

Seminários de Pesquisa Econômica I (1ª parte)

"BALANCE OF PAYMENT CRISES AND CAPITAL FLOWS: THE ROLE OF LIQUIDITY"

✓
ILAN GOLDFAJN

(Brandeis University)

LOCAL:	Fundação Getúlio Vargas Praia de Botafogo, 190 - 10º andar Auditório
DATA:	23/01/96 (3ª feira)
HORÁRIO:	16:00h

Balance of Payment Crises and Capital Flows: The Role of Liquidity*

Ilan Goldfajn[†]
Brandeis University

Rodrigo O. Valdés[‡]
M.I.T.

First Version: April 12, 1995
This Version : August 30, 1995

Abstract

A model of external crisis is developed focusing on the interaction between liquidity creation by financial intermediaries and foreign exchange collapses. The intermediaries' role of transforming maturities is shown to result in larger movements of capital and a higher probability of crisis. This resembles the observed cycle in capital flows: large inflows, crisis and abrupt outflows. The model highlights how adverse productivity and international interest rate shocks can be magnified by the behavior of individual foreign investors linked together through their deposits in the intermediaries. An eventual collapse of the exchange rate can link investors' behavior even further. The basic model is then extended, quite naturally, to study the effects of capital flow contagion between countries.

JEL Classification Numbers: F31, F34, F41.

*We would like to thank Daron Acemoglu, Andrés Almazán, Olivier Blanchard, Andrew Bernard, Ricardo Caballero, Rudi Dornbusch, Mike Lee, Stacey Tevlin, and participants of the Money Lunch and International Breakfast at M.I.T. for several valuable comments and suggestions. Of course, any remaining errors are our own. Ilan Goldfajn would like to acknowledge support from CAPES in Brazil.

[†]Address: Department of Economics, Brandeis University, P.O. Box 9110, Waltham, MA 02254.
E-mail: Goldfajn@binah.cc.brandeis.edu

[‡]E-mail: rvaldes@mit.edu

1 Introduction

The Mexican external crisis of December 1994 brought into question our basic understanding of this type of events. The collapse of the Peso was prompted by an initial devaluation and was characterized by a severe run against the foreign reserves caused by a sudden outflow of capital. The immediate preoccupation of the Mexican government (and several policy makers in the US) was to solve the very short run problem of rolling over the debt and avoiding the major step of announcing their default. The run against Mexican assets gave the impression that there was a strong component of a liquidity crisis involved which is more similar to the models of the Bank Run literature than to the traditional models of balance of payment crises.¹

Other balance of payment crises, in particular the severe ones, as in Chile (1982), Finland (1992) and Mexico (1982), share with Mexico (1994) the above phenomenon as well as three other interesting features. First, they all experienced a capital inflow surge in the years preceding the crisis. Second, this capital inflow is intermediated, at least in part, by the domestic financial sector which, in addition, increases its proportion of short term liabilities in the process. Finally, the external collapses are accompanied by severe banking crises.²

The capital cycles of surges and sudden outflows have been documented extensively in the literature³ and have been a major issue of concern to policy makers who are caught in the dilemma of introducing capital controls.⁴ In their recent analysis of the Mexican crisis, Sachs, Tornell and Velasco (1995) argue that the volatility of capital flows (and the inadequate response of Mexican authorities) played a major role in the crisis. Figure 1 shows the capital inflows in the years preceding the crises for the countries cited above.

The composition of capital inflows is also interesting. Table 2 presents the figures for the countries in the study of Schadler et al. (1993). The main conclusion is that Foreign Direct Investment is not the driving force. Other capital—which is more associated with intermediation—explains the bulk of the inflows. This includes bonds, direct borrowing, and other short and long run fixed income instruments.

¹See, e.g., Sachs (1995).

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

³See Calvo et al. (1993) and Schandler et al. (1993)

⁴See IMF(1995).

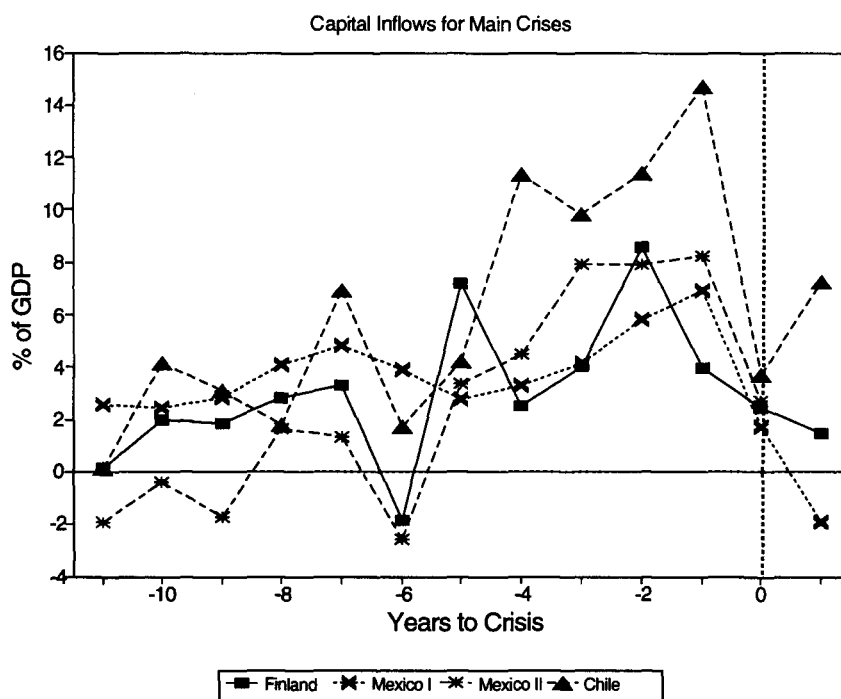


Figure 1: Capital Inflows for Mexico, Chile and Finland - Percentage of GDP

Table 1: Composition of Some Capital Inflow Surges

First Year of Surge minus Previous Year, US\$ mill.						
	Years of Surge	Direct Invest.	Port. Invest.	Other Long/T.	Other Short/T	Total
Chile	1990-93	-697	272	2053	212	1840
Egypt	1991-92	-531	6	7758	-900	6333
Mexico	1989-93	774	177	6411	-1757	5605
Spain	1987-91	752	2571	7601	4946	15870
Thailand	1988-92	899	184	-341	2035	2777

Source: IFS.

Note: The countries are those studied in Schadler et al. (1993). Colombia was left out because of lack of intermediation data.

