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THREE ESSAYS ON BANKING CRISES

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Contents

Dedicatoria

A mis padres, José y Chela, por acompañarme, comprenderme y motivarme.

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Resumen

En el capítulo I se presenta el estado actual de la literatura bancaria y se plantean los principales problemas aún no resueltos y que se investigarán en los siguientes capítulos. En el capítulo II se analiza el rol de la información y de las diferentes estructuras del sistema bancario en la generación de pánicos y sus posibles efectos sobre el resto del sistema bancario a través del contagio. Se presentan posibles medidas para prevenirlos como la utilización de las líneas de crédito contingente. El capítulo III analiza el rol de los grandes depositantes, aquellos con más incentivos a monitorear la actividad bancaria, en la prevención de posibles problemas de riesgo moral de los banqueros. Por último, en el capítulo IV, se plantean algunos inconvenientes que puede generar aumentar los impuestos cuando la economía entra en recesión, como son las crisis bancarias. También se estudian distintas medidas para prevenir tales crisis como la reducción del gasto público o la postergación de la recaudación impositiva.

Chapter 1

General Introduction

1.1 Introduction

Banking crises are costly and quite frequent events which can spread to banks and regions all around the world. During the last twenty five years, more than two thirds of the IMF countries have suffered some kind of financial troubles, a fact which has called attention of researchers (see Lindgren, Garcia and Saal, 1996). However, the exact nature of the transmission mechanism and the best ways to diminish the impact of the crises are still unresolved.

It has been estimated that the recent bankruptcies in Thailand, Indonesia, South Korea and Japan had an approximate cost of one hundred thousand million of dollars for the IMF (see Beim and Calomiris, 2001). These crises, together with the ones suffered in Scandinavia at the beginning of the nineties and in Latin America (Mexico, Argentina, Brazil, and Venezuela) at the end of the XX century, stimulated a vast literature on bank runs and contagion. Nevertheless, the literature on financial contagion through the banking sector is newer and less developed, although it is not a new phenomenon.

In these papers, the term "contagion" will refer to the transmission of an idiosyncratic shock that affects one bank or possibly a group of banks, and how this shock is transmitted to other banks or banking sectors. This notion of contagion is part of the broader concept of systemic risk , which may result from contagion or a common shock affecting all banks simultaneously.

Banking crises have shed light on the fact that the financial system, and especially the banking sector, not only can amplify and transfer problems originated in one sector of the economy, but can also be a main driver of such crisis. Another important fact is that banking problems are difficult to eradicate and they may survive once the economies are recovered. This phenomenon is stimulated by the high capital mobility and open financial systems. While emergent economies usually benefit from such inflows when the system is at rest, it is at the cost of higher vulnerability during the crisis.

Prudential regulation in the form of liquidity or capital requirements are designed to enhance the resilience to shocks of financial systems by requiring institutions to maintain prudent levels of liquidity and capital under a broad range of market conditions. However, at times of market turbulence the remedial actions prescribed by these regulations may have perverse effects on systemic stability. Forced sales of assets may feed back on market volatility and produce a downward spiral in asset prices, which in turn may affect adversely other financial institutions (Cifuentes, Ferrucci and Shin, 2005). The aim of this introduction is to revise the existing literature on financial crises and, more specifically, in the financial contagion issue and to provide the background for the rest of the dissertation.

1.2 Banking Crises

We should not start analyzing contagion without discussing the existing literature on banking panics. Given the historical importance of banking crises remarked by the recent episodes around the world, a huge literature has emerged trying to analyze the causes of its occurrence, and the best policies to prevent and remove its effects. Although there is lot of controversy concerning the causes of global banking crises, there exists now some consensus concerning the main source of fragility for individual banks: the fractional reserve system, under which long term, illiquid, loans or investments are financed by deposits on demand.

1.2.1 Bank Runs

There are two views in the theoretical literature: one is the pure panic view pioneered by Diamond and Dybvig (1983). The other is the information based view where bank runs are triggered by information asymmetries and uncertain returns.

Diamond and Dybvig (1983) formalize the idea of the demand for liquidity, which was previously introduced by Bryant (1980), and analyze bank runs as a coordination problem among depositors, even in the presence of safe assets. The service that allows better risk sharing among people with different consumption horizons (and provides the rationale for the existence of banks), makes banks vulnerable to runs.

Whenever a large fraction of depositors decide to withdraw, it is individually rational for others to do the same, thus provoking an inefficient bank run. This will happen when the bank under attack is forced to liquidate prematurely its assets. In the absence of aggregate uncertainty, suspension of convertibility can impede the bank run equilibrium, while under other circumstances deposit insurance would be preferred.[1]

The alternative view stresses problems of uncertainty and asymmetric information about banks' financial conditions as the source of bank runs. Chari and Jagannathan (1988) argue that runs occur when some individuals receive a signal about bank's return which may lead them to withdraw funds early. Others must then try to deduce from observed behavior whether an unfavorable signal was received by this group or whether liquidity needs happen to be high. Here, both information induced and pure panic runs occur because uninformed depositors misinterpret liquidity shocks as bad news about the condition of bank assets. Hence, a public policy should aim at reducing informational asymmetries.

Jacklin and Bhattacharya (1988) consider the choice between deposit and equity contracts in an environment where some agents receive superior information about future expected return, while Green and Lin (2003) and Peck and Shell (2003) analyze more flexible theoretical contracts that allow the bank to condition the payment to each depositor on the number of agents who claimed early withdrawal before her.

[1] Gorton (1988) provides several critics to this model, namely, that bank runs are not "pure random".

In this environment they obtain different results, while Green and Lin show that the mechanism that supports the constrained-efficient allocation does not permit a bank-run equilibrium, Peck and Shell provide examples where bank runs can occur in equilibrium under the optimal deposit contract, if the bank run is triggered by sunspots.

Cooper and Ross (2002) argue that deposit insurance alone will not provide adequate incentives for depositors, they will not monitor banks, and consequently banks will invest in excessively risky projects. However, the requirement that banks put up a minimum amount of their capital, along with full deposit insurance, can restore the first-best allocation.

Goldstein and Pauzner (2004) analyze the conditions under which banks increase welfare overall, and construct a demand-deposit contract that trades off the benefits from liquidity against the costs of runs, while Samartín (2003) provides a model where, in the presence of risky assets and aggregate uncertainty, some individuals are better informed about bank's asset quality. She shows that although it is optimal for the bank to prevent runs, in some situations the bank run allocation is welfare superior.

In a recent paper, Chen and Hasan (2006) use a simple model to answer whether greater information transparency always increases bank safety and improves depositor welfare. They find that greater informational transparency may reduce depositor welfare by increasing the chance of an inefficient bank run. Building in their model but introducing a government who raises taxes so as to provide public services, chapter IV shows that a government might be responsible of a banking crisis. This is due to the fact that the government has to compete with the private sector for those funds. Then, during a recession, banks will find it difficult to get enough liquidity.

The literature on banks and bank runs that emerged from the Diamond and Dybvig model is vast, and cannot be fully covered here. We refer the interested reader to an excellent recent survey by Gorton and Winton (2003).

1.3 Contagion through the Banking System

Linkages among agents in financial markets are a concern because of the risk of financial contagion, that is, the risk that a small shock to one agent will propagate to other agents in a domino effect. This effect occurs if the failure of one financial institution to settle payment obligations triggers a chain reaction that threatens the stability of the whole financial system.

The literature identifies three main channels for financial contagion: The asset market channel, the banking channel, and the currency channel. We will focus our attention on the banking channel. This line of research seeks to extend the seminal[2] contribution of Diamond and Dybvig (1983) from a run in one bank to a collapse of the entire banking system, and they attribute such imperfection in the interbank market to either information asymmetry or limited availability of liquidity.

1.3.1 Theoretical Literature

Antecedents

An interesting antecedent of this literature can be found in Bhattacharya and Gale (1985). They consider many intermediaries, each one having private information only about the proportion of the population that will withdraw from it at the intermediate date. They show that there are welfare gains from setting up institutions such as a central bank or, at any rate, a market for intermediaries to trade in the interim period.

An additional concern of the interbank market is its role in settlement of payments. The maintenance of deposit balances with other banks facilitates the clearing of payments across the banking system. Rochet and Tirole (1996) analyze the effects of interbank lending in generating systemic risk, since banks do not collateralize their exposition to other banks' risk in the interbank market. A natural consequence is the spillover of a crisis in one bank to the whole banking system (domino effect). Interbank credit lines reduce the costs of maintaining reserves at the expense of

[2] For a deeper analysis of the different channels for financial contagion see Kaminsky, Reinhart and Vegh (2003) and Pritsker (2000).

exposing the system to coordination failures, even if all banks are solvent (Freixas, Parigi and Rochet 2000).

Payoff and information externalities might be important in causing inefficient bank runs and contagion. When depositors are differently informed, uniformed depositors have incentives to respond to different sources of information before the value of the bank's assets is revealed. Chen (1999) proposes an incentive-compatible reform of the Federal Deposit Insurance Corporation (FDIC) that can make bank runs an efficient mechanism to discipline banks.

New literature on Contagion

Interbank exposures may lead to domino effects, where the failure of a bank results in the failure of other banks even if the latter are not directly affected by the initial shock. The recent literature has shown that this risk of contagion depends on the structure of the interbank network.

There exist at least two explanations for the rationality of contagion. The first one is an informational one, where the adverse information that precipitates a crisis in one institution also implies adverse information about the other. This view emphasizes correlations in the underlying values across institutions and Bayes learning by rational agents (Chen, 1999).

The second explanation deals with the fact that financial institutions are often linked to each other through direct portfolio or balance sheet connections. Although such linkages may be desirable ex-ante, during a crisis, such balance sheet connections may cause the failure of one institution to spill-over on others by contagion.

Concentrating upon the direct effects of increased risk of default; Allen and Gale (2000) introduce contagion as an equilibrium phenomenon. Banks maintain interbank deposits to insure against imperfectly correlated liquidity shocks, but make them fragile against an "improbable" liquidity preference shock. In such context, the "incompleteness" of the interbank claims will determine the possibility of contagion.

Interbank market claims are said to be "complete" when banks are allowed to maintain deposits in all the other banks in every region.[3] From such extreme case, we have many other possibilities where banks are somehow restricted in their possibility to keep deposits in other banks. The intuition is that banks may specialize in particular areas of business or have closer connections with banks that operate in the same geographical or political unit.

Nevertheless, Allen and Gale do not consider the possibility that the change in depositors behavior might be due to bad news about the evolution of banks portfolio performance and an incomplete market structure of banks.

Allen and Gale's analysis assumes a pecking order for asset liquidation, where short assets are sold before interbank deposits, and interbank deposits before long-term assets. In a paper that changes the pecking order condition, Saez and Shi (2004) show that when a bank becomes bankrupt and the liquidity gap is small, banks holding deposits on the disturbed bank may liquidate their own long assets before liquidating the deposits on the disturbed bank. By doing so, the safe bank can transfer liquidity to the illiquid bank in order to insure later consumers its deposits and impede systemic illiquidity and contagion. They also introduce the concept of liquidity pool, a claim structure where banks are indirectly connected, which guarantees liquidity in the presence of an insolvent bank and impedes contagion. In chapter II it is shown that in order to facilitate the use of the interbank market under incomplete markets, some kind of coordination might be needed. Usually, the Central Bank is the one assuming such a role.

Brusco and Castiglionesi (2007) analyze a model where different regions are subject to different levels of moral hazard, and have negatively correlated liquidity needs. Integrated financial markets increase expected social welfare, but only at the cost of greater financial instability. Consequently, and contrary to Allen and Gale finding, contagion is greater the more interconnected banks are. In chapter II it is shown that similar results are obtained when banks use the interbank market to protect themselves against technological shocks, and not only for liquidity reasons. In chapter III, it is shown that in the presence of a partial deposit insurance, big depositors (those whose deposits are not full insured) have incentives to monitor banks' activity. Moreover, the existence of such depositors would prevent bankers

[3] A region is a spatial metaphor that can be interpreted in several ways. It can correspond to a single bank, a geographical region within a country, a country or a specialized sector within the banking industry.

from investing in high risk investments.

The intuition behind this idea is that in an incomplete structure, contagion is going to be limited to the two adjacent banks, while in a complete structure, contagion will spill-over to all the regions that have suffered the same type of shock in the first period. However, the loss of each region in a complete structure is smaller. Babus (2006) arrives to the opposite conclusion while considering the optimal network structure (her results coincide with the ones of Allen and Gale, 2000). Again, the problem is that there is a trade-off between high losses for a small number of banks (Brusco and Castiglionesi) and small losses for all banks (Babus). However, although the results of Babus are consistent if the failure of a bank occurs in the first period, they are not robust to the failure of the bank occurring in the second period.

In the same line of research, there is the paper by Aghion, Bolton and Dewatripont (2000), that considers the case of a private clearinghouse arrangement as a way to reduce individual banks' insolvency. They conclude that in such environment, a private banking system may not be immune to contagious bank runs, since there is a trade-off between reducing the potential insolvency of individual banks and keeping contagious runs away.

Castiglionesi (2007) analyzes another solution to prevent contagion, when it is due to an unexpected liquidity shortage. In his model, the Central Bank's problem is to choose the optimal level of reserves that ensures enough liquidity in the bad state of nature minimizing its impact on profitable activities. The problem of this model is that it assumes differently informed agents, where banks and individuals share their "ignorance"; the Central Bank has more information about changes in individual preferences. Chapter II of the thesis analyzes how a Central Bank can prevent contagion, using a contingent credit line procedure and without assuming that this institution has superior information.

Leitner (2005), suggests that once the crisis appears banks may be willing to bail out those banks in trouble. The difference with respect to chapter II of the thesis is that in Leitner, the threat of contagion is part of the optimal network design, while in this thesis it is a cost that banks have to bear in order to save on liquidity provisions during good times.

1.4 Three Essays on Banking Crises

Historical events have shown that there is still a lot of work to be done in order to decrease, or at least alleviate the effects of systemic risk. When calm seems to be the rule, a new crisis appears sometimes as a result of "magic" events while other times as the consequence of an accumulation of factors.

Since banks constitute a pillar of the economic system in their activity of capturing funds and transforming them into investment, the threat that a problem at a single bank might spread to the whole financial system, sometimes across the borders, has called the attention of researchers in the incipient literature on "contagion". In the following chapters, three theoretical papers are presented that attempt to give some new insights on how banking problems appear and how they can spread to other banks and regions.

The next two chapters of this dissertation will be devoted to the phenomenon of contagion. Chapter II incorporates costly voluntary acquisition of information à la Nikitin and Smith (2008), in a framework similar to Allen and Gale (2000), without relying on any unexpected shock to model contagion. In this framework, contagion and financial crises are the result of information gathering by depositors, weak fundamentals and an incomplete market structure of banks. It also shows how financial systems entering a recession can affect others with apparently stronger economic conditions (contagion). Finally, this is the first paper to investigate the effectiveness of the Contingent Credit Line procedures, introduced by the IMF at the end of the nineties, as a mechanism to prevent the propagation of crises.

Chapter III incorporates differently informed agents in the model of Brusco and Castiglionesi (2007). It is shown that the monitoring activity by informed depositors might generate a bank run if those depositors can anticipate the appearance of moral hazard problems by banks. The results of the paper suggest that a fractional deposit insurance system can be an optimal instrument to promote market discipline. Moreover, contagion is a very rare event.

Finally, Chapter IV analyses the impact that taxes have on the emergence of financial crises. The accuracy of different policies to prevent banking crises (such as reducing the public budget and taxes, or postponing their collection via taxes on financial transactions) is also analyzed. A key finding of this paper is that even though the government is usually an expected-utility maximizer, it might be responsible for the emergence of banking sector problems since raising taxes reduces the availability of funds for private investments. However, it is shown that consumers might prefer a banking crisis when consuming public services is important enough for them. Finally, a government may face a commitment problem if avoiding crises implies going against its principles, like reducing the provision of public services. This is the first paper that analyzes bank runs due to the presence of taxes so as to provide public services in a closed economy with banks. Moreover, the effectiveness of taxes on financial transactions, which have extensively been used in emerging markets, is investigated.

