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

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BALANCE OF PAYMENT CRISES AND CAPITAL FLOWS: THE ROLE OF LIQUIITY

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Resumen

El trabajo desarrolla un modelo de crisis externas enfocado a la interacción entre la creación de liquidez por parte de intermediarios financieros y colapsos cambiarios. Se muestra que el rol de transformar madureces por parte de los intermediarios resulta en mayores movimientos de capital y mayor probabilidad de crisis. Este tipo de ciclo es el observado en la realidad: grandes influjos, crisis y una corrida abrupta desde el país. El modelo muestra como shocks negativos de productividad o alzas en la tasa de interés internacional pueden ser magnificados por el comportamiento de los inversionistas que están interelacionados a través de sus depósitos en agentes intermediadores. Un colapso eventual del tipo de cambio puede interelacionar aún más el comportamiento de los inversionistas.

Abstract

A model of external crises 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 crises. This resembles the observed cycle in capital flows: large inflows, crises 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.

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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, such 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 crises. Second, this capital inflow was intermediated, at least in part, by the domestic financial sector which, in addition, increased its proportion of short term liabilities. Finally, the external collapses were accompanied by severe banking crises.[2]

The capital cycles of surges and sudden outflows have been documented extensively in the literature[3] and have been a major issue of concern to policy makers who are caught in the dilemma of introducing capital controls.[4] In their 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 1 presents the figures for the countries in the study of Schadler et al. (1993) which focuses on capital inflow surges. The main conclusion from this table 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

[1]See, e.g., Sachs (1995).
[2]For a description of these 4 crises see Dornbusch, Goldfajn and Valdés (1995).
[3]See Calvo et al (1993) and Schandler et al. (1993).
[4]See IMF(1995).

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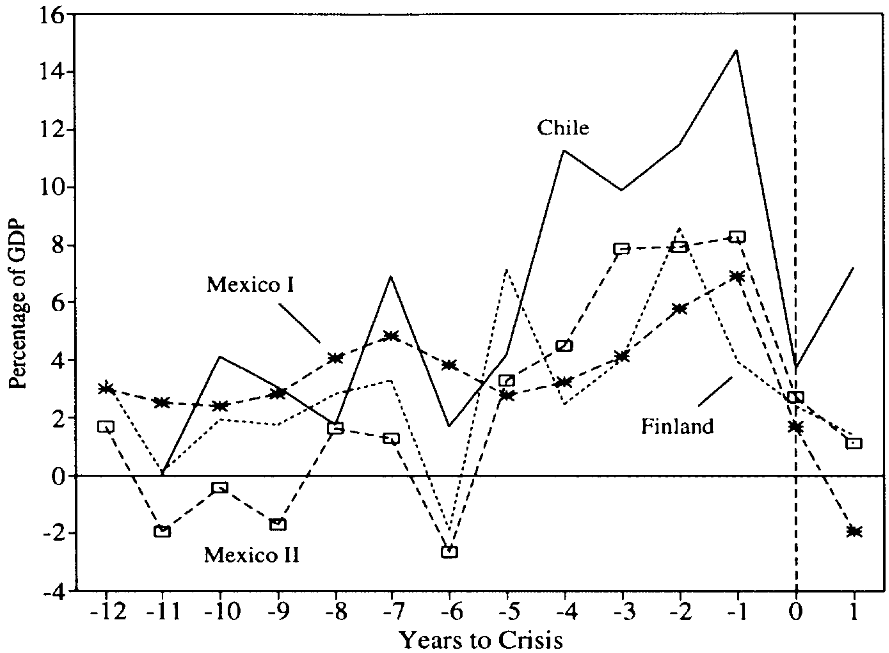

Figure 1: Capital Inflows in Mexico, Chile and Finland

short and long run fixed income instruments.

Less emphasized is the fact that capital inflows are usually accompanied 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.