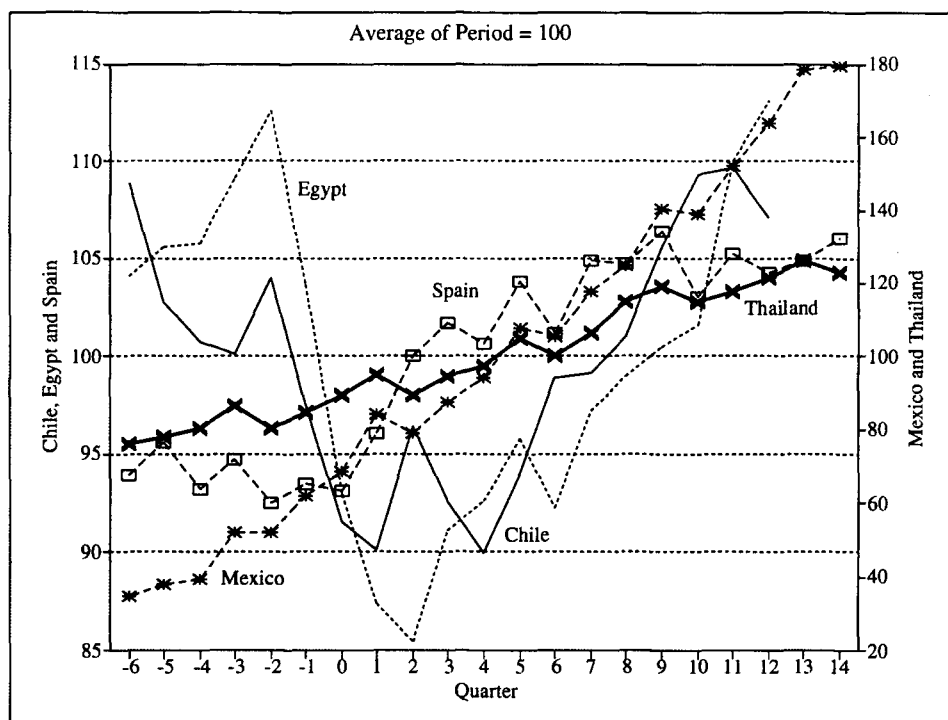


Figure 2: Real Financial Claims on the Private Sector - Percentage of GDP

Less emphasized is the fact that capital inflows are usually followed by increased intermediation and, sometimes, shortening of maturities. The idea that higher capital inflows are related to increasing intermediation is a phenomenon that has a strong counterpart in the real world. For instance, if we analyze the episodes of capital inflow surges studied in Schadler, et al. (1993), there is evidence that financial intermediation increased significantly during the time of the surges. Figure 2 presents real claims of the financial sector on the private sector during these episodes (Chile, Egypt, Mexico, Spain, and Thailand). The surge starts in quarter 0. It is clear from the figure that in all five countries financial intermediation increased during the surges.

Even less attention is given to the fact that when capital flows are abruptly reversed, banking crisis emerge as an additional strain. In all the 4 cases highlighted above, banking crisis was indeed an important consideration to policy makers.⁵

⁵See the recent papers on banking crises in Latin America: Gavin and Hausman (1995) and

It is always difficult to explain major external crises in a context where all agents - investors, intermediaries and policy makers- are rational (usually it is assumed that policy makers are following an inconsistent policy) given the magnitude of the currency crises and the relatively small size of the underlying shocks (internal or external). Surprisingly, it will be easier to explain them in association with the observed capital swings and banking crises. The latter will provide the magnification and propagation effects that are needed to provide a complete explanation.

The traditional theoretical framework on balance of payment crises is based on the large literature on speculative attacks that followed the seminal article by Krugman (1979). The key starting point of this literature is that the government follows an inconsistent policy combined with a fixed exchange rate regime, that would eventually have to collapse. The major contribution, then, is to use rational investors to define exactly when and how the collapse occurs.⁶

The main candidate for government inconsistency tends to be its fiscal policy. The Mexican, Finish and Chilean experiences, however, do not support this contention (although it is a good explanation in several other cases). The normal measures of fiscal budget indicated that Mexico was running budget surpluses up to the year of the crisis.⁷ Equivalently, credit creation by the central bank was relatively stable up to 1994 .

This paper departs from the Krugman tradition and does not assume an inconsistency in policy making.⁸ 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 that generate more than proportional capital flows. The model is able to replicate the observed cycles in capital flows: large 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 focuses on the interaction between liquidity, capital flows and exchange rate collapses. Liquidity considerations arise only in a world where there are inter-

Rojas-Suarez and Weisbrod (1995).

⁶See, e.g., Agénor et al. (1992), Dornbusch(1987) and Flood and Garber (1984).

⁷As of September of 1994 the fiscal budget surplus - GDP ratio figures are as follows: 1.6% in 1992, 1.0% in 1993, and -0.5% in 1994.

⁸Although an inconsistent policy is completely compatible with the model and would reinforce the results obtained.

mediaries transforming maturities, offering liquid assets to their customers and, implicitly, allowing 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 below highlights the fact 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 need the money 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 offer these assets to investors in order to attract them. On the other side they invest in production which needs time to mature (early interruptions are not profitable). In other words, they transform their illiquid assets into liquid ones in order to attract capital. It is precisely this transformation that brings capital to the economy but it is also the one that introduces the possibility of runs. Ex-post, the good equilibrium is the one in which the intermediary offers liquid assets, there are no runs and (more) investment is realized. 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 the foreign investors. On the other hand, they may generate runs that induce large capital outflows, amplifying initial shocks that otherwise would not have generated crises.

Intermediation, together with its creation of liquid assets, *allows* for the possibility of runs and crises but it does not generate crises by itself. Throughout the paper, we analyze three types of shocks: productivity, international interest rates, and exogenous need for liquidity by foreign investors. For each type of shock, there will be a cutoff point that determines a region where runs against the intermediary are the equilibrium outcome. This region is determined by the foreign investors, who decide whether to accelerate the timing of their withdrawals. With this region defined we can explicitly determine the probability of crises. In this sense we 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.

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, independent 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.

This paper is organized as follows. In section 2 we set up the simplest possible model with its basic components: foreign investors, intermediaries, technology and the central bank. As a useful benchmark, we initially solve the model for the capital flow pattern that would exist in the absence of intermediation. Then, we introduce intermediation, solve for the optimal early withdrawal policy, and identify the endogenous probability of runs. We show that this probability is strictly positive and does not decrease when intermediaries offer more liquidity. In section 2.2.2, we verify that runs effectively increase the capital outflows and in section 2.2.3 we propose that, under certain conditions, capital inflows may actually increase with intermediation. In section 3 we give a closed-form solution of the model using a Constant Relative Risk Aversion (CRRA) utility function and a Bernoulli distribution of the shocks. In several simulations, we show that capital inflows effectively increase with intermediation and we look at some comparative statics.

The relationship between runs on intermediaries and exchange rate collapses is explored in section 4. First, we verify that runs increase the probability of an exchange rate collapse. Then, we show that the possibility of a devaluation increases the region where runs against intermediaries are the unique equilibria. Finally, we analyze the interactions of two intermediaries with imperfectly correlated investment pools, showing that runs against an otherwise liquid intermediary can occur if there is a run against the other intermediary. This effect increases both the size and probability of the collapse.

Once the main contributions of the chapter are completed, we explore some extensions. First, in section 5 we demonstrate how all the effects can still go through when the nature of the initial shock is changed. We explore the interesting case where the impulse is the international interest rate. Finally, in section 6 we show how the model can be used to explore contagion effects in capital flows. When there is a crisis in some part of the world and investors have more liquidity needs, the model shows how that a domestic crisis can easily result.

2 The Basic Model

International Investors are risk averse agents that maximize their expected utility of wealth, choosing their optimal portfolio allocation between a safe international asset and a risky foreign technology (*home* from the perspective of the receiving country).⁹ They solve

$$Max_a E[U[\tilde{W}]] \quad (1)$$

s.t.

$$\tilde{W} = W_0(a\tilde{r} + (1 - a)r^*), \quad (2)$$

where W_0 is the initial endowment, henceforth set equal to 1. r^* and \tilde{r} are the gross returns on the safe international asset and the risky asset abroad, respectively.