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Chapter 2

Information Acquisition and Financial Contagion

"*We are giving countries a greater financial incentive to adopt crisis-resistant policies by offering those that do Contingent Credit Lines to protect them from contagion effects*"

Stanley Fisher, First Deputy Managing Director of the IMF (1994 - 2001), Policy Issues Forum, Washington DC, april 28, 2001.

2.1 Introduction

Financial crises are costly and frequent events. During the last twenty five years, more than two thirds of the International Monetary Fund (IMF) member countries have suffered some kind of financial troubles (see Lindgren, Garcia and Saal, 1996 and Beim and Calomiris, 2001).

These financial crises reflect the fact that the financial system, and especially the banking sector, not only can amplify and transfer problems originated in other sectors of the economy, but can also be a main driver of such crises (for example, the financial crises of Mexico 1994, Korea 1997 and Turkey 2000 had the banking sector weaknesses at the core). Financial institutions are often linked to each other through direct portfolio or capital connections that are desirable ex-ante, but during a crisis the failure of one institution can have direct negative effects on the other institutions linked to it (see Rochet and Tirole, 1996; Aghion, Bolton and Dewatripoint, 2000; Freixas and Parigi, 1998; Freixas, Parigi and Rochet, 2000; Allen and Gale, 2000).

This paper provides a novel view on the interplay of sunspots and fundamentals in the development of financial crises. In particular, it does not rely on any unexpected shock to model contagion. It also shows how financial systems entering a recession can affect others with apparently stronger economic conditions (contagion). Finally, this is the first paper to investigate the effectiveness of the Contingent Credit Line procedures, introduced by the IMF at the end of the nineties, as a mechanism to prevent the propagation of crises.

In the present paper, contagion and financial crises are the result of information gathering by depositors and an incomplete market structure of banks. We model a four region economy, where the representative bank of each region has access to an illiquid long term investment project that allows depositors to increase their expected welfare. Half of the banks are going to receive a low return on their investment and will be called "bad banks", the other half will receive a high return on their projects and will be called "good banks". Additionally, banks will maintain interbank linkages to reduce aggregate uncertainty. Nevertheless, full linkages among banks are not always possible and sometimes unstable structures are set and contagion may occur.

We present three different banking market structures. First, a market where all banks maintain interbank linkages (complete market structure). Second, the neighboring case, where banks are just financially connected to their neighbors but indirectly to all the others. Finally, the island case, where each bank keeps linkages with only one bank. We will show that in the complete market structure the first best allocation is achieved. In the neighboring case, different equilibria are possible: a verification equilibrium with partial runs (with and without contagion), a verification equilibrium with total runs, a full-run equilibrium and a no-run equilibrium.

In the verification equilibria depositors gather information and penalize inefficient banks. In one of those equilibria, bank runs only take place in bad banks (partial bank runs), although other banks might be affected as well (contagion). In the second equilibrium, there is a global withdrawal from the banking system in a contagious fashion. There is also a full-run equilibrium, where depositors do not gather information but withdraw in a pure panic way, and one, characterized by no runs and no information gathering. In the island case three different equilibria are possible: the verification equilibrium, the full-run equilibrium, and the no-run equilibrium. In the verification equilibrium, bank runs are partial and there is no contagion. Nevertheless, the expected utility is higher in the neighboring case than in the island case.

The equilibria with crises of the model are fundamentals-based and panic-based at the same time. Bank runs are related to fundamentals, although this does not mean that bad fundamentals per se cause the run. Investors' coordination on a particular equilibrium is triggered by a self-fulfilling prophecy. When the system is at rest, individuals do not find it optimal to gather information and so the model explains why there are periods in which individuals do not modify their expectations on banks. However, if for any reason they decide to invest in information gathering they would penalize those states of nature in which banks establish inefficient links. This would cause the liquidation of bad projects, but it might also generate contagion and financial crises when financial linkages are very inaccurate.

Following, we define the role for a Central Bank as a market completer. The mechanism we analyze is the one similar to the Contingent Credit Line (CCL) of the IMF. The idea of the CCL is to provide a precautionary line of defense for members with sound policies, who are not at risk of an external payments crisis of their own making, but vulnerable to contagion effects from capital account crisis in other countries. We show that the CCL is a powerful mechanism to prevent financial crises in environments characterized by incomplete markets and distrustful depositors.

The lack of strong evidence of contagious bank failures in the periods in which the Central Bank played an active role as a lender of last resort does not disprove the possibility of financial contagion through the banking system. The recent episode (September 2007) of depositors queuing at the Northern Rock bank in the UK trying to withdraw their money, has shown that it is possible to have distrustful depositors even in the presence of deposit insurance, authorities defending the solvency of the institution and a healthy real economy. Additionally, banks in England and other countries in Europe[1]attempting to get more liquidity is a warning of the possibility of

[1]For example, the Deutsche bank had bought 3,56 percent of Northern Rock, consequently, the values of its shares were also affected.

contagion. Our model is an attempt to give some insights into this possibility, and in explaining that a healthy interbank market is crucial in preventing contagious bank failures. It is obvious that more work on anticipating and preventing such crises is needed, and our paper is an attempt to go in such direction.

This paper goes in line with Allen and Gale (2000), Saez and Shi (2004), Leitner (2005) and Brusco and Castiglionesi (2007) in the sense that banks maintain interbank linkages but with the purpose to insure against negatively correlated technological shocks (fundamentals). The proposed model incorporates voluntary costly acquisition of information *à la* Nikitin and Smith (2007), but in our case individuals are not allowed to maintain deposits in different banks, although this is done by banks themselves. This allows us to explain contagion.

As in Allen and Gale (2000), we model contagion as an equilibrium phenomenon. However, we do not require an unexpected event to model contagion. Banks maintain interbank linkages to insure against technological shocks and this makes them fragile against information acquisition by depositors. In such context, the "incompleteness" of the interbank claims will determine the possibility of contagion.

Saez and Shi (2004) introduce the concept of a liquidity pool, a claim structure where banks are indirectly connected, which guarantees liquidity in the presence of an insolvent bank and impedes contagion. In our case the Central Bank provides an efficient solution to overcome financial contagion. As in Castiglionesi (2007), the Central Bank plays the role of a market completer but when the problems are due to fundamentals and not to liquidity ones. Therefore, the results of the present paper indicate that those institutions should be free of intervention by local governments since their objective is to work as a "market completer" or global insurer avoiding the usual political restrictions to capital mobility. Such institutions reallocate resources from developed to underdeveloped economies allowing the system to achieve the first best allocation.

The work by Leitner (2005), introduced the threat of contagion as part of the optimal network design. The idea is that when agents are not linked to one another, agents who have high endowments have no incentive ex-post to help out those who have low endowments. Thus, some positive net present value investments do not take place. On the other hand, when agents are linked to one another, agents with high endowments are willing to bail out those with low endowments, since failure to do so leads all projects to fail by contagion. On the contrary, in the present paper, the linkages appear because banks cannot anticipate the success of their projects, and therefore the possibility of contagion is a cost that banks have to assume.

The seminal contribution by Brusco and Castiglionesi (2007) provides a model where different regions are subject to different levels of moral hazard, and have negatively correlated liquidity needs. Integrated financial markets increase expected social welfare, but only at the cost of greater financial instability. As a consequence, and contrary to Allen and Gale's finding, contagion is greater the more interconnected banks are. They conclude that banks establish links and accept the risk of contagion, only when the risk is not too high. In this respect, it is close to our results for incomplete markets. We find that the more incomplete the banking structure is, read the island case, the less vulnerable to contagion it is. Nevertheless, depositors prefer the neighboring case to the island case.

The rest of the paper is organized as follows: the basic model is presented in section 2. Section 3 describes the social optimal allocation. Section 4, introduces financial intermediaries (banks), and analyzes different market structures and their respective equilibria. Sections 5 shows how a Central Bank provides an efficient solution to overcome financial contagion. Finally, section 6 presents a numerical example and section 7 concludes.

2.2 The Model

We consider a three date (t = 0, 1, 2) economy and one single good. There are two types of assets: A liquid asset that takes one unit of the good at date t and converts it into one unit of the good at date $t+1$ (storage). An illiquid asset that takes one unit of the good at date 0 and transforms it into R^H or R^L units of the good at date 2 depending on the state of nature. It is assumed that $0 \leq R^L < 1 < R^H$ and that the expected return ($\overline{R} = \frac{1}{2}R^L + \frac{1}{2}R^H$) is greater than one. If the illiquid technology is liquidated prematurely at $t = 1$, we obtain r, with $0 \leq r < 1$.

There are four regions in this economy. Each region consists of a continuum of ex-ante identical consumers-depositors with an endowment of one unit of the consumption good at $t = 0$. They are subject at $t = 1$ to a privately observed uninsurable risk of being of either of two types. Type 1 (or impatient) agents derive only utility from consumption in period one and type 2 (or patient) agents derive only utility from consumption in period 2. In addition, type 2 agents can privately store the good from $t = 1$ to $t = 2$. Their utility function is as follows:

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{with probability } \gamma \quad \text{(Type 1)} \\ u(c_2) & \text{with probability } (1-\gamma) \quad \text{(Type 2)} \end{cases} \tag{2.1}$$

Where the utility function $u(.)$ is defined over non-negative levels of consumption, is strictly increasing, strictly concave, twice continuously differentiable, and satisfies Inada conditions. There is no aggregate uncertainty and so the probability γ represents the fraction of early consumers in the economy. Consumer's type is his private information.

There is also a continuum of identical banks in each region, or a representative bank in each region. A bank is a financial institution which invests in the technology on behalf of consumers and provides them with consumption at $t = 1$ or $t = 2$. Each consumer deposits his endowment in the bank at $t = 0$, and in exchange he receives a demand deposit contract. Competition among banks forces them to offer a contract that maximizes the expected utility of the representative consumer. This contract pays a fixed amount at each date, and in the event that this is not possible all available funds will be divided pro rata in proportion to claims (as in Allen and Gale, 1998, we do not assume a sequential service constraint). In particular, the demand deposit contract gives the depositor the right to withdraw either c_1 at $t = 1$ or $c_2(R)$ at $t = 2$. The second period random return reflects the fact that having invested in a random technology, the bank may not be able to make its promised payment at date 2. In this sense the only risk the depositors bear is that they will not be repaid their money in the situation in which it is physically impossible to repay them.

It is also assumed that banks in half of the regions will obtain a high return on their investment project (expansion banks, from now on good banks), and the other half a low one (recession banks, from now on bad banks). Neither bankers nor depositors know the *type* of their own banks nor that of the other ones. Nevertheless, they know the distribution of shocks in the whole economy. The information is revealed to consumers-depositors at $t = 2$, although they can obtain information at $t = 1$ at a cost of ε. This information cost can be understood as a monitoring cost. Although information might be perfect and free, depositors need time and other resources to process it.[2]

Notice that if we consider all banks as a single one there is no aggregate uncertainty concerning technology shocks, since $\bar{R} = \frac{1}{2}R^L + \frac{1}{2}R^H$. Finally, it is assumed that depositors cannot deposit in banks in more than one region.

2.3 Social Optimum

The problem of the social planner is to maximize the expected welfare of a representative consumer. We will focus on the range of parameters under which the social planner should never interrupt illiquid technology investment at $t = 1$[3] and even inefficient projects should be completed and resources on verification should not be spent. The social planner should use storage to provide for consumption of impatient agents. The planner maximizes:

$$\underset{\{x,y,c_1,c_2\}}{Max} \ \gamma u(c_1) + (1-\gamma)u(c_2), \tag{2.2}$$

subject to

$$x + y \leq 1; \tag{2.3}$$

$$\gamma c_1 \leq y; \tag{2.4}$$

$$(1-\gamma)c_2 \leq \overline{R}x; \tag{2.5}$$

$$x \geq 0; \quad y \geq 0; \quad c_1 \geq 0; \quad c_2 \geq 0. \tag{2.6}$$

Where y is the amount invested in storage, x is the amount invested in the illiquid technology, c_1 is the consumption of impatient consumers and c_2 the consumption of patient ones. Equation (2.2) is the expected utility to be maximized. Equation (2.3) is the date 0 constraint which states that all the resources should be used for storage or investment and equation (2.4) the first period one. It states that the amount of storage should be enough to provide for consumption of type 1 consumers. Similarly, equation (2.5) shows that the consumption of type 2 consumers comes from the illiquid technology.

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[2] See Nikitin and Smith (2007) for a discussion of this assumption.

[3] Verification is never socially optimal for values of ε, such that, $\varepsilon \geq \varepsilon^* = \max\{\frac{1}{2}(r - \frac{R^L}{\overline{R}}), 0\}$. For a detailed derivation of this result, see Nikitin and Smith (2007).

Optimality requires that the feasibility constraints are satisfied with equality, so we can write the problem as

$$\underset{y\epsilon[0,1]}{Max}\ \gamma u\left(\frac{y}{\gamma}\right)+(1-\gamma)\,u\left(\frac{1-y}{1-\gamma}\overline{R}\right) \tag{2.7}$$

Since $u(.)$ is strictly concave and satisfies the Inada conditions, the solution to problem (2.7) is unique and interior. The optimal value $y^*\epsilon(0,1)$ is obtained from the first order condition

$$u'\left(\frac{y^*}{\gamma}\right)=\overline{R}u'\left(\frac{1-y^*}{1-\gamma}\overline{R}\right) \tag{2.8}$$

and once y^* has been determined by equation (2.8) we can use the feasibility constraints to determine the other variables:

$$c_1^*=\frac{y^*}{\gamma},\qquad c_2^*=\frac{(1-y^*)}{1-\gamma}\overline{R},\qquad x^*=1-y^* \tag{2.9}$$

Notice that (2.8) and (2.9) imply that $u'(c_1^*)=\overline{R}u'(c_2^*)$, which in turn implies $u'(c_1^*)>u'(c_2^*)$ and $c_2^*>c_1^*$. Thus, the first-best allocation automatically satisfies the incentive constraint $c_2\geq c_1$, that is late consumers have no incentive to behave as early consumers. We will call $\Psi^*\equiv(y^*,x^*,c_1^*,c_2^*)$ the first-best allocation, and U^* the expected utility achieved under the first best allocation.

2.4 Decentralized Economy with Banks

Decentralization of the social optimal allocation can be achieved in the same way as in Allen and Gale (2000). Each bank issues demand deposits contracts. These deposits pay $c_1^*=\frac{y^*}{\gamma}$ if withdrawn in the first period, provided that the bank is solvent. In the second period all remaining assets are liquidated and allocated among deposit holders on a *pro rata* basis.

Each bank stores y^* share of the period 0 deposit, and invests the rest in the illiquid technology. The amount of storage technology should be enough to just satisfy the liquidity needs of impatient agents. Additionally, banks are going to establish linkages ex ante, in order to insure against the technology shock. Let z_{ij} be defined as the loan that bank j receives from bank i (by assumption $z_{ij}=z_{ji}$). Given that agents are risk averse, and that the bank type may be revealed only in period 1, it is optimal that bank i spreads interbank loans for an amount of

$z_i = [\frac{n}{n+1}] = \sum_{j=1, j\neq i}^{n+1} z_{ij}$ across the banking system (where n is the number of links each bank has). This interbank loans pays $z_{ij}R^H x$ if kept until t = 2, when the bank is of a good type, and $z_{ij}R^L x$ when the bank is of a bad type.[4] If liquidated at t = 1, it will pay the same as other deposits withdrawn in the first period ($z_{ij}c_1$). Recall that the interbank loans are compensated simultaneously between banks, so if bank 1 decides to cancel its interbank loan at $t = 1$, it will also have to pay back its obligation with the other banks in that period.

With four banks there are three types of financial linkages that are symmetrical: 1) the full linked case (complete market structure), 2) the neighboring case, and 3) the island case (the last two cases are examples of incomplete market structures).[5] We assume that the structure of the banking system is known at the very beginning but not the type of each bank nor that of the depositor.

2.4.1 Complete Market Structure

In the complete market structure (full linked case), each bank is linked to three other banks and therefore there is only one possible state of nature which is represented in figure 1.

From now on, G_1 and G_4 are going to be the good banks and B_2 and B_3 the bad banks. A number 1 in the matrix means that there is a linkage between those banks. In this case, $z_i = \frac{3}{4}$ and $z_{ij} = \frac{1}{4}$. In the presence of full linkages among banks, the first best equilibrium is achievable.