Less attention is given to the fact that when capital flows are abruptly reversed, often a banking crisis emerges as an additional strain. In all the four cases highlighted above, banking crisis was indeed an important consideration to policy makers. In fact, the study by Kaminsky and Reinhart (1995) concludes that there is a strong link between banking and balance of payment crises for a large number of episodes.[5]

[5]Their goal is more ambitious. They aim to establish a causal link between the *twin crises*. See

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.

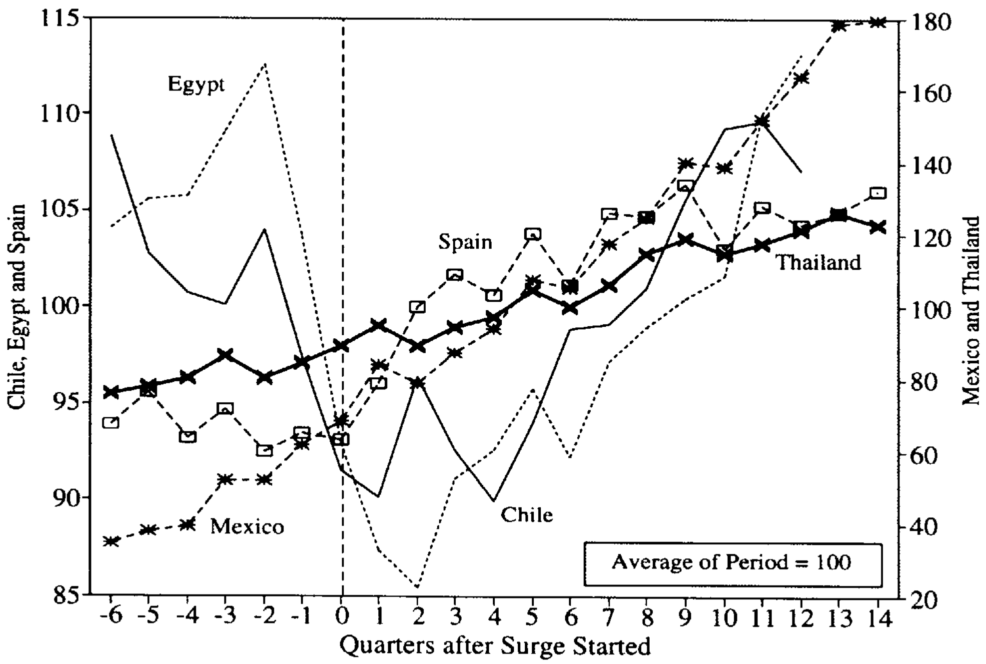

Figure 2: Real Financial Claims on the Private Sector

It is 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). Usually, it is assumed that policy makers are following an inconsistent policy. Surprisingly, it is easier to explain major 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 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, which 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 is 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 who 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 intermediaries transforming maturities, offering liquid assets to their customers and, im-

also the papers on banking crises in Latin America by Gavin and Hausman (1995) and Rojas-Suarez and Weisbord (1995).

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

[7]As 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.

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

plicitly, 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 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 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 and 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 two types of shocks: productivity and international interest rates. 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, 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.

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 an extension. 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, section 6 concludes.

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

$$Max_a E[U[\tilde{W}]] \tag{1}$$

s.t.

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

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:

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.

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]

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:

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

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

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

[10] We normalize the total number of investors to be 1. In a previous version, we relaxed this assumption and analyze the model when there is uncertainty with respect to the proportion of early consumers.

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:

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

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 of the economy:[12]

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

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

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

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

[11]The 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.