Investors may have liquidity needs. They have a random probability of requiring the money. At time zero each investor does not know if he will need the money in the next period. We assume that the discount rate equals to 1.

Time is discrete and there are three periods. As in Diamond and Dybvig (1983), investors are divided between two types:

Type 1 - Early Consumers There is a proportion θ of the population that needs the money in period one. Their utility function is $U[W_1]$, where W_1 is wealth in period 1. These are the investors that will always interrupt the investment in period one.

Type 2 - Late Consumers They are in proportion $1 - \theta$ and their utility function is $U[W_2]$, where W_2 is wealth in period 2. These investors have the option to maintain their resources invested in the technology but may choose to withdraw in period 1 if this is more profitable.

Although each investor does not know what his type is in period 0, we will assume that the proportion of the population θ that have liquidity needs is fixed and known.¹⁰ In section 6 we will relax this assumption and analyze the model when there is uncertainty with respect to the proportion of early consumers.

⁹Here we do not need a riskless international technology but only a safer one.

¹⁰We normalize the total number of investors to be 1.

The return on the investment abroad is ultimately tied to a constant returns 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:

$$\text{Return} = \begin{cases} \tilde{R} & \text{if } t = 2 \\ q & \text{if } t = 1. \end{cases} \quad (3)$$

Here we assume that $q < r^*$. This captures the fact that investment is irreversible or illiquid. Illiquidity is defined as the cost to liquidate an asset in the short run. This cost is the difference between the return on the short run and the return per period of the technology in the long run. The technology generates \tilde{R} if it is not interrupted in period 1. This return has a publicly known distribution $\mathcal{G}(\tilde{R})$. We assume its support has a lower bound $\underline{R} = q$.

The investors do not need to invest directly in the technology. They can use the services of the intermediaries, that compete à la Bertrand. The intermediaries 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 the banks), other fixed income assets (investment banks or governments) or simple quotas (as in mutual funds). Here we will simply assume that they offer the following contract to the investors:

$$\tilde{r} = \begin{cases} \tilde{r}_2 & \text{in } t = 2 \\ r_1 & \text{in } t = 1. \end{cases} \quad (4)$$

The transformation of liquidity is done by investing the proceeds in the technology and offering the foreign investors a contract that pays a 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 because the intermediaries, constrained by the technology, will pay a rate $r_2 \leq R$ in the second period. This reduction of the spread increases utility for sufficiently risk averse consumers.¹¹

The link between the rates in different periods is given by the resource constraint

¹¹The model does not change in any substantial way if we allow the intermediaries to directly invest a portion of their portfolios in the international safe asset.

of the economy:¹²

$$\frac{r_1\theta}{q} + \frac{r_2(1-\theta)}{\tilde{R}} = 1, \quad (5)$$

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

$$\tilde{r}_2 = \frac{\tilde{R}(1 - \frac{r_1\theta}{q})}{1 - \theta}. \quad (6)$$

It is immediately apparent from (6) that $r_1 \geq q$ implies $r_2 \leq R$.

The intermediaries compete à la Bertrand, offering investors better rates in order to attract capital and maximize profits. They end up with zero profits and offering a contract with interest rates that maximize investors utility.

The return in equation (6) is feasible if only early consumers withdraw in period one. However, the intermediary cannot distinguish between types and will have to honor the withdrawals of every investor. The return that it will effectively be able to offer will be:

$$\tilde{r}_2 = \max \left\{ \frac{\tilde{R}(1 - \frac{r_1 f_1}{q})}{1 - \theta}, 0 \right\}, \quad (7)$$

where f_1 is the proportion of withdrawals in period 1 which cannot generate an outflow greater than what the technology is able to produce:

$$r_1 f_1 \leq q. \quad (8)$$

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 1 (e.g. 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. All the late consumers will have an incentive to withdraw early. This may generate a self-fulfilling run on the intermediary. Moreover, if the return promised in period one ends up being higher than the realized r_2 (under a normal proportion of withdrawals θ), it will be optimal for everybody to withdraw in period one, 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

¹²Initial wealth is one because individual endowments and the number of investors were both normalized to one.

precisely defined.

We assume that in the case of a run the intermediary will distribute all its assets equally among the investors.¹³ Since the bank will have to interrupt all its investment in the technology to pay for the withdrawals, every investor will get q . Thus, the final return profile is:

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

The Central Bank fixes the nominal exchange rate $e = \bar{e}$. In order to clearly depart from the exchange rate collapse literature, we will 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.

Also, we will *initially* assume that the authority has enough reserves RX to maintain the exchange rate fixed even in the event of capital outflows resulting from a liquidity crisis. Therefore, in this section, the returns to foreign investment can be thought of as denominated in the international currency (in order to simplify notation we will normalize the nominal exchange rate to be 1). The more interesting case where reserves are not sufficient to overcome a liquidity crises is analyzed in section 4.

Investment is carried out in period 0, the returns are known only in period 1, and realized in period 2. The timing of the model is given below where it is clear that all uncertainty is resolved in period 1:¹⁴

¹³This 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). See also section 6 where we follow this approach.

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.

$$\begin{array}{ll}
t = 0 & \left\{ \begin{array}{l} \text{Banks specify } r_1 \text{ and } r_2, \\ \text{Investors decide } a. \end{array} \right. \\
t = 1 & \left\{ \begin{array}{l} \text{Investors learn their type,} \\ \tilde{R} \text{ is realized,} \\ \text{Withdrawal decision made: possibility of runs,} \\ \text{Central bank sustains or fails to sustain } \bar{e}. \end{array} \right. \\
t = 2 & \text{Patient investors get } r_2 \text{ if there was no run.}
\end{array}$$

2.1 Absence of Intermediation

In the absence of intermediation the foreign investors still have the option to invest directly in the technology. The returns are given by the technology in (3) 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. The maximization problem is

$$Max_a E[U[\tilde{W}]] = \theta U(aq + (1-a)r^*) + (1-\theta) \int_q^{\tilde{R}} U(aR + (1-a)r^*) d\mathcal{G}(\tilde{R}), \quad (9)$$

where a is the amount (and proportion) of initial wealth invested in the technology.

Each investor has 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 we assume that the central bank has enough reserves Rx to sell to all the early consumers, after subtracting the current account deficit X from the total reserves RX :

$$Rx = RX - X \geq \theta qa^*,$$

and, therefore, is able to sustain the fixed parity. Neither, is there the 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), hence, the self-fulfilling run cannot exist.

The maximization in (9) implies an optimal amount invested in the country given by:

$$a_{ni}^* = a_{ni}^*(q, \tilde{R}, \theta, r^*), \quad (10)$$

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

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

2.2 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. It will be particularly interesting when this new pattern increases the capital inflows to the country. Second, with intermediaries there is always the possibility of runs on their assets, provided they are transforming 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 returns, as shown in (7).

2.2.1 Higher probability of runs

In order to precisely define the investors' problem, we need to solve backwards and first obtain the probability of runs. The runs are defined when all the investors withdraw in period 1. Since early consumers are those who always withdraw in period 1, the runs will be determined only by late consumers, who may decide to withdraw early. These will choose to withdraw only if the payoff of waiting is lower than the payoff to immediate withdrawal. In terms of the model, the late consumers will accelerate their withdrawals if

$$r_1 r^* \geq r_2,$$

which implies that there will be a cutoff in the realization of \tilde{R} , say \hat{R} , such that for values smaller than \hat{R} a run is the unique equilibrium. The cutoff is determined by:

$$r_1 = \frac{R(1 - \frac{r_1 \theta}{q})}{1 - \theta} \rightarrow$$

$$\hat{R} = \frac{r_1(1 - \theta)}{(1 - \frac{r_1\theta}{q})}, \quad (11)$$

where we have normalized $r^* = 1$.

