 1 and 2 are given by the amount invested a_{ni}^* multiplied by the proportion of consumers (θ or $1-\theta$) and multiplied by the returns on the technology (q or \tilde{R}).

¹²There is no constraint on short sales. In equilibrium, the likely outcome is that $0 \leq a \leq 1$.

Intermediation

Including the possibility of investment through intermediaries introduces two interesting features. First, the intermediary may offer a different return profile to the foreign investor which may change his investment decisions.¹³ It will be particularly interesting when this new pattern increases the capital inflows to the country. Second, there is always the possibility of runs against the intermediary's assets, provided there is transformation of illiquid assets into liquid ones. This possibility has to be taken into consideration by the investor when choosing his portfolio allocation, since it affects the return, as shown in (1).

The timing of the model in case of intermediation is given in Figure 3 where it is clear that all uncertainty is resolved in period 1.¹⁴

Figure 3: Timing of Moves

0	1	2
Intermediary offers r_1 Investors decide a	Investors learn their type \tilde{R} is realized Withdrawal decision made Central bank may fail to sustain e	Patient investors get r_2 (if there was no run)

Probability of runs

In order to define precisely the investors' problem, we need to solve backwards and first obtain the probability of runs. A run happens when all the investors withdraw in period 1. Since early consumers are those who always withdraw in period 1, runs will be determined only by late consumers, who may decide to withdraw early. These will

¹³There is only one intermediary because there is only one technology in the country and therefore no scope for diversification. This does not yield any monopoly power because there are other potential intermediaries ready to enter.

¹⁴We assume that there is no side-trading in the form of early consumers selling their "shares" of the intermediary to late consumers. In the model this is equivalent to assuming that the risk-free investment is not sufficient to finance these transactions. In the actual world we do not observe much of these transactions. A lack of an institutional arrangement and adverse selection considerations may explain this phenomenon.

choose to withdraw only if the payoff of waiting is lower than the payoff to immediate withdrawal. The payoff for waiting is the return r_2 given by the bank in period 2 while the payoff for withdrawing in period 1 is given by the return r_1 multiplied by the return r^* of investing the proceeds in the international safe asset. Thus, late consumers will accelerate their withdrawals if

$$r_1 r^* \geq r_2, \quad (10)$$

Since r_2 is a function of \tilde{R} from the resource constraint of the economy and the returns r_1 and r^* are given, the decision to withdraw depends on the realizations of the return of the technology. There will be a cutoff in the realization of the return of technology, say \hat{R} , such that for values smaller than \hat{R} a run is the unique equilibrium.¹⁵ Using the resource constraint faced by the intermediary from equation (4), the cutoff is determined by:

$$\begin{aligned} r_1 r^* &= \frac{R(1 - \frac{r_1 \theta}{q})}{1 - \theta} \Rightarrow \\ \hat{R} &= \frac{r_1 r^* (1 - \theta)}{(1 - \frac{r_1 \theta}{q})}. \end{aligned} \quad (11)$$

For sufficiently low returns of the technology in the country, all the investors will withdraw their deposits from the bank and capital outflows will follow. Therefore, the probability of crisis on the intermediary can be calculated from the likelihood that the returns are lower than \hat{R} .

One important caveat is the possibility of self-fulfilling runs independent of the realization of \tilde{R} .¹⁶ If all the rest of the investors withdraw, it is optimal for a specific investor to withdraw because the return in period 2 depends on the amount withdrawn in period 1 (see equation (4)). However, the probability of self-fulfilling runs cannot be specified from the model and, unless given by an exogenous coordinating event, it must be zero.¹⁷

¹⁵Here we analyze the incentive to withdraw of a marginal late consumer in the case that there is no self-fulfilling run. In this case the appropriate return to use in period 1 is r_1 instead of q . If the inequality holds then a bank run is the only equilibrium.

¹⁶Provided $r_1 > q$, which is exactly the case when intermediaries create liquidity.

¹⁷Along the equilibrium path beliefs have to be correct. This means that without an exogenous coordinating event—which makes agents act in a particular way so that the initial beliefs turn out to be correct—the expected probability of a self-fulfilling run has to be zero (if it does not occur) or one (if it occurs). However, if this probability were

Therefore, we can claim that **under intermediation the probability of a run will be given by $\mathcal{G}(\hat{R})$, which is strictly positive, provided $r^* \geq 1$, and non-decreasing with respect to the international interest rate.** The first part of this claim is a straightforward consequence of the fact that intermediaries create liquidity which, using equation (11) implies that $\hat{R} > q = \underline{R}$, and therefore $\mathcal{G}(\hat{R}) > 0$.¹⁸ The second part is obtained by differentiating (11) with respect to r^* and using the definition of liquidity provision by intermediaries ($r_1 > q$) to get $\frac{\partial \hat{R}}{\partial r^*} > 0$. Given that $\mathcal{G}'(\hat{R}) \geq 0$ we establish that the probability of runs cannot decrease with higher r^* .

Investors' problem and the intermediaries

Once we determined the probability of runs, we can now present clearly the decision faced by the investor. He must decide how much to invest in this economy taking into consideration the returns offered by the intermediary but also the possibility of runs.

