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Abstract

This paper examines the effects that capital flows have on the financial system in the context of a demand deposit banking model. In this environment, an adverse selection problem arises where short-term capital has the incentive to enter the domestic banking system while long-term capital chooses to stay out. Then, short term capital flows limit the insurance function of banks. As inflows increase, a threshold is reached beyond which it becomes optimal to restrict these short-term capital inflows. In addition, when the quantity of inflows is unknown, large short-term capital flows will cause a banking crisis.

JEL Classification: D92, E44, F32, G21.

Key words: Financial Intermediation, Capital Flows, Liquidity Provision, Banking crises.

Resumen

Este artículo examina el efecto de los flujos de capital sobre el sistema financiero en el contexto de un modelo bancario a la Diamond-Dybvig. En este modelo surge un problema de selección adversa donde capitales de corto plazo tienen el incentivo de participar en el sistema bancario doméstico, mientras que capitales de largo plazo deciden no entrar. Luego, flujos de corto plazo limitan la función de seguro que cumplen los bancos. A medida que éstos aumentan, se llega a un umbral donde se vuelve óptimo restringir los flujos de capital de corto plazo. Además, cuando la cantidad de éstos es desconocida, cantidades grandes de flujos de capital causan crisis bancarias.

Banks and Capital Flows

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Abstract

This paper examines the effects that capital flows have on the financial system in the context of a demand deposit banking model. In this environment, an adverse-selection problem arises where short-term capital has the incentive to enter the domestic banking system while long-term capital chooses to stay out. Then, short-term capital flows limit the insurance function of banks. As inflows increase, a threshold is reached beyond which it becomes optimal to restrict these short-term capital inflows. In addition, when the quantity of inflows is unknown, large short-term capital flows will cause a banking crisis.

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1 Introduction

The past decade has seen many developing economies move towards opening their financial systems to unrestricted inflows and outflows of capital. With the increased liberalization and growth of these flows came a resurgence of financial crises, particularly in Latin America and Asia. At the center of these crises is the interaction between capital flows and financial intermediaries. In particular, short-term capital flows have been pointed out as being a crucial factor in causing financial distress [1]. This has renewed the discussion on the costs and benefits of restricting short-term capital flows.

The goal of this paper is to specifically examine the effects that capital flows have on domestic banks, and thus depositors, in the context of a demand deposit environment. The model is a two asset, open economy version of Diamond and Dybvig (1983), where two types of agents are introduced. Agents are either domestic or foreign depositors. They have access to the same savings and production technologies, and share the same preferences, but differ only in the time they learn their idiosyncratic withdrawal demand. Domestic agents are the standard Diamond-Dybvig agent in the sense that they are uncertain about their liquidity needs at the time they deposit their endowments in banks. Foreign agents, on the other hand, know their liquidity preference at the time they are born. This paper then examines the effect that foreign agents have on entering the demand deposit contract offered by domestic banks.

Banks arise endogenously in this environment as a coalition of domestic agents to provide two services. They provide insurance among ex-ante identical agents who need to consume at different times, and they prevent suboptimal liquidation of assets. However, when banks are not able to distinguish domestic from foreign deposits, an adverse-selection problem arises. That is, short-term flows, which in our model turn out to be detrimental, have the incentive to join the financial system while beneficial long-term capital does not. Further, as short-term capital flows in, a moral hazard problem emerges, where foreigners exploit the bank's service of liquidity provision at the expense of domestic depositors. Implementing a self-selection constraint in this case fully thwarts liquidity provision, and thus may or may not be preferred, depending on the relative size of short-term flows.

In addition, if the quantity of capital inflows is unknown, then sufficiently large short-term flows will cause a banking crisis. In this case, both services banks provide, liquidity provision and prevention of costly liquidation, are lost. A constraint that produces a separating contract will prevent banking

[1] See, for example, Rodrik and Velasco (1999).

crises, but at the cost of losing the insurance function of banks. In spite of this, restricting short-term capital inflows may not be optimal at all times, since the cost of doing so may be greater than the expected loss in allowing crises to occur with positive probability.

On the insurance function of banks, this analysis is related to the work of Jacklin (1987, 1993) and von Thadden (1997). Jacklin shows that the insurance function provided by demand deposit contracts completely disappears if trading opportunities are introduced. Von Thadden develops a model where time is continuous, and shows that if agents are allowed to withdraw and reinvest their funds, the insurance function may not be incentive compatible. In this model, short-term flows will reduce, but not completely eliminate the insurance function of banks for low quantities of capital flows. For large quantities of capital flows, the optimal bank contract will do away with liquidity provision.

