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LIQUIDITY CRISES AND THE INTERNATIONAL FINANCIAL ARCHITECTURE

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Liquidity Crises and the International Financial Architecture*

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Abstract

The paper analyzes the effect of different proposals for the new international financial architecture in an open economy liquidity crises model. It shows that an international lender of last resort that provides a complete financial rescue leads, in the short run, to a lower probability of a BoP crises and financial runs. However, the perverse incentives of a complete bailout lead to an increasing probability of financial runs in the long run. A partial financial package may not reduce the probability of financial runs and twin crises. Private sector participation rules can increase the probability of financial runs and twin crises if a large proportion of foreign investors expect to withdraw their investment without loss.

JEL Codes: F32, F33.
Key Words: Twin Crises; Bailout; Lender of Last Resort; Capital Controls.

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1 Introduction

There is a growing literature in international economics that acknowledges that the recent currency crises have a large liquidity run component, defined as a situation in which investors holding short term obligations of the country decide simultaneously to redeem their assets and flee the country in amounts that exceed the debtor's available reserves. The fact that there is a large stock of short run obligations has its roots in the past behavior of the domestic financial system which, in moments of distress, also suffers a run. This leads to the observed, and recently documented, simultaneous occurrence of balance of payments (BoP) and banking crises, the so called "twin crises."[1]

This type of crises seem to have several undesirable characteristics. First, after crisis countries suffer large real effects, one has the impression that the punishments are larger than the crimes. For example, Korea, Indonesia and Thailand GDPs are expected to shrink by astonishing –7.0, –8.0 and –15.3 percent (Interim WEO, Dec 1998). These magnitudes were also observed in previous currency crises as in Chile (1982), Finland (1991), and Mexico (1995) that shrunk –14.0, –7.1, and –6.9 percent respectively (Dornbush, Goldfajn and Valdés, 1995). Yet not in all cases the underlying macro fundamentals were weak —or at least not weak enough to justify the depressions observed. Second, these crises generate (and possibly also reflect) an increase in the volatility of capital flows with its perverse consequences. Of course, one could argue that the costs of higher volatility per se are not large but only for the mentioned recessions or "sudden stops" the crises produce.[2] Third, these crises tend to spread to other countries in a phenomenon dubbed "contagion" (Valdés, 1996, and Masson, 1997). The recent contagion from Thailand to the rest of Asia, then to Russia, and more recently to Latin America has led economists and policy makers to fear for the stability of the international financial system.

Several alternatives have been proposed to cope with this alleged threat to the global financial system. Important economists and policy makers have been advocating the creation of a global level institutions that could act as an international lender of last resort, in a parallel to how central banks act in national levels (Sachs, 1995 and Fischer, 1999). In contrast to central banks, however, the resources of the existing institutions, such as the IMF, are limited by the size of international claims and potential capital movements. Another proposal is the introduction of orderly workout rules with creditors, in case of crisis, that makes it easier to involve (or "bail in") the private sector in the financial rescue plans of distressed debtors.

The paper analyzes, theoretically, the effect of different proposals for the new international financial architecture in an open economy liquidity model. It evaluates separately the effect of the introduction of an international lender of last resort and the introduction of orderly workout (or "bail in") rules for the private sector, on the probability of BoP and banking crises, the degree of financial intermediation and on capital inflows. The paper uses an open economy extension of the Diamond and Dybvig (1983) model of bank runs devel-

[1] The importance of the ratio of short term obligations to reserves has long been stressed by Calvo (1995). Sachs (1995) has pointed out the importance of the liquidity run component. Goldfajn and Valdés (1997) and Chang and Velasco (1998) have modelled liquidity runs using the insights from the Diamond and Dybvig (1983) bank run models. Caballero and Krishnamurphy (1998) explain the sudden breakdown of the country's access to international capital markets with an inadequacy (real or perceived) of its international collateral. Empirically, Kaminsky and Reinhart (1998) have documented the large incidence of twin crises.

[2] As in the famous bankers' adage "it is not the speed that kills, it is the sudden stop."

oped in Goldfajn and Valdés (1997, 1998). We model financial intermediaries as channeling foreign funds towards profitable but illiquid domestic investment projects. Intermediaries offer short-term deposits which make early withdrawal from an investment less costly for potentially illiquid foreign investors. Such contracts may attract capital from abroad, but at the same time they make the economy vulnerable to the risk of runs against the intermediaries. In particular, for a sufficiently negative productivity shock (or, equivalently, a large enough world interest-rate shock) bank runs are the unique equilibrium outcome. BoP crisis are defined as occurring when foreign exchange reserves are smaller than net capital outflows, so that the central bank is unable to maintain its currency peg. As in the case of a banking crisis, if there is a sufficiently large negative shock to net foreign exchange reserves, then a currency crisis is the unique equilibrium.