When agents invest through intermediaries, each foreign investor takes into account the probability of a run, $\mathcal{G}(\hat{R})$, and the return q in this event. He now solves:

$$\begin{aligned} Max_a E[U[\tilde{W}]] = & \\ (1 - \mathcal{G}(\hat{R}))[\theta U(ar_1 + (1 - a)r^*) + (1 - \theta) \int_{\hat{R}}^{\tilde{R}} U(a \frac{\tilde{R}(1 - \frac{r_1 \theta}{q})}{1 - \theta} + (1 - a)r^{*2}) d\mathcal{G}(\tilde{R})] & \\ + \mathcal{G}(\hat{R})[\theta U(aq + (1 - a)r^*) + (1 - \theta)U(aqr^* + (1 - a)r^{*2})], & \end{aligned} \quad (12)$$

which yields an optimal investment policy with an intermediary:

$$a_i^* = a_i^*(r_1, q, \theta, r^*). \quad (13)$$

There are two parts in the maximization above. With probability $(1 - \mathcal{G}(\hat{R}))$ there is no run and the investor obtains r_1 and r^* if he is an early consumer or $r_2 = \frac{\hat{R}(1 - \frac{r_1 \theta}{q})}{1 - \theta}$ and r^{*2} if he is a late consumer. With probability $\mathcal{G}(\hat{R})$ there is a run and the investor's return is q and r^* or qr^* and r^{*2} depending if he is an early or late consumer.

The intermediaries, knowing the investors' function $a_i^* = a_i^*(r_1, \tilde{R}, \theta, r^*)$, will choose the rate r_1 to maximize profits. Bertrand competition among intermediaries will one, agents would never invest in the first place since runs generate a return lower than the safe return r^* . See Postlewaite and Vives (1987) and Fudenberg and Tirole (1991).

¹⁸Liquidity provision was defined as setting $r_1 > q$. More liquidity is increasing r_1 , making it closer to $\sqrt{\hat{R}}$, which is the one-period-equivalent return of the technology.

lead to zero profits and an r_1 that maximizes investors utility. That is, they will maximize equation (12) with respect to r_1 subject to equation (13). This gives the equilibrium r_1 (and optimal from the private point of view):

$$r_1^* = r_1^*(q, r^*, \theta). \quad (14)$$

Capital outflows and inflows

The flow of capital in the case of intermediation will be given by:

$$\begin{aligned} t = 0 & \quad a_i^* \\ t = 1 & \quad \begin{cases} -\theta r_1 a_i^* & \text{with probability } (1 - \mathcal{G}(\hat{R})) \\ -q a_i^* & \text{with probability } \mathcal{G}(\hat{R}) \end{cases} \\ t = 2 & \quad \begin{cases} -(1 - \theta)\tilde{r}_2 a_i^* & \text{with probability } (1 - \mathcal{G}(\hat{R})) \\ 0 & \text{with probability } \mathcal{G}(\hat{R}) \end{cases} \end{aligned} \quad (15)$$

Thus, comparing these flows with those without intermediation, one verifies that **there are proportionally more capital outflows with intermediaries in period 1 and, particularly, in the event of runs, that is $\theta q < \theta r_1 < q$.** The second inequality says that capital outflow in period 1 is higher with runs. This comes from the fact that the intermediary cannot contract to pay to investors in period 1 more than the technology allows (i.e., $r_1 \theta < q$). The first inequality is a straightforward consequence of the fact that intermediaries create liquidity: $r_1 > q$.

Plugging the equilibrium r_1^* back in the investment function (13) one gets the equilibrium capital inflows with intermediation. Intermediation produces a higher risk of sudden outflows and, more importantly, may produce a larger capital inflow in period 0. This shows the first intuition we want to stress: **there is a trade-off in the sense that intermediation may generate larger inflows but, at the same time, a higher probability of a run against the country.** The next subsection presents an example of parametrization in which intermediation produces these two phenomena.

A numerical example: CRRA utility and Bernoulli distribution

In this subsection we work out an example with closed-form solution where $a_{ni}^* \leq a_i^*$. Even though investors rationally expect crises in bad states of nature, the benefits from the liquidity provision by intermediaries will more than compensate that effect and will induce them to invest a higher proportion of their portfolio in the economy.

We assume that investors have a constant relative risk aversion (CRRA) utility function, that the international interest rate r^* equals 1, and that \tilde{R} follows the following Bernoulli distribution:

$$\tilde{R} = \begin{cases} \bar{R} & \text{with probability } \alpha \\ q & \text{with probability } 1 - \alpha, \end{cases} \quad (16)$$

with $\alpha \in (0, 1)$.

The optimization problem in this case (under $\hat{R} < \bar{R}$) becomes:

$$\begin{aligned} \text{Max}_{a_i, r_1} \quad & (1 - \alpha) \frac{(aq + 1 - a)^{1-\gamma}}{1 - \gamma} + \\ & \alpha \left[\theta \frac{(ar_1 + 1 - a)^{1-\gamma}}{1 - \gamma} + (1 - \theta) \frac{\left(a \frac{\bar{R}(1 - \frac{r_1 \theta}{q})}{(1 - \theta)} + 1 - a \right)^{1-\gamma}}{1 - \gamma} \right], \end{aligned}$$

where γ is the coefficient of risk-aversion.