On the relationship of capital flows and banking crises, this work is mainly related to the papers of Chang and Velasco (2001) and Goldfajn and Valdés (1998). Chang and Velasco develop an open economy version of Diamond and Dybvig, where agents can borrow in international markets. In a demand deposit environment, a self-fulfilling bank run may occur when banks' potential short-term obligations exceed the liquidation value of its assets. They find that increased international borrowing by agents may exacerbate this potential illiquidity of banks and thus increase their vulnerability. In contrast, Goldfajn and Valdés model an economy with international depositors, where adverse productivity shocks may trigger a fundamental bank run. They find that intermediation of external funds increases the probability of crises, and magnifies capital outflows. In this paper, unpredictable large capital outflows are the direct cause of a banking crisis. This result is consistent with empirical studies, such as Kaminsky and Reinhart (1999) and Calvo and Reinhart (2000). Calvo and Reinhart find that nearly all banking crises in developing countries are associated with a negative reversal in capital flows.

The remainder of the paper proceeds as follows. Section 2 describes the environment and benchmark problem of the banks. The effect of short-term inflows on the domestic financial system when there is no aggregate uncertainty is discussed in section 3. In section 4 we add aggregate uncertainty about withdrawal demand, as in Champ, Smith and Williamson (1996) and Smith (2002). Section 5 concludes.

2 The Model

2.1 ***Environment***

The model consists of an open economy populated by a continuum of agents. Time is discrete and there are three periods indexed by $t = 0, 1, 2$. There are two types of agents, domestic and foreigners. Both types are endowed one unit of a single good when young, and nothing in periods 1 and 2. Goods are freely traded across countries. Agents care only about consumption in periods 1 and 2, and are expected utility maximizers. Their utility has the form $U(c) = c^{(1-\rho)}/(1-\rho)$, with the coefficient of relative risk aversion $\rho > 1$.

Domestic and foreign agents differ only in the time they learn their liquidity preference shock. Local agents learn their need of liquidity after the portfolio decision is made, and thus are the classic Diamond-Dybvig agent. Let π_1^d and π_2^d be the total population of domestic impatient and patient agents, respectively, with $\pi_1^d + \pi_2^d = 1$. There is no aggregate uncertainty for the total population or the share of domestic impatient and patient agents.

In contrast, foreigners know at the time they are born whether they will prefer to consume in periods 1 or 2. We label π_1^f, π_2^f as the total population of impatient and patient foreigners, respectively[2]. Agents' type, domestic or foreigner, is observable. However, the liquidity preference shock is private information for both types of agents.

Both types of agents have access to a linear production technology whereby one unit of the good invested in period 0 yields $R>1$ units of the good at time 2. This technology is illiquid, in the sense that an investment that is interrupted in period 1 generates $r<1$ units of consumption. In addition, there is a liquid storage technology, whose return is equal to 1 in both periods. In this sense, the liquid asset dominates the production technology in the short-term, while investing in the production technology dominates the liquid asset in the long-term.

The timing of events follows. At the beginning of period 0, young agents receive their endowments, and foreigners learn their liquidity preference. Agents then choose their portfolio allocation, i.e. the mix of storage and the illiquid investment. In period 1, domestic agents learn whether they will consume in periods 1 or 2. Following this, period 1 consumption occurs, where the

[2] Alternatively, we can think of the π_1^f foreigners as Diamond-Dybvig agents with a larger share of impatient agents relative to domestic agents, where here we look at the limiting special case where all are impatient. Likewise, the π_2^f foreigners have a lower probability relative to locals of becoming impatient, set here at zero.

illiquid technology may be liquidated in order to be consumed. In period 2 the long-term investment technology matures, and patient agents consume.

2.2 ***Bank Behavior***

Banks arise endogenously in our environment as a coalition of domestic agents. This is because domestic agents benefit from pooling their resources in order to overcome idiosyncratic uncertainty, and they gain from insuring themselves against their liquidity preference shock. In contrast, foreign agents face no uncertainty at the time the investment decision is made, and thus have no need to pool their resources nor require insurance. In this sense, banks arise naturally as domestic banks that care about domestic agents.

Given this, domestic banks will offer a contract that maximizes the expected utility of local agents. Banks announce contracts in period 0, which specify returns to depositors that depend on their liquidity preference (early vs. late-withdrawers) reported by agents. After young agents deposit their endowments with banks, banks use these deposits to save in the liquid asset and make investments in the production technology. In period 1, domestic depositors learn whether they will withdraw in period 1 or 2. Following this, banks pay to agents who wish to withdraw early. In period 2 the long-term investment matures, and banks dispense payments to the patient agents.

We do not impose a sequential service constraint, so that self-fulfilling banking crises are ruled out. In section 4 we explore the case of aggregate uncertainty about withdrawal demand, where large early withdrawals will cause a banking crisis.