The paper shows that under a complete financial rescue not only BoP crises are avoided but it is also possible to reduce financial runs in the short run. However, the perverse incentives that a complete bailout pose on investors and the financial system generate an increasing probability of financial runs in the long run. If the amount of reserves offered at the pre-devalued exchange rate is positively related to the amount of reserves available to the central bank, the probability of banking and twin crises may increase with a partial rescue package. In this case the international organization will only help to bailout foreign investors. With respect to private sector participation, the model shows that both the probability of a financial run and twin crisis increase the larger is the proportion of foreign investors that expect to withdraw their investment without loss.

Recent papers have analyzed similar issues. Jeanne (1998) finds that orderly workout rules are unambiguously welfare decreasing while the introduction of a lender of last resort could be optimal provided it demands tough conditions from the lender. Zettelmeyer (1998) argues that a partial rescue plan can lead to more investors running in the case of a crisis.

The rest of the paper is organized as follows. The next section describes the basic liquidity model and its solution. Section 3 evaluates the ex-post effect on the model of the different proposals for the international financial system. Section 4 analyzes and simulates the ex-ante effect of the proposals on capital inflows, interest rates and the probability of crises. Finally, section 5 concludes.

2 Liquidity Model

The model is based on Goldfajn and Valdés (1997, 1998) and is summarized below. Consider a small open-economy in a three-period world with a continuum of risk-averse international investors (with mass normalized to 1), who have the option of investing in the small economy or in a risk-free liquid international asset during period 0. There are two types of investors with utility function $U(\tilde{c}_t)$, divided into "early" and "late" consumers, where $\tilde{c}_t$ is consumption in period t ($t = 1, 2$ depending on the type of investor). U is smooth and satisfies $U' > 0$ and $U'' < 0$. Being an early consumer is an idiosyncratic risk with fixed and known probability θ.

The international asset yields $r^* \geq 1$ per period (measured in terms of international currency) while the small open economy has a local investment opportunity, based on a constant-returns-to-scale technology, that needs time to mature. The latter yields a random return $\tilde{R}$ if the investment is kept in place for two periods (measured in local currency), but only a fixed and known return $q < 1$ if it is interrupted in period 1. $\tilde{R}$ is known only in

period 1, but it is publicly known that it has a distribution function $\mathcal{G}(.)$ with $qr^* \leq \tilde{R} < \overline{R}$.

Financial intermediaries compete in a free-entry environment by offering a contract that changes the yield profile of the investment in the small open economy. Bertrand competition ensures that the intermediaries will maximize international investors' expected utility. Intermediaries pool resources from international investors and invest the proceeds in the small-economy project. They offer a return of i to investors who keep the investment for one period (starting in period 0), possibly higher than the return produced by the technology q, and they finance this payment by offering a return on a two-period investment lower than $\tilde{R}$.

The return for investors who stay in for two periods depends on how many investors withdraw in period 1 and the outcome of $\tilde{R}$. We denote by $\tilde{r}_2$ the return that a late consumer obtains in period 2 by investing in the small economy (through intermediaries, if they exist, because they will offer contracts that maximize investors expected utility). If early consumers alone liquidate their investment in period 1 (i.e. a proportion θ of total investors), then:

$$\tilde{r}_2 = \frac{(1 - \theta i/q)\,\tilde{R}}{1 - \theta}. \tag{1}$$

The timing of moves and events in this economy is summarized as follows. In period 0, intermediaries offer the short-term return, and investors decide how to allocate their portfolio. In period 1 both idiosyncratic and aggregate uncertainties are resolved, early consumers withdraw, late consumers decide whether to roll-over their investment and the central bank tries to defend the currency peg. In period 2 late consumers receive $\tilde{r}_2$.

If late consumers decide to withdraw early they will generate a run against the intermediaries. In this case, because of their budget constraint, each intermediary would fail to pay i—there would be a banking crisis—and would have only q to pay to each investor per unit invested. We assume they would pay this amount to each and every investor withdrawing their investment. We denote by $\tilde{r}_1$ the return that an early consumer gets in period 1 by investing in the small economy (through intermediaries, if they exist). Hence, as of period 0, each investor faces the following return structure on an investment in the small economy (measured in domestic currency):[3]

$$\tilde{r}_1 = \begin{cases} i & \text{if there is no run, and} \\ q & \text{if there is a run} \end{cases}$$

and

$$\tilde{r}_2 = \begin{cases} \tilde{R}\,(1 - \theta i/q)\,/\,(1 - \theta) & \text{if there is no run, and} \\ qr^* & \text{if there is a run.} \end{cases}$$