The FOCs for this case are given by:

$$\frac{(r_1 - 1)\theta\alpha}{(a(r_1 - 1) + 1)^\gamma} - \frac{(1 - \alpha)(1 - q)}{(1 - a + aq)^\gamma} + \frac{\alpha(1 - \theta)(r_2^H - 1)}{(1 - a - ar_2^H)^\gamma} = 0 \quad (17)$$

and

$$\frac{\theta\alpha a}{(a(r_1 - 1) + 1)^\gamma} + \frac{\alpha(1 - \theta)a \frac{\bar{R}\theta}{q}}{(1 - a - ar_2^H)^\gamma} = 0, \quad (18)$$

where r_2^H is given by equation (4) applied to \bar{R} and θ . That is,

$$r_2^H = \frac{\bar{R}(1 - \frac{r_1 \theta}{q})}{1 - \theta}. \quad (19)$$

In order to find a_i^* and r_1^* explicitly we used Maple V and solved equation (17) for a (simplifying terms using equation (18)), solved equation (18) for a , and equate. The final solutions are given by:

$$a_i^* = \frac{\Phi_2 \left\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \right\} - \Phi_1 \left\{ \theta \bar{R} + q(1 - \theta) \right\}}{(1 - q) \Phi_2 \left\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \right\} - \Phi_1 \left\{ (\theta - q) \bar{R} + q(1 - \theta) \right\}} \quad (20)$$

and

$$r_1^* = \frac{q \left[\Phi_1 \left\{ \bar{R} - (1 - \theta) \right\} + (1 - \theta) \right]}{\theta \bar{R} \Phi_1 + q(1 - \theta)} + \{q(1 - \Phi_1)(1 - \theta)\} \times \frac{(1 - q) \Phi_2 \left\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \right\} - \Phi_1 \left\{ (\theta - q) \bar{R} + q(1 - \theta) \right\}}{\left\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \right\} (1 - \Phi_2) \left\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \right\}}, \quad (21)$$

where

$$\Phi_1 \equiv \left(\frac{q}{\bar{R}} \right)^{\frac{1}{\gamma}}$$

and

$$\Phi_2 \equiv \left(\frac{(1 - \alpha) \left\{ \bar{R}(q - \theta) - q(1 - \theta) \right\}}{\bar{R}\alpha(1 - q)} \right)^{\frac{1}{\gamma}}.$$

Note that for the problem to be well defined we need to restrict the parameter values such that $\bar{R}(q - \theta) - q(1 - \theta) \geq 0$.

For the case of no intermediation, on the other hand, the optimal investment level a_{ni}^* is given by:

$$a_{ni}^* = \frac{1 - \Phi_3}{1 - q + \Phi_3(\bar{R} - 1)}, \quad (22)$$

where

$$\Phi_3 \equiv \left(\frac{(1 - q) \{ \theta + (1 - \theta) \alpha \}}{(1 - \theta)(1 - \alpha)(\bar{R} - 1)} \right)^{\frac{1}{\gamma}}.$$

We present here some simulations using a concrete numerical example. The baseline case parameter values are shown in Table 1, while the baseline results of capital inflows and intermediation are shown in Table 2. Intermediation in this example results in liquidity provision ($r_1^* > q$), even in excess of the risk-free rate, an increase in capital inflows ($a_i^* > a_{ni}^*$), and an increase in the probability of collapse, which changes from zero to $(1 - \alpha)$. Moreover, capital outflows with intermediation is more than six times

Table 1: Baseline Example Parameter Values

Parameter	Value
\bar{R}	1.7
q	0.8
α	0.4
θ	0.2
γ	2.0
r^*	1.0

larger than without intermediation in the bad state of nature. In other words, the existence of liquidity creating intermediaries can magnify substantially the initial shock.

Figure 4 shows the results of varying parameters in terms of optimal capital inflows with and without intermediaries and the level of liquidity provision. For parameter values where the intermediaries provide liquidity, that is $r_1^* > q = .8$, capital inflows under intermediation are systematically higher than in the case without it. In principle, there are two opposite effects determining the amount of investment when there is intermediation. On one hand, by providing liquidity, intermediaries make investment in the country more attractive to potentially illiquid investors. On the other hand, the provision of liquidity allows for the possibility of runs and makes rational investors more cautious with regard to investing in the country.¹⁹

In the example shown here, the liquidity effect dominates the risk of being forced to early withdraw (in the case of a run) as we observe larger capital inflows when there is intermediation. Notice that when there is no liquidity creation (that is $r_1 = q = 0.8$) the amount of inflows with intermediaries is the same as without intermediation, i.e., $a_i^* = a_{ni}^*$. At these parameter combinations the return and probability of the different states that the investor faces are identical, regardless of the presence of intermediation. Interestingly, for parameter values at which the intermediaries (optimally) offer illiquid contracts (that is when $r_1^* < q = .8$) there are fewer capital inflows.

Figure 4 also allows us to analyze some of the comparative statics involved in

¹⁹In general, there is a third effect. By changing the expected wealth of investors, intermediation can potentially change investors' risk-aversion and, consequently, the amount invested. In our example we have left out this effect by fixing the relative risk-aversion.