Once we introduce a banking contract, the possibility that foreigners disguise themselves as domestic agents arises. Assume initially that agents are allowed to deposit only one unit per person. This assumption is made so that we can discuss, as a benchmark, a separated world. We relax this assumption in the following section. Given this, banks will be able to offer a contract to domestic agents only, where foreigners are not allowed to participate.

Let k denote the share of bank's investments in the production technology, and m denote the share of liquid reserves. Therefore, banks will face the constraint

$$m + k = 1. \tag{1}$$

Finally, let c_1^d and c_2^d be consumption for domestic early and late-withdrawers, respectively. Then, the problem of the bank is

$$V^d = \max_{c_1^d, c_2^d} \pi_1^d U(c_1^d) + (1 - \pi_1^d) U(c_2^d) \tag{2}$$

subject to

$$\pi_1^d c_1^d = m \tag{3}$$

$$(1-\pi_1^d)c_2^d = R(1-m) \tag{4}$$

$$c_2^d \geq c_1^d \tag{5}$$

$$V^d > V^a \tag{6}$$

$$c_1^d, c_2^d \geq 0 \tag{7}$$

Where (3) and (4) are the resource constraints, and (5) is the incentive compatibility or truth-telling constraint for domestic agents. (6) is the participation constraint of domestic agents, where V^a is the indirect utility of domestic agents behaving in autarky. Given constant relative risk aversion preferences, the solution to this problem sets the share of liquid reserves as

$$m^d = \frac{1}{1 + \frac{(1-\pi_1^d)}{\pi_1^d} R^{(1-\rho)/\rho}}, \tag{8}$$

and, since $\rho > 1$, we have that the returns imply $c_1^d > 1$, and $c_2^d < R$.

Foreign agents, in contrast, are able to achieve their optimal outcome without the need for banks. Young foreigners that know that they will want to withdraw in the first period, can simply acquire the liquid asset, while foreign late-withdrawers can invest all of their endowment in the illiquid technology in order to realize higher returns. Thus, consumption for foreigners in a separated world will be $c_1^f = 1$ and $c_2^f = R$.

Local depositors choose to deposit all of their endowments in banks, since the expected utility of an agent whose funds are intermediated will be greater than the expected utility when they behave autarkically, i.e. $V^d > V^a$. This is because financial intermediation in this model provides two services[3].

First, banks prevent suboptimal holding of assets. A coalition of agents takes advantage of the law of large numbers, and is able to offer $c_1^d = 1$ and $c_2^d = R$, an allocation not attainable under autarky. Notice that this is identical to the solution for foreigners. For this instance it is particularly clear to see that a coalition of agents completely resolves the idiosyncratic uncertainty about the timing of consumption, which is the distinction between both types of agents.

Second, banks provide insurance should agents become early-withdrawers. That is, $c_1^d > 1$. This is achieved at the cost of foregoing some consumption if they are late-withdrawers, where $c_2^d < R$. This risk-sharing service that is realized through financial intermediation is what Diamond and Dybvig define as banks providing liquidity.

[3] Bencivenga and Smith (1991) first introduce two assets in an OG-Diamond-Dybvig environment and discuss these two services, and their effect on growth.

Finally, notice that the higher the level of risk aversion, the more agents value liquidity provision. This can be seen by noting that $\frac{\partial m}{\partial \rho} > 0$. As risk aversion increases, in the limit we have $c_1^d = c_2^d$, where agents choose to fully insure against early consumption.

3 Capital Inflows

In this section we examine the case when foreign agents cannot be prevented from depositing their endowments in banks under the contract offered to domestic agents, if they wish to do so. We consider the more general, and perhaps more realistic case where banks are not able restrict deposits to one unit per agent. Therefore, even if foreigners are discernible from domestic agents, if there are gains from depositing in a local bank, foreigners can offer to share the profits with a domestic agent that is willing to deposit for them. While domestic agents collectively would like to thwart these associations from happening, at the individual level agents may consider this associations beneficial. Our goal is to look at the optimal solution for domestic agents in the presence of capital inflows[4]. Given this, the problem of a domestic bank now becomes

$$V^* = \max_{c_1, c_2} \pi_1^d U(c_1) + (1 - \pi_1^d) U(c_2) \tag{9}$$

subject to

$$\lambda c_1 = m \tag{10}$$

$$(1 - \lambda) c_2 = R(1 - m) \tag{11}$$

$$c_2 \geq c_1 \tag{12}$$

$$V^* > V^a \tag{13}$$

$$\phi_1^f = \begin{cases} 0 & \text{if } c_1 \leq 1 \\ \pi_1^f & \text{if } c_1 > 1 \end{cases} \tag{14}$$

$$\phi_2^f = \begin{cases} 0 & \text{if } c_2 \leq R \\ \pi_2^f & \text{if } c_2 > R \end{cases} \tag{15}$$

$$c_1, c_2 \geq 0, \quad 0 \leq \phi_1^f \leq \pi_1^f, \quad 0 \leq \phi_2^f \leq \pi_2^f$$

where λ is the endogenous share of total impatient depositors given by

$$\lambda = \frac{\pi_1^d + \phi_1^f}{\pi_1^d + \pi_2^d + \phi_1^f + \phi_2^f} \tag{16}$$

[4] We do not think about competition among banks, thus we are looking at the constrained-optimum problem.