The central bank attempts to maintain the exchange rate pegged at a rate initially set equal to 1 and has net reserves amounting to $\tilde{X}$ in period 1, known only in that period due to current-account shocks. We assume the following behavior by the central bank: if capital outflows F in period 1 (determined endogenously by international investors' withdrawal decisions) are less than $\tilde{X}$, then the central bank maintains the peg. If outflows are larger than the amount of reserves, then the central bank devalues and there is a BoP crisis. In

[3]We implicitly assume that there is no side-trading in the form of a secondary market.

this event, however, it sells reserves at the initial exchange rate to a proportion β (fixed and known in period 0) of interested agents and at a devalued exchange rate to a proportion $(1-\beta)$ of the agents. We assume $\tilde{X}$ has a distribution function $\mathcal{F}(.)$ and support $(\underline{X}, \overline{X})$. We further assume that $\tilde{X}$ and $\tilde{R}$ are independent. With these assumptions, the period 1 exchange rate e_1 profile faced by investors is given by:

$$e_1 = \begin{cases} 1 & \text{if } F < \tilde{X}, \\ 1 & \text{with prob. } \beta \text{ if } F > \tilde{X}, \text{ and} \\ 1+\hat{e} & \text{with prob. } 1-\beta \text{ if } F > \tilde{X}, \end{cases} \tag{2}$$

and the period 2 exchange rate e_2 is given by $\max\langle 1, 1+\hat{e}\rangle$. $\hat{e}$ is assumed to be large enough to clear the remaining demand for foreign exchange reserves.

2.1 Model Solution and Probabilities of Crises

There is one reserve constraint given by the amount of reserves available on the central bank and one incentive compatible constraint associated to the roll-over decision faced by late consumers in period 1. Once this decision is made one can determine the complete distribution of returns. Moreover, given realizations of $\tilde{X}$ and $\tilde{R}$, it is possible to determine whether there is a run on the intermediary, the amount of capital outflows in period 1 and, consequently, the existence of a BoP crisis. Once we have the distribution of returns we solve the bank's and investors' decisions in period 0. The bank's maximization problem determines the return i promised in period 1, and the investors' portfolio solution determines the size of inflows a in the small open economy.

Different realizations of $\tilde{X}$ and $\tilde{R}$ may trigger any of four possible outcomes: (i) no crisis, (ii) a BoP crisis, (iii) a banking crisis, or (iv) twin crises (both BoP and banking). For each type of crisis (BoP and banking) there are two relevant cutoff points or thresholds for the corresponding random variable. One of the thresholds determines the level at which there will be one type of crisis (either BoP or banking) independently of the occurrence of the other type, while the other threshold determines at what point there will be a (BoP or banking) crisis given the existence of the other one (banking or BoP). These four thresholds define the four possible outcomes.

Capital outflows F define a threshold for international reserves at which a BoP crisis exist. Given the initial investment a in the small country (through intermediaries, if they exist), outflows F can take two values: $a\theta i$ and aq. Hence, there is a threshold $\hat{X}$ for $\tilde{X}$ associated with each capital outflow level:

$$\hat{X} = \begin{cases} a\theta i & \text{if there is no bank run, and} \\ aq & \text{if there is a bank run} \end{cases} \tag{3}$$

Of course, if $\underline{X} \geq aq$ the probability of BoP crisis is zero.

The occurrence of a banking crisis depends on what happens with the exchange rate and the outcome of $\tilde{R}$. The individual roll-over decision assumes that all other late consumers are rolling-over their investment.[4] If no devaluation occurs under "normal" outflows (i.e. if

[4]If a late consumer decides to withdraw in this case, then a bank run is the unique equilibrium. Indeed, if $\tilde{R}$ is low and all other investors run then it is always profitable to run. It is possible to consider "sun-spot" equilibria in the model. However, a variable to coordinate expectations would have to be specified and its distribution taken into account in the period-0 portfolio allocation problem.