The probability of a run will be given by $\mathcal{G}(\hat{R})$.¹⁵

Proposition 1 *The probability of runs with intermediation is strictly positive. Also, when more liquidity is provided, the probability of runs does not decrease.*¹⁶

The first part of the proposition is a straightforward consequence of the fact that intermediaries create liquidity which, using equation (11) implies that $\hat{R} > q = \underline{R}$, and therefore $\mathcal{G}(\hat{R}) > 0$. The second part is obtained by differentiating (11) with respect to r_1 and using the definition of liquidity provision by intermediaries ($r_1 > q$) we conclude that $\frac{\partial \hat{R}}{\partial r_1} > 0$. Given that $\mathcal{G}'(\hat{R}) \geq 0$ we establish that the probability of runs cannot decrease (and will most likely increase) with higher r_1 .

In summary, for every $R \leq \hat{R}$ the only possible equilibrium is a run. The probability of the equilibrium being a run does not decrease when the intermediary increases r_1 , increasing the cutoff \hat{R} .

In addition to the equilibria described above, there is always the possibility of a self-fulfilling run independent of the realization of \tilde{R} .¹⁷ 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 8). There are two problems with this type of equilibrium. First, as in any sunspot equilibrium, there is not an endogenous probability of the occurrence of this event. A coordinating event is required and this has to be exogenously defined. Second, there are problems involved in defining rigorously the equilibrium concept because along the equilibrium path beliefs have to be correct.¹⁸ 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 one, agents

¹⁵As explained below, we do not consider self-fulfilling runs here.

¹⁶Liquidity provision was defined as setting $r_1 > q$. More liquidity is increasing r_1 , making it closer to \sqrt{R} , which is the one-period-equivalent return of the technology.

¹⁷Provided $r_1 > q$, which is exactly the case when intermediaries create liquidity.

¹⁸See, e.g., Postlewaite and Vives (1987) for more on the problems involved in specifying this as an equilibrium. See Fudenberg and Tirole (1991), pp. 99-100, for some problems that the requirement of correct beliefs along the equilibrium path may cause.

would never invest in the first place since runs generate a return lower than the safe return r^* . Thus, without a coordinating event the sunspot equilibrium has to have probability zero and the probability of a run will continue to be given by $\mathcal{G}(\hat{R})$.

2.2.2 Investors' Problem, Runs and Capital Outflows

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:

$$\begin{aligned} \text{Max}_a E[U[\tilde{W}]] = & \\ & (1 - \mathcal{G}(\hat{R}))[\theta U(ar_1 + (1 - a)) + (1 - \theta) \int_{\hat{R}}^{\bar{R}} U(a\tilde{r}_2 + (1 - a))d\mathcal{G}(\tilde{R})] \\ & + \mathcal{G}(\hat{R})U(aq + (1 - a)), \end{aligned} \quad (12)$$

which gives an optimal investment policy with an intermediary:

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

where Ω includes all the parameters in the distribution. The flow of capital in this case will be given by:

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

Proposition 2 *There are more capital outflows per unit of inflow in period 1 with intermediation and, particularly, in the event of runs, i.e., $\theta q < \theta r_1 < q$.*

The second inequality says that capital outflow in period one is higher with runs. This comes from the fact that the intermediary cannot contract to pay to investors in $t=1$ more than the technology allows (i.e. $r_1\theta < q$; see equation (8)). The first inequality is a straightforward consequence of the fact that intermediaries create liquidity $r_1 > q$.

The increased capital outflows means that with a run against the intermediaries there will be a higher demand on the central banks foreign reserves. We assume in this section that the central bank has enough reserves, after paying net imports payments, to pay for the capital outflows (i.e., $Rx = RX + X \geq \theta r_1 a_i^*$).

2.2.3 Intermediaries Competition and Capital Inflows

The intermediaries, knowing the investors' function $a_i^* = a_i^*(r_1, \tilde{R}, \theta, \Omega)$, will choose the rate r_1 to attract more investment and maximize profits. Bertrand competition among intermediaries will lead to zero profits and an r_1 that maximizes investors utility:

$$\begin{aligned} \text{Max}_{r_1} E[U[\tilde{W}]] = & \\ & (1 - \mathcal{G}(\hat{R}))[\theta U(a_i^* r_1 + (1 - a_i^*)) + (1 - \theta) \int_{\hat{R}}^{\tilde{R}} U(a_i^* \tilde{r}_2 + (1 - a_i^*)) d\mathcal{G}(\tilde{R})] \\ & + \mathcal{G}(\hat{R}) U(a_i^* q + (1 - a_i^*)) \end{aligned} \quad (14)$$

subject to equation (13).

This gives us an equilibrium r_1 :

$$r_1^* = r_1^*(q, \Omega, \theta). \quad (15)$$

Plugging this equilibrium r_1^* back in the investment function 13 we get the equilibrium capital inflows with intermediaries.

Proposition 3 *For reasonable assumptions on the utility and distribution functions capital inflows in period 0 increase with intermediation.*

In the next section we work out a closed-form solution where $a_{ni}^* \leq a_i^*$ (constant relative risk aversion utility function and Bernoulli distribution). 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.

3 A Closed-Form Solution: CRRA Utility and Bernoulli Distribution

In order to solve this problem explicitly we will assume a specific distribution for $\mathcal{G}(\hat{R})$. In particular we assume:

$$\tilde{R} = \begin{cases} \bar{R} & \text{with probability } \alpha \\ q & \text{" } 1 - \alpha \end{cases}$$

We also assume a constant relative risk aversion utility function (CRRA).

The maximization for the case where $\hat{R} < \bar{R}$ becomes:

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

where γ is the coefficient of risk-aversion.

The FOCs for this case are given by:

$$\frac{(r_1 - 1)\theta(1 - \alpha)}{(a(r_1 - 1) + 1)^\gamma} - \frac{\alpha(1 - q)}{(1 - a + aq)^\gamma} + \frac{(1 - \alpha)(1 - \theta)(r_2^H - 1)}{(1 - a - ar_2^H)^\gamma} = 0 \quad (16)$$

and

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

where r_2^H is given by equation (6) applied to \bar{R} .

The closed-form solutions for the capital inflow a_i^* and liquidity provision r_1^* are given in the appendix. The solution for the capital inflow without intermediary, a_{ni}^* , is presented there as well. Although it is possible to compute partial derivatives from the closed-form solutions, for simplicity we present here some simulations using a concrete numerical example. Figure 3 presents the optimal capital inflows with and without intermediaries, and the optimal liquidity provision for different parameter values. The baseline case has the following parameter values: $\bar{R} = 1.7$, $q = 0.8$, $\alpha = 0.6$, $\theta = 0.2$, $\gamma = 2$. These parameters imply the following results: $a_i^* = 0.942$, $r_1^* = 1.054$, and $a_{ni}^* = 0.753$. That is, intermediation results in liquidity provision

—even in excess of the risk-free rate—, an increase in capital inflows, and an increase in the probability of collapse—which changes from zero to $1 - \alpha$.