In this problem, domestic banks decide whether to allow foreign agents to enter by way of choice of the consumption schedule. This is described by the constraints (14) and (15), which are the participation constraints of foreign agents, where ϕ_1^f and ϕ_2^f are the number of impatient and patient foreigners that choose to enter, respectively[5].

Before we get to the solution to (9), we can simplify the problem by ruling out participation of patient foreigners.

Lemma 1: $\phi_2^f = 0$ *for* $\rho>1$.

Proof: See the appendix.

Lemma 1 says that patient foreigners will never have the incentive to enter the banking contract in equilibrium. In contrast, impatient foreigners may have the incentive to enter, depending on the value of c_1 chosen by banks. $\rho>1$ entails that early consumption will be greater or equal to one, and by feasibility, late consumption will be less than or equal to R. Thus, patient foreigners prefer not to enter, since their return in autarky equals R. In this sense, an adverse-selection problem arises, where short-term capital may have the incentive to enter while long-term capital decides to stay out of the domestic financial system[6].

Given this, we turn our attention to the bank's problem where only short-term capital may want to enter the domestic contract. Consider first the pooling case where banks opt to let foreign short-term capital enter, that is $\phi_1^f = \pi_1^f$. In this case, the solution to (9) sets the optimal reserve ratio as

$$m^p = \frac{1}{1 + \left(\frac{(1-\lambda)}{\lambda}\right)^{1-1/\rho} \left(\frac{(1-\pi_1^d)}{\pi_1^d}\right)^{1/\rho} R^{(1-\rho)/\rho}} \tag{17}$$

However, local agents may prefer a contract that gives foreign impatient agents the incentive not to deposit in banks. Consider the separating case where $\phi_1^f = 0$. This implies from the participation constraint that period 1 consumption needs to be set to $c_1 \leq 1$. It follows that by the resource constraint and the

[5] Truly, when $c_1 = 1$, $\Rightarrow$ $\phi_1^f \in [0, \pi_1^f]$, where foreigners are indifferent between entering or not. In this case we assume that they choose not enter.

[6] We could still have foreign long-term capital enter the economy for $\rho > 1$, if we assumed domestic long-term returns being greater than foreign returns, that is $R^d > R^f$, which is the usual rationale for long-term foreign direct investment. In this case patient foreigners would enter as long as $c_2 > R^f$.

first order condition, the solution sets

$$m^s = \pi_1^d \tag{18}$$

Proposition 1*: Define the threshold*

$$\widehat{\pi}_1^f = \pi_1^d (R^{\rho-1} - 1) \tag{19}$$

Then the solution to the bank's problem is the contract (c_1, c_2) *given by*

$$\left.\begin{array}{l} c_1 = \frac{1}{\lambda} m^p \\ c_2 = \frac{R}{(1-\lambda)}(1-m^p) \end{array}\right\} \quad \text{for} \quad \pi_1^f \leq \widehat{\pi}_1^f$$

$$\left.\begin{array}{l} c_1 = 1 \\ c_2 = R \end{array}\right\} \quad \text{for} \quad \pi_1^f > \widehat{\pi}_1^f \tag{20}$$

Proof: see the appendix.

The solution portrays the trade-off between the bank's contract providing insurance and the loss of resources to foreigners who exploit this service. When domestic agents implement a risk-sharing contract, they redistribute resources from late to early-withdrawers. Therefore, when foreign early-withdrawers enter this contract, they are receiving transfers from domestic late-withdrawers. This unintended transfer of goods from local to foreign depositors reduces the welfare of domestic agents. For a small enough share of foreign agents, domestic agents will prefer the loss of transferring some resources to foreigners rather than give up the insurance service. Conversely, for shares of foreign impatient agents greater than $\widehat{\pi}_1^f$, agents will prefer the self-selection outcome. Here the cost of subsidizing foreigners' consumption exceeds the benefits of insurance, so separation is chosen.