$F = a\theta i$), then each late consumer compares the two-period return under withdrawal, given by ir^*, with the two-period return $\tilde{r}_2$ under a no-run situation. This comparison yields a cutoff $\hat{R}$ for $\tilde{R}$ that leaves late consumers indifferent between the two alternative returns, and defines a banking crisis, given no BoP crisis. The cutoff $\hat{R}$ is given by:[5]

$$\hat{R} = \frac{ir^*(1-\theta)}{1 - i\theta/q}. \tag{4}$$

In the same way we can determine a banking crisis threshold R' for $\tilde{R}$ if a devaluation occurs with normal outflows (that is, if $\tilde{X} < a\theta i$). In this case, every late consumer compares his dollar returns from withdrawing and getting exchange rate 1 with probability β, or getting the new exchange rate with probability $1-\beta$, against the dollar return from rolling-over and getting $\tilde{r}_2$ under a no-run situation and the new devalued exchange rate. The cutoff R' is implicitly defined by:

$$\begin{array}{c} U\left[\left[aR'\left(1 - i\theta/q\right)/\left(1-\theta\right)\right]/e_2 + (1-a)r^{*2}\right] = \\ \beta U\left[(ai + (1-a)r^*)r^*\right] + (1-\beta)\,U\left[(ai/e_2 + (1-a)r^*)r^*\right], \end{array} \tag{5}$$

where $e_2 = 1 + \hat{e}$, which is the exchange rate prevailing in period 2. Provided $0 < \beta < 1$, we have $\hat{R} < R'$.

Given these four thresholds and outcomes, each investor solves his portfolio allocation problem, taking other investors' portfolios as given. At the same time, because we assumed that intermediaries engage in Bertrand competition, intermediaries end up choosing i so as to maximize investors' expected utility. Therefore, one can simultaneously determine the two endogenous variables, the portfolio allocation, a, and the interest paid by intermediaries in the first period, i, by solving the following maximization problem:

$$max_{\{a',i\}}\theta E\left[U(\tilde{c}_1)\right] + (1-\theta)\,E\left[U(\tilde{c}_2)\right],$$

with

$$\begin{array}{rl} \tilde{c}_1 = & a'\tilde{r}_1/\tilde{e_1} + (1-a')r^* \\ \tilde{c}_2 = & a'\tilde{r}_2/\tilde{e_2} + (1-a')r^{*2}, \end{array}$$

and where, in equilibrium, the individual portfolio decision a' must be equal to a, the portfolio chosen by the other agents. $\tilde{c}_1$ and $\tilde{c}_2$ assume different values depending on the results of $\tilde{X}$ and $\tilde{R}$ and the four possible crisis outcomes.

In Figure 1, we illustrate the areas where BoP, banking and twin crises occur using the cutoffs defined in equations (3)-(5). From the figure it is straightforward to calculate the probabilities associated with BoP and banking crises. The results are:

- Unconditional probability of a BoP crisis

$$\Pr(\text{BoP}) = \mathcal{G}(\hat{R})\left[\mathcal{F}(aq) - \mathcal{F}\left(a\theta i\right)\right] + \mathcal{F}\left(a\theta i\right), \tag{6}$$

- Unconditional probability of a banking crisis

$$\Pr(\text{Banking}) = \mathcal{F}\left(a\theta i\right)\left[\mathcal{G}(R') - \mathcal{G}(\hat{R})\right] + \mathcal{G}(\hat{R}), \tag{7}$$

[5]Notice, however, that $\mathcal{G}(\hat{R})$ is not the conditional probability of a banking crisis conditional on no BoP crisis because the events are not independent (even though $\tilde{R}$ and $\tilde{X}$ are).

- Probability of a twin crisis

$$\Pr(\text{Twin}) = \mathcal{G}(\hat{R})\left[\mathcal{F}(aq) - \mathcal{F}\left(a\theta i\right)\right] + \mathcal{G}(R')\mathcal{F}\left(a\theta i\right). \tag{8}$$

3 International Financial Structure: Ex-Post Analysis

When analyzing the effect of having a lender of last resource and financial rescue packages one may distinguish two temporal dimensions, namely the effect ex-post and ex-ante of an international financial rescue. In our model, an analysis ex-post means investigating the effects on the probability of crises (BoP, banking, or twin) given the decisions on capital inflows and interest rates (but before the random productivity and reserve shocks are realized). In this case, the analysis concentrates on evaluating the effect of the different policies on the incentives given to investors to withdraw in period 1 and on the effect the policy has on the need for the central bank to devalue the currency. A given policy will possibly change the cutoffs on the exogenous variables, productivity and net reserves, that determine the probability of the different crises.

3.1 International Lender of Last Resort

What is the effect of an international financial rescue on the probability of crises and capital inflows on this small open economy? There are two cases to consider, depending on the amount of reserves made available to the country: a complete and a partial bailout.

3.1.1 Complete Bailout

In a complete bailout the amount of resources made available for the country is higher than all possible outflows (in the model this happens when $F = aq \leq \underline{X}$). Of course, this possibility seldom occurs in reality since the amount of the financial package would have to be prohibitively high. However, it is still important to evaluate this case because it is an important theoretical benchmark to evaluate policies. In the case of complete bailout we have the following lemma:

Lemma 1 *Under a complete bailout the probability of balance of payment crises and twin crises is zero and the probability of financial runs decreases.*

If the resources available to the country are such that $F = aq \leq \underline{X}$ then both $\mathcal{F}(aq)$ and $\mathcal{F}(a\theta i)$ are equal to zero and the probability of BoP crisis in equation (6) collapses to zero.