Figure 4: Simulated Capital Inflows and Intermediation

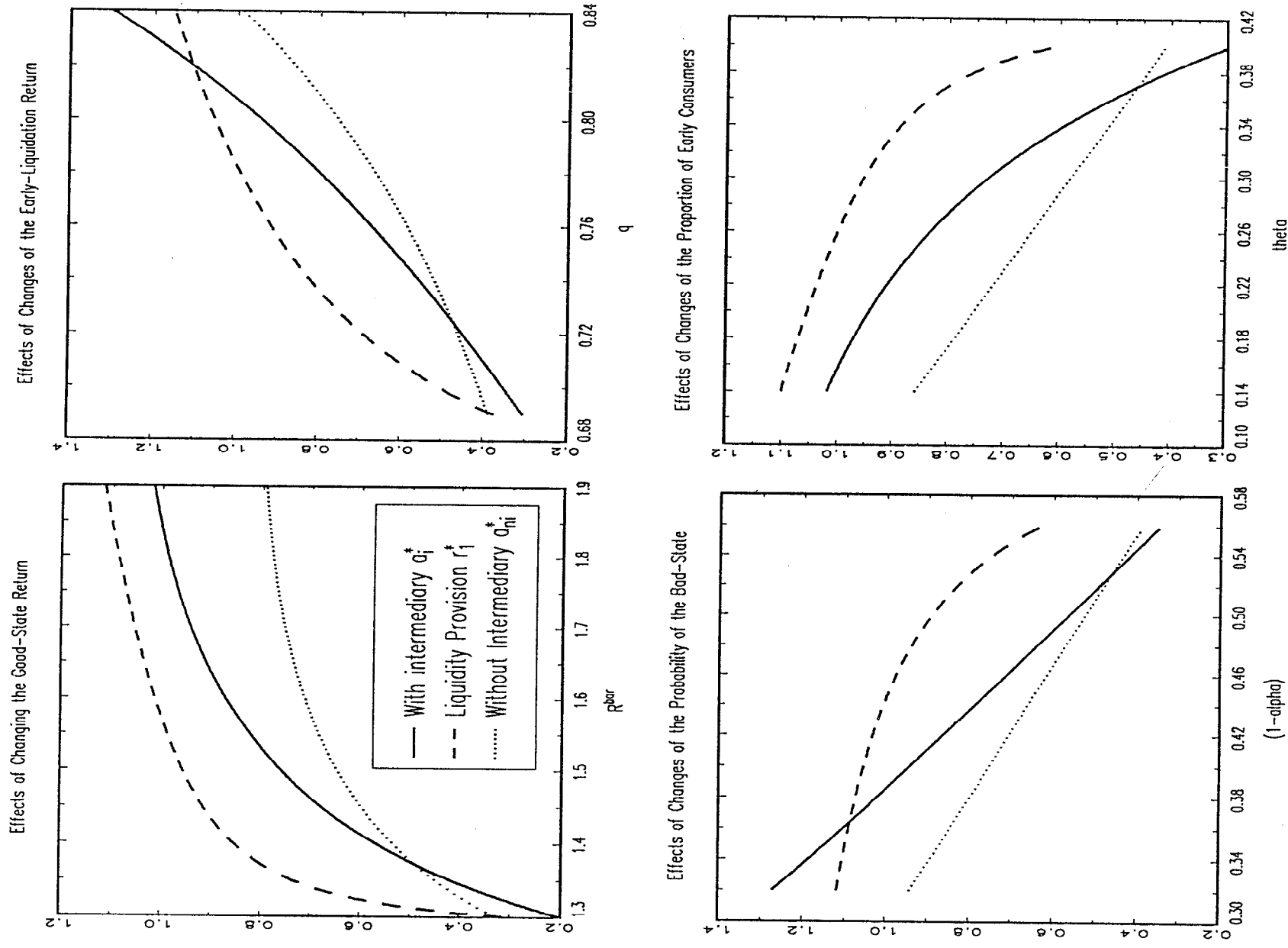


Table 2: Baseline Example Results

	Without Intermediation	With Intermediation
r_1	—	1.054
Capital Inflows	0.753	0.942
Capital Outflows without Run	0.120	0.199
Capital Outflows with Run	0.120	0.754

the example. As expected, a higher good-state return, \bar{R} increases the inflows both with and without intermediation. More important, however, both the difference between the inflows with and without intermediation and the provision of liquidity increase. For a given q , a higher good-state return increases the spread of the returns and makes liquidity creation and intermediation more valuable.

A higher liquidation return q also increases capital inflows. The difference between the two inflows expands too. As q rises, the cost for each individual investor in the case of a run against the intermediaries decreases. This makes investment with the intermediaries more attractive.

A higher probability of a lower return (that is a higher $1 - \alpha$) has opposite effects. Inflows with and without intermediation fall, but the former drops more because of a higher probability of runs on the intermediary. Finally, a higher proportion of Early-Consumers (that is a higher θ) produces less inflows and intermediation in equilibrium. The extra inflows generated by intermediation decreases for higher values of θ because the existence of a higher proportion of withdrawals in period 1 makes intermediaries provide less liquidity (because the marginal investment through the intermediaries is less attractive).

The rest of the section introduces the exchange rate problem. Interestingly, this other consideration only enhances this trade-off.

C. Solution with Exchange Rate Risk

The model presented so far has analyzed the effect of financial intermediation on both capital inflows and outflows. This subsection extends the model in order to investigate the interactions between runs against intermediaries and balance of payments collapses in economies with an eventually unsustainable fixed exchange rate. We now assume that the returns of the domestic technology are measured in local currency.