Notice that the threshold $\widehat{\pi}_1^f$ given by (19) is increasing in π_1^d, ρ and R. That is, when π_1^d is large, then a bigger share of agents benefit from insurance and thus they are less willing to give it up. Also, the higher the degree of risk aversion, the more agents value insurance, and thus are less willing to sacrifice this function of banks. In the limit we have that as $\rho \to \infty$, $\widehat{\pi}_1^f \to \infty$. Finally, the higher the return on the production technology, the higher intertemporal transfers, and thus the threshold at which domestic agents are willing to give up insurance is raised.

Lastly notice that while insurance is reduced in the pooling case, or is completely lost for the separating case, domestic agents still prefer to deposit their endowments in banks. This is so since the other service banks provide, efficient intertemporal investment, is still achieved. However, as $r \to 1$, $V^* \to V^a$ for $\pi_1^f > \widehat{\pi}_1^f$. That is, as the potential cost of holding the production technology disappears, banks lose their role when they do not provide insurance.

4 Unknown Capital Inflows

In this section we assume aggregate uncertainty about withdrawal demand, as in Champ, Smith and Williamson (1996) and Smith (2002). In our case we assume that the quantity of foreign agents, π_1^f is now a random variable whose realization is unknown at the time banks make the portfolio decision.

The timing of events follows. Banks announce contracts in period 0. Based on the contract banks offer, both foreign and domestic agents choose whether to deposit or not. Banks then receive deposits and choose the portfolio allocation. After domestic depositors learn their type, both domestic and foreign agents who wish to withdraw early report to banks, at which time π_1^f is revealed. Following this, banks pay to agents based on this new information. In period 2 the production technology matures, and banks dispense payments to the remaining patient agents.

As in the previous section, foreign patient agents will never find it optimal to deposit in banks for $\rho > 1$. Define $\pi_1 = \frac{\pi_1^d + \pi_1^f}{\pi_1^d + \pi_2^d + \pi_1^f}$ as the share of both foreign and domestic impatient agents, its value drawn from a distribution $G(\pi_1)$ with pdf $g(\pi_1)$, which is common knowledge, and with finite support in the interval $[\pi_1^d, 1]$.

Then, the bank's problem is given by

$$\tilde{V} = \max_{\substack{c_1(\pi_1), c_2(\pi_1) \\ \alpha, \delta}} \int_{\pi_1^d}^{1} \left[\pi_1^d U(c_1) + (1 - \pi_1^d) U(c_2) \right] g(\pi_1) d\pi_1 \tag{21}$$

subject to

$$\lambda c_1 = \alpha m + \delta r (1 - m) \tag{22}$$

$$(1 - \lambda) c_2 = (1 - \alpha) m + (1 - \delta) R (1 - m) \tag{23}$$

$$c_2 \geq c_1 \tag{24}$$

$$\tilde{V} > V^a \tag{25}$$

$$\phi_1^f = \begin{cases} 0 & \text{if } \int\limits_{\pi_1^d}^{1} U(c_1)g(\pi_1)d\pi_1 \leq U(1) \\ \pi_1^f & \text{if } \int\limits_{\pi_1^d}^{1} U(c_1)g(\pi_1)d\pi_1 > U(1) \end{cases} \tag{26}$$

$$c_1, c_2 \geq 0, \qquad \alpha, \delta \in [0,1], \qquad 0 \leq \phi_1^f \leq \pi_1^f$$

The resource constraints (22) and (23) are the counterparts of (10) and (11), where α and δ represent the fraction of liquid reserves and investments, respectively, that banks liquidate in period one. They capture the fact that there is aggregate uncertainty, so banks at times may hold liquid reserves across periods for low realizations of π_1^f, or may have to scrap investments in order to meet liquidity needs of early-withdrawers for high realizations of π_1^f. Efficiency in holding investments dictates that if $\alpha<1$ then $\delta = 0$, and if $\delta > 0$ then α=1. (26) is the participation constraint for impatient foreigners, the aggregate uncertainty counterpart of (14).

Consider first the pooling case where foreign patient agents choose to deposit. Here we have $\lambda = \pi_1$, which implies aggregate uncertainty.

Proposition 2*: The pooling contract to the problem with aggregate uncertainty can be described by the optimal return schedule*

$$c_1 = c_2 = m + R(1-m) \quad \text{for} \quad \pi_1 \in (\pi_1^d, \underline{\pi}_1) \tag{27}$$

$$\left.\begin{aligned} c_1 &= \tfrac{1}{\pi_1}m \\ c_2 &= \tfrac{R}{(1-\pi_1)}(1-m) \end{aligned}\right\} \quad \text{for} \quad \pi_1 \in (\underline{\pi}_1, \overline{\pi}_1)$$

$$\left.\begin{aligned} c_1 &= \tfrac{1}{\overline{\pi}_1}m \\ c_2 &= \tfrac{R}{r}\tfrac{1}{\overline{\pi}_1}m \end{aligned}\right\} \quad \text{for} \quad \pi_1 \in (\overline{\pi}_1, 1)$$

where $\underline{\pi}_1 = \frac{m}{m+(1-m)R}$, *and* $\overline{\pi}_1 = \frac{m}{m+(1-m)r}$.