The interesting part of the lemma is that not only BoP are prevented but the probability of financial runs also fall. If $\mathcal{F}(a\theta i)$ is equal to zero in equation (7) then the probability of a financial run is equal to $\mathcal{G}(\hat{R})$. The latter will be smaller than the probability of financial runs without a bailout (with $\mathcal{F}(a\theta i)$ positive) provided $R' \geq \hat{R}$. This condition is proved in Goldfajn and Valdés (1998).

It is easy to see the result from Figure 1. If $\underline{X} \geq aq$, the part of the figure before aq vanishes and the BoP crisis area goes to zero while the financial run area is just $\mathcal{G}(\hat{R})$.

3.1.2 Partial Bailout

In a partial bailout the reserves made available to the economy are not sufficient to completely prevent BoP crises. In the model this means that $\underline{X}$ increases but we still have $\underline{X} \leq a\theta i \leq aq \leq \overline{X}$. If we maintain the assumption that β is constant (which as we will see below is no longer just a "simplification"), we have the following lemma:

Lemma 2 *Maintaining the amount of reserves offered at the pre-devalued exchange rate constant, the unconditional probabilities of BoP, banking and twin crisis fall with introduction of a partial rescue.*

From an ex-post point of view, both a and i are given, and the increase in net reserves available will strictly decrease $\mathcal{F}(a\theta i)$ and $\mathcal{F}(aq)$ as long as X is continuous. For a given β, R' and $\hat{R}$ are constant, and one can easily show from equations (6)-(8) that a decrease in $\mathcal{F}(a\theta i)$ and $\mathcal{F}(aq)$ reduces the probabilities of BOP, banking and twin crises.[6]

Therefore, this model provides a result that is not obtained in pure multiple equilibria models. In the latter, a partial bailout cannot prevent runs (the bad equilibria) and is interpreted as ineffective in avoiding crises. This is a consequence of the fact that multiple equilibria models in general does not provide an endogenously determined probability of crises. For example, Zettelmeyer (1998) uses a Diamond and Dybvig (1983) structure and finds that a partial bailout can worsen the crises generating more withdrawals from foreign investors.

However, in general one cannot treat β as a constant. In a more extended model β probably is a positive function of reserves, since the amount of reserves available for the central bank to defend its currency increases relative to the amount of potential capital outflows. This higher β will provide incentives for late consumers to withdraw early and run against the reserves of the central bank. More formally, if one modifies equation (2) such that $\beta = \underline{X}/F$ we have:

Lemma 3 *If the amount of reserves offered at the pre-devalued exchange rate is positively related to the amount of reserves available, the probability of financial runs and twin crises may increase with the partial bailout.*

From equation (5) one can observe that $\partial R'/\partial\beta > 0$. A higher R', in turn, increases the probability of financial runs and twin crises for given level of minimum reserves $\underline{X}$ (and also a and i), as can be observed from equations (7) and (8). If this effect is strong enough and compensates the fact that $\mathcal{F}(a\theta i)$ and $\mathcal{F}(aq)$ decrease, then we would observe an overall increase in the probability of crises. [7]

Intuitively, there are two effects to consider. On one hand, the probability of BoP crises falls since there are more available reserves which generates also more financial runs. On the other hand, the incentives to withdraw increase with more reserves available at the old exchange rate once there is a BoP crises and may generate more financial runs.

[6] In the trivial case of $a\theta i \leq \underline{X} \leq aq \leq \overline{X}$ by definition there are no pure BOP crises, only twin crises. The probability of pure financial runs will not change with the partial bailout because there are no feedback effects. The probability of twin crises will fall with the decline of $\mathcal{F}(aq)$

[7] Again, in the trivial case of $a\theta i \leq \underline{X} \leq aq \leq \overline{X}$ the probability of twin crises will also be affected by the change in R'. The overall effect is ambigous has in the general case.

3.2 Private Sector Participation

As seen in section 3.1.1, a complete bailout provides enough reserves to avoid a devaluation and reduces the probability of a BoP crisis to zero. However, the incentives that a complete bailout poses may generate higher inflows than in "normal cases" and, even more, a higher probability of financial runs in the long run. This is the moral hazard effect that complete bailouts generate. In order to reduce this problem it has been proposed to let the private sector suffer a loss in moments of crisis.