Intermediation, together with an upper bound to the stock of reserves, both amplifies and propagates shocks. First, given that forced devaluations are now possible and that portfolio returns depend on them, investors have to recalculate their optimal allocation and the optimal withdrawal policy. The anticipation of a devaluation produces strong incentives for a run against the central bank. As in the case of intermediaries offering bank-type deposits, the position in the queue of the central bank matters because a devaluation produces a capital loss to those at the end of the line. Therefore, even if the investors' portfolios include other "liquid" intermediaries or direct investment, these agents may have incentives for early liquidation because the returns measured in the international currency are affected by the eventual devaluation. Typically, there will be runs in more states of nature.²⁰

Second, there is an effect of outflows on the sustainability of the exchange rate. Without a sufficiently high level of reserves, runs can generate abnormal capital outflows that may force a devaluation. This will be the case if the central bank is not able to finance the sudden outflow by, in the short run, borrowing against future reserves.²¹

There are three different possibilities regarding the amount of reserves available to the central bank. First, it may have enough reserves to overcome even a run on the banking system. In this case, with zero probability of devaluation, the model behaves as before. Second, it may be the case that the level of reserves is lower than the normal outflows in period 1. That is, even in the absence of a banking crisis, the central bank is unable to sustain the peg. Finally, there is the interesting case where the central bank

²⁰There is an alternative link between intermediation and balance of payments based on a fiscal-backed deposit insurance system. In this case runs against intermediaries will produce an extra burden on the fiscal sector bringing forward a balance of payments crises. This link is investigated in Calvo (1995).

²¹This is a common assumption in the balance-of-payments collapse literature. This will typically be the case if the required future fiscal policy is not credible or if there is risk of strategic repudiation. In this model, the assumption implies that there are no immediate public compensatory flows of capital.

can sustain the exchange rate for normal outflows but is unable to defend the peg when it faces an attack on its reserves, as a result of a banking crisis. In what follows we investigate the latter case.

Effect of exchange collapses on runs

In this subsection we show that an expected devaluation increases the probability of a run against the intermediary (holding constant the feedback effect from runs to devaluations).

Investors who are able to keep the investment until period 2 will evaluate whether it is convenient to withdraw in period 1. As without exchange risk, there will be a cutoff, say R^c , such that if the project return is lower than R^c it is optimal to withdraw. The cutoff level in this case will depend on the reserve level of the central bank and the reserve level at which the authority auctions the remaining reserves. In particular, given the amount invested in period 0, a_i^* , the cutoff which defines optimal early withdrawal is uniquely defined by:

$$R^c = \begin{cases} \hat{R} & \text{if } a^*r_1\theta \leq RX \\ R' & \text{otherwise,} \end{cases} \quad (23)$$

where $\hat{R} = r_1r^*(1 - \theta) / (1 - \frac{r_1\theta}{q})$ is the cutoff defined before. If $a^*r_1\theta \leq RX$, then there is no devaluation if late consumers do not run and the returns are the same as in the simple model.

If reserves are not enough to finance normal outflows (the ones with a proportion θ of people withdrawing in period 1), then the expected devaluation changes the cutoff to R' , which is defined by the implicit equation:

$$U \left[\frac{a^*\tilde{r}_2}{e_2} + (1 - a^*)r^{*2} \right] = \beta U [(a^*r_1 + (1 - a^*)r^*)r^*] + (1 - \beta) U \left[\left(\frac{a^*r_1}{e_2} + (1 - a^*)r^* \right) r^* \right], \quad (24)$$

where $\tilde{r}_2 = R' (1 - \frac{r_1\theta}{q}) / (1 - \theta)$, $e_2 = e_1$ and β are as defined in equation (6) above, with $F = a^*r_1\theta$.

If $a^*r_1\theta > RX$, then there is devaluation with probability 1, and there exists a unique R' such that late consumers are indifferent between early and late withdrawal. Waiting to withdraw in period 2 gives a return r_2 but discounted by the devalued exchange rate $e_1 = e_2$ while withdrawing early provides, with probability β , the opportunity of exchanging the proceeds a^*r_1 at the old exchange rate $e_0=1$ and reinvesting in the safe asset with return r^* . R' exists and is unique because, given F , the RHS of equation (24)

is constant and the LHS is monotonic and continuous in R' (assuming a well behaved utility function: continuous, with $U'(\cdot) > 0$ and $U''(\cdot) < 0$).

Therefore, **if devaluations are expected, runs against the intermediary are more likely.** Proving this amounts to showing that $\mathcal{G}(\hat{R}) < \mathcal{G}(R')$, or, equivalently,

$$\frac{r_1 r^* (1 - \theta)}{1 - \frac{r_1 \theta}{q}} < R'. \quad (25)$$

The inequality can be verified by noticing that if $a^* r_1 \theta > RX$, then $1 < e_2$, regardless of the existence of a run against the intermediary. Therefore, the LHS of equation (24), which is equal to a convex combination of two terms, has to be larger than $U[(a^* r_1 / e_2 + (1 - a^*) r^*) r^*]$, the smallest of the two terms of the combination. Comparing the arguments of the two functions and using the fact that $U'(\cdot) > 0$, yields the result.