	G_1	B_2	B_3	G_4
G_1	0	1	1	1
B_2	1	0	1	1
B_3	1	1	0	1
G_4	1	1	1	0

Figure 1: Complete Market Structure

[4]This structure of interbank loan payments facilitates savings in monitoring costs while profiting from diversification. It may also be interpreted as banks' shares in other banks in the system.

[5]We use symmetrical allocations for simplicity of exposition. However, similar results can be obtained with non symmetrical linkages.

The demand deposit contract is obtained as a solution to the following problem:

$$\underset{\{x,y,c_1,c_2\}}{Max} \ \gamma u(c_1) + (1-\gamma)[\frac{1}{2}u(c_2^B) + \frac{1}{2}u(c_2^G)], \tag{2.10}$$

subject to

$$x + y + z_j - z_i \leq 1; \tag{2.11}$$

$$\gamma c_1 \leq y; \tag{2.12}$$

$$(1-\gamma)c_2^B \leq [R^L(1-z_j) + R^L z_{ij} + R^H z_{ij} + R^H z_{ij}]x; \tag{2.13}$$

$$(1-\gamma)c_2^G \leq [R^H(1-z_j) + R^L z_{ij} + R^L z_{ij} + R^H z_{ij}]x; \tag{2.14}$$

$$\frac{1}{2}u(c_2^B) + \frac{1}{2}u(c_2^G) \geq u(c_1); \tag{2.15}$$

$$x \geq 0; \quad y \geq 0; \quad c_1 \geq 0; \quad c_2^B \geq 0; \quad c_2^G \geq 0; \quad z_i = z_j = \sum_{j=1, j\neq i}^{4} z_{ij}; \tag{2.16}$$

where c_2^G represents second period consumption in a good type bank and c_2^B second period consumption in a bad type one. z_j are total interbank loans received from other banks in the system and obviously $z_j = z_i = \sum_{j=1,j\neq i}^{4} z_{ij}$. Equation (2.10) is the expected utility to be maximized. Equation (2.11) is the period 0 constraint and equation (2.12) the first period one. Equations (2.13) and (2.14) correspond to the second period constrains, in the case of a bad bank and a good bank, respectively.

Given that each bank has an obligation equal to $z_j \widetilde{R}_i x$ with the rest of the system and at the same time has the right to receive $z_i \widetilde{R}_j x$ from the other banks; the resources available in the second period are given by the return of the projects minus the obligations with the system plus the right to receive from other banks: $[\widetilde{R}_i - z_j \widetilde{R}_i + z_i \widetilde{R}_j]x$, where $\widetilde{R}_i$ is the expected return from our technology, and $\widetilde{R}_j$ is the expected return from our neighbors. Finally, equation (2.15) is the incentive compatibility constraint, that guarantees that type 2 depositors do not have incentives to imitate type 1 depositors.

It is straightforward to see that $c_2^B = c_2^G = c_2$ and $[R^L(1-z_j) + R^L z_{ij} + R^H z_{ij} + R^H z_{ij}] = \overline{R}$; and therefore we have the same problem as in the social optimum given by equations (2.2) to (2.9). Since $c_2^* > c_1^*$, each agent has incentives to respect his type, and the social optimal allocation is attained. It is never optimal for consumers to spend resources in obtaining information about the type of the bank in the first period. This result is summarized in the following proposition.

Proposition 1 *The first best allocation Ψ^* is attainable in a complete market structure.*

2.4.2 The Neighboring Case

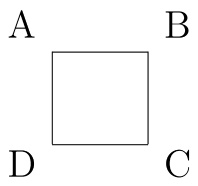

Figure 2: The Neighboring Case

In the neighboring case, banks are financially connected to two other banks in the system forming a close group. Given political, geographical and/or historical reasons, some regions like A and C or B and D in figure 2 are not directly connected although they are indirectly connected through their neighbors.

Bankers and consumers-depositors know this information from the very beginning, although they don't know in which type of bank they are nor the type of their neighbor banks (they just know the structure of the game). Nevertheless, depositors can obtain this information at $t = 1$ at a cost of ε.

We have three possible states of nature: One case where a good bank is linked to two bad ones or a bad bank connected to two good ones, figure 3 (a), and two cases where a good bank is connected to one good bank and one bad one, figures 3 (b) and (c). All states are going to be equally probable, and are represented in the following matrices:

	G_1	B_2	B_3	G_4
G_1	0	1	1	0
B_2	1	0	0	1
B_3	1	0	0	1
G_4	0	1	1	0

(a) State I

	G_1	B_2	B_3	G_4
G_1	0	1	0	1
B_2	1	0	1	0
B_3	0	1	0	1
G_4	1	0	1	0

(b) State II

	G_1	B_2	B_3	G_4
G_1	0	0	1	1
B_2	0	0	1	1
B_3	1	1	0	0
G_4	1	1	0	0

(c) State III

Figure 3. States of nature in the Neighboring Case

However, those three states of nature can be separated into two: that of figure 3(a) with probability $\frac{1}{3}$ and those of figure 3(b) and figure 3(c) with probability $\frac{2}{3}$. In the neighboring case, each bank will maintain total interbank loans of $\mathrm{z}_i = \frac{2}{3}$ and so $\mathrm{z}_{ij} = \frac{1}{3}$. Now, consumers-depositors are going to solve the following problem:

$$\underset{\{x,y,c_{1N},\{c_{2i}^t\}_{i=L,H}^{t=1,2}\}}{Max} \gamma u(c_{1N}) + (1-\gamma)\left\{\frac{1}{2}\left[\frac{1}{3}u(c_{2L}^1) + \frac{2}{3}u(c_{2L}^2)\right] + \frac{1}{2}\left[\frac{1}{3}u(c_{2H}^1) + \frac{2}{3}u(c_{2H}^2)\right]\right\} \tag{2.17}$$

subject to

$$x + y - z_i + z_j \leq 1; \tag{2.18}$$

$$\gamma c_{1N} \leq y; \tag{2.19}$$

$$(1-\gamma)c_{2L}^2 \leq \left[R^L(1-z_j) + R^H z_{ij} + R^L z_{ij}\right] x = \left[\frac{2}{3}R^L + \frac{1}{3}R^H\right] x; \tag{2.20}$$

$$(1-\gamma)c_{2L}^1 \leq \left[R^L(1-z_j) + R^H z_{ij} + R^H z_{ij}\right] x = \left[\frac{1}{3}R^L + \frac{2}{3}R^H\right] x; \tag{2.21}$$

$$(1-\gamma)c_{2H}^1 \leq \left[R^H(1-z_j) + R^L z_{ij} + R^L z_{ij}\right] x = \left[\frac{1}{3}R^H + \frac{2}{3}R^L\right] x; \tag{2.22}$$

$$(1-\gamma)c_{2H}^2 \leq \left[R^H(1-z_j) + R^L z_{ij} + R^H z_{ij}\right] x = \left[\frac{2}{3}R^H + \frac{1}{3}R^L\right] x; \tag{2.23}$$

$$\frac{1}{2}\left[\frac{1}{3}u(c_{2L}^1) + \frac{2}{3}u(c_{2L}^2)\right] + \frac{1}{2}\left[\frac{1}{3}u(c_{2H}^1) + \frac{2}{3}u(c_{2H}^2)\right] \geq u(c_{1N}); \tag{2.24}$$

$$x \geq 0; \quad y \geq 0; \quad z_i = \sum_{j \epsilon \{i-1,i+1\}} z_{ij}; \tag{2.25}$$

$$c_{1N} \geq 0; \quad c_{2L}^1 \geq 0; \quad c_{2L}^2 \geq 0; \quad c_{2H}^1 \geq 0; \quad c_{2H}^2 \geq 0; \tag{2.26}$$

where c_{1N} is the consumption of impatient consumers, c_{2L}^1 (c_{2H}^1) is the consumption of a patient depositor in a bad (good) bank in state 1, and c_{2L}^2 (c_{2H}^2) is the consumption of a patient depositor in a bad (good) bank in states 2 and 3. Equation (2.17) is the expected utility to be maximized. The first row of the objective function is the expected consumption of type 1 agents and the expected consumption of type 2 agents in a bad bank. The second row represents the expected consumption of type 2 agents in a good bank. Equation (2.18) is the period 0 constraint, where as before y is the amount invested in storage, x the amount invested in the illiquid asset and z_j (z_i) are total interbank loans received from (given to) the neighbor banks. Equation (2.19) is the first period constraint, and equations (2.20) to (2.23) are the second period ones, that will depend on the bank type and the state. Equation (2.20) corresponds to the case where a depositor is at a bad bank that is in states 2 or 3. The equation states that the consumption offered to patient depositors comes from the bank's project return ($R^L x$), less its obligations with the banking system ($z_j R^L x$) plus the funds received from its neighbors ($z_{ij} R^H x + z_{ij} R^L x$). Equation (2.21) corresponds to the case of a bad bank in state 1. The bad bank is connected to two good banks. Similarly, equation (2.22) represents the contract offered to patient depositors by a good bank that is in states 2 or 3, while equation (2.23) is the one offered by a good bank that is in state 1. Finally, equation (2.24) is the incentive compatibility constraint, which is expressed in expected terms, as the bank ignores both its return and that of its neighbors.

Although $c_{2L}^1 = c_{2H}^2 = c_2^H$ and $c_{2L}^2 = c_{2H}^1 = c_2^L$, we will treat them separately because they will have different consequences in understanding the equilibria.

Let

$$\overline{\Psi} = \left\{ \overline{y}, \overline{x}, \overline{c_{1N}}, \{\overline{c_{2i}^s}\}_{i=L,H}^{s=1,2} \right\}$$

be the optimal allocation offered to consumers-depositors in an incomplete market structure of the neighboring case. It will be shown that in this case the first best allocation is not achievable. In the neighboring case, a depositor would find it optimal ex-post to liquidate his deposits prematurely if the cost of obtaining information about their bank type in the first period is not too high, and provided other depositors are also acquiring information.

Equilibria with liquidation and Contagion in the Neighboring Case

In this case, the possible equilibria are: a verification equilibrium with partial runs (with and without contagion), a verification equilibrium with total runs, a full-run equilibrium and a no-run equilibrium. In the last two equilibria, depositors do not verify the type of banks. They either withdraw from all banks or do not acquire information and do not withdraw.

As shown below, if condition (2.27) is satisfied, when depositors verify the type of banks, and they are in states 2 or 3, it is always optimal to withdraw their deposits from bad banks. As a result, these banks have to liquidate their technology and their interbank loans, and will be able to pay a total amount of $\widehat{c_{1N}} = \frac{xr+y+z_{ij}\overline{c_{1N}}}{1+z_{ij}} < \overline{c_{1N}}$.[6] On the other hand, the good bank will have to liquidate part of its long term asset in order to pay its interbank loans to the bad bank; however it won't enter into a bank run as long as $\widehat{c_{2H}} = \frac{R^H(1-\lambda)x}{(1-\gamma)} > \overline{c_{1N}}$, where λ is the proportion of the investment in the long term asset that has to be liquidated in the first date in the good bank in order to be able to guarantee the promised consumption of $\overline{c_{1N}}$.[7]

Nevertheless, if second period consumption in the good bank is less than the promised one, that is, $\widehat{c_{2H}} < \overline{c_2^H}$, the good bank is affected by contagion and is contractually bankrupt. This is the case of a verification equilibrium with partial bank runs and contagion. There is contagion because the expansion bank, even if it does not experience a run, it cannot pay its promised consumption to its late consumers.[8]

Another interesting case is the one of state 1, where a good bank is connected to two bad banks. In this state, depositors of good banks will generate a financial crisis due to the fundamentals of bad banks. As $\overline{c_{1N}} > \overline{c_2^L}$ patient depositors have incentives to withdraw from the good banks (note that $\overline{c_{2L}^2} = \overline{c_{2H}^1} = \overline{c_2^L}$). On the other hand, if we define $\widehat{c_{2L}} = \frac{xR^L(1-\lambda)}{(1-\gamma)}$, where as before λ is the proportion of the investment in the long term asset that has to be liquidated in the first date in the bad bank in order to be able to guarantee a consumption of $\overline{c_{1N}}$, then as $\widehat{c_{2L}} < \overline{c_{1N}}$ patient depositors will also withdraw from bad banks. The curiosity is that if patient depositors of good banks wait until t = 2, they would receive less than depositors from bad banks. In this verification equilibrium with total bank runs all depositors receive $xr + y$.[9]

[6] Notice that $\widehat{c_{1N}} = \frac{xr+y+z_{ij}\overline{c_{1N}}+z_{ij}\widehat{c_{1N}}}{1+z_i}$, where the numerator represents assets available given by the liquidation of the long term asset, the storage technology and liquidation of interbank loans with the good and the bad bank respectively. The liabilities of the bank are given by the denominator of the equation. Therefore, $\widehat{c_{1N}} = \frac{xr+y+z_{ij}\overline{c_{1N}}}{1+z_{ij}}$.

[7] with $\lambda = \frac{[\overline{C_{1N}}(\gamma+z_{ij})-y-z_{ij}\widehat{C_{1N}}]}{rx}$.

[8] This verification equilibrium with contagion will occur whenever λ is greater than a value λ^*, for which $\widehat{c_{2H}} = \overline{c_2^H}$, that is, $\lambda^* = \frac{1/3(R^H-R^L)}{R^H}$. We thank the reviewer for pointing out this possibility.

[9] This equilibrium takes place because of the linkages that good banks have established ex ante, due to the uncertainty about the future return. Finally, those linkages result in worse than being alone. This can be the case of depositors of banks in developed countries disapproving of their banks investing in other banks in underdeveloped countries.

The following propositions describe conditions for the existence of the different equilibria. All proofs are contained in the appendix.

Proposition 2 *In states 2 and 3, there is a verification equilibrium in which only bad banks are liquidated and good banks can either be affected or not by contagion, whereas in state 1, all depositors will withdraw their deposits generating a financial crisis based on fundamentals.*

The previous statement is going to be true when the following conditions are satisfied:

$$\overline{c_{1N}} \geq \overline{c_2^L} \tag{2.27}$$

$$\widehat{c_{2H}} \geq \overline{c_{1N}} \tag{2.28}$$

$$\frac{1}{3}u(\widehat{c_{2H}} - \varepsilon) + \frac{1}{3}u(xr + y - \varepsilon) + \frac{1}{3}u(\widehat{c_{1N}} - \varepsilon) \geq \frac{1}{3}u(\widehat{c_{2H}}) + \frac{2}{3}u(0) \tag{2.29}$$

$$\frac{1}{3}u(\widehat{c_{2H}} - \varepsilon) + \frac{1}{3}u(xr + y - \varepsilon) + \frac{1}{3}u(\widehat{c_{1N}} - \varepsilon) \geq \frac{1}{3}u(\overline{c_{1N}}) + \frac{1}{3}u(\widehat{c_{1N}}) + \frac{1}{3}u(xr + y) \tag{2.30}$$

Equation (2.27) indicates that the lowest possible consumption in the second period is smaller than consumption promised to impatient depositors. As a result it is optimal for patient depositors of bad banks in states 2 and 3 to withdraw their deposits in the first period (as well as for patient depositors of good banks in state 1). Equation (2.28) guarantees that good banks will have enough resources to compensate patient depositors and avoid a bank run in states 2 and 3.

Finally, equations (2.29) and (2.30) state that if all other depositors are playing the verification equilibrium it is optimal to play it.[10]

Additionally, we still have the traditional equilibria, which are given in the following proposition:

Proposition 3 *The no-run and the full run are also Nash Equilibria of this game, if the following conditions are satisfied:*

$$\frac{1}{2}u(\overline{c_2^H}) + \frac{1}{2}u(\overline{c_2^L}) \geq u(\overline{c_{1N}}) \tag{2.31}$$

[10]For a better description of these two equations, see the Appendix A.

$$\frac{1}{2}u(\overline{c_{1N}} - \varepsilon) + \frac{1}{2}u(\overline{c_2^H} - \varepsilon) \leq \frac{1}{2}u(\overline{c_2^H}) + \frac{1}{2}u(\overline{c_2^L}) \tag{2.32}$$

$$\overline{c_{1N}} \geq r \tag{2.33}$$

Equations (2.31) and (2.32) guarantee that an agent has no incentive to deviate in the no run equilibrium. Equation (2.31) is the incentive compatibility constraint while equation (2.32) guarantees that the benefit obtained by verifying and withdrawing when the outcome is inefficient, is lower than the expected utility achieved in the no-run equilibrium. Finally, equation (2.33) guarantees the existence of the full run equilibrium. This condition says that if all depositors withdraw in the first period, neither good nor bad banks have enough resources to pay them the promised amount of $\overline{c_{1N}}$.