Figure 3 show that for parameter values where the intermediaries provide liquidity, that is $r_1^* > q = .8$, capital inflows under intermediation are systematically higher. 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 by intermediaries 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 been forced to early withdraw (in the case of a run). Notice that for some parameter values the amount of inflows with intermediaries is the same as without intermediation (i.e., $a_i^* = a_{ni}^*$). At these points $r_1^* = q$, and the return and probability of the different states that the investor faces are identical, regardless of the presence of intermediation. Interestingly, for parameters values at which the intermediaries (optimally) offer illiquid contracts, i.e. $r_1^* < q = .8$, there are fewer capital inflows.

The assumption about competition among intermediaries means that the liquidity provided in equilibrium is the optimal one from the 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. If a country prefers to have a low crisis risk rather than larger capital inflows, capital movement controls, Tobin taxes, and intermediation controls might be desirable. The experience of Chile during the last two years provides a good example of such policies (see, e.g., Corbo and Hernandez, 1995).

Figure 3 allows us to analyze some of the comparative statics involved in the problem. As expected, a higher good-state return, \bar{R} , and a higher early-liquidation return (bad-state return), q , increase the inflows both with and without intermediation. More important, however, is the fact that both the difference between the two inflows and the provision of liquidity increase. A higher probability of a higher

¹⁹In general, there is a third effect. By changing the 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.

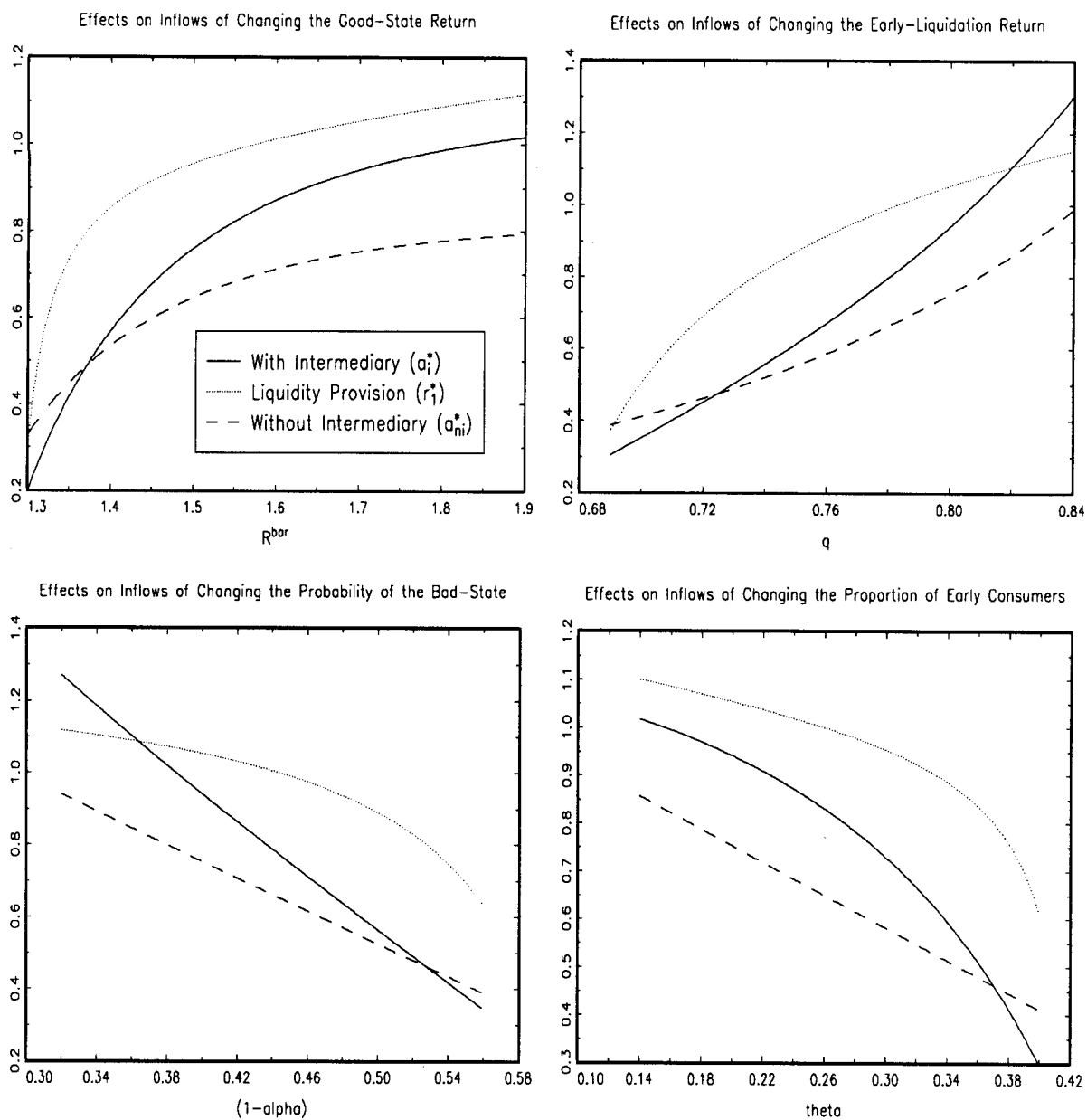


Figure 3: Capital Inflows Simulations

return (that is a higher α) has similar effects. Finally, if a higher proportion of Late-Consumer type of investors (that is a lower θ) is expected, there are more inflows and intermediation in equilibrium. However, the difference between inflows with and without intermediation is not monotonic. Initially, it increases when θ decreases, but then it decreases. What happens is that at very low values of θ the problem with and without intermediation become identical, with no agents taking advantage of the liquidity that intermediaries provide.

4 Exchange Rate Collapses

The model presented so far has analyzed the effect of financial intermediation on both capital inflows and outflows. This section extends the model in order to investigate the interactions between runs against intermediaries and balance of payments collapses in economies with a fixed exchange rate.

The introduction of an upper bound to the stock of reserves in our previous model both amplifies and propagates the runs against the intermediaries. First, there is the effect of runs on the sustainability of the exchange rate. Relaxing our previous assumption of 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, in the short run, borrowing immediately against future reserves.²⁰ Thus, outflows generated by runs against intermediaries—even against a small number—will put pressure on the exchange rate and will propagate the effects of a negative shock to the rest of the economy. Second, given that forced devaluations are now possible and that portfolio returns depend on them, investors have to recalculate their optimal allocation and the optimal time to withdraw. 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 line 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 “liquid” intermediaries or direct investment, these agents may have incentives for early

²⁰This is the typical 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.

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. This is the amplification effect that exchange collapses have on intermediaries' crises.

There is an alternative link between intermediation and Balance of Payments. If intermediaries have a fiscal-backed deposit insurance system, runs against intermediaries will produce an extra burden on the fiscal sector. This extra burden, in turn, will both bring forward a Balance of Payments crises and make it more likely. This link is investigated in Calvo (1995).

In what follows below we will concentrate on the direct amplification and propagation effects between exchange collapses and intermediaries that were described above. The effect of runs against the intermediaries on the sustainability of the exchange rate is investigated first in section 4.2. Then, the feedback of exchange collapses on runs are analyzed in sections 4.3 and 4.4.