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

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:

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

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:

$$r_1 f_1 \leq q. \tag{8}$$

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 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:

[13]This 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). A version of the model with this assumption can be obtained directly from the authors.

$$\tilde{r} = \begin{cases} q & \text{in the case of run} \\ r_1 & \text{in t=1 if there is } \textit{no} \text{ run} \\ \tilde{r_2} & \text{'' t=2 ''} \end{cases}$$

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 to maintain the exchange rate fixed even in the event of capital outflows resulting from a liquidity crisis. [14] 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 crisis 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:[15]

$$t = 0 \quad \begin{cases} \text{Banks specify } r_1 \text{ and } r_2, \\ \text{Investors decide } a. \end{cases}$$

$$t = 1 \quad \begin{cases} \text{Investors learn their type,} \\ \tilde{R} \text{ is realized,} \\ \text{Withdrawal decision made: possibility of runs,} \\ \text{Central bank sustains or fails to sustain } \bar{e}. \end{cases}$$

$$t = 2 \quad \text{Patient investors get } r_2 \text{ if there was no run.}$$

[14]Formally, the Central Bank has net reserves Rx, after subtracting the current account X, such that: $Rx = RX - X > qa^*$, where qa^* is the maximum outflow in period 1.

[15]We 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.

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

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

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, 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:

$$\begin{array}{ll} t=0 & a^*_{ni} \\ t=1 & -\theta q a^*_{ni} \\ t=2 & -(1-\theta)Ra^*_{ni}. \end{array}$$

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:

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

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

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

The probability of a run will be given by $\mathcal{G}(\hat{R})$. [16]

Proposition 1 *The probability of runs with intermediation is strictly positive. Also, this probability is non-decreasing in the level of liquidity that is provided.*[17]

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

[16] As explained below, we do not consider self-fulfilling runs here.

[17] Liquidity 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.

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 a 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 $\tilde{R}$.[18] 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.[19] 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 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:

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

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

[19] See, 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.

which gives an optimal investment policy with an intermediary:

$$a_i^* = a_i^*(r_1, q, \theta, \Omega), \tag{13}$$

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

$$\begin{array}{ll} t=0 & a_i^* \\ t=1 & \begin{cases} -\theta r_1 a_i^* & \text{with probability } (1-\mathcal{G}(\hat{R})) \\ -q a_i^* & \text{with probability } \mathcal{G}(\hat{R}) \end{cases} \\ t=2 & \begin{cases} -(1-\theta)\tilde{r_2} a_i^* & \text{with probability } (1-\mathcal{G}(\hat{R})) \\ 0 & \text{with probability } \mathcal{G}(\hat{R}) \end{cases} \end{array}$$

Proposition 2 *There are proportionally more capital outflows 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 assumed in this section that the central bank has enough reserves, after paying net imports payments, to pay for the capital outflows (i.e., $Rx \geq \theta r_1 a_i^*$).

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:

$$Max_{r_1} E[U[\tilde{W}]] =$$

$$(1-\mathcal{G}(\hat{R}))[\theta U(a_i^* r_1 + (1-a_i^*)) + (1-\theta)\int_{\hat{R}}^{\bar{R}} U(a_i^* \tilde{r}_2 + (1-a_i^*)) d\mathcal{G}(\tilde{R})]$$
$$+\mathcal{G}(\hat{R}) U(a_i^* q + (1-a_i^*)) \quad (14)$$

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 *There exist utility functions and distribution functions such that 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:

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

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

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

$$Max_{a_i, r_1} \quad (1-\alpha)\frac{(aq+1-a)^{1-\gamma}}{1-\gamma} +$$

$$\alpha[\theta\frac{(ar_1+1-a)^{1-\gamma}}{1-\gamma}+(1-\theta)\frac{(a\frac{\bar{R}(1-\frac{r1\theta}{q})}{(1-\theta)}+1-a)^{1-\gamma}}{1-\gamma}],$$

where γ is the coefficient of risk-aversion.