2.4.3 The Island Case

In the island case, each bank is financially connected to just one bank in the system. As a consequence, we also have three possible states: One case where a good bank is connected to the other good and the bad bank to the other bad one, figure 4(a) and two cases where a good bank is linked to a bad bank, figure 4(b) and figure 4(c). Each state is going to be equally probable.

	G_1	B_2	B_3	G_4
G_1	0	0	0	1
B_2	0	0	1	0
B_3	0	1	0	0
G_4	1	0	0	0

(a) State I

	G_1	B_2	B_3	G_4
G_1	0	0	1	0
B_2	0	0	0	1
B_3	1	0	0	0
G_4	0	1	0	0

(b) State II

	G_1	B_2	B_3	G_4
G_1	0	1	0	0
B_2	1	0	0	0
B_3	0	0	0	1
G_4	0	0	1	0

(c) State III

Figure 4. States of nature in the Island Case

In this case, banks will maintain total interbank loans of $z_i = \frac{1}{2}$ and so $z_j = \frac{1}{2}$.

Now, consumers-depositors are going to solve the following problem:

$$\underset{\{x,y,c_1,\{c_{2i}^t\}_{i=L,H}^{t=1,2}\}}{Max} \quad \gamma u(c_{1I}) + (1-\gamma)\left\{\frac{1}{2}\left[\frac{2}{3}u(c_{2L}^B) + \frac{1}{3}u(c_{2L}^A)\right] + \frac{1}{2}\left[\frac{1}{3}u(c_{2H}^A) + \frac{2}{3}u(c_{2H}^B)\right]\right\} \tag{2.34}$$

subject to

$$x + y - z_i + z_j \leq 1; \tag{2.35}$$

$$\gamma c_{1I} \leq y; \tag{2.36}$$

$$(1-\gamma)c_{2L}^A \leq [R^L(1-z_j) + R^L z_i]x = R^L x; \tag{2.37}$$

$$(1-\gamma)c_{2L}^B \leq [R^L(1-z_j) + R^H z_i]x = [\frac{1}{2}R^L + \frac{1}{2}R^H]x; \tag{2.38}$$

$$(1-\gamma)c_{2H}^A \leq [R^H(1-z_j) + R^H z_i]x = R^H x; \tag{2.39}$$

$$(1-\gamma)c_{2H}^B \leq [R^H(1-z_j) + R^L z_i]x = [\frac{1}{2}R^H + \frac{1}{2}R^L]x; \tag{2.40}$$

$$\frac{1}{2}[\frac{2}{3}u(c_{2L}^B) + \frac{1}{3}u(c_{2L}^A)] + \frac{1}{2}[\frac{1}{3}u(c_{2H}^A) + \frac{2}{3}u(c_{2H}^B)] \geq u(c_{1I}) \tag{2.41}$$

$$x \geq 0; y \geq 0; c_{1I} \geq 0; c_{2L}^A \geq 0; c_{2L}^B \geq 0; c_{2H}^A \geq 0; c_{2H}^B \geq 0 \tag{2.42}$$

where c_{1I} is the consumption of an impatient consumer, c_{2L}^A (c_{2H}^A) is the consumption of a patient depositor of a bad (good) bank in state I, and c_{2L}^B (c_{2H}^B) is the consumption of a patient depositor of a bad (good) bank in states II and III. Equation (2.34) is the expected utility to be maximized. The first row of the objective function is the consumption of type 1 agents and the expected consumption of type 2 agents in a bad bank. The second row represents the expected consumption of type 2 agents in a good bank. Equation (2.35) is the period 0 constraint, where y is the amount invested in storage, x the amount invested in the illiquid asset and z_j (z_i) are total interbank loans received from (given to) the partner bank. Equation (2.36) is the first period constraint, and equations (2.37) to (2.40) are the second period ones, that will depend on the bank type and the state. Equation (2.37) corresponds to the case of a bad bank in state I. It states that the consumption of patient depositors comes from the banks's return ($R^L x$), less its obligation with the system ($z_j R^L x$), and from the return obtained from the other bank ($z_{ij} R^L x$). Equation (2.38) corresponds to the case of a bad bank in states II and III. Similarly, equation (2.39) refers to the case of a good bank in state I and equation (2.40)represents the case of a good bank in states II and III. Finally, equation (2.41) is the incentive compatibility constraint, which is expressed in expected terms, as the bank ignores both its return and that of its neighbors.

Let

$$\hat{\Psi} = \left\{ \hat{y}, \hat{x}, \hat{c}_{1I}, \{\hat{c}_{2i}^{s}\}_{i=L,H}^{s=A,B} \right\}$$

be the optimal allocation offered to consumers-depositors in an incomplete market structure of the island case. It will be shown that the equilibrium achieved in the island case is worse than the first best allocation achieved in the complete market structure and also worse than the second best offered in the neighboring case.

Equilibria with liquidation in the Island Case

In the island case, three different equilibria are possible: a verification equilibrium (with partial bank runs), a full-run equilibrium and a no run-equilibrium.

In the verification equilibrium, depositors verify the type of banks, and withdraw from bad ones. As a result, in state I, impatient and patient depositors of bad banks will receive $xr + y$. Impatient depositors of good banks will receive $\widehat{c}_{1I}$, while patient depositors of good banks will receive $\widehat{c}_{2H}^{A}$. In the other two cases (states II and III), impatient depositors will receive $\hat{c}_{1I}$, while patient depositors will receive $\hat{c}_{2H}^{B} = \hat{c}_{2L}^{B} = \hat{c}_{2}^{T}$.

The difference with the verification equilibrium of the neighboring case is that NO contagion occurs.

The following propositions describe conditions for the existence of the different equilibria. All proofs are contained in the appendix.

Proposition 4 *In state I of the Island case, there is a verification equilibrium where depositors of bad banks withdraw their deposit in the first period due to fundamentals and depositors of good banks wait until $t = 2$ and obtain the maximum return, if the following conditions are satisfied:*

$$\hat{c}_{1I} \geq \hat{c}_{2L}^{A} \tag{2.43}$$

$$\frac{2}{3}u(\hat{c}_2^T - \varepsilon) + \frac{1}{6}(xr + y - \varepsilon) + \frac{1}{6}(\hat{c}_{2H}^A - \varepsilon) \geq \frac{2}{3}u(\hat{c}_2^T) + \frac{1}{6}u(0) + \frac{1}{6}u(\hat{c}_{2H}^A) \quad (2.44)$$

$$\frac{2}{3}u(\hat{c}_2^T - \varepsilon) + \frac{1}{6}u(xr + y - \varepsilon) + \frac{1}{6}u(\hat{c}_{2H}^A - \varepsilon) \geq \frac{5}{6}u(\hat{c}_{1I}) + \frac{1}{6}u(xr + y) \quad (2.45)$$

Equation (2.43) guarantees that it is optimal for depositors of bad banks to withdraw their deposits in the first period. Equations (2.44) and (2.45) ensure that if all agents play the verification equilibrium, it is not optimal for any agent to deviate.

As in the neighboring case, we have the traditional equilibria, which are summarized in the proposition below:

Proposition 5 *In the Island Case, the no-run and the full-run are still Nash Equilibria, if the following conditions are satisfied:*

$$\frac{2}{3}u(\hat{c}_2^T) + \frac{1}{6}u(\hat{c}_{2L}^A) + \frac{1}{6}u(\hat{c}_{2H}^A) \geq u(\hat{c}_{1I}) \quad (2.46)$$

$$\frac{2}{3}u(\hat{c}_2^T) + \frac{1}{6}u(\hat{c}_{2L}^A) + \frac{1}{6}u(\hat{c}_{2H}^A) \geq \frac{2}{3}u(\hat{c}_2^T - \varepsilon) + \frac{1}{6}u(\hat{c}_{1I} - \varepsilon) + \frac{1}{6}u(\hat{c}_{2H}^A - \varepsilon) \quad (2.47)$$

$$\hat{c}_{1I} \geq r \quad (2.48)$$

Equations (2.46) and (2.47) guarantee that an agent has no incentive to deviate in the no run equilibrium. Equation (2.46) is the incentive compatibility constraint while equation (2.47) guarantees that the benefit obtained by verifying and withdrawing when the outcome is inefficient, is lower that the expected utility achieved in the no-run equilibrium. Finally, equation (2.48) guarantees the existence of the full run equilibrium. This is the condition that guarantees that if all depositors withdraw in the first period, neither good nor bad banks have enough resources to pay them the promised amount of $\widehat{c}_{1I}$.

2.5 The Role for a Central Bank

As a consequence of the rapid spread of the Asian crisis of 1997 – 1998 to the global financial markets, the IMF introduced the Contingent Credit Lines (CCL) in 1999. The idea of the CCL was to provide a precautionary line of defense for members with sound policies, who were not at risk of an external payments crisis of their own making, but were vulnerable to contagion effects from capital account crisis in other countries. The package allowed those countries that met certain eligibility criteria, to draw on a pre-specified amount of resources if hit by a financial crisis due to factors outside of the member's control.

We have seen in the previous sections that in the presence of an incomplete market structure of the neighboring case, banks are subject to the risk of contagion and financial crises. In this section, we will show that there is a role for a Central Bank to complete markets. In our setting, the Central Bank will require reserves from banks at date 0 and will redistribute such reserves into the banking system in the form of credit lines to banks. With the Central Bank, the first best allocation is achieved when the financial system is incomplete.[11]

The World Bank and other international institutions like the IMF reallocate resources during financial crises. In what follows, we show that such behavior can be socially optimal. The Central Bank is going to require reserves of (T_i=$\frac{1}{4}$) from each bank which is going to maintain in the system ($\mathrm{T}_j = \frac{1}{4}$) in order to allow banks to maximize depositors' expected utility.

These reserves work in the same way as interbank loans, banks will have to pay an amount to the Central Bank, that is contingent on the resources available in the second period, that is, $T_j[\widetilde{R}_i - z_j\widetilde{R}_i + z_i\widetilde{R}_j]x$ (where $\widetilde{R}_i$ is the expected return from our technology, and $\widetilde{R}_j$ is the expected return from our neighbor banks). Additionally, banks will receive a payment in the form of a "Contingent Credit Line" from the Central Bank that will restore the social optimal allocation. The intuition says that the Central Bank will complete markets, and so bad banks that are in states 2 and 3 and good banks in state 1 will receive T_iR^Hx, which is more than what they pay ($T_iR^Hx > T_j[R^L(1 - z_j) + R^Hz_{ij} + R^Lz_{ij}]x$). On the other hand, good banks that are in states 2 and 3, and bad banks of state 1 will receive T_iR^Lx, which is less than what they pay ($T_iR^Lx < T_j[R^L(1 - z_j) + R^Hz_{ij} + R^Hz_{ij}]x$).[12]

[11] It should be noted that in the island case, there is no role for a Central Bank, as in the bad state of nature there is no contagion and that is why bad banks are penalized and good banks are not affected.

[12] Recall that patient depositors of bad banks in states 2 and 3 obtained the same consumption as patient depositors of good banks in state 1 ($c^2_{2L} = c^1_{2H} = c^L_2$). Similarly, patient depositors of good banks in states 2 and 3 received the same as those of bad banks in state 1 ($c^1_{2L} = c^2_{2H} = c^H_2$).

The problem to be maximized, when a Central Bank is introduced, is as follows:

$$\underset{\{x,y,c_{1N},\{c_{2i}^t\}_{i=L,H}^{t=1,2}\}}{Max} \gamma u(c_{1N}) + (1-\gamma)\left\{\frac{1}{2}\left[\frac{1}{3}u(c_{2L}^1) + \frac{2}{3}u(c_{2L}^2)\right] + \frac{1}{2}\left[\frac{1}{3}u(c_{2H}^1) + \frac{2}{3}u(c_{2H}^2)\right]\right\} \quad (2.49)$$

subject to

$$x + y - z_i + z_j - T_i + T_j \leq 1; \quad (2.50)$$

$$\gamma c_{1N} \leq y; \quad (2.51)$$

$$(1-\gamma)c_{2L}^2 \leq \{[R^L(1-z_j) + R^H z_{ij} + R^L z_{ij}](1-T_j) + T_i R^H]\}x \quad (2.52)$$

$$(1-\gamma)c_{2L}^1 \leq \{[R^L(1-z_j) + R^H z_{ij} + R^H z_{ij}](1-T_j) + T_i R^L\}x \quad (2.53)$$

$$(1-\gamma)c_{2H}^1 \leq \{[R^H(1-z_j) + R^L z_{ij} + R^L z_{ij}](1-T_j) + T_i R^H]\}x \quad (2.54)$$

$$(1-\gamma)c_{2H}^2 \leq \{[R^H(1-z_j) + R^L z_{ij} + R^H z_{ij}](1-T_j) + T_i R^L\}x \quad (2.55)$$

$$\frac{1}{2}\left[\frac{1}{3}u(c_{2L}^1) + \frac{2}{3}u(c_{2L}^2)\right] + \frac{1}{2}\left[\frac{1}{3}u(c_{2H}^1) + \frac{2}{3}u(c_{2H}^2)\right] \geq u(c_{1N}) \quad (2.56)$$

$$x \geq 0; \quad y \geq 0; \quad c_{1N} \geq 0; \quad c_{2L}^1 \geq 0; \quad c_{2L}^2 \geq 0; \quad c_{2H}^1 \geq 0; \quad c_{2H}^2 \geq 0; \quad (2.57)$$

$$z_i = \sum z_{ij}; \qquad T_i = T_j = \frac{1}{4} \quad (2.58)$$

Equation (2.49) is equal to equation (2.17), the objective function in the neighboring case. Equation (2.50) is the budget constraint, that is equal to equation (2.18) of the neighboring case, except that it considers reserves required and received from the Central Bank. Equation (2.51) is the first period constraint which is also identical to equation (2.19) in the neighboring case and finally, equations (2.52) to (2.55) are the second period constraints, which take into account amounts paid to and received from the Central Bank, respectively.

Equation (2.52) corresponds to the case where a depositor is at a bad bank that is in states 2 or 3. Recall that the bad bank is connected to one good bank and to one bad one. In this case, the bank pays a proportion $T_j x$ of the resources available in the second period, that is, $T_j x[R^L(1-z_j) + R^H z_{ij} + R^L z_{ij}]$, and so it has $(1-T_j)x[R^L(1-z_j) + R^H z_{ij} + R^L z_{ij}]$ left. On the other hand, it receives the amount $T_i x R^H$ as a contingent credit line. The rest of the equations have a similar interpretation. Equation (2.53) corresponds to the case of a bad bank in state 1. Equation (2.54) represents the contract offered to patient depositors by a good bank that is in states 2 or 3, while equation (2.55) is the one offered by a good bank that is in state 1. Finally, equation (2.56) is the incentive compatibility constraint, which is identical to equation (2.24) of the neighboring case.

Under these conditions, it is easy to show that the first best allocation is achieved. Notice that $c^2_{2L} = c^1_{2H} = \frac{\{[R^L(1-z_j)+R^H z_{ij}+R^L z_{ij}](1-T_j)+T_i R^H]\}x}{1-\gamma} = \frac{\overline{R}x}{1-\gamma}$. Similarly, $c^1_{2L} = c^2_{2H} = \frac{[R^L(1-z_j)+R^H z_{ij}+R^H z_{ij}](1-T_j)+T_i R^L x}{1-\gamma} = \frac{\overline{R}x}{1-\gamma}$, and so the problem is reduced to the social planner's problem analyzed in section 3.

The idea is that the Central Bank guarantees the optimal level of risk sharing and therefore avoids contagion and financial crises. Those international institutions work as international market insurers (or market completers), since it is frequent to observe that although some financial systems are not connected due to political or economic reasons, they can be indirectly connected through those international institutions in order to avoid financial crises and increase social welfare.