4.1 The Economy Under Fixed Exchange Rate

Before introducing the possibility of devaluations, we need to be more specific with respect to the units in which the projects and the final returns to the investor are measured. The projects are investment opportunities in the non-tradable goods sector, with returns measured and paid in the local currency. Therefore, a devaluation of the currency reduces the return on the foreign investment.

There are N intermediaries that compete à la Bertrand, each one with a pool of projects which gives an aggregate return \tilde{R}_i . We assume that these returns are not perfectly correlated, and, for simplicity, that have the same c.d.f. $\mathcal{G}(\cdot)$.²¹

The rest of the economy is represented by a sequence of current account deficits X_t which are exogenous to the model. We assume the current account surplus in period 2 is high enough to finance the highest possible capital outflow in period 2, which, in turn, is given by the maximum possible realization of \tilde{R} .²²

There are two key assumptions about central bank behavior. First, under a fixed

²¹One intermediary would dominate the existence of many intermediaries if administration costs and sector-specific knowledge were not important. We assume here that they are important, meaning that more than one intermediary is optimal. At the same time, these costs make full diversification suboptimal.

²²This assumption precludes exotic cases in which future returns and capital repatriation are so high, that there is a Balance of Payments crisis in period 2.

exchange rate regime, it will try to maintain the exchange rate fixed whenever it is possible. In period one, the authority would like to keep the exchange rate fixed at the level it started in period 0.²³ In the event of a devaluation in period 1, given the assumption of a current account surplus in period 2, the Central Bank will fix the exchange rate at the new level. Second, we assume that the central bank follows the following rule-of-thumb in the case of being forced to devalue. As long as the amount of net reserves Rx (reserves RX net of current account deficit) is bigger than the demand for reserves (or capital outflows) the exchange rate is kept fixed. If the demand for reserves is higher than the net reserve stock, reserves are exchanged at the fixed exchange rate until they hit a predetermined-specified level Rx_{\min} . At that level the remaining reserves are publicly auctioned so as to clear the market.

With these assumptions, for a given stock of net reserves in period 1, $Rx = RX + X$, and a given demand for reserves in period 1, F/e , where F is capital outflows measured in local currency, the exchange rates will take the following values at the end of each period:

$$\begin{aligned} e_0 &= 1 \\ e_1 &= \begin{cases} 1 & \text{if } F \leq Rx \\ 1 + \frac{F - Rx}{Rx_{\min}} & \text{otherwise} \end{cases} \\ e_2 &= e_1. \end{aligned}$$

In period one, if there are not enough reserves, the exchange rate will increase so that the demand for reserves will match the remaining supply.

Investors, in turn, will face the following exchange rates in period 1:

$$e_1 = \begin{cases} 1 & \text{if } F \leq Rx \\ 1 & \text{with prob. } \alpha \quad \text{if } F > Rx \\ 1 + \frac{F - Rx}{Rx_{\min}} & \text{with prob. } 1 - \alpha \quad \text{if } F > Rx, \end{cases}$$

where $\alpha = (Rx - Rx_{\min})/F$. Of course, the smaller Rx_{\min} , the higher the devaluation.

²³Normalized to be equal to 1.

4.2 The Effect of Intermediation Runs on the Exchange Rate

A run against a financial intermediary has a simple direct effect on the exchange rate determination. Given an amount of reserves and a current account deficit level, these runs increase 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.

In terms of the model, and in the simple case of one intermediary, outflows of capital increase by $\Delta = a_i^*(q - \theta r_1)$ when there is a run, where $a^*\theta r_1$ is the “normal” capital outflow. If we assume that there is no Balance of Payment crisis under the “normal” capital outflow, the extra outflow translates into a Balance of Payment crisis if $\Delta > Rx - a^*\theta r_1 > 0$. 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 $1 + (a_i^*q - Rx) / Rx_{\min}$.

Given our assumption that under a “normal” capital outflow there is no exchange collapse, we can extract the probability of collapses from the likelihood of runs against the intermediaries. If we denote by R^c the early withdrawal policy cutoff for \tilde{R} , the probability of a crisis will be simply given by $\mathcal{G}(R^c)$.²⁴

Proposition 4 *Under a fixed exchange rate regime, the probability of devaluation increases when there is intermediation and the risk of runs.*

Under our assumptions, where we normalized the probability of exchange rate collapse to zero if there are no runs against the intermediary, the proposition will be true when $\mathcal{G}(R^c) > 0$. Following the same reasoning as in proposition 1, this proves to be indeed correct.

²⁴As shown below, in section (4.3) it is not always the case that this is the same cutoff as before, \hat{R} .

4.3 The Effect of Exchange Collapses on Runs: 1 Intermediary

In this section we will show that an expected devaluation will increase the probability of a run against the intermediary (holding constant the feedback from runs on intermediaries to devaluations, shown to exist in the previous section).

Investors who are able to keep the investment until period 2 will evaluate whether it is convenient to withdraw in period 1. As in the simple model, there will be a cutoff R^c , such that if the project return is higher than R^c it is optimal not to withdraw. The cutoff level in this case will depend on the reserve level of the central bank, the current account deficit, and the reserve level at which the authority auctions the remaining reserves.²⁵ In particular, given the amount invested in period 0, a_i^* , the cutoff which defines optimal early withdrawal is uniquely defined by:

$$R^c = \begin{cases} \hat{R} & \text{if } a^* r_1 \theta \leq Rx \\ R' & \text{otherwise,} \end{cases}$$

where $\hat{R} = r_1 (1 - \theta) / (1 - \frac{r_1 \theta}{q})$ is our previous cutoff. If reserves are not enough to finance “normal outflows”, we can show that the expected devaluation changes the cutoff to R' , which is defined by the implicit equation:

$$U \left[\frac{a^* \tilde{r}_2}{e_2} + 1 - a^* \right] = \alpha U [a^* r_1 + 1 - a^*] + (1 - \alpha) U \left[\frac{a^* r_1}{e_2} + 1 - a^* \right], \quad (18)$$

where $\tilde{r}_2 = R' (1 - \frac{r_1 \theta}{q}) / (1 - \theta)$, and where α is as defined above, with $F = a^* r_1 \theta$.

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 $a^* r_1 \theta > Rx$, then there is devaluation with probability 1, and there exist a unique R' such that late consumers are indifferent between early and late withdrawal, taking into account the effect of a devaluation (with $F = a^* r_1 \theta$). R' exists and is unique because, given F the RHS of equation (18) is constant and the LHS is monotonic and continuous in R' (assuming a well behaved utility function: continuous, with $U'(\cdot) > 0$ and $U''(\cdot) < 0$).

²⁵If we allow for a sunspot equilibrium it is possible to have a full collapse of the intermediary independently of the amount of reserves.

It is worth noticing that the cutoff \hat{R} is the same as before, in the case in which there were sufficient reserves to finance any capital outflow. The main result, however, is summarized in the following proposition.

Proposition 5 *If devaluations are expected, runs against the intermediary are more likely.*

Proving this proposition amounts to showing that $\mathcal{G}(\hat{R}) < \mathcal{G}(R')$, or, equivalently,

$$\frac{r_1(1-\theta)}{1-\frac{r_1\theta}{q}} < R'.$$

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 (18), which is equal to a convex combination of two terms, has to be bigger than $U[a^*r_1/e_2 + 1 - a^*]$, 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.

Given this proposition and the previous one in section 4.2, runs against intermediaries and exchange rate collapses have a reinforcing effect on each other. This will be investigated in the next section where we do not keep the probability of devaluation constant.