The FOCs for this case are given by:

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

and

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

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

In order 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:

$$a_i^*=\frac{\Phi_2\left\{\theta\overline{R}\Phi_1+q(1-\theta)\right\}-\Phi_1\left\{\theta\overline{R}+q(1-\theta)\right\}}{(1-q)\Phi_2\left\{\theta\overline{R}\Phi_1+q(1-\theta)\right\}-\Phi_1\left\{(\theta-q)\overline{R}+q(1-\theta)\right\}} \tag{18}$$

and

$$r_1^*=\frac{q\left[\Phi_1\left\{\overline{R}-(1-\theta)\right\}+(1-\theta)\right]}{\theta\overline{R}\Phi_1+q(1-\theta)}+\left\{q(1-\Phi_1)(1-\theta)\right\}\times \tag{19}$$

$$\frac{(1-q)\Phi_2\left\{\theta\overline{R}\Phi_1+q(1-\theta)\right\}-\Phi_1\left\{(\theta-q)\overline{R}+q(1-\theta)\right\}}{\left\{\theta\overline{R}\Phi_1+q(1-\theta)\right\}(1-\Phi_2)\left\{\theta\overline{R}\Phi_1+q(1-\theta)\right\}},$$

where

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

and

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

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

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

$$a_{ni}^{*} = \frac{1-\Phi_3}{1-q+\Phi_3\left(\overline{R}-1\right)}, \tag{20}$$

where

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

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 shows 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.[20]

In the example shown here, the liquidity effect dominates the risk of been forced to early withdraw (in the case of a run) and we observe larger capital inflows when intermediaries provide liquidity. Notice that in all the graphs, when there is no liquidity creation ($r_1 = q = 0.8$) the amount of inflows with intermediaries is the same as without intermediation, i.e., $a_i^* = a_{ni}^*$. At these points 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

[20]In 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.