2. Effect of Intermediation Runs on the Exchange Rate

A run increases both the probability of a balance of payments crisis, and, if there is a collapse, the size of the devaluation. The non-linearities produced by the intermediation process make small real shocks in project returns translate into balance-of-payment crises. This is the second key intuition we want to stress in this paper: **the intermediation process generates a transmission and amplification mechanism in which small shocks translate into large effects.**

Formally, capital outflows in period 1 increase by $\Delta = a_i^*(q - \theta r_1)$ when there is a run, where $a_i^* \theta r_1$ is the “normal” capital outflow. In this case, there is no balance-of-payment crisis if $\Delta > RX - a_i^* \theta r_1 > 0$. That is, if the central bank does not have enough reserves to sustain the extra capital outflow that results from the run on the intermediary. Moreover, if there is a devaluation, the new exchange rate level will be given by $1 + (a_i^* q - RX) / (RX - RX_{lim})$.

We can calculate the probability of collapses from the likelihood of runs against the intermediaries. If we denote by R^c the early withdrawal policy cutoff for \hat{R} , the probability of a crisis will be simply given by $\mathcal{G}(R^c)$.²² Thus, intermediation increases the likelihood of an exchange collapse from zero to $\mathcal{G}(R^c)$. Therefore, there is an effect of outflows on the sustainability of the exchange rate. Without a sufficiently high level of reserves, runs can generate abnormal capital outflows that may force a devaluation.

²²As shown before, it is not always the case that this is the same cutoff as before, \hat{R} .

IV. FURTHER APPLICATIONS

A. International Interest Rates

There is a lively debate in the literature about the role of external factors in determining capital flows to (or from) less developed countries (LDC). There is some evidence that movements in the international interest rate are an important determinant of the *direction* of capital flows to (or from) LDCs.²³ However, it is fairly difficult to justify how rather modest changes in the US interest rates can determine the *magnitude* of these impressive capital inflow and outflow surges. This is certainly the case of a crisis, when the magnitudes of the capital outflows are much larger than the ones predicted by fundamentals.

The structure developed in the previous section is suitable to show how relatively small shocks may generate large swings in capital flows and, in the case of insufficient reserves, even an exchange rate crisis. Although the focus up to this point has been the role of internal (or country specific) factor shocks, exemplified by productivity shocks, it is straightforward to extend the model in order to include external factors as the initial impulse.

An initial increase of US interest rates, for example, may prompt more than the normal withdrawals if late consumers have the incentive to withdraw early to take advantage of better opportunities abroad. If this is reinforced by the contract offered by intermediaries, basically offering liquidity and reducing the cost of withdrawal at short notice, the incentive is even higher and a surge of capital outflows may occur. Capital inflows can also be explained if the intermediation process becomes endogenous. For instance, a small inflow prompted initially by a drop in the international interest rate can produce a surge if there are thick market externalities in the process of intermediation, which, in turn facilitate the liquidity provision process.

Using the same methodology as in the case of internal factors, there will be a cutoff \hat{r}^* , such that for second-period international interest rates higher than \hat{r}^* all late consumers will have an incentive to withdraw early.²⁴ ²⁵ Denoting by \mathcal{F} the c.d.f. of

²³See, e.g., Calvo, Leiderman and Reinhart (1993).

²⁴See Hellwig (1994) for a similar model based on the Diamond and Dybvig approach to analyze the interest rate risk. The focus of that paper is quite different from this one; it aims to analyze the optimality of deposit contracts when the interest rate is stochastic.

²⁵The cutoff in this case is $\hat{r}^* = \frac{R(1-\frac{r_1^\theta}{q})}{r_1(1-\theta)}$.

r^* , the probability of crises will be given by $\mathcal{F}(\hat{r}^*)$, which will be strictly positive and non-decreasing in r_1 . The runs against the intermediaries will generate a larger outflow and, in the absence of enough international reserves, this may trigger a devaluation. The more the liquidity creation by intermediaries, the smaller will be the cutoff and, therefore, smaller realizations of the international interest rate will be able to generate a run.

An important consideration is that because it is an external shock, the international interest rate simultaneously affects all intermediaries (and countries) and, hence, could help explain the generalized effect that movements in the US interest rate produce in capital flows across countries. Moreover, if this was the source of instability, cross-country insurance schemes would not work.

B. Several Intermediaries

A further and interesting interaction between a fixed exchange rate regime and the intermediation process occurs when there is more than one technology and intermediary. In this case, a shock to the return of one technology can propagate to a run against the intermediary of the other technology through their interaction through the exchange rate. We assume here that there are 2 technologies with constant-return-to-scale returns that are not perfectly correlated and have the same c.d.f. $\mathcal{G}(\cdot)$. Intermediaries continue to compete à la Bertrand, but in equilibrium there is one intermediary for each technology.²⁶

Potentially, the return on the investment in both intermediaries matters for the decision of early withdrawal from a particular intermediary. The return of the other intermediary matters because the exchange rate affects the final return and the size of an eventual devaluation is a function of the total amount withdrawn in period 1. In general, the early withdrawal solution will be characterized by multiple Nash-equilibria.

Restricting our attention to symmetric solutions and indexing two intermediaries by i and j we now characterize the Nash-equilibrium strategies. Depending on the amount of reserves in period 1, three different cases can be isolated. In the first one the amount of reserves in period 1 is sufficient to cover the outflows generated by the runs against one or both intermediaries in addition to the “normal” capital outflow (that is the non-run outflow). In this case the decision rule is the same as in the simple case: withdraw in period 1 if and only if $\tilde{R} < \hat{R}$, with \hat{R} defined as above (notice that the strategy in this case is independent of the return of the other intermediary).