4.4 Early Withdrawal Decision: 2 Intermediaries

An interesting interaction between a fixed exchange rate regime and the intermediation process occurs when there is more than one intermediary. In this case, we can show the total effect of having intermediation on both exchange rate crises and the probability of runs, taking into account their mutual feedback (shown to exist in the last two sections).

Potentially, the return on the investment in all intermediaries matters for the decision of early withdrawal from a particular intermediary. The return of other intermediaries 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 in the case of two intermediaries (indexed 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, the equilibrium strategies can depend on the portfolio returns of *both* intermediaries. In particular, assuming that $2a^*r_1\theta \leq Rx < a^*q + a^*r_1\theta$, and that Rx_{\min} is sufficiently high (but less than Rx), the optimal strategies are characterized as follows:²⁶

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 (18), 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

²⁶If Rx_{\min} is not high 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 (18).

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_{\min} , and a well behaved utility function, it is always possible to find an R' that solves equation (18). 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_{\min} is sufficiently high, these cutoffs are determined by the implicit equation (18), 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 as in the second case.

Proposition 6 *With an eventual unsustainable fixed exchange rate and two or more 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).*

Following similar steps as in the case of one intermediary it is straightforward to show that $\hat{R} \leq R_L^c < R_H^c$, which gives the result.²⁷

5 International Interest Rates

There is a lively debate in the literature about the role of external factors in determining capital flows to (or from) LDCs. 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.²⁸ However, it is fairly difficult to justify how rather

²⁷Again, we need to assume here that Rx_{\min} is high enough so that R' is increasing in F .

²⁸See, e.g., Calvo, Leiderman and Reinhart (1993).

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 sections 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 a cutoff \hat{r}^* , such that for second-period interest rates higher than \hat{r}^* all late consumers will have an incentive to withdraw early.^{29 30} The probability of crises will be given by $\mathcal{G}(\hat{r}^*)$ 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 liquidity creation by intermediaries, the smaller will be the cutoff and, therefore, higher 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,

²⁹See 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.

³⁰The cutoff in this case is $\hat{r}^* = \frac{R(1-\frac{r_1\theta}{q})}{r_1(1-\theta)}$

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.

6 Contagion

One of the puzzles of capital flows to less developed countries has been their excess correlation. The comovement of capital flows is still present after controlling for the effect of fundamentals (different sets of them have been tried) and cannot be easily explained away by simple theories.³¹

This section contributes to the understanding of this phenomena stressing that the correlation between capital outflows from LDCs can be reinforced by the nonlinearities caused by runs against intermediaries. If there is a shock that increases the liquidity needs of foreign investors, then the existence of intermediation may generate a crisis elsewhere. This suggest that shocks are not only magnified within a country but can also be propagated to other countries in a way that simple regressions of capital flows on fundamentals may not capture.

In this section, we will relax the assumption of known proportions of early investors. There will be an exogenous shock to θ , which means that the proportion of early consumers that will need the money in period one is unknown. This is a shortcut for a particular external shock that affects the liquidity needs of the investors and generate endogenous crises. In particular we will have in mind the “contagion effect,” the effect of crises in one country and the resulting withdrawal needs, affecting the outcome of another country (withdrawals from Latin American investment funds prompted by lack of confidence following the Mexican 1994 crisis provides an example). The probability distribution of θ , $\mathcal{F}(\cdot)$ is publicly known.

We will show that intermediation will generate an amplification effect on the capital outflows. The realized proportion of early consumers determines the “normal” capital outflow which can then be compared to the outflow in the case of crisis. For sufficiently high $\tilde{\theta}$, crises will occur and withdrawals will exceed the normal proportion $\tilde{\theta}$.

In terms of methodology, in order to show the equivalence to our previous treat-

³¹This has been documented in Valdés (1995). See also Calvo and Reinhart (1995).

ment, in this section we will explore the case where the intermediary, facing a crisis, pays in a “first come, first serve basis.” Under this scheme the last investors to withdraw do not get anything if the contracted r_1 is higher than the liquidation return, i.e., if there is liquidity provision.³²

6.1 No Intermediaries

With stochastic θ the investor solves

$$Max_{a_{ni}}[U[\tilde{W}]] = \int_0^1 \{\tilde{\theta}U(aq + (1-a)) + (1-\tilde{\theta})U(aR + (1-a))\}d\mathcal{F}(\tilde{\theta}). \quad (19)$$

Again, for the utility function with constant relative risk aversion (CRRA) with parameter γ , the optimal a_{ni}^* will be given by:

$$a_{ni}^* = \frac{(1-\Psi)}{(1-q) + \Psi(R-1)}, \quad (20)$$

where

$$\Psi \equiv \left[\frac{E[\theta](1-q)}{(1-E[\theta])(R-1)} \right]^{\frac{1}{\gamma}}. \quad (21)$$

6.2 With intermediaries

As in section 2, the cutoff for runs is found by equating the payoffs of withdrawing in period 1 versus period 2, at the realized $\tilde{\theta}$:

$$r_1 = \frac{R(1 - \frac{r_1 \hat{\theta}}{q})}{1 - \hat{\theta}} \rightarrow \hat{\theta} = \frac{R - r_1}{r_1(\frac{R}{q} - 1)} \quad (22)$$

Differing from section 2, we will assume that the intermediary will pay r_1 until it has no money. After that point, everybody in line will receive a zero return.

³²This follows Diamond and Dybvig (1983)

Assuming that there is a uniform probability of being in the position s_j of the line, we can determine the probability p of receiving r_1 in the case of a run:

$$p = \frac{q}{r_1}$$

The maximization problem for the investor now depends on both $\hat{\theta}$ and p :

$$\begin{aligned} \text{Max}_{a_i} \quad & [1 - \mathcal{F}(\hat{\theta})][pU(ar_1 + (1 - a)) + (1 - p)U(1 - a)] + \\ & \mathcal{F}(\hat{\theta}) \int_0^{\hat{\theta}} \{ \tilde{\theta}U(ar_1 + 1 - a) + (1 - \tilde{\theta})U(a \frac{R(1 - \frac{r_1}{q}\tilde{\theta})}{(1 - \tilde{\theta})} + 1 - a) \} \frac{d\mathcal{F}}{\mathcal{F}(\hat{\theta})}. \end{aligned}$$

This will generate an optimal amount of investment through the intermediary:

$$a_i^* = a_i^*\{R, q, r_1, \Omega\}. \quad (23)$$

In the case of a run, the excess capital outflow (the amplification effect produced by intermediation) is equal to:

$$1 - \tilde{\theta},$$

which occurs with probability $\mathcal{F}(\hat{\theta})$.

6.3 Uniform Distribution

This subsection explores the concrete case in which θ is distributed uniformly between 0 and $\theta^{max} \leq 1$.

Competition among intermediaries implies that the solution of this problem is equivalent to the solution of the following program:

$$\begin{aligned} \text{Max}_{a_i, r_1} \quad & [1 - \frac{\hat{\theta}}{\theta^{max}}][pU(ar_1 + (1 - a)) + (1 - p)U(1 - a)] + \\ & \int_0^{\hat{\theta}} \{ \tilde{\theta}U(ar_1 + 1 - a) + (1 - \tilde{\theta})U(a \frac{R(1 - \frac{r_1}{q}\tilde{\theta})}{(1 - \tilde{\theta})} + 1 - a) \} \frac{d\theta}{\theta^{max}}. \end{aligned}$$

The rather complicated FOCs are omitted. Notice, however, that the choice of r_1

will affect $\hat{\theta}$, and, therefore, the probability of a crisis. A concrete example where the intermediary increases capital flows, utility, and volatility is given by the following set of parameters. The parameters were chosen to show the trade-off between the size of capital inflows and the probability of crisis.