Proof: See the Appendix.

As we can see from the optimal return schedule, banks provide full insurance for withdrawal demand in $(\pi_1^d, \underline{\pi}_1)$. Here, $\alpha<1$ and some reserves will be forwarded to the next period. For withdrawals in $(\underline{\pi}_1, \overline{\pi}_1)$, reserves are exhausted, and impatient get lower returns than patient agents. However, $\delta = 0$ so that no early liquidation of the production technology is carried out. Lastly, when withdrawal demand exceeds $\overline{\pi}_1$, $\delta > 0$ where banks interrupt the production process in order to satisfy early withdrawals. We consider it a banking crisis when the share of early withdrawers is large enough so that reserves are depleted and output losses take place.

Proposition 2 also shows that for realizations of $\pi_1 \in (\pi_1^d, \underline{\pi}_1)$, where no crisis occurs, foreigners receive transfers from domestic agents. When cash reserves are exhausted, for $\pi_1 \in (\underline{\pi}_1, \overline{\pi}_1)$, foreigners may exploit the insurance function, as long as the realization of π_1 is less than the optimal reserve ratio m. Finally, when a full fledged crisis occurs, foreigners receive lower returns compared to when they do not enter.

Similar to the case where the share of capital flows is known, expected utility of local depositors is reduced as foreigners enter the banking contract. In particular, this is so for two reasons. First, domestic agents that value insurance end up transferring resources to foreign agents for low realizations of π_1. Second, here the uncertainty of withdrawal demand potentially forces both assets to be used suboptimally. That is, liquid assets may be held inefficiently across periods, or the production technology may be liquidated early. Further, for $\pi_1 \in (\overline{\pi}_1, 1)$, both services that banks provide, insurance and optimal intertemporal investment, are lost.

Here again, it is feasible for domestic banks to choose a separating contract by promising $(c_1, c_2) = (1, R)$. Then, $\phi_1^f = 0$ where foreign agents choose not to enter, and thus we have $\lambda = \pi_1^d$. It follows that the term in brackets in (21) can be pulled out of the integral, since there is no longer aggregate uncertainty when foreigners do not enter. Also by no aggregate uncertainty, we have $\alpha = 1$ and $\delta = 0$, where assets are held optimally.

Define $\tilde{V}^p$and $\tilde{V}^s$as the values to the pooling and separating indirect utilities.

Proposition 3: *Define* $T = f(G(\pi_1), R, \rho)$ *as the threshold that satisfies* $\tilde{V}^p = \tilde{V}^s$.*Then the solution to the problem given in* (21) *satisfies*

$$\tilde{V} = \max\left\{\tilde{V}^p, \tilde{V}^s\right\}. \tag{28}$$

Proof: See the appendix.

For certain parameters, domestic agents will ex-ante prefer the pooling contract where banking crises may occur, while for others they will prefer the separating contract. To illustrate this welfare trade-off, consider a representative example of the model. Specifically, assume a uniform distribution $G(\pi_1)$ with pdf $g(\pi_1) = 1/(1 - \pi_1^d)$, and consider the following parameters. The coefficient of relative risk aversion is ρ =3, the share of domestic impatient agents is $\pi_1^d = 0.5$ and the return to investments, are R =2 and r=0.5. Given these parameters, the indirect utilities are $\tilde{V}^p = -0.326$ and $\tilde{V}^s = -0.313$. It follows that for this case the separating contract is chosen. In contrast, if we increase the return to investments to R =3, leaving all other parameters unchanged, we get $\tilde{V}^p = -0.277$ and $\tilde{V}^s = -0.278$, where the pooling contract is preferred. Similarly, increasing the coefficient of relative risk aversion ρ, will raise the threshold T, and thus increase the parameter set at which the pooling contract will be preferred.

The contract where agents self-select comes at the cost of losing the service of liquidity provision but allows for the other service of banks, which is the optimal intertemporal holding of assets, and a banking crisis will be ruled out. In contrast, the pooling contract will not be able to prevent suboptimal holding of assets, and may or may not be able to provide insurance. That is, for low quantities of short-term capital inflows it will provide insurance, but will not be able to for large quantities of unpredicted capital inflows.

5 Conclusion

This paper studies the effects that capital flows have on the financial system in the context of a demand deposit banking model. When banks are not able to distinguish domestic from foreign deposits, short-term foreign capital has the incentive to enter the banking contract to take advantage of the insurance service that domestic banks provide, and thus is detrimental to the local economy. Banks are able to restrict short-term inflows by way of an incentive compatibility constraint, but at the cost of losing the insurance function of banks. Given this cost, it would be interesting to look at ways in which short-term inflows could be restricted without losing the insurance service that banks provide. The benchmark case in section 2.2 achieved this, but with the assumption that the size of individual deposits could be limited by banks. This assumption may be unrealistic in a more general environment, for example, when agents may have heterogeneous endowments.