In the second case, where reserves are enough to cover the “normal” outflow of capital, but not sufficient to additionally finance the outflow of a run in one intermediary,

²⁶One reason for such a result is the existence of administration costs and sector-specific knowledge that make full diversification suboptimal.

the equilibrium strategies can depend on the portfolio returns of *both* intermediaries. In particular, denoting by a^* the period 0 optimal investment in *each* intermediary and assuming that $2a^*r_1\theta \leq RX < a^*q + a^*r_1\theta$, and that RX_{lim} is sufficiently low (but greater than 0), the optimal strategies are characterized as follows:²⁷

There are two cutoff values for \tilde{R}_i , R_H^c and R_L^c , such that for $\tilde{R}_i < R_L^c$ early withdrawal is optimal, and for $R_H^c \leq \tilde{R}_i$ late withdrawal is optimal, regardless of \tilde{R}_j . For $R_L^c \leq \tilde{R}_i < R_H^c$, the withdrawal decision depends on the realization of the return of the other intermediary \tilde{R}_j . If $\tilde{R}_j < R_L^c$, then early withdrawal is optimal, and if $R_H^c \leq \tilde{R}_j$ late withdrawal is optimal. If both returns are between the two cutoff values there exist three Nash-equilibria: two pure strategy equilibria (both investors withdraw or both choose to wait) and a mixed strategy one (early withdrawal with probability λ_i , which in turn depends on the realization of the returns). Moreover, given a^* —the amount invested through *each* intermediary—the cutoff R_H^c is determined by the implicit equation (24), with $F = a^*q + a^*r_1\theta$.

Given the central bank policy, the lower bound cutoff R_L^c is given by \hat{R} . Returns below \hat{R} will trigger early withdrawal regardless of the exchange rate, and therefore regardless of \tilde{R}_j . This is so because a devaluation will never turn (relatively) less attractive an early withdrawal (given the possibility of getting $e = 1$). The upper bound R_H^c defines the region where higher returns will induce late withdrawal even if there is a devaluation. This cutoff is defined at the highest level of the exchange rate in the absence of a run against i , which occurs when there is a run against j . Given that particular exchange rate level, the assumptions about RX_{lim} , and a well behaved utility function, it is always possible to find an R' that solves equation (24). Let R_H^c be equal to this R' . Since the LHS is increasing in R' returns higher than R_H^c make late withdrawal strictly preferred. When $R_L^c \leq \tilde{R}_i < R_H^c$, early withdrawal is optimal if and only if there is a devaluation and hence the importance of the realization of \tilde{R}_j .

In the third case, where reserves are not enough even to cover the “normal” outflow (so that a devaluation occurs with probability 1), the equilibrium strategies will also depend on the returns of both intermediaries because runs will affect the size of the devaluation. In this case we have $RX < 2a^*r_1\theta$ and again there are two cutoff values for \tilde{R}_i , R_H^c and R_L^c , which determine the optimal withdrawal policy. If RX_{lim} is sufficiently low, these cutoffs are determined by the implicit equation (24), with $F = a^*q + a^*r_1\theta$ and $F = 2a^*r_1\theta$, respectively. For $\tilde{R}_i < R_L^c$ and $R_H^c \leq \tilde{R}_i$ early and late withdrawal are optimal respectively, regardless of \tilde{R}_j . For $R_L^c \leq \tilde{R}_i < R_H^c$, the optimal strategy depends on \tilde{R}_j

²⁷If RX_{lim} is not low enough, it is not possible to insure that R' is increasing in F , and the proposed solution does not need to hold. To show that R' is increasing in F totally differentiate equation (24).

as in the second case.

Thus, with an eventual unsustainable fixed exchange rate and two intermediaries, both the probability of runs against intermediaries and the probability of a balance-of-payments crisis increase (*vis-à-vis* the case of a sustainable fixed exchange rate or one intermediary). This follows from the fact that $\hat{R} \leq R_L^c < R_H^c$.²⁸

V. CONCLUDING REMARKS

Exchange rate crises sometimes occur in a disproportional manner. The resulting capital flows and price movements happen with a force above and beyond any observable initial impulse, generated by an external or internal event. In addition, some crises seem to have a strong component of a *run* on liquid assets, where a large proportion of the investors (if not all of them) try to cash-in their investments ahead of the rest and transfer them abroad. The magnitude and size of the devaluation that follows suggest that this behavior is important and that it is worthwhile to attempt to introduce them into our standard exchange rate collapse models.

In this paper we stressed the role of *run behavior* on exchange rate crises and capital flows. We showed that intermediaries, by offering assets that pay a better return in the case of early withdrawal, allow for the possibility of runs and magnify the outflows of capital (in particular, in bad states of nature) relative to the no intermediation case.

We also showed that if credit is funneled through liquidity creating intermediaries, internal or external adverse shocks may generate runs and large exchange rate devaluations that would not have occurred otherwise. The devaluation, then, propagates the shocks to the rest of the economy. Therefore, it is the fragile financial situation of the intermediaries that allows for the propagation and amplification of a given initial shock and produces strong capital movements and exchange rate overreaction.

Interestingly, we find the effect working in the other direction, as well. The expectation of an exchange rate collapse exacerbates the financial fragility of the intermediaries by reducing the return of the investments in the event of runs, measured in foreign currency units. Therefore, the mutual interaction between financial fragility and exchange collapses can multiply and amplify an initial adverse shock and resemble the magnitude of the crises that are sometimes observed in reality.