An investment loss can be thought of as a discount on the value of the assets that arises as a consequence of pure unilateral default, discount on withdrawal during debt renegociations, or the implicit loss following a forced rescheduling.

Let us assume that the involvement of the private sector is a discount in the amount $L \geq 1$ to investors that decide to withdraw out of the country. A complete bailout would generate enough dollars to avoid a devaluation, but depending on the distribution of the loss there can still exist incentives to withdraw. The effects on capital flows and on the probability of crises depend on the distribution of losses among withdrawing investors. A benchmark case is when the loss is equal to the value of the underlying (implicit) devaluation $L = (1 + \hat{e})$ and a proportion β of the runners is able to withdraw their investment without loss. In this case, the probability of crises and the amount of capital inflows are the same as if there was no bailout and no loss. The only difference is that there is no devaluation and part of the reserve losses is financed by the rescue package in case of loss.

However, if the tax distribution is, say, $\phi \leq \beta$, the probability of "BoP crises" is higher under this scheme. The reason is that the cutoff R' changes from (5) to:

$$\begin{array}{c} U\left[\left[aR'/L\left(1-i\theta/q\right)/\left(1-\theta\right)\right]/e_2+(1-a)r^{*2}\right]= \\ \phi U\left[(a\bar{i}+(1-a)r^*)r^*\right]+(1-\phi)\,U\left[(ai/L+(1-a)r^*)r^*\right], \end{array} \tag{9}$$

where L is the discount applied to holders of assets in the small open economy. Provided $\phi \leq \beta$, R' is lower in this case and the probability of BoP crisis decreases.

In reality the probable "losers" from a devaluation are not the same that from a coordinated restructuring of the debt. Depending on the composition of "losers" we may have different effects on capital flows and crises.

Lemma 4 *Under a rescue package with private sector participation, the probability of financial runs and twin crises increases the larger is the proportion ϕ of the runners that is able to withdraw their investment without loss.*

If the loss is structured in such a way that there is a larger ϕ, then there is a higher probability of runs although there is no devaluation—it will be the typical case which the international organization is funding dollars so that foreign investors are able to leave the country. In contrast, if the loss is imposed to every investor that decides to withdraw, i.e., the government is able to make $\phi = 0$, then R' equals $\hat{R}$ and there are less financial runs and no twin crises.

4 International Financial Structure: Ex-ante Analysis

An important component of the exercise is to identify the general equilibrium effect of the policy once capital inflows and interest rates are allowed to react to policies. In this

Table 1. Baseline Simulation Parameters

Description	Parameter	Value
Relative risk aversion	γ	3.00
Maximum domestic return	$\overline{R}$	1.80
Interrupted return	q	0.85
International interest rate	r^*	1.04
Probability of mass return	π	0.65
Proportion of early consumers	θ	0.20
Reserves lower bound	$\underline{X}$	0.00
Reserves upper bound	$\overline{X}$	1.40
Proportion who gets $e = 1$	β	0.25
BoP crisis exchange rate	$1 + \hat{e}$	1.05

See text for further description.

section we present a simulation exercise that allows us to numerically analyze the effects of alternative policies.

Numerical Simulations Given that there are no closed-form solutions in our model, we resort to numerical simulations to analyze the overall effects on probabilities, intermediation and capital inflows of alternative rescue packages and capital controls. In those simulations we consider the following baseline numerical example of the model presented above. Given that the model is highly stylized and abstract, this example should be taken exclusively as such.

We assume that the two-period return of the emerging economy technology R has a mixed distribution with mass at r^{*2}. In particular, $R = r^{*2}$ with probability π, and R has a uniform distribution with support in $(qr^*, \overline{R})$ with probability $1 - \pi$. As for period 1 available international reserves X, we assume that they have a uniform distribution with bounds given by $(\underline{X}, \overline{X})$.[8] International investors have a constant relative risk aversion (CRRA) utility function with parameter γ. Table 1 summarizes the specific parameter values we consider in the baseline simulation.

Table 2 shows the results after assuming the model structure described above and these parameter values.[9] It shows that in equilibrium there is positive intermediation ($i > q$). More importantly, while the probabilities of BoP, financial and twin crisis all increase with intermediation, capital inflows also increase. In particular, the probabilities of BoP only, banking and twin crisis increase from 3.14, 0.00, and 0.01% to 4.25, 4.52, and 1.15%, respectively. Meanwhile, inflows increase from 0.26 to 0.33.

[8]Notice that in the model it is irrelevant how large are international reserves after the aq bound has been reached because the exchange rate will not change. The only effect of a larger $\overline{X}$ is to change the probability of a BoP crisis.