One policy that has been proposed as a way of restricting short-term capital flows is Chilean-style unremunerated reserve requirements. One of the principal shortcomings of this measure has been the capacity of foreign investors to find loopholes and ways to evade this rule[7]. This is consistent with our assumption in section 3, where associations between foreigners and domestic agents are not verifiable, and thus they are able to evade a ban on direct foreign deposits. Imposing a reserve requirement on all short-term deposits, independent of origin, would obviously hurt domestic depositors and thus would not be optimal either.

[7] See Ulan (2000) for a review of the literature on the Chilean-style tax.

Finally, in this paper, when the quantity of inflows is unknown, then short-term capital flows may cause a banking crisis. This is consistent with empirical evidence that links banking crises with sharp reversals in capital flows.

6 Appendix

6.1 Proof of Lemma 1

Suppose the opposite, that is, that foreign patient agents choose to deposit in a domestic bank. Then $\phi_2^f = \pi_2^f$, and by (15) $c_2 > R$. It follows that $c_1 < 1$ by the feasibility constraints. This implies that $\phi_1^f = 0$ by (14). The first order condition to this problem sets

$$m = \frac{1}{1 + \left(\frac{(1-\lambda)}{\lambda}\right)^{1-1/\rho} \left(\frac{(1-\pi_1^d)}{\pi_1^d}\right)^{1/\rho} R^{(1-\rho)/\rho}} \tag{29}$$

where $\lambda = \frac{\pi_1^d}{\pi_1^d + \pi_2^d + \pi_2^f} < \pi_1^d$. Also, $c_1 < 1$ implies $m < \lambda$ by (10). Thus we have

$$\frac{1}{1 + \left(\frac{(1-\lambda)}{\lambda}\right)^{1-1/\rho} \left(\frac{(1-\pi_1^d)}{\pi_1^d}\right)^{1/\rho} R^{(1-\rho)/\rho}} < \lambda \tag{30}$$

after some algebra and taking the natural logarithm to the above expression, we have

$$\ln\left(\frac{(1-\lambda)}{(1-\pi_1^d)} \frac{\pi_1^d}{\lambda}\right) < (1-\rho)\ln(R) \tag{31}$$

Which is a contradiction for ρ>1, since both expressions inside the logarithms are greater than one, and thus the log expressions are greater than zero. ■

6.2 Proof of Proposition 1:

It is easy to verify that the optimal reserve ratios that solve for the pooling and separating outcomes are m^p and m^s given by (17) and (18), respectively.

It is also straightforward to verify that the threshold $\widehat{\pi}_1^f$ given by (19) satisfies $V^*(pooling) = V^*(separating)$.

Consider first the pooling case. Then $\lambda = \frac{\pi_1^d + \pi_1^f}{\pi_1^d + \pi_2^d + \pi_1^f}$. Further suppose that that π_1^f is small enough so that λ is arbitrarily close to π_1^d. It follows that m^p

is arbitrarily close to the benchmark m^d given by (7). Thus $V^*(pooling)$ is arbitrarily close to V^d, and the pooling contract is preferred to a separating contract. Then, by continuity, the threshold $\widehat{\pi}_1^f$ satisfies $\phi_1^f = \pi_1^f$ (pooling) for $\pi_1^f \leq \widehat{\pi}_1^f$, and $\phi_1^f = 0$ (separating) for $\pi_1^f > \widehat{\pi}_1^f$. ■

6.3 ***Proof of Proposition 2:***

The optimal fraction of currency banks liquidate, α, needs to satisfy the incentive compatibility constraint $c_2 \geq c_1$. Substituting (22) and (23) we have

$$\frac{(1-\alpha)}{(1-\pi_1)}m + \frac{(1-\delta)}{(1-\pi_1)}R(1-m) \geq \frac{\alpha}{\pi_1}m + \frac{\delta}{\pi_1}r(1-m) \tag{32}$$

with strict equality for $\alpha<1$. Then the threshold $\underline{\pi}_1$follows from setting $\alpha = 1$ with strict equality of (32), and $\delta = 0$. Solving for α in (32) we have the optimal currency liquidation strategy

$$\alpha = \begin{cases} \pi_1(1 + R\frac{(1-m)}{m}) & \text{for } \pi_1 \leq \underline{\pi}_1 \\ 1 & \text{for } \pi_1 > \underline{\pi}_1 \end{cases} \tag{33}$$