It should be noted that in practice the behavior of the IMF is affected by the fear of moral hazard problems. This implies that the CCL would be extended in state 1, or in states 2 and 3, but when there is contagion ($\lambda > \lambda^*$). In our setting moral hazard is absent and so it is welfare superior to avoid information gathering and to prevent every financial crisis equilibria.

2.6 Numerical Example

A numerical example nicely illustrates the results presented in this paper. In the example that follows, preferences and parameters values are displayed in the upper part of the table; while the results from the optimization problem appear in columns 1, 2, 3 and 4 for the complete market structure, the neighboring case, the island case and autarky, respectively. For these values, all the conditions for the existence of the different equilibria in the neighboring case are satisfied for any $\varepsilon \in (0,058; 0,06)$. Similarly, all the conditions for the existence of the different equilibria in the island cased are satisfied for any $\varepsilon \in (0,126; 0,151)$. Note that for these values verification is never socially optimal, as $\varepsilon^* = 0,023$.

Value of Parameters

$u(c_1)$	$u(c_2)$	R^H	R^L	r	γ	$\overline{R}$	k
$Ln(c_1+k)$	$Ln(c_2+k)$	1.7	0.5	0.5	0.5	1.1	0.000001

λ	λ^*	ε^*
0.25	0.235	0.023

Complete Market structure	Neighboring Case	Island Case	Autarky
$x=0.5$ $y=0.5$ $c_1=1$ $c_2=1.1$ $EU=0.0476$	$x=0.5$ $y=0.5$ $c_{1N}=1$ $c_{2L}^2=0.9$ $c_{2L}^1=1.3$ $c_{2H}^1=0.9$ $c_{2H}^2=1.3$ $EU=0.039$ $(xr+y)=0.75$ $\widehat{c_{1N}}=0.8125$ $\widehat{c_{2H}}=1.275$ $\widehat{c_{2L}}=0.375$	$x=0.5$ $y=0.5$ $c_{1I}=1$ $c_{2L}^A=0.5$ $c_{2L}^B=1.1$ $c_{2H}^A=1.7$ $c_{2H}^B=1.1$ $EU=0.0182$ $(xr+y)=0.75$	$x=0.514$ $y=0.486$ $c_{1IMP}=0.973$ $c_{2H}=1.7458$ $c_{2L}=0.513$ $EU=-0.041$

Table 1: Numerical Example

Additionally, we obtain that in states 2 and 3 of the neighboring case there is a verification equilibrium with partial bank runs and contagion. There is contagion because the expansion bank, even if it does not experience a run, it cannot pay its promised consumption to its late consumers. Recall that this equilibrium takes place whenever the proportion of the long term asset that is liquidated at t=1 (λ), is greater than a threshold level of λ^*, which guarantees that second period consumption is equal to the promised one. In the example, $\lambda = 0,25 > \lambda^* = 0,235$, and so we have a verification equilibrium with partial runs and contagion.

Obviously, the highest expected utility corresponds to the complete market structure where the first best is achieved followed by the neighboring and the island cases respectively. The occurrence of contagion does not impede that the allocation reached in the neighboring case is higher than that of the island case. Therefore, contagion and crisis are the consequences of the higher expected utility that can be reached when a complete market structure is not a possible one.

2.7 Conclusion

The paper incorporates costly voluntary acquisition of information *à la* Nikitin and Smith (2007), in a framework similar to Allen and Gale (2000). This allows us to model the relationship between shocks to fundamentals and contagion, without relying on any unexpected shock to model contagion.

In the paper, depositors can modify their behavior due to the use of costly information. When the system is at rest, individuals do not find it optimal to gather information and so our model explains why there are periods in which individuals do not modify their expectations on banks. However, if for any reason they decide to invest in information gathering they would penalize those states of nature in which banks establish inefficient links. This would cause the liquidation of bad projects, but it might also generate contagion and financial crises when financial linkages are very inaccurate.

In the neighboring case, two possible equilibria with contagion, due to fundamentals, are possible. In the first one, bad banks fail and good banks are affected by contagion. Even though good banks are not affected by bank runs and can meet their obligations with impatient depositors, the malfunctioning of the interbank payment system obliges them to liquidate part of their long term technology. As a result, good banks go bankrupt in the second period. In the second equilibrium, depositors in good banks withdraw their deposits generating a collapse of the entire banking system. These equilibria have very low probability but can explain the occurrence of some international financial crises.

From our analysis, it can be concluded that a complete market structure is resilient to shocks in fundamentals. For the case of incomplete market structures, we find that the more incomplete the banking structure is, read the island case, the less vulnerable to contagion it is. Nevertheless, depositors prefer the neighboring case to the island case. In this respect our results are similar to those of Brusco and Castiglionesi (2007). They find that banks establish links and accept the risk of contagion only when the risk is not too big.

Finally, we analyze the existence of international institutions like the World Bank and the IMF. In our model, those institutions appear as an optimal solution when political restrictions impede perfect capital flows. We present the importance of some mechanisms like the Contingent Credit Line (CCL) of the IMF to eradicate crises and prevent contagion.

It should be noted that in our setting moral hazard is absent and so it is welfare superior to avoid information gathering and to prevent every financial crisis equilibrium. An avenue for future research would be to analyze the optimality of those institutions in the presence of moral hazard or aggregate uncertainty.

2.8 Appendix

First, consider conditions for the existence of equilibria in the Incomplete Market Structure of the Neighboring Case.

Proof of proposition 2: In states 2 and 3, depositors of bad banks receive $\overline{c_2^L}$, which is smaller than $\overline{c_{1N}}$ (equation (2.27)). If depositors acquire information and find out that they are in those states, they will withdraw their deposits in the first year. Equation (2.28) guarantees that patient depositors of good banks will still find it beneficial to wait until t=2, and so there are no bank runs. On the other hand, if depositors gather information and realize that they are in state 1, they would behave as impatient consumers and will generate a financial crisis. Equation (2.27) ensures that patient depositors of good banks would prefer to behave as impatient depositors (note that $\overline{c_{2H}^1} = \overline{c_{2L}^2} = \overline{c_2^L}$), but since bad banks don't have enough resources to compensate its interbank loans, patient depositors of bad banks will also withdraw their deposits generating a global financial crisis.

Finally, equations (2.29) and (2.30) ensure that if all other agents are playing the verification equilibrium, it is optimal to play it. Equation (2.29) states that the expected utility an agent achieves by acquiring information and withdrawing from inefficient banks is higher than that obtained by doing nothing, and waiting until the second year. Equation (2.30) ensures that an indiscriminate withdrawal is neither optimal.

Proof of proposition 3: Equations (2.31) and (2.32) ensure that patient depositors do not have an incentive to deviate in the no-run equilibrium. Equation (2.31) is the incentive compatibility constraint that results from:

$$\frac{1}{2}\left[\frac{1}{3}u(\overline{c_{2L}^1}) + \frac{2}{3}u(\overline{c_{2L}^2})\right] + \frac{1}{2}\left[\frac{1}{3}u(\overline{c_{2H}^1}) + \frac{2}{3}u(\overline{c_{2H}^2})\right] \geq u(\overline{c_{1N}})$$

where the left hand side is the expected utility of patient depositors and the right hand side is the expected utility of impatient ones. We obtain the result of the formula by making use of the fact that $\overline{c_{2L}^1} = \overline{c_{2H}^2} = \overline{c_2^H}$ and $\overline{c_{2L}^2} = \overline{c_{2H}^1} = \overline{c_2^L}$.

Equation (2.32) guarantees that the expected utility of patient depositors is greater than the expected utility obtained by the policy of acquiring information and withdrawing when the consumption offered for being patient is low.

Finally, equation (2.33) guarantees the existence of the full run equilibrium. This is the condition that guarantees that if all depositors withdraw in the first period, neither good nor bad banks have enough resources to pay them the promised amount of $\overline{c_{1N}}$.

Second, consider conditions for the existence of equilibria in the Incomplete Market Structure of the Island Case.

Proof of Proposition 4: In state I, if depositors from bad banks obtain information and realize that they are in that state, they will receive $\widehat{c}_{2L}^A$ which is less than $\widehat{c}_{1I}$, so they will behave as impatient depositors. As a consequence, bad banks are liquidated and pay $xr + y$ to all depositors. Good banks are not affected by the shock since they do not have links with bad banks, and so they will pay depositors as promised in the demand deposit contract.

Equations (2.44) and (2.45) guarantee that if all agents play the verification equilibrium, it is not optimal for any agent to deviate. Equation (2.44) states that the expected utility an agent achieves by acquiring information and withdrawing from inefficient banks is higher than that obtained by doing nothing, and waiting until the second year. Equation (2.45) ensures that an indiscriminate withdrawal is neither optimal.

Proof of Proposition 5: Equations (2.46) and (2.47) guarantee that if all other agents do not gather information (play the no-run equilibrium) it is not optimal for any agent to deviate.

Equation (2.46) is the incentive compatibility constraint that results from:

$$\frac{1}{2}\left[\frac{2}{3}u(\widehat{c}_{2L}^B) + \frac{1}{3}u(\widehat{c}_{2L}^A)\right] + \frac{1}{2}\left[\frac{1}{3}u(\widehat{c}_{2H}^A) + \frac{2}{3}u(\widehat{c}_{2H}^B)\right] \geq u(\widehat{c}_{1I})$$

where the left hand side is the expected utility of patient depositors and the right hand side is the expected utility of impatient ones. We make use of the fact that $\hat{c}_{2L}^{B}=\hat{c}_{2H}^{B}=\hat{c}_{2}^{T}$.

Equation (2.47) guarantees that the expected utility of patient depositors is greater than the expected utility obtained by the policy of acquiring information and withdrawing when the consumption offered for being patient is low.

Finally, equation (2.48) guarantees the existence of the full run equilibrium. This is the condition that guarantees that if all depositors withdraw in the first period, neither good nor bad banks have enough resources to pay them the promised amount of $\widehat{c}_{1N}$.

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Chapter 3

Financial Contagion and Depositor Monitoring

3.1 Introduction

A number of papers have focused on the incentive properties of demand deposits. The idea of these papers is that liquid deposits keep the bank's portfolio choice in line with depositors' preferences. In these papers, the threat of a bank run by informed depositors after receiving negative information discourages banks' owners from investing in projects that are too risky or committing fraud. In this way, demand deposits discipline bank managers and reduce moral hazard problems. The deposit contract serves this role due to the combination of two inherent characteristics: the *on demand clause* and the sequential service constraint. The demandable nature of the contract motivates some depositors to monitor the bank, while the sequential service constraint discourages free riding by depositors on others' monitoring (see Calomiris and Khan 1991, Flannery 1994, Jean-Baptiste 1999, Gorton and Huang 2002a, 2003).[1]

This paper analyzes market discipline in a many banks economy, where contagion may arise. A common feature of this contagion literature is that banks have incentives to establish links ex ante but during a crisis, the failure of one institution

[1]Qi (1998) and Diamond and Rajan (2001a, 2001b, 2005, 2006), also study the disciplinary effects of liquid deposits in models that abstract from asymmetric information.

may have negative effects on other institutions to which it is linked (see Allen and Gale, 2000, Brusco and Castiglionesi, 2007, Castiglionesi, 2007 and chapter II).

We follow this strand of the literature in order to motivate the existence of the interbank market. In particular, we build on the paper by Brusco and Castiglionesi (from now on BC, 2007), but we introduce the possibility of differently informed depositors. BC (2007) analyzed the propagation of financial crises among regions affected by moral hazard problems. In their paper, the existence of limited liability and insufficiently capitalized banks promoted excessive risk taking by banks. This lead to a situation where bankruptcy (and contagion) occurred with positive probability.

Information in our setting induces depositors to run on banks and so the moral hazard problem can be eliminated. This paper shows that when information is considered, depositors might prefer a contract that is subject to bank-runs in the interim period (and therefore avoids moral hazard by banks) to a contract in which depositors allow banks to gamble with their funds (moral hazard), when those banks are insufficiently capitalized, provided that the probability of success of the gambling asset is low. The existence of partial deposit insurance in many economies generates strong incentives for big depositors to monitor banks' activities, and so they will prevent banks from investing in very risky assets. Furthermore, in this framework the probability of contagion is very small (which is usually remarked by the empirical literature, see Sheldon and Maurer, 1998, Furfine, 2003, Upper and Worms, 2002 and Wells, 2002).

This is the first paper to analyze market discipline in a many bank economy where bank runs and contagion can interact. The paper emphasizes the importance of information in eliminating moral hazard problems, and hence in promoting market discipline.

The rest of the paper is organized as follows: the basic model is presented in section 2. Section 3 introduces the optimal contracts under different scenarios, and provides some comparative statics. Finally, the concluding remarks are summarized in section 4.

3.2 The Model

This is a three dates ($t = 0, 1, 2$) and one single good economy. There are two regions, labeled A and B. Each region contains a continuum of agents and banks. Agents are ex ante identical and are endowed with one unit of the good at $t = 0$. At $t = 1$, individuals can be of type 1 (or impatient) with probability w^i and derive utility from consumption only in that period, or they can be of type 2 (or patient) with probability 1-w^i and derive utility from consumption only at $t = 2$. The probability w^i is also the fraction of impatient consumers in the population of region i, and w^i can take two values w^H and w^L, with $w^H > w^L$ and equal probabilities. The average fraction of impatient consumers is $\gamma = \frac{w^H + w^L}{2}$.

As in Allen and Gale (2005), a second class of agents is considered. Risk-neutral investors are endowed with e_t units of the consumption good such that $(e_0, e_1, e_2) = (e, 0, 0)$. These investors can either consume or buy shares from the banks, in such case they receive dividends d_t at $t = 1, 2$. Their utility function is as follows:[2]

$$U(d_o, d_1, d_2) = Rd_o + d_1 + d_2 \tag{3.1}$$

The representative bank in each region has access to long term investment opportunities, and so individuals will deposit their endowment in the banking sector, in order to exploit those opportunities. Also, as liquidity shocks are negatively correlated across regions, banks are interested in maintaining interbank deposits to protect themselves against the liquidity shock.[3]

There are three types of assets or opportunities in this economy: the first one takes one unit of the consumption good at t and transforms it into one unit at $t + 1$ (*storage* or *short asset*), the second one is an illiquid but *safe asset* that takes one unit at $t = 0$ and transforms it into R units at $t = 2$ with certainty, and finally there is a second illiquid asset, the *gambling asset*, that transforms one unit at $T = 0$ into λR units ($\lambda > 1$) with probability η and 0 with probability (1-η),with $\eta\lambda < 1$, which guarantees that it is never optimal to interrupt the safe technology in order to invest in the gambling asset. It is assumed that when the return on the gambling asset is λRx, only a proportion Rx is observable and so a contract can

[2]Since investors obtain a utility of Re by immediate consumption, they have to be rewarded at least R for each unit of consumption they give up today.

[3]For a motivation and description of the interbank market, see Allen and Gale (2000).

not be made contingent on its appearance. Additionally, due to the limited liability assumption, depositors receive zero when the *gambling asset* does not succeed and when it succeeds the unobservable part of the investment, $(\lambda - 1)Rx$, goes to the banks' owners. Finally, it is also assumed that the opportunity of investing in the gambling asset appears with probability p.[4]

To complete the argument, we will consider that a proportion α of type 2 depositors are more informed and they can observe whether the opportunity to invest in the gambling asset appears in their own bank but not in the bank in the other region.[5]

3.3 Liquidity Coinsurance and Moral Hazard

3.3.1 The benchmark case

As a benchmark case, we will first analyze liquidity coinsurance and moral hazard, in the absence of information. This is the problem introduced by BC (2007).

It should be noted that when banks are sufficiently capitalized, moral hazard is restrained and the first best allocation is achievable through an interbank deposit market as in Allen and Gale (2000) or BC (2007). Banks issue demand deposits and establish an interbank market at $t = 0$, in order to protect themselves against the liquidity shock. By shifting deposits across regions banks are able to achieve the first best allocation.[6]

[4]The moral hazard problem is introduced in the same way as in BC (2007).

[5]This assumption is motivated by the fact that if information were costly, type 2 depositors would be more likely to acquire information. Furthermore, if depositors were partially insured, bid depositors would also be more likely to acquire the costly signal. These unmodeled aspects are taken into account by assuming that a fraction of type 2 depositors becomes informed. See Jacklin and Bhattacharya (1988) for a motivation of this assumption.