[9]The routine we use to find the optimal solution has three phases. Given i and a (the portfolio chosen by other agents) and implicit state-probabilities, it searches for the optimal a' (the agent's optimal portfolio). It then updates a to this new solution and repeats the search of the optimal a', iterating until convergence. Finally, it searches for the optimal i given the optimal a chosen for each i.

Table 2. Baseline Simulation Solution

Description	Variable	Value
No Intermediation		
Capital Inflow	a_n	0.26
Probability of BoP crisis only		3.14
Probability of financial crisis only		0.00
Probability of twin crisis		0.01
Free Intermediation		
Capital Inflow	a_i	0.33
Intermediation offered	i	0.96
Probability of BoP crisis only		4.25
Probability of financial crisis only		4.52
Probability of twin crisis		1.15

See text for further description.

4.1 Financial Packages and Private Sector Involvement

What is the ex-ante effect of a future bailout on capital inflows? Intuitively, capital inflows should increase due to a lower probability of both crises. Moreover, the increased level of available net reserves reduces the probability of financial runs and allows for more flattening in the yield curve. This, in turn, may attract further capital inflows. However, this extra intermediation dampens the initial effect of higher reserves on the probability of financial runs.

Foreign investors are better off due to a lower probability of crises and a more flatten yield curve (a net liquidity gain). However, because short-term interest rates increase beyond what their "normal" level, the probability of financial runs increases, dampening the initial benefits of higher reserves on the probability of crises. This effect is in line with the typical trade-off highlighted in the literature of large bailouts that rescue distressed economies but induce moral hazard behavior by the part of investors.

Figure 2 shows the results of a simulation exercise in which we consider financial bailouts of different sizes. The most immediate result, as expected, is that the probability of a BoP crisis falls to zero as the size of the package increases. More interestingly, financial runs decrease in the short run as the incentives to run decrease. However, as the size of the package increases, liquidity is easy, capital inflows become very large, and the probability of financial runs increases steeply. Once the probability of financial runs are higher, capital inflows level up.

Figure 3 shows the same exercise but allowing the proportion of reserves to defend the currency, β, to depend on reserves. In this case, although the probability of a BoP crisis decreases rapidly, the probability of financial runs increases steadily. The reason is that, even for low values of financial assistance, withdrawals are expected to be more rewarding measured in foreign currency.

Finally, figure 4 shows the results of an exercise using a rule in which there is private sector participation. In particular, investors have to pay a penalty L in case of exit. The

probability of financial runs initially increases, the more so the less universal is the penalty. However, at some very high level of non forced participation, liquidity offered by financial institutions decreases and, accordingly, the probability of financial runs falls.

5 Conclusion

The paper hints on a few policy implications. First, paradoxically, partial rescues should not be used to defend currencies in the case of financial runs. Otherwise, the rescue package could be providing incentives to withdrawals and financial runs. The additional reserves provided by the package should rather be used to smooth other external shocks. Alternatively, to prevent perverse incentives, international rescues should be complete, i.e., covering all possible outflows. In this case, the customary moral hazard problems arise.

Second, private sector participation rules should be as universal as possible. Partial rules and loopholes that allow individual investors to flee provide incentives that increase the probability of crises.

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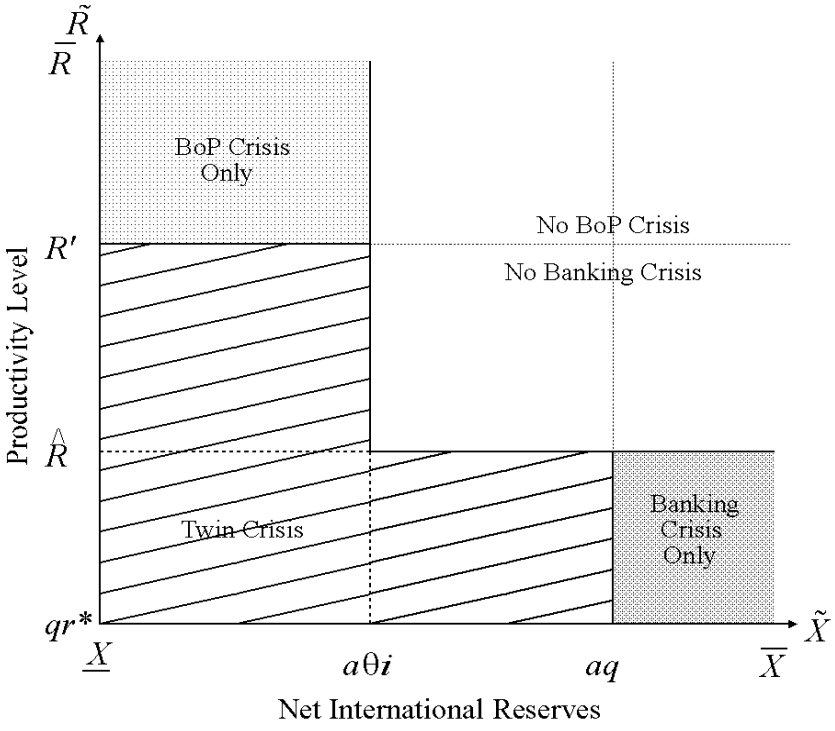