²⁸Again, we need to assume here that RX_{lim} is low enough so that R' is increasing in F .

The assumption about competition among intermediaries means that the liquidity provided in equilibrium is the optimal one from the international investors' point of view. However, the optimal level of intermediation from the recipient country's point of view—which takes into account the trade-off between the size of capital inflows and the probability of crisis—is not necessarily the same. This could give a rationale for capital movement controls, Tobin taxes, and intermediation controls if a country prefers to have a low crisis risk rather than larger capital inflows.

The focus on the financial fragility of liquidity creating intermediaries may help explain the different nature of some exchange rate collapses. In recent stabilized countries, where intermediaries are readily available to offer liquid assets (as a consequence of either a recent financial liberalization or a previous inflationary environment), external crises take the full proportion, with *a bank run* phenomenon as a major part of the collapses. In other countries, with less creation of liquid assets, exchange rate crises are costly events, but do not reproduce the *bank run* effects.

BIBLIOGRAPHY

- Agénor, P., Bhandari, P.S., and P. Flood, 1992, "Speculative Attacks and Models of Balance of Payment Crises," *Staff Papers*, International Monetary Fund, Vol. 39 (June), pp. 357–92.
- Calvo, G., 1995, "Varieties of Capital-Market Crises," University of Maryland Working Paper, No. 15, April, (Maryland: University of Maryland).
- Calvo, G., Reinhart, C., and L. Leiderman, 1993, "Capital Inflows and Real Exchange Rate Appreciation in Latin America: The Role of External Factors," *Staff Papers*, International Monetary Fund, Vol. 40 (March), pp. 108–51.
- Corbo, V., and L. Hernández, 1995, "Macroeconomic Adjustment and Capital Inflows," World Bank Policy Research Working Paper No. 1377 (Washington: World Bank).
- Diamond, D., and P. Dybvig, 1983, "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy*, Vol. 91 (June), pp. 401–19.
- Dornbusch, R., Goldfajn, I., and R.O. Valdes, 1995, "Currency Crises and Collapses," *Brookings Papers on Economic Activity*: 2, Brookings Institution, pp. 219–70.
- Eaton, J., Gersovitz, M., and J.E. Stiglitz, 1983, "The Pure Theory of Country Risk," *European Economic Review*, Vol. 30 (3), pp. 401–19.
- Eichengreen, B., Rose, A., and C. Wyplosz, 1994, "Speculative Attacks on Pegged Exchange Rates: An Empirical Investigation," NBER Working Paper No. 4898 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Flood, R., and P. Garber, 1984, "Collapsing Exchange Rate Regimes: Some Linear Examples," *Journal of International Economics*, Vol. 17 (August), pp. 1–13.
- Fudenberg, D., and J. Tirole, 1991, *Game Theory*, (Cambridge, Massachusetts: MIT Press).
- Gorton, G., and G. Pennacchi, 1990, "Financial Intermediaries and Liquidity Creation," *Journal of Finance*, Vol. 45 (March), pp. 49–71.
- Hausman, R., and M. Gavin, 1995, *The Roots of Banking Crises: The Macroeconomic Context*, Inter-American Development Bank.
- Hellwig, M., 1994, "Liquidity Provision, Banking, and the Allocation of Interest Rate Risk," *European Economic Review*, Vol. 38 (August), pp. 21–42.
- International Monetary Fund, 1995 (August), *International Capital Markets: Developments, Prospects, and Policy Issues*, World Economic and Financial Surveys (Washington: International Monetary Fund).
- Kaminsky, G.L., and C.M. Reinhart, 1996, "The Twin Crises: The Causes of Banking and Balance of Payments Problems," International Finance Discussion Paper (Washington: Board of Governors of the Federal Reserve System).
- Krugman, P., 1979, "A Model of Balance of Payment Crises," *Journal of Money Credit and Banking*, Vol. 11 (August), pp. 311–25.
- Obstfeld, M., 1986, "Rational and Self-Fulfilling Balance of Payments Crises," *American Economic Review*, Vol. 76 (March), pp. 72–81.
- , 1994, "The Logic of Currency Crises," NBER Working Paper No. 4640 (Cambridge, Massachusetts: National Bureau of Economic Research).

- Postlewaife, A., and X. Vives, 1987, "Bank Runs as an Equilibrium Phenomenon," *Journal of Political Economy*, Vol. 95 (June), pp. 485–91.
- Rojas-Suarez, L., and S. Weisbrod, 1995 (October), *Banking crises in Latin America: Experiences and Issues*, Inter-American Development Bank.
- Sachs, J., 1995, *Do We Need an International Lender of Last Resort?* Harvard University.
- Sachs, J., Tornell, A., and A. Velasco, 1995 "The Collapse of the Mexican Peso: What Have We Learned? NBER Working Paper No. 5142 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Schandler, S., Carkovic, M., Bennet, A., and R. Khan, 1993, *Recent Experiences with Surges in Capital Inflows*, IMF Occasional Paper, (Washington: International Monetary Fund).
- Svensson, L., 1993, "Fixed Exchange Rates as a Means to Price Stability: What Have We Learned?" NBER Working Paper No. 4504, (Cambridge, Massachusetts: National Bureau of Economic Research).