[6]The first best allocation can be attained by a decentralized banking system as follows: each bank offers the first best contract (c_1^*, c_2^*, x^*, y^*) to the depositors and to the bank in the other region, where $c_1^* = \frac{y^*}{\gamma}, c_2^* = \frac{1-y^*}{1-\gamma}, x^* = 1 - y^*$, and c_1^* represents consumption for the type 1 consumer, c_2^* consumption for the type 2 consumer, y^* amount invested in storage and x^* amount invested in the long term asset. On the other hand it deposits $(w^H - \gamma)$ in the bank in the other region. At $t = 1$, when a bank turns out to have the high liquidity shock it liquidates interbank deposits held in the other bank. In the second year, interbank deposits move in the opposite

The intuition is that when the amount of capital is large, the bank's owners are more reluctant to gamble with their own money, and so the bank will invest in the safe asset. However, when capital is scarce and the probability of appearance of the gambling asset is sufficiently low, depositors will prefer a contract that is subject to bankruptcies and contagion to one that restricts moral hazard by banks, by requiring banks to be sufficiently capitalized. In fact, it can be shown that this contract converges to the first best as the probability of appearance of the gambling asset converges to zero. [7]

As we are interested in analyzing how information and bank runs eliminate moral hazard problems and hence promote market discipline we assume that capital is scarce so that bank's owners will have incentives to invest in the gambling asset.

Also, it is assumed that banks can offer contracts contingent on the liquidity shock, although not on the appearance of the gambling asset.

The problem to be solved, in the absence of information and when capital is scarce, is the following one:[8]

$$\begin{aligned}\max_{x,y,k,\{c_t^s,d_t^s\}_{t=1,2}^{s=L,H}} \widetilde{U} = & \tfrac{1}{2}\{w^H u(c_1^H) + (1-w^H)[qu(c_2^H) + (1-q)u(c_2^A)]\}+ \\ & \tfrac{1}{2}\{w^L u(c_1^L) + (1-w^L)q[qu(c_2^L) + (1-q)u(c_2^c)]\}+ \\ & \tfrac{1}{2}(1-w^L)(1-q)[qu(c_2^F) + (1-q)u(c_2^B)]\end{aligned} \tag{3.2}$$

subject to

$$\xi x \geq e, \tag{3.3}$$

$$w^H c_1^H + d_1^H \leq y + k_i c_1^L \tag{3.4}$$

$$(1-w^H)c_2^A \leq (y + k_i c_1^L - w^H c_1^H - d_1^H) - k_j c_2^A \tag{3.5}$$

direction. See BC (2007), (pages 2279-2280) or Allen and Gale (2000), (pages 8-9).

[7] In particular, BC (2007) show that the bank will invest in the safe asset only if the bank's capital is $e \geq \xi x$, where $\xi = \eta(\lambda - 1)/(1 - \eta\lambda)$, and x represents the amount invested in the long term asset.

[8] This is a revised version of the original problem solved by BC (2007), (pages 2299 - 2300).

$$(1-w^H)c_2^H + d_2^H \leq Rx + (y + k_i c_1^L - w^H c_1^H - d_1^H) - k_j c_2^H \tag{3.6}$$

$$w^L c_1^L + d_1^L \leq y - k_j c_1^L \tag{3.7}$$

$$(1-w^L)c_2^L + d_2^L \leq Rx + (y - k_j c_1^L - w^L c_1^L - d_1^L) + k_i c_2^H \tag{3.8}$$

$$(1-w^L)c_2^c \leq Rx + (y - k_j c_1^L - w^L c_1^L - d_1^L) + k_i c_2^A \tag{3.9}$$

$$(1-w^L)c_2^F \leq (y - k_j c_1^L - w^L c_1^L - d_1^L) + k_i c_2^H \tag{3.10}$$

$$(1-w^L)c_2^B \leq (y - k_j c_1^L - w^L c_1^L - d_1^L) + k_i c_2^A \tag{3.11}$$

$$\frac{1}{2}(d_1^H + q d_2^H) + \frac{1}{2}(d_1^L + q^2 d_2^L) + p\eta(\lambda - 1)Rx \geq eR \tag{3.12}$$

$$k \geq 0, \qquad c_2^A \geq 0, \qquad c_2^c \geq 0, \qquad c_2^F \geq 0, \qquad c_2^B \geq 0 \tag{3.13}$$

$$d_t^s \geq 0, \quad c_t^s \geq 0, \text{ where } s = L, H \text{ and } t = 1, 2. \tag{3.14}$$

$$y + x - k_i + k_j \leq 1 + e, \quad x \geq 0, \quad y \geq 0, \tag{3.15}$$

where k_i represents interbank loans given to the other bank and k_j interbank loans received from the other bank, (with $k_i = k_j = k$), $q = (1-p) + \eta p$ is the probability that the gambling asset does not appear or that it appears and succeeds; while $(1-q) = p(1-\eta)$ is the probability that the gambling asset appears and fails, c_t^s is the consumption of a type t consumer (with $t = 1, 2$) in state s (with $s = L, H$), when the gambling asset does not appear in none of the two regions, or it appears and succeeds in both of them, c_2^A is the consumption of a patient depositor in a high liquidity region, when its own investment fails and so all the available funds are those from storage (if any), c_2^c is the consumption of a patient depositor in the low liquidity region when its long term investment is successful and the bank in the other region (say B) fails. In this case, bank A cannot retrieve completely the interbank deposit, and so there is contagion from region B to region A, c_2^F is the consumption of a patient depositor in the low liquidity region when its own investment fails, but that of the other region does not. In this case, the available funds to pay depositors are those obtained from the interbank market and from storage (if any). When both regions' investments fail, which happens with probability $(1-q)^2$, then there is a meltdown of the entire financial system, and depositors receive c_2^B.

The interpretation of this problem is as follows:[9] Equation (2) is the expected utility to be maximized. The first row of the optimization program is the expected utility of a depositor when the region has the high liquidity shock at $t = 1$. Note that in this case second period consumption is not affected by what happens in the other region. The second and third rows represent the expected utility of a depositor when the region is affected by a low liquidity shock at $t = 1$. In this case, second period consumption is affected by what happens in the other region.

Equation (3) states that the bank is insufficiently capitalized, and so it has incentives to invest in the gambling asset. Equation (4) is the first period constraint in a high liquidity shock region while equations (5) and (6) are the second period constraints in this high liquidity shock region. Equation (7) is the first period constraint in a low liquidity shock region while equations (8) to (11) are second period constraints for a low liquidity shock region, depending on what has happened in the other region.

Equation (12) is the participation constraint for investors. It is explained as follows: with probability 1/2 the bank will have a high liquidity shock, and the capitalist receives the second period dividend if the gambling asset does not appear or it appears and succeeds (which occurs with probability q). With probability 1/2 the bank will have a low liquidity shock, and in this case the capitalist receives the second period dividend if in both regions either the gambling assets do not appear or they appear and succeed (which happens with probability q^2). Finally, when the gambling asset appears and succeeds the capitalist retains the amount $(\lambda - 1)Rx$. Equations (13) and (14) present the nonnegativity constraints. Finally, the budget

[9] For a detailed description of the problem see BC (2007).

constraint at $t = 0$ is given by equation (15).

Let us call $U_B = \{c_1^B, c_t^{sB}, x^B, y^B, k^B\}$ the optimal solution to the above problem. Then, U_B represents the expected utility achieved when moral hazard is allowed. The following results are obtained.

Proposition 1 *If $p \to 0$, the expected utility achieved under moral hazard (U_B) tends to the first best optimum. Therefore, for a sufficiently low p a contract that allows for gambling will be preferred to one that prevents moral hazard by restricting banks to be sufficiently capitalized.*

Proof: See BC (2007).

The intuition is that the contract where moral hazard is prevented, does not reach the first best, as it restricts the amount of the long term investment, with respect to the optimal one. Additionally, the value of the expected utility does not depend on p. Therefore, it can be demonstrated that for a sufficiently low p gambling is preferred.

3.3.2 The run-proof contract

The discussion of the previous section ignored the possibility that agents could acquire information about the bank's investments. In this section, it is shown, that if we assume that the bank is undercapitalized (and hence has incentives to invest in the gambling asset) and a subset of depositors can observe whether the opportunity to invest in the gambling asset appears in their own bank, then the characterization of the bank's optimization problem has to consider two new constraints. These constraints impose that it is never optimal for informed depositors to run on the bank upon receiving information, that is, the informed type 2 depositor does not have incentives to mimic the type 1 depositor. We will call the result to the bank's optimization problem, when information is considered, the *run-proof contract*.

Moreover, it is also shown that the conditions under which this *run-proof* contract is preferred, become more restrictive.

The problem to be solved, when the possibility of α informed depositors is considered, is the one analyzed in section 3.3.1, with two additional constraints:

$$\eta[qu(c_2^L) + (1-q)u(c_2^c)] + (1-\eta)[qu(c_2^F) + (1-q)u(c_2^B)] \geq u(c_1^L) \tag{3.16}$$

$$\eta u(c_2^H) + (1-\eta)u(c_2^A) \geq u(c_1^H) \tag{3.17}$$

These equations state that when an informed depositor observes that the gambling asset has appeared, he has no incentives to withdraw in the low and high liquidity regions, respectively. Observe that when $\eta \rightarrow 1$, both constraints are automatically satisfied and we are in the benchmark case, of section 3.3.1, that does not take into account the incentive compatibility constraints (that ignores information). In general, we can define a value η^*, as the lowest value of the parameter η for which the more restrictive of the two incentive constraints (16) and (17) is automatically satisfied. Note that for values of $\eta \geq \eta^*$, we are in the benchmark case.

Let $\tilde{U}(p, \eta$ denote the expected utility achieved when banks offer the run-proof contract.

3.3.3 Informed Depositors and Bank Runs

The run-proof contract of the preceding section, is compared to one in which interim information is ignored, that is, the bank designs the ex ante contract as if no information appeared at $t = 1$. The problem to be solved is the benchmark case of section 3.3.1. Nevertheless, in this case, bank runs will take place at $t = 1$. In fact, for values of $\eta \leq \eta^*$, constraints (16) and (17) are never satisfied and so informed type 2 agents will find it optimal to withdraw at $t = 1$. However, it will be shown, that the allocation that involves runs might be preferred to the run-proof contract of the preceding section.[10]

Let us describe the sequence of events at date $t = 1$. First, banks observe the liquidity shock and withdraw interbank deposits when its region results to be in the high liquidity demand one. Then, the appearance of the gambling asset is observed by banks and informed depositors and finally, impatient and informed depositors

[10] For a similar type of analysis, in a single bank economy without Moral Hazard, see Alonso (1996).

withdraw their money from banks. Recall that the first come first serve rule plus the illiquidity of the long term investment, makes the bank subject to runs whenever the proportion of withdrawals at $t = 1$ is greater than w^i.

This problem can be solved by backward induction, we consider the ex-post utility levels of the allocation obtained in section 3.3.1. Then, to compute the ex ante utility when there is a run, we use the ex post utility levels, rearranged in order to consider the probability of appearance of the gambling asset, and of being paid, once type 1 and informed type 2 start to withdraw.

Let the probability of being paid in state i, when the gambling asset appears, be $\rho_i = \frac{w^i}{\alpha(1-w^i)+w^i}$, where the numerator represents total supply and the denominator total demand. So with probability $\rho_i (i = L, H)$, type 1 and informed type 2 receive c_1^i, and with probability $1 - \rho_i$ they will receive zero.[11]

The ex ante utility when there is a run is as follows:

$$\begin{gathered}
\widehat{U} = (1-p)\{\tfrac{1}{2}[w^H u(c_1^H) + (1-w^H)u(c_2^H)] + \tfrac{1}{2}\{w^L u(c_1^L) + \\
(1-w^L)[(1-p)u(c_2^L) + pu(c_2^c)]\}\} \\
p\{\tfrac{1}{2}\{w^H[\rho_H u(c_1^H) + (1-\rho_H))u(0)] + \\
+(1-w^H)\{\alpha\rho_H u(c_1^H) + \\
[\alpha(1-\rho_H) + (1-\alpha)]u(0)\} + \\
\tfrac{1}{2}\{[w^L[\rho_L u(c_1^L) + (1-\rho_L)u(0)] + \\
(1-w^L)[\alpha\rho_L u(c_1^L) + \\
+[\alpha(1-\rho_L) + (1-\alpha)]u(0)]\}\}
\end{gathered} \tag{3.18}$$

Let us consider the case of a depositor in region A, that is symmetrical to that of a depositor in region B. The first and second row represent the expected utility of a depositor in region A, when the gambling asset does not appear in that region. If the region faces a high liquidity shock, consumption in both periods are as promised. However, when the region faces a low liquidity shock and in region B there was a bank run at $t = 1$, the bank in region A will be affected by contagion at $t = 2$ since it cannot retrieve completely its interbank loans, and so patient depositors receive the lower amount c_2^c.[12] The other rows present the case where the gambling asset

[11] It is assumed that the long term investment is illiquid, or equivalently, that its liquidation value is close to zero.

[12] The value of c_2^c is given in equation (3.9).

appears in region A (the one we are considering as home) and so the bank in region A is affected by a bank run. Note, however, that in this allocation, contagion is a very rare event. It occurs with lower probability than in the benchmark case. In this case, contagion just occurs when the bank has a low liquidity shock and in the other bank, there was a bank run at $t = 1$.

3.3.4 Comparative Statics

A comparison between the different allocations is summarized in the proposition below.

Proposition 2 *For values of $\eta < \eta^*$ and a sufficiently low p, the allocation that allows for runs at $t = 1$ (and hence prevents moral hazard by banks) is preferred to the run-proof contract, or to a contract that requires banks to be sufficiently capitalized. In fact,*

$$\lim_{p \to 0} \widehat{U}(p) = U^* > \tilde{U}(p, \eta) \tag{3.19}$$

The demonstration is straightforward. The allocation that allows for runs is calculated with the consumption levels of the original problem of BC (2007), derived in section 3.3.1. Therefore, as shown in Proposition 1, as $p \to 0$, this allocation converges to the first best. On the contrary, in the run-proof allocation, two additional constraints need to be added to the problem of section 3.3.1, and hence the first best cannot be reached. Similarly, the allocation that allows for runs should be preferred to a contract that requires banks to be sufficiently capitalized (see Proposition 1).

Obviously, for values of $\eta \geq \eta^*$, we are in the benchmark case, banks would be allowed to gamble and so bankruptcy (and therefore contagion) would occur with positive probability.

3.4 Concluding Remarks

This paper incorporates differently informed agents in the model by Brusco and Castiglionesi (2007). It is shown that their model is a particular case of a broader one that is presented here.

When banks can gamble with depositors funds (given the limited liability assumption), more informed depositors will monitor banks' behavior (and hence run on the bank) when the probability of success of the gambling asset is low. Nevertheless, bank runs are not necessarily bad from an ex ante point of view and contagion is a very rare event. When the probability of success of the gambling asset is high, depositors will let the bank gamble with their funds and so the economy will be in BC framework, and contagion will occur with positive probability.

This is the first paper to analyze market discipline in a many banks economy where bank runs and contagion can interact. The paper emphasizes the importance of information in eliminating moral hazard problems, and hence in promoting market discipline.

A policy implication of this paper is that in a presence of a fractional deposit insurance system, big depositors (those with deposits partly uninsured) will have incentives to monitor banks' activity; they will try to be the first in the line at the bank's window in order to be paid the full amount of their deposits. This will prevent moral hazard problems but not bank failures (see Bhattharya, Boot and Thakor (1998) for a discussion of the optimality of partial deposit insurance and empirical evidence that supports it).

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Chapter 4

Government, Taxes and Financial Crises

4.1 Introduction

The recurrent episodes of financial crises have called the attention of scholars for years. Nevertheless, it is still not clear why these crises occur nor how to resolve them. It is frequently remarked by international institutions like the International Monetary Fund (IMF) and the World Bank that a balanced budget in the public sector is a necessary condition for stability, but is that always true? For example, the recent financial crises of Mexico (1994) and the East Asian Emerging Markets (1997) appeared in the absence of an unsustainable imbalanced budget. Moreover, taxes on financial transactions have been proposed as a means of improving the taxing capacity of developing countries. The aim of this paper is to show that in some cases the results of such policies might be the opposite to the ones pursued.