Similarly, the optimal fraction of investments liquidated, δ, satisfies

$$\frac{(1-\alpha)}{(1-\pi_1)}m + \frac{(1-\delta)}{(1-\pi_1)}R(1-m) \leq \frac{R}{r}\left[\frac{\alpha}{\pi_1}m + \frac{\delta}{\pi_1}r(1-m)\right] \tag{34}$$

with strict equality for $\delta>0$. Then the threshold $\overline{\pi}_1$ follows from setting $\delta = 0$ with strict equality of (34), and $\alpha = 1$. Then we have the optimal investment liquidation strategy

$$\delta = \begin{cases} 0 & \text{for } \pi_1 < \overline{\pi}_1 \\ \frac{1}{r}\frac{\pi_1 - \overline{\pi}_1}{\overline{\pi}_1}\frac{m}{(1-m)} & \text{for } \pi_1 \geq \overline{\pi}_1 \end{cases} \tag{35}$$

Then the optimal return schedule in (27) follows from substituting the optimal α and δ into the bank's budget constraints (22) and (23), and using the definitions for$\underline{\pi}_1$and$\overline{\pi}_1$. Finally, the first order condition follows from substituting the optimal return schedule(27) into the objective function(21), and using the definitions for $\underline{\pi}_1$and $\overline{\pi}_1$. Noting that c_1 and c_2 are continuous at $\underline{\pi}_1$and $\overline{\pi}_1$, we arrive at the first order condition that implicitly defines the optimal reserve ratio. ■

6.4 ***Proof of Proposition 3:***

Consider a degenerate distribution $G(\pi_1)$ that places mass 1 to an arbitrarily small π_1^f, such that $\tilde{V}^p$ is arbitrarily close to V^d, the benchmark indirect utility. Then $\tilde{V}^p > \tilde{V}^s$, and pooling is preferred. Then, by continuity of the von Neumann-Morgenstern expected utility function, a threshold T exists at which $\tilde{V}^p = \tilde{V}^s$. Beyond T, the probability of large π_1^f is such that $\tilde{V}^p < \tilde{V}^s$. ■

References

[1] Bencivenga, Valerie and Bruce Smith. (1991). "Financial Intermediation and Endogenous Growth." *Review of Economic Studies*, 58, 195-209.

[2] Calvo, Guillermo A. and Graciela Kaminsky. (2000). "When Capital Inflows Come to a Sudden Stop: Consequences and Policy Options." In *Key Issues in Reform of the International Monetary and Financial System,* edited by Peter Kenen and Alexandre Swoboda, pp. 175-201. Washington DC: International Monetary Fund.

[3] Chang, Roberto and Andrés Velasco. (2001). "A Model of Financial Crises in Emerging Markets." *Quarterly Journal of Economics*, May, 489-517.

[4] Champ, Bruce, Bruce Smith and Stephen Williamson. (1996). "Currency Elasticity and Banking Panics: Theory and Evidence." *Canadian Journal of Economics*, 29, 826-864.

[5] Diamond, Douglas and Philip Dybvig. (1983). "Bank Runs, Deposit Insurance and Liquidity." *Journal of Political Economy*, 85,191-206.

[6] Goldfajn, Ilan and Rodrigo Valdés. (1998). "The Twin Crises and the Role of Liquidity." Manuscript.

[7] Jacklin, Charles J. (1987). "Demand Deposits, Trading Restrictions, and Risk Sharing." in *Contractual Arrangements for Intertemporal Trade,* edited by Ed Prescott and Neil Wallace, University of Minnesota Press, 26-47.

[8] Jacklin, Charles J. (1993). "Market Rate versus Fixed Rate Demand Deposits." *Journal of Monetary Economics*, 32, 237-258.

[9] Kaminsky, Graciela and Carmen Reinhart. (1999). "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems." *American Economic Review*, 89, June, 473-500.

[10] Rodrik, Dani and Andrés Velasco. (1999). "Short-Term Capital Flows." in *Annual World Bank Conference on Development Economics,* edited by Boris Pleskovic and Joseph Stiglitz, pp. 59-90.

[11] Smith, Bruce D. (2001). "Appendix to Monetary Policy, Banking Crises and the Friedman Rule." *Manuscript*.

[12] Smith, Bruce D. (2002). "Monetary Policy, Banking Crises and the Friedman Rule." *AER Papers and Proceedings,* 92, 128-134.

[13] Ulan, Michael K. (2000). "Is a Chilean-Style Tax on Short-Term Capital Inflows Stabilizing?" *Open Economies Review*, 11, 149-177.

[14] von Thadden, Ernst-Ludwig. (1997). "The Term Structure of Investments and the Bank's Insurance Function." *European Economic Review*, 41, 1355-1374.