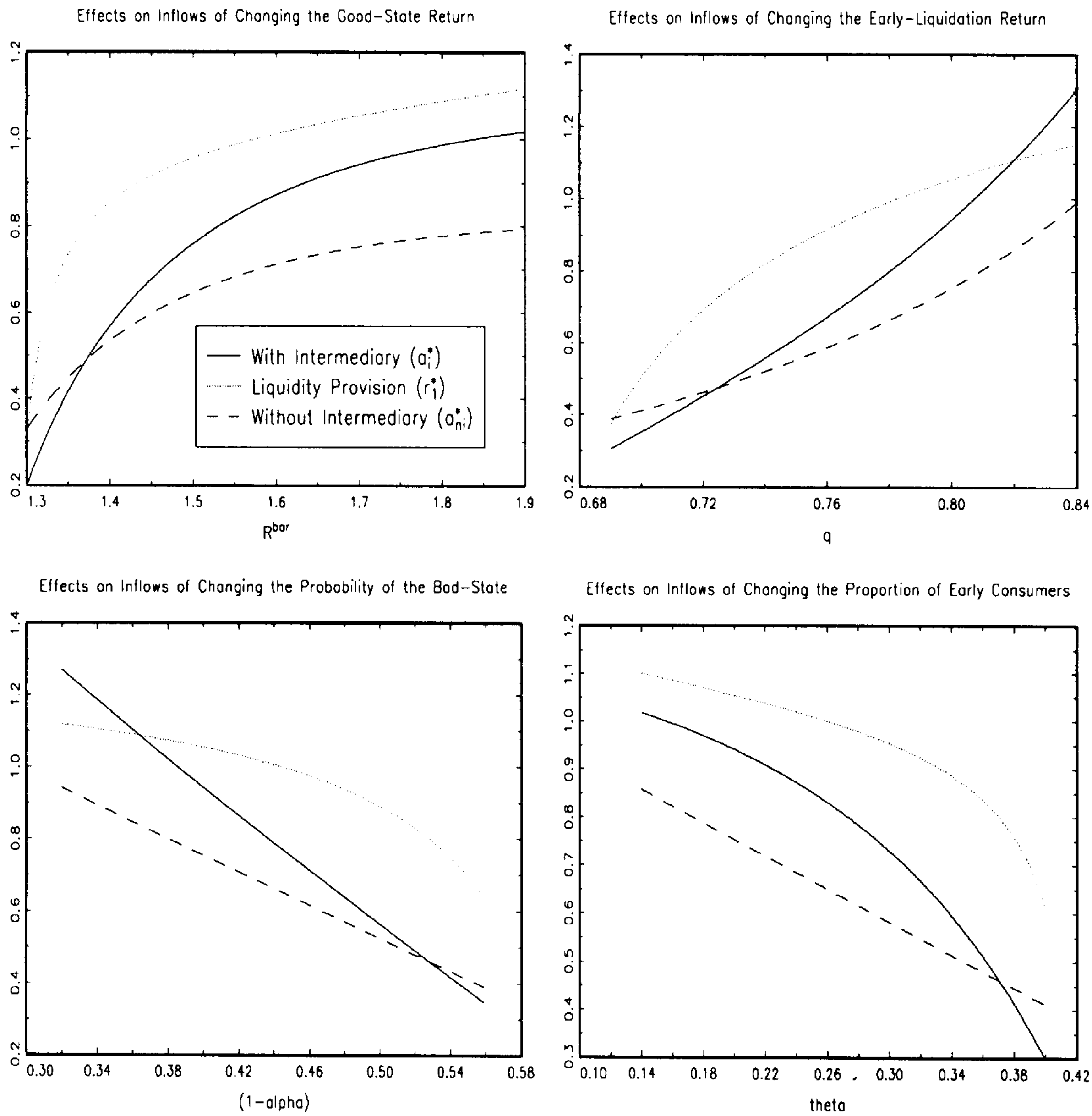

Figure 3: Capital Inflows Simulations

(optimally) offer illiquid contracts, i.e. $r_1^* < q = .8$, there are fewer capital inflows.

Figure 3 allows us to analyze some of the comparative statics involved in the problem.

As expected, a higher good-state return, $\bar{R}$ increases 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. 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 on 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, if a higher proportion of Early-Consumer type of investors (that is a higher θ) is expected, there are less inflows and intermediation in equilibrium. The extra inflows generated by intermediation drops for higher values of θ because the existence of a higher proportion of withdrawals in period 1 makes intermediaries provide less liquidity (in other words, the existence of a large proportion of short term capital inflows makes less attractive the marginal investment through the intermediaries).

4 Exchange Rate Collapses

The model presented so far has analyzed the effect of financial intermediation on both capital inflows and outflows. This section, introduces an upper bound to the stock of foreign exchange reserves available to the central bank, 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.[21] 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 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

[21]This 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.

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.

The devaluations in period 1 are possible because we assume the Central Bank faces the following restriction:

$$\theta r_1 a^* \leq Rx \leq qa^*.$$

There are enough reserves to sustain the fixed parity in the event of normal capital outflows but not in the case of crisis in the intermediaries.

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. $\mathcal{G}(.)$.[22]

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 $\tilde{R}$.[23]

There are two key assumptions about central bank behavior. First, under a fixed 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.[24] 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

[22] One 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.

[23] This 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.

[24] Normalized to be equal to 1.

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:

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

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

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 $\mathcal{G}(R^c)$.[25]

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.

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.[26] In particular, given the amount invested in period 0, a_i^*, the

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

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

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 $\hat{R} = r_1 (1-\theta) / \left(1 - \frac{r_1 \theta}{q}\right)$ 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:

$$\begin{gathered} U\left[\frac{a^* \tilde{r}_2}{e_2} + 1 - a^*\right] = \\ \alpha U\left[a^* r_1 + 1 - a^*\right] + (1-\alpha) U\left[\frac{a^* r_1}{e_2} + 1 - a^*\right], \end{gathered} \tag{21}$$

where $\tilde{r}_2 = R'\left(1 - \frac{r_1\theta}{q}\right) / (1-\theta)$, 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 (21) is constant and the LHS is monotonic and continuous in R' (assuming a well behaved utility function: continuous, with $U'(.) > 0$ and $U''(.) < 0$).

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 (21), which is equal to a convex combination of two terms, has to be bigger than $U\left[a^* r_1 / e_2 + 1 - a^*\right]$, the smallest of the two terms of the combination. Comparing