

MEMORANDUM

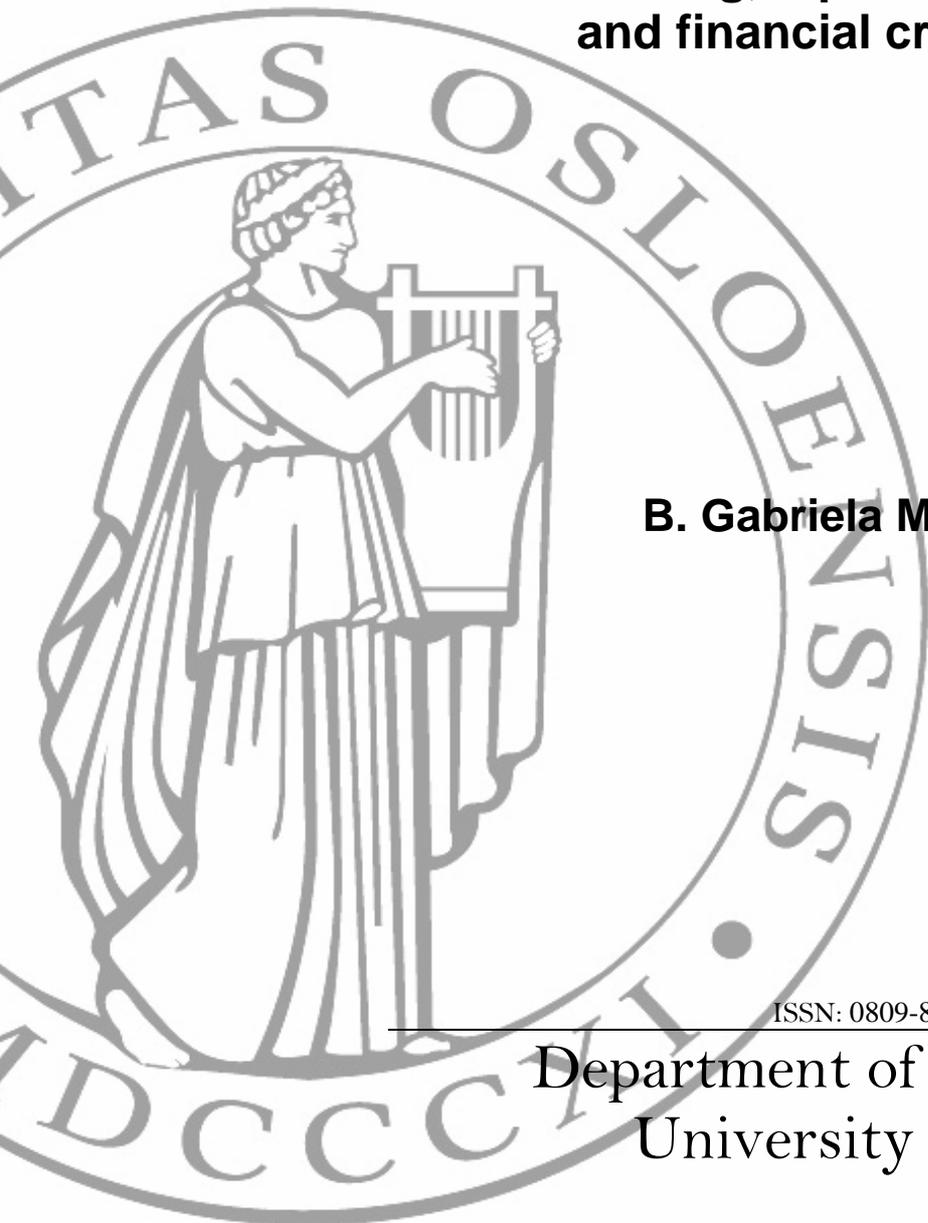
No 04/2007

**Monitoring, liquidity provision
and financial crisis risk**

B. Gabriela Mundaca

ISSN: 0809-8786

Department of Economics
University of Oslo



This series is published by the
University of Oslo
Department of Economics

P. O.Box 1095 Blindern
N-0317 OSLO Norway
Telephone: + 47 22855127
Fax: + 47 22855035
Internet: <http://www.oekonomi.uio.no/>
e-mail: econdep@econ.uio.no