If $\theta^{max} = 0.6$, $R = 5.6$, $q = 0.4$, and $\gamma = 3$, the investment volume without intermediation, a_{ni}^* , is 0.26. With intermediation the results are: $a_{ni}^* = 0.28$ (more investment), $r_1^* = 0.86$ (liquidity effect), and $\hat{\theta} = 0.43$ (more volatility). The implied run probability is 0.28.

7 Conclusion

Exchange rate crisis 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 chapter 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 the possibility of runs and magnify the outflows of capital (in particular, in bad states of nature) relative to the no intermediation case.

Also, we showed that if credit is funneled through liquidity creating intermediaries, internal or external adverse shocks may generate runs and large exchange rate devaluations that otherwise would not have occurred. The devaluation, then, propagates the shocks to the rest of the economy. Therefore, it is the fragile financial situation of the intermediaries that allows 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.

The financial fragility of intermediaries raises two valid questions. First, is there a competitive structure that generates this fragile situation? In the model of the chapter, the existence of relatively illiquid investments and investors that have strong liquidity needs, combined with Bertrand competition between intermediaries, produces a situation where the main role of the intermediaries is to create liquidity. The financial fragility situation is embedded in this role.

Second, with rational investors, does the financial fragility still allow us to reproduce the observed surges in capital flows that precede the crisis?³³ Under reasonable assumptions about the utility function and the distribution function of the shocks, we were able to simulate several cases where capital inflow *increases* with intermediation, even though rational investors anticipate the possibility of runs. The liquidity provision services provided by intermediaries more than compensate for the risk of runs.

The focus on the financial fragility of liquidity creating intermediaries may help explain the different nature of some exchange rate collapses. In Latin America or other recently stabilized countries, where intermediaries are still readily available to offer liquid assets (as a consequence of the 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.

³³See the graph and description in the introduction.

Appendix: Closed-Form Solutions

This appendix presents the closed-form solutions of the optimal levels of investment and liquidity provision for the case of a CRRA utility function and a Bernoulli distribution. The maximization problem and the corresponding FOCs were presented in section 3. To find a_i^* and r_1^* explicitly we solve equation (16) for a (simplifying terms using equation (17)), solve equation (17) for a , and equate. The final solutions are given by:

$$a_i^* = \frac{\Phi_2 \{ \theta \bar{R} \Phi_1 + q(1 - \theta) \} - \Phi_1 \{ \theta \bar{R} + q(1 - \theta) \}}{(1 - q) \Phi_2 \{ \theta \bar{R} \Phi_1 + q(1 - \theta) \} - \Phi_1 \{ (\theta - q) \bar{R} + q(1 - \theta) \}} \quad (24)$$

and

$$r_1^* = \frac{q [\Phi_1 \{ \bar{R} - (1 - \theta) \} + (1 - \theta)]}{\theta \bar{R} \Phi_1 + q(1 - \theta)} + \{ q(1 - \Phi_1)(1 - \theta) \} \times \frac{(1 - q) \Phi_2 \{ \theta \bar{R} \Phi_1 + q(1 - \theta) \} - \Phi_1 \{ (\theta - q) \bar{R} + q(1 - \theta) \}}{\{ \theta \bar{R} \Phi_1 + q(1 - \theta) \} (1 - \Phi_2) \{ \theta \bar{R} \Phi_1 + q(1 - \theta) \}}, \quad (25)$$

where

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

and

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

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, the optimal investment level is given by:

$$a_{ni}^* = \frac{1 - \Phi_3}{1 - q + \Phi_3 (\bar{R} - 1)}, \quad (26)$$

where

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

References

- [1] G. Calvo. Varieties of capital-market crises. University of Maryland, April 1995.
- [2] G. Calvo, C. Reinhart, and L. Leiderman. Capital inflows and real exchange rate appreciation in latin america: The role of external factors. *IMF Staff Papers*, 40(1):108–151, March 1993.
- [3] S. Calvo and C. Reinhart. Capital flows to latin america: Is there evidence of contagion effects? April 1995.
- [4] V. Corbo and L. Hernandez. Macroeconomic adjustment and capital inflows. *World Bank Policy Research Working Paper*, 1995. No. 1377.
- [5] D. Diamond and P. Dybvig. Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, pages 401–19, June 1983.
- [6] R. Dornbusch. Collapsing exchange rate regimes. *Journal of Development Economics*, 27:71–83, October 1987.
- [7] R. Dornbusch, I. Goldfajn, and R. Valdes. Currency crises and collapses. *Brookings Papers on Economic Activity*, Forthcoming, 1995.
- [8] B. Eichengreen, A. Rose, and C. Wyplosz. Speculative attacks on pegged exchange rates: An empirical investigation. *NBER Working Paper*, October 1994. no. 4898.
- [9] R. Flood and P. Garber. Collapsing exchange rate regimes: Some linear examples. *Journal of International Economics*, 1/2:1–13, 1984.
- [10] D. Fudenberg and J. Tirole. *Game Theory*. The MIT Press, 1991.
- [11] International Monetary Fund. International capital markets: Developments, prospects, and policy issues. *World Economic and Financial Surveys*, August 1995.
- [12] M. Gavin and R. Hausman. The roots of banking crises: The macroeconomic context. *Inter-American Development Bank*, Forthcoming, 1995.

- [13] G Gorton and G. Pennachi. Financial intermediaries and liquidity creation. *Journal of Finance*, pages 49–71, March 1990.
- [14] M. Hellwig. Liquidity provision, banking, and the allocation of interest rate risk. *European Economic Review*, pages 21–42, August 1994.
- [15] P. Krugman. A model of balance of payment crises. *Journal of Money Credit and Banking*, pages 311–325, August 1979.
- [16] M. Obstfeld. The logic of currency crises. *NBER Working Paper*, February 1994. No 4640.
- [17] Agénor P., P.S. Bhandari, and P. Flood. Speculative attacks and models of balance of payment crises. *IMF Staff Papers*, 39(2):357–392, June 1992.
- [18] A. Postlewaife and X. Vives. Bank runs as an equilibrium phenomenon. *Journal of Political Economy*, pages 485–491, June 1987.
- [19] L. Rojas-Suarez and S.R. Weisbrod. Banking crises in latin america: Experiences and issues. *Inter-American Development Bank*, Forthcoming, 1995.
- [20] J. Sachs. Do we need an international lender of last resort. Harvard University, April 1995.
- [21] S. Schandler, M. Carkovic, A. Bennet, and R. Khan. Recent experiences with surges in capital inflows. *IMF Occasional Papers*, December 1993.
- [22] L. Svensson. Fixed exchange rates as a means to price stability: What have we learned? *NBER Working Paper*, October 1993. no. 4504.
- [23] R. Valdes. Capital movements contagion: Empirical evidence for latin american countries. MIT, March 1995.



N.Cham. P/EPGE SPE G618b

Autor: Goldfajn, Ilan.

Título: Balance of payment crises and capital flows : the



087375

50754

FGV - BMHS

Nº Pat.:F3488/98