Figure 1: Period 1 Outcomes

Figure 2: Capital Flows and Crises under a Financial Rescue

Figure 3: Capital Flows and Crises under a Financial Rescue and Proportional Reserves

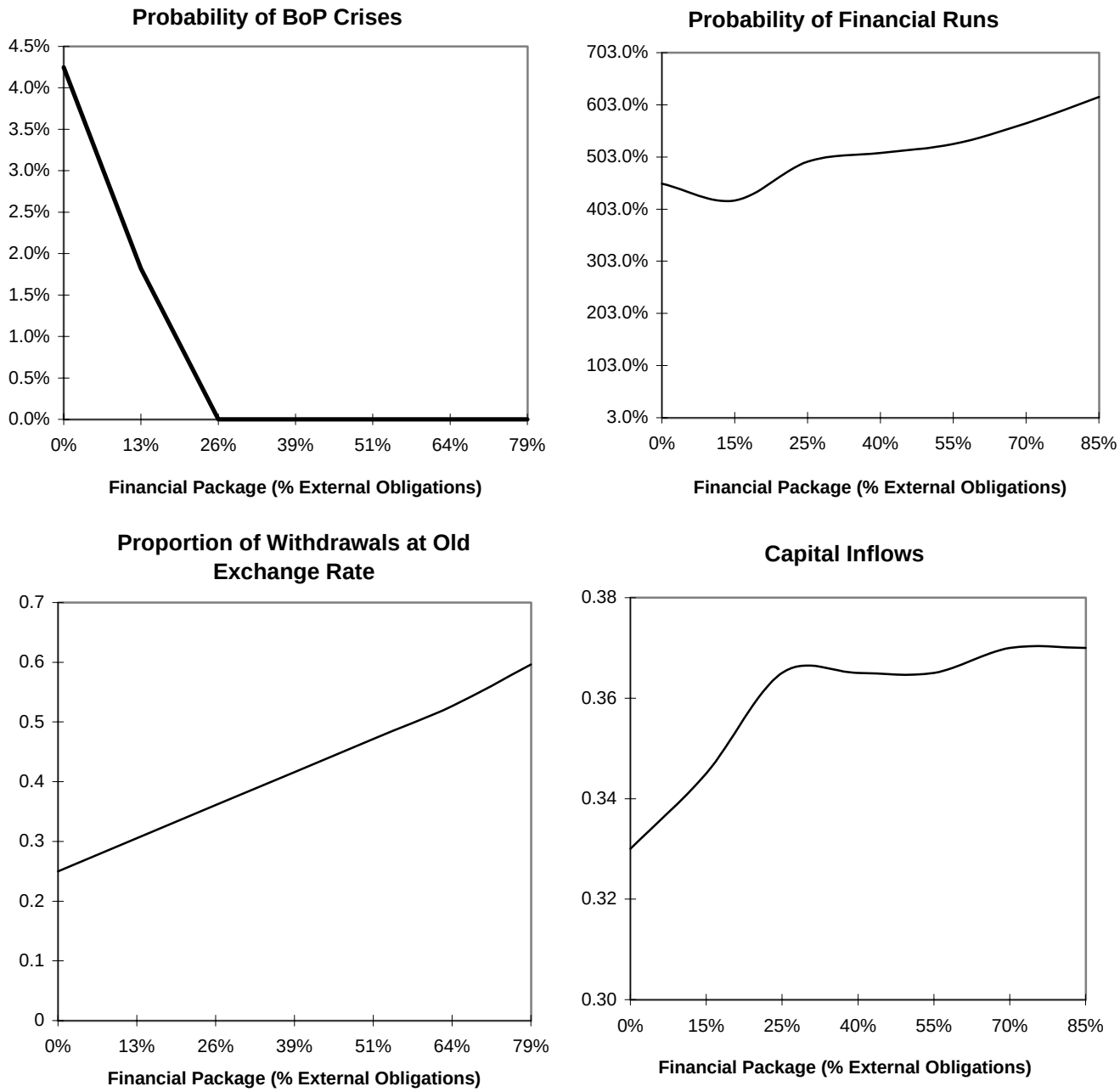

Figure 4: Capital Flows and Crises under a Private Sector Forced Participation