We address the following questions: Can a government who cares about its citizens' welfare generate financial crises? If so, has it any power to mitigate the effect of those crises? When is it optimal to do so? Indeed, recent examples in Argentina and Uruguay (2001 – 2002) have shown that government policies might in some cases intensify while in others ameliorate the effect of financial crises.[1] This

[1] While Uruguay kept property rights, the currency denomination of bank deposits and public debt, and promoted a mutual agreement with international debt holders, Argentina did exactly

paper is a first attempt to give some insight in such direction.

We also study taxes on financial transactions that exist in some developing countries like Argentina, Brazil, Colombia and Serbia. These taxes, while improving the taxing capacity of the government, negatively affect the financial intermediation activity of banks. Indeed, these taxes represent an important source of funding for those governments (22,471.9 millions of dollars for Brazil and around 2,700 millions of dollars for Argentina in 2007), although they are subject to discrepancies by different political parties. For example, in January 1999 the socialist President of Brazil, Fernando Henrique Cardoso, had many difficulties to prolong and increase such taxes, since the congress was reluctant to accept it. More recently, in December 2007, the Brazilian Government's attempt to pass the measure failed in the congress and was seen as the worst defeat in the history of this government. Similarly, during the presidential election campaign of Argentina in 2007, the leader of the opposition, Ricardo López Murphy, insisted many times on the distorting character of such taxes and in their negative effects on the private activity.

Our objective in this paper is to highlight the importance that government policies on public expenditure play in the development as well as in the administration of financial crises. We allow for the possibility that a government may raise taxes so as to provide public services. The idea is that this government can use these funds to pay the social security system, national security, education, health, recreation activities, etc. Nevertheless, taxing has an implicit cost because at the same time it lowers the availability of funds for private investments and consequently may generate financial crises during recessions. On the other hand, those funds might be reoriented once a financial crisis is expected to occur, however this practice normally has an additional cost, say for example "bureaucracy", that decreases its effectiveness.

We model an economy where agents face two possible types of governments and can invest their money in banks or privately invest it in a long-term technology. Consumers face a liquidity shock: they might become impatient or patient depositors. Impatient depositors face a utility loss from not having enough liquid assets, and therefore the possibility of risk sharing provided by banks is generally welfare improving. We show that in the absence of taxes, agents may not face the risk of

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the opposite; more specifically, it "pesified" deposits (changed the denomination of deposits from American dollars to Argentinean pesos), unilaterally declared default and devaluated the currency.

a bank run but they do not consume public services either. Instead, a government that raises taxes to invest in public services makes the system more prone to bank runs. In this paper we also show that even though such a government is usually an expected-utility maximizer, it might be "responsible" for a banking crisis. We then analyze the effectiveness of different policies in hands of governments to prevent banking crises such as injecting funds previously assigned to other uses into the banking system, reducing taxes or postponing their collection. Nevertheless, banking crises may sometimes be unavoidable. This is the case when consumers prefer to consume public services early and/or the government is not always able to redirect resources efficiently, given the costs of the bureaucracy. Moreover, the government might have a commitment problem if avoiding crises implies going against its principles (like reducing the provision of public services).

This paper is related to several papers in the banking literature. In the seminal paper by Diamond and Dybvig (1983), banks are considered to be liquidity providers, but are subject to bank runs in the form of sunspots. In our setting, agents also face liquidity shocks but bank runs are the result of a bad signal about the success of the long-term project. Relatedly, Gorton (1988) suggests that bank runs are not due to sunspots but to the existence of rational agents that modify their expectations due to a change in economic conditions (e.g., a change in the business cycle).

In our paper, a smaller banking activity is compensated by a greater government size. Governments and banks improve welfare but they have to compete for private funds. Besides the fact that a government can provide more public services, it makes banking crises more likely to occur. Thus, crises occur with positive probability as in Cooper and Ross (1998) and Chang and Velasco (2000a, 2000b). The difference is that in our model, crises are the result of updating the belief on the evolution of bank loans (fundamentals) and not the result of sunspots.[2] Our paper is close in spirit to Goldstein and Pauzner (2005), which presents bank runs as a phenomenon closely related to the state of the business cycle.

We build on the model of Chen and Hasan (2006), although we modify their framework by introducing a government that may raise taxes so as to provide public services. Additionally, in our model, depositors receive a clearer signal about the

[2]Recent studies, see e.g., chapter II and chapter III of this thesis, have shown that information concerning the evolution of bank loans plays an important role not only in generating a banking crisis but also in its propagation.

evolution of the investments. To the best of our knowledge, this is the first article that analyses bank runs due to the presence of taxes so as to provide public services in a closed economy with banks. Moreover, we investigate the effectiveness of taxes on financial transactions extensively used in emerging markets. For open economies, Chang (2007) presents a very good approach for the coexistence of financial and political crises but without focusing either on the financial activity of banks or on the role of the government as a provider of public services, which are our main concerns. Moreover, we investigate how governments can affect the occurrence as well as the resolution of banking crises instead of focusing only on the bank side as it is the case in most of the previous academic literature on banking.[3]

The rest of the paper is organized as follows. Section 2 presents the basic features of the model. Section 3 describes the basic trade-off that governments face and how bank runs can be originated. Section 4 analyzes different government policies that may resolve a banking crisis. Section 5 concludes.

4.2 The Model

We consider a three-date (0, 1, and 2) and one-good economy. There is a continuum of agents, with measure one, in the economy. Each agent receives an endowment of one unit of the good at date 0 and can deposit it at a bank or, alternatively, invest it in a long-term project. At date 2 this long-term project transforms each unit of the good into R units with probability p and nothing with probability $1-p$. Let $p = p_0$ be the prior probability of success of this project. We assume that $p_0 R > 1$, so the long-term project has a positive expected rate of return, moreover this technology can be liquidated at no cost. At date 1, depositors receive a public signal $s \in \{H, L\}$ on the true return of the long-term project, where H reveals that the probability of success is higher than 1/2 and L reveals the contrary. Depositors update their beliefs in accord with Bayes' rule. Let p^H and p^L be, respectively, the posterior probabilities of success when $s = H$ and $s = L$. We assume that $p^H > p_0 > p^L$,[4] and that $p^L R > 1$, so the long-term project yields a profitable expected return even

[3]For an excellent review of the academic literature on banking see chapter I and Gorton and Winton (2003).

[4]Therefore, $p^H \equiv \Pr[R|H] = \Pr[H|R] * p_0 / (\Pr[H|R] * p_0 + \Pr[H|0] * (1-p_0))$ and $p^L \equiv \Pr[R|L] = \Pr[L|R] * p_0 / (\Pr[L|R] * p_0 + \Pr[L|0] * (1-p_0))$.

if agents receive the bad signal.

We consider two possible types of governments: K and M. At date 1 the type-K government raises τ taxes to invest in a public asset that costs T, i.e., $\tau = T$ with $0 < T < 1$.[5] All agents, depositors and those who invest in the long-term project, must pay these taxes. The public asset transforms the T units of the good into public services that are consumed by everybody simultaneously afterwards. We assume that the consumer's utility of consuming public services is a linear function of its global cost: θT, where $\theta > 0$. Conversely, the type-M government does not raise taxes, so $\tau = 0$.

Banks offer divisible contracts such that depositors can withdraw part of their deposits at date 1. The incumbent government's type $i = K, M$ is common knowledge among all agents. For a given type i, the government's objective is to maximize the agents' expected utility.

We assume that this economy has a given level of public debt at the very beginning, which, for simplicity of exposition, is in the hand of banks. If banks sell the debt during a crisis, then they will receive a zero payoff (a junk bond), whereas the government can repurchase the debt whenever it wants.[6]

At date 1 agents face a liquidity shock: a proportion γ of them becomes impatient and must consume by date 1. While agents do not know at date 0 whether they will be impatient (type-1) or patient (type-2) at date 1, they know the value of γ. If impatient agents consume less than $r > 1$ of the private good at date 1, they will suffer a disutility $X > 0$. Normally agents face fixed payments. Nevertheless, sometimes they may need extra funds to deal with special contingencies. In such a case, they need liquid assets in order to afford the payments plus the contingencies, i.e., so as to cover r. Conversely, if they do not have enough cash, then they will not

[5] We assume that the size of the public expenditure, T, is exogenous. For instance, T could be the result of a political program or the rate of taxation at which maximal revenue is generated (the point at which the Laffer curve achieves its maximum).

[6] For example, in 2001 economic difficulties led the Argentinean government to oblige banks to buy public bonds. However, this in turn raised the interest rate and as a result lowered the price of the public bonds. By the end of 2001, the situation was worse and the panic spread through the depositors, consequently the banks were forced to constrain the withdrawals of bank deposits (the so-called "corralito"). The banking system collapsed and a massive popular revolt that toppled the government followed.

only have to deal with the bureaucracy, but also have to face different costs (e.g., bankruptcy, dealing with lawyers, searching costs) so as to get cash, this can be seen as a utility loss (X) of having illiquid assets and facing special contingencies. Let c_t denote the agent's consumption at date t. The utility function of type-1 agents in the type-M government, U_1^M, is

$$U_1^M(c_1^M, X) = \begin{cases} c_1^M - X & if \quad c_1^M < r \\ c_1^M & if \quad c_1^M \geq r \end{cases},$$

whereas the type-2 agents' utility function is $U_2^M(c_1^M, c_2^M) = c_1^M + c_2^M$. Instead, in the type-$K$ government the agents' utility functions are given by $U_1^K(c_1^K, X, T) = U_1^M(c_1^K, X) + \theta T$ and $U_2^K(c_1^K, c_2^K, T) = c_1^K + c_2^K + \theta T$, respectively.

We assume a perfectly competitive banking industry, so the banks' expected profit is zero. At the beginning of date 0 each bank offers a deposit contract $d = (d_1, d_2)$ to agents, where d_t denotes the maximum amount of money that they can withdraw at date t, i.e., contracts are divisible and agents can withdraw any amount of money y equal or less than d_t at date t. Notice that any impatient depositor who has not invested his money in a bank succeeds to obtain one unit of the good from liquidation, consequently, such an agent will always suffer the utility loss X. Thus, the existence of a banking industry that promises $d_1 \geq r$ should improve his welfare. At $t = 1$, the depositor's type is private information; banks therefore must pay any amount of money $y \leq d_1$ to every depositor who wants to withdraw. Moreover, depositors are sequentially served, so if all of them run to withdraw their money at date 1, only a fraction of them will receive the promised amount. Nonetheless, we impose that banks must pay at least T to every depositor, so that they can pay taxes. Additionally, in section 4.2.2 we will study taxes on financial transactions.

The sequence of events is as follows: at $t = 0$ and for a given type of government i, agents invest their resources in banks or in the long-term investment project; at $t = 1$, all agents (also those that do not invest in banks) pay taxes and consume public services in the presence of a type-K government, moreover they receive the public signal s and some of them suffer the liquidity shock. Finally, at $t = 2$, the long-term project matures and patient depositors are paid.

4.3 Bank Runs and the Role of the Government

We first turn to the issue of deriving the optimal deposit contract $d = \{d_1, d_2\}$. Notice that the total amount of money left in banks at date 2 is $(1-(1-\gamma)y-\gamma d_1)R$,[7] provided that the long-term project succeeds. Perfect competition implies that this amount of money is totally transferred to type-2 depositors,[8] therefore it must hold that $(1-\gamma)d_2 = (1-(1-\gamma)y-\gamma d_1)R$. The optimal deposit contract is then given by

$$d_2(y, d_1) = \max\left\{0, \left(\frac{1-(1-\gamma)y-\gamma d_1}{1-\gamma}\right)R\right\}.$$

At date 1 depositors update their beliefs according to Bayes' Rule, so the expected return of a patient depositor is pd_2, where $p = \{p^L, p^H\}$ is the posterior probability of success for a given event $s = \{L, H\}$. At date 0, agents can also privately invest their endowment in the long-term project, this means that banks can only attract deposits by offering a sufficiently attractive contract. When agents do not invest their endowment in the banking industry, there is a probability γ that they suffer the liquidity loss X: liquidating the technology yields 1 but $r > 1$. On the other hand, $d_1 = r + \tau$ may not be enough to attract deposits. The reason is that if a bank run occurs, then there is a positive probability that any patient depositor gets only τ from the bank, these agents would then be worse off than privately investing their endowment in the long-term technology. To ensure full participation, we thus need that for a given type of government, the agent's expected utility of depositing the endowment at banks, $W^B(d_1, \tau)$, is equal or higher than the agent's expected utility of privately investing it in the long-term project, $W^{NB}(\tau)$, where

$$W^{NB}(\tau) = \gamma(1-\tau-X) + (1-\gamma)p_0(1-\tau)R + \theta\tau. \tag{4.1}$$

In what follows, we show that the optimal contract is $d = (d_1, d_2) = (d_2(\tau, r+\tau))$ when X is large enough. First, notice that perfect competition implies that in equilibrium banks maximize the agents' expected utility. Let π denote the prior

[7] Recall that γ impatient depositors withdraw d_1 and $(1-\gamma)$ patient depositors withdraw y to pay taxes, thus the funds left in the long term investment at t=1 are $(1-(1-\gamma)y-\gamma d_1)$.

[8] This is the standard debt contract whereby banks offer the total return of the long-term project when it succeeds at maturity and the return from liquidating the bank's assets when it does not succeed (the latter return is zero in our model).

probability of the event H,[9] and consider the case $i = M$, we have that

$$W^B(d_1, 0)\big|_{d_1 \geq r} = (1-\pi)[\gamma d_1 + (1-\gamma)\frac{(1-\gamma d_1)}{(1-\gamma)}p^L R] + \pi[\gamma d_1 + (1-\gamma)p^H \frac{(1-\gamma d_1)}{(1-\gamma)}R]. \quad (4.2)$$

Moreover,

$$\frac{\partial}{\partial d_1}\left(W^B(d_1, 0)\big|_{d_1 \geq r}\right) = (1-\pi)\gamma(1-p^L R) + \pi\gamma(1-p^H R) < 0.$$

Additionally, $d_1 > pd_2$, with $p \in \{p^L, p^H\}$, triggers a bank run,[10] in such a case the expected utility is always lower than $W^B(r, 0)$ since some depositors are not paid and/or suffer the utility loss. Thus, in equilibrium banks will not offer $d_1 > r$.

Suppose now that d_1 is below r, i.e., $d_1 = r - \varepsilon$, where $r \geq \varepsilon > 0$. Then, $W^B(d_1, 0)$ can be written as

$$W^B(d_1, 0)\big|_{d_1 < r} = (1-\pi)[\gamma(r-\varepsilon-X) + (1-\gamma(r-\varepsilon))p^L R] + \pi[\gamma(r-\varepsilon-X) + (1-\gamma(r-\varepsilon))p^H R].$$

In this case impatient depositors always suffer the utility loss, then $\partial\left(W^B(d_1, 0)\big|_{d_1 < r}\right)/\partial\varepsilon > 0$, since $p^H R > p^L R > 1$, thus $d_1 = 0$ is optimal. As a result, under perfect competition, banks offer $d_1 = r$ whenever $W^B(r, 0) > W^B(0, 0)$; this inequality holds if the utility loss X is large enough so that

$$X > r[(1-\pi)p^L R + \pi p^H R - 1].$$

Consider now the case $i = K$, i.e., $\tau = T$. The higher the taxes, the less capital the banks have to invest in the long-term project and hence the lower the expected return of date 2 bank's deposit contract. Agents face a clear trade-off. On the one hand, higher taxes decrease the depositors' expected utility due to its negative impact on the banks' expected return, but on the other hand they increase the consumers' expected utility because of the consumption of public services. Moreover, as it will be shown later, $s = L$ triggers a bank run under the type-K government. Thus, we have that

$$W^B(d_1, T)\big|_{d_1 \geq r+T} = (1-\pi)\, V^K_{BR}\big|_{d_1 \geq r+T} + \pi[\gamma(d_1 - T) + (1-\gamma)p^H \frac{(1-\gamma d_1 - (1-\gamma)T)}{(1-\gamma)}R + \theta T], \quad (4.3)$$

[9] Therefore, $\pi = \Pr[H|R] * p_0 + \Pr[H|0] * (1-p_0)$.

[10] Notice that the upper bound of d_1 is given by $\gamma d_1 \leq 1 - \tau$.

where V_{BR}^K is the depositor's expected utility when $i = K$ and there is a bank run:

$$V_{BR}^K\big|_{d_1 \geq r+T} = \gamma \left[\frac{(1-T)}{d_1 - T}(d_1 - T) - \left(1 - \frac{(1-T)}{d_1 - T}\right) X \right] \\ +(1-\gamma)\left[\frac{1-T}{d_1 - T}(d_1 - T)\right] + \theta T = (1-T)\left(1 + \frac{\gamma X}{d_1 - T}\right) - \gamma X + \theta T.$$

Here, $(1-T)/(d_1-T)$ is the probability of being paid $(d_1 - T)$ when a bank run occurs. Notice that T has a threefold impact on the depositors' expected utility. Firstly, increasing T lowers the probability of being paid: $\partial[(1-T)/r]/\partial T = -1/r$. Secondly, an increase in T lowers the expected utility of type-1 depositors through the liquidity loss: (γX); Thirdly, an increase in T has a positive impact on the depositors' expected utility since it raises the consumption of public services. We have that

$$\frac{\partial}{\partial d_1}\left(W^B(d_1, T)\big|_{d_1 \geq r+T}\right) = \pi\gamma(1 - p^H R) - (1-\pi)(1-T)\frac{\gamma X}{(d_1 - T)^2} < 0.$$

Moreover, $d_1 > pd_2$, with $p \in \{p^L, p^H\}$, triggers a bank run, in which case the expected utility is lower than $W^B(r+T, T)$. Thus, in equilibrium banks will not offer $d_1 > r + T$. If d_1 is below $r+T$, agents suffer the utility loss with probability γ. Consider the contract $d_1 = r + T - \varepsilon$, where $r \geq \varepsilon > 0$, $W^B(d_1, T)$ is given by

$$W^B(d_1, T)\big|_{d_1 < r+T} = (1-\pi)\, V_{BR}^K\big|_{d_1 < r+T} + \pi[\gamma(r - \varepsilon - X) \\ + p^H(1 - \gamma(r + T - \varepsilon) - (1-\gamma)T)R + \theta T],$$

where

$$V_{BR}^K\big|_{d_1 < r+T} = (1-T) - \gamma X + \theta T.$$

Notice that $\partial\left(W^B(d_1, T)\big|_{d_1 < r+T}\right)/\partial\varepsilon > 0$, thus $d_1 = 0$ is optimal. Therefore, in the presence of perfect competition, $d_1 = r + T$ whenever $W^B(r+T, T) > W^B(0, T)$, which is satisfied for a large enough X so that

$$X > \frac{\pi r(p^H R - 1)}{(1-\pi)(1-T)/r + \pi}.$$

In the presence of the type-M government, agents will deposit their endowment at banks when $W^B(r, 0) > W^{NB}(0)$. Using (4.2) and (4.1), we have that this inequality is strictly satisfied when X is large enough so that

$$X > \frac{1}{\gamma}\left[\gamma + (1-\gamma)p_0 R - \gamma r - (1 - \gamma r)(p^L R + \pi(p^H - p^L)R\right].$$

Intuitively, if agents do not deposit their endowment at banks, then they will suffer the disutility X with probability γ.

Similarly, under the type-K government, agents will deposit their endowment at banks when $W^B(r+T,T) > W^{NB}(T)$. Using (4.3) and (4.1), this inequality holds if X is large enough so that

$$\begin{aligned} X \;&>\; \frac{1}{\gamma\pi}\left[\gamma(1-T)+(1-\gamma)p_0(1-T)R-(1-\pi)(1-T)\left(1+\frac{\gamma X}{r}\right)\right. \\ &\qquad \left. -\pi(\gamma r+p^H(1-\gamma r-T))\right].\end{aligned}$$

Intuitively, if agents deposit their endowment at banks, then they will suffer the disutility X with probability $\gamma(1-\pi)$ (i.e., agents must be impatient and also receive the bad signal), whereas if they invest their endowment in the long-term project, then they will suffer this disutility with a higher probability: γ.

Therefore, for a given $\tau \in \{0, T\}$ and a large enough X, the optimal deposit contract is

$$d(\tau) = \left[r+\tau, \left(\frac{1-(1-\gamma)\tau-\gamma(r+\tau)}{1-\gamma}\right)R\right].$$

We need that

$$T < 1-\gamma r,$$

so that $d_2(T) > 0$. The reason is that if $T > 1-\gamma r$, then there is no investment in the long-term project at $t = 1$ since the endowment is then used to pay taxes. Obviously, $d_2(0) > d_2(T)$. Additionally, if $d_1 \geq d_2$ held, then a bank run would always occur since in such a case (patient and impatient) depositors would withdraw at date 1; to exclude this trivial case we assume throughout that $\gamma < ((1-T)R-(r+T))/(rR-(r+T))$.

A type-2 depositor will not withdraw if $pd_2(\tau) \geq d_1$, or equivalently, if

$$p \geq \widehat{p}(\tau) = \frac{(1-\gamma)d_1}{(1-(1-\gamma)\tau-\gamma d_1)R}.$$

For simplicity of exposition we have assumed that the present value of the debt is zero, but the government can always buy it at its face value.[11] Notice that $\widehat{p}(T) > \widehat{p}(0)$. We focus on the case $\widehat{p}(T) < p^H$ for $d_1 = r+T$. This means that

[11] Assuming that the debt has a positive present value will not change the qualitative results of the model.

independently of the government's type, if the realization of s is H, then patient consumers will not withdraw at date 1. Consequently, the observation of H rules out the possibility of bank runs. Given this, if $s = L$, the economy will face three possible states of nature: i) if $p^L < \widehat{p}(0) < \widehat{p}(T)$, a bank run will occur whatever the type of government; ii) if $\widehat{p}(0) < p^L < \widehat{p}(T)$, a bank run will only occur in the type-K government;[12] iii) if $\widehat{p}(0) < \widehat{p}(T) < p^L$, a bank run will never occur whatever the type of government. We are primarily interested in the second case, which reflects a situation in which the economy is more sensitive to the observation of a low profitability signal due to taxes. The reason is that in the presence of taxes there is less money invested in the long-term project, and this in turn lowers its expected return $pd_2(T)$. From now on, we assume that this case holds.[13]

In order to analyze which government policy will be preferred, we must compare the expected utility of agents under the type-K and the type-M government. In particular, agents prefer the type-K government when $\Delta = W^B(r+T, T) - W^B(r, 0) > 0$. We have that $\partial\Delta/\partial\theta = T > 0$ and

$$\frac{\partial \Delta}{\partial X} = \gamma(1-\pi)\left[\frac{1-T}{r} - 1\right] < 0.$$

Therefore, for a given X there exists a high enough θ so that raising taxes is socially optimal. Instead, for a given θ there exists a large enough X so that raising taxes is not socially optimal. Notice that the probability of being an impatient depositor and receiving the bad signal has a clear impact on $\partial\Delta/\partial X$: decreasing γ or increasing π, lowers the impact of X on Δ.

4.4 How to Stop a Run on Banks

Recall that when $s = L$, there is a bank run in the type-K but not in the type-M government since $\widehat{p}^M < p^L < \widehat{p}^K$. In such a case depositors prefer the type-M government for X large enough or θ small enough. However, the type-K government

[12] If agents do not invest their endowment in the banking industry and observe $s = L$ at date 1, they will not find it optimal to liquidate the technology when they are patient since $p^L R > 1$. Conversely, if they invest their endowment in the banking industry and observe $s = L$ at date 1, they will find it optimal to run on banks. Moreover, the banks will have to liquidate assets even if by doing so they lose resources (investments with positive net present value, are liquidated).

[13] Notice that for any given $d_1 > 0$ and $d_2 > 0$, there exists a low enough p^L so that $p^L d_2 < d_1$.

may resolve this banking crisis by means of different policies. Next, we analyze some of them.

4.4.1 Liquidating the Public Asset

The type-K government may resolve the crisis by liquidating the public asset for cash and injecting this money into the banking industry.[14] The government can do so by repurchasing the public debt owned by banks. Let δ denote the amount of money that is necessary to inject into the banking industry so as to stop the bank run and $\overline{\delta}$ the maximum amount of money that can be liquidated from the public asset. To stop a bank run the government should inject money into the banking system so that $r = p^L d_2(T) + \delta$, which implies that patient depositors are indifferent between withdrawing and not. The depositors' utility is given by $U^K = d_1 - T + \theta(T - \delta)$, where $d_1 = r + T$. Therefore, it is welfare improving to stop the bank run only if $V_{BR}^K\big|_{d_1=r+T} < U^K = r + \theta(T - \delta)$, which holds if

$$\delta < \delta^* \equiv \frac{r + \gamma X - (1 - T)(1 + \gamma X/r)}{\theta}.$$

When δ is lower than δ^*, the utility loss of consuming less public services is offset by the utility gain of having liquidity. Notice that δ^* is decreasing in θ. The reason is that the higher is θ, the higher will be the utility of consuming public services, which makes liquidating public services more costly and consequently lowers δ^*. Recall that the type-K government can stop the bank run only if $\delta^* < \overline{\delta}$, we have the following:

Proposition 1 *Suppose that $\widehat{p}^M < p^L < \widehat{p}^K$ and $\delta < \delta^* < \overline{\delta}$, then if $s = L$ and the government raises taxes, a bank run is triggered; however, liquidating the public asset to stop the run on the banks is welfare improving.*

[14] By liquidating the public asset we mean modifying the direction of public funds before they are spent but once they have been accepted in the public budget.

4.4.2 Optimal government policies as functions of the timing and the information structure

From above we have that when $\overline{\delta} < \delta < \delta^*$ holds, the type-K government cannot resolve the banking crisis even though it would be optimal to do so. In such a case the government may have incentives to create a buffer or to gather information about the realization of the signal before the agents receive it. Let us divide date 1 into the three consecutive subdates 1.1, 1.2 and 1.3; we may face two different cases in terms of the timing: i) at subdate 1.1 the government raises taxes and at subdate 1.2 it anticipates the realization of the event s; ii) at subdate 1.1 the government anticipates the realization of the event s and given this it may raise taxes at subdate 1.2. Finally, at subdate 1.3 agents receive the signal s.

Case i: creating a buffer

In this case the government can only anticipate the realization of the event after having raised taxes, as a result at subdate 1.1 it may prefer to invest only a part of the funds in the public services and store the rest of them as a buffer for a potential financial crisis. Let B denote the necessary buffer size to stop the financial crisis, then $B = r - p^L d_2(T)$, as a result the type-K government invests only $T' = T - B$ in the public service. We may also assume that when the government anticipates the realization of the event H, it may reinvest B in the public service but at expense of some cost λ.[15] Here, the government faces the following trade-off: whether to spend money in public services but to make the system more prone to shocks or to spend less money in public services and to make the system more resilient to shocks. More specifically, it is socially optimal to create the buffer as long as the agents' expected utility of doing so is higher than the agents' expected utility of investing all the taxes in public services:

$$(1-\pi)r + \pi(\gamma r + (1-\gamma)p^H d_2(T)) + \theta(T' + \pi\lambda B) \geq (1-\pi)V_{BR}^K + \pi(\gamma r + (1-\gamma)p^H d_2(T)) + \theta T$$

This last expression can be rewritten as follows:

$$(1-\pi)(r - V_{BR}^K) \geq \theta[T - (T' + \pi\lambda B)]$$

[15]For instance, consumers may prefer to consume the public services early.

This condition says that creating the buffer B is socially optimal when the expected gain of stopping the bank run is higher than the expected utility loss of consuming less public services. Therefore, the size of θ and λ are key in determining whether the type-K government will prefer to invest all the funds in the public services or not. More specifically, for given π and λ there may exist a high enough θ so that the government may prefer that financial crises occur with positive probability.

Case ii: a more informed government (taxes on financial transactions)

In this case at subdate 1.1 the government may anticipate that $s = L$, if so at subdate 1.2 it can remove the taxes and allow for the possibility of an ex-post tax raising, that is, at date 2.[16] Notice that the project may not succeed, in such a case taxes could not be charged and consequently public services will not be provided. Moreover, agents prefer to consume the public services early ($\lambda < 1$). If the project succeeds we have that $\tau = T_2$ taxes are collected at date 2, where $T_2 \equiv T/(1-\gamma)$, now fewer agents have to pay the whole amount of taxes. The agents' expected utility of raising taxes at $t = 2$ is

$$V^K\big|_{\tau=T_2} = \gamma(r+T) + (1-\gamma)p^L\left[\frac{R(1-\gamma(r+T)) - T}{(1-\gamma)}\right] + \theta\lambda p^L T.$$

Suppose now that taxes are not charged (at any period), then there will not be a banking crisis since $\widehat{p}^M < p^L$, thus the agents' expected utility is given by

$$V^K\big|_{\tau=0} = \gamma(r+T) + p^L R(1-\gamma(r+T)).$$

The question is whether it is optimal to charge taxes ex-post, and this is so when i) patient depositors do not mimic impatient depositors, i.e., the expected return at period 2 is higher than $r + T$:

$$p^L\frac{[R(1-\gamma(r+T)) - T]}{(1-\gamma)} > r + T, \tag{4.4}$$

[16] The possibility of raising taxes at $t = 2$, represents the case of taxing on withdrawals. Patient depositors can profit from using delayed checks, which is a common use in Argentina (the so called "cheques posdatados") that is subject to taxes (while the use of debit cards is not). Additionally, by law it is compulsory to use checks for payments higher than 1000 argentinean pesos, which is higher than the basic consumption basket for Argentina.

and ii) $V^K\big|_{\tau=T_2} > V^K\big|_{\tau=0}$, or, equivalently,

$$p^L[R(1-\gamma(r+T))-T]+\lambda p^L\theta T > p^L R(1-\gamma(r+T)),$$

which boils down to

$$\lambda\theta > 1. \tag{4.5}$$

Conversely, if $\lambda\theta < 1$, then it is optimal to provide no public services. The reason is simple, the marginal utility of increasing taxes and consuming public services is θ, whereas the marginal utility of consuming private goods is 1, so charging taxes ex-post is only welfare improving as long as the discounted marginal utility of consuming more public services, $\lambda\theta$, is higher than the marginal utility of consuming less private goods.

4.4.3 A type-K government will never look like a type-M government. A commitment problem.

So far, we have assumed that for a given government's type, the government's objective is to maximize the agents' expected utility. However, as we have seen, if (4.5) is not satisfied, then it is not optimal to raise taxes but to behave as the type-M government so as to increase the patient depositors' expected utility. Suppose that (4.4) does not hold, then it follows a banking crisis and public services are not provided. In such a case, the type-K government may behave as if its type were M, because this behaviour would increase the expected welfare (given that in any case public services cannot be provided). However, if the long-term project succeeds at date 2, then this government may charge taxes and invest in public services (even if this policy is not socially optimal) because it is the *raison d'être* or 'reason to be' of that kind of government. This means that ex-ante the type-K government will never look like the type-M government; patient depositors will anticipate this commitment problem and even if the type-K government does not announce at subdate 1.2 the possibility of ex-post taxes they will run on banks and trigger a banking crisis whenever (4.4) does not hold. The "reason to be" of the type-K government plus a "bad profitability signal" are now the causes of this banking crisis. This will be the case when the government has a bad history of commitment (weak institutions).

Notice that a bank run triggered by raising taxes at date 1 is quite different to a bank run triggered by taxes on financial transactions. In the latter case, public services are not provided, while in the former case agents enjoy these services.

4.5 Concluding Remarks

A key finding of this paper is that a government who cares on providing public services (through taxes) can generate banking crises. This is due to the scarcity of funds and the competition for them between the government and the private sector. Nevertheless, we showed that under certain conditions, governments can provide public services while preventing banking crises. Additionally, we showed that such governments might find it impossible to prevent a crisis if doing so goes against its "moral" principles, which for the type-K government are here represented by its investment decision in public services. Additionally, we studied the case of taxes on financial transactions and showed that these taxes can prevent crises when the government has superior information than banks and depositors.

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