In co-operation with
**The Frisch Centre for Economic
Research**

Gaustadalleén 21
N-0371 OSLO Norway
Telephone: +47 22 95 88 20
Fax: +47 22 95 88 25
Internet: <http://www.frisch.uio.no/>
e-mail: frisch@frisch.uio.no

List of the last 10 Memoranda:

No 03/07	B. Gabriela Mundaca and Kjell Bjørn Nordal Corporate investment, cash flow level and market imperfections: The case of Norway 51 pp.
No 02/07	Geir B. Asheim Procrastination, partial naivete, and behavioral welfare analysis 23 pp.
No 01/07	Fridrik M Baldursson and Nils-Henrik von der Fehr Vertical Integration and Long-Term Contracts in Risky Markets. 35 pp.
No 26/06	Reyer Gerlagh, Snorre Kverndokk and Knut Einar Rosendahl Optimal Timing of Environmental Policy; Interaction Between Environmental Taxes and Innovation Externalities. 29 pp.
No 25/06	Tiziano Razzolini Study on labour supply when tax evasion is an option with Box-Cox functional forms and random parameters. 39 pp.
No 24/06	Kjell Arne Brekke and Mari Rege Advertising as Distortion of Learning in Markets with Network Externalities. 28 pp.
No 23/06	Kjell Arne Brekke and Mari Rege. Advertising as a Distortion of Social Learning. 22 pp.
No 22/06	Line Smart Bakken The Golden Age of Retirement. 44 pp.
No 21/06	Rolf Golombek and Michael Hoel Climate agreements:emission quotas versus technology policies. 34 pp.
No 20/06	John K. Dagsvik, Marilena Locatelli and Steinar Strøm Simulating labor supply behavior when workers have preferences for job opportunities and face nonlinear budget constraints. 46 pp.

A complete list of this memo-series is available in a PDF® format at:
<http://www.oekonomi.uio.no/memo/>

Monitoring, liquidity provision and financial crisis risk

By

B. Gabriela Mundaca*

Ragnar Frisch Centre for Economic Research
University of Oslo
Gaustadalléen 21
N-0349 Oslo
NORWAY
gabriela.mundaca@frisch.uio.no

and

Johns Hopkins University
The Paul H. Nitze School of Advanced International Studies
1717 Massachusetts Avenue NW
Washington, DC 20036
USA
gmundaca@jhu.edu

January 10th, 2007

JEL classifications: G21 G28 G38 E58 Key words: monitoring, bailouts, banking crises, commitments, conditionality

ABSTRACT

We compare the effects of central bank policies, discretionary and commitment, to monitor banks in distress, when possible bailouts are made conditional on the banks' performance and a bad shock occurring in a future period. Our results are, *first*, banks exert higher effort and take lower risk under commitment than under discretion. *Second*, with commitments, the central bank monitors more, but the need for bailing out decreases a great deal in comparison to the discretionary policy. *Third*, by committing, the problem of multiple equilibria arising under discretion is avoided, and a unique equilibrium, where the incidence of banking crisis is reduced, emerges. The central bank's ability to commit credibly can be questionable but we show that acting with discretion does not reduce moral hazard problems and banking crisis risk.

*I thank Steinar Holden for his comments. I have also received valuable comments from Jon Strand and seminar participants at the University of Maryland, Johns Hopkins University, Federal Deposit Insurance Corporation and Econometric Society Summer Meetings, Vienna 2006. I am very grateful for the financial support of the Norwegian Fund for Financial Markets, Norwegian Research Council, project "Liquidity problems, financing constraints and investment decisions: A theoretical modeling with application to Norway", project no. 172582/I99.

1. Introduction

The issue of how to handle financial crises is today at the top of the agenda for international economists and policy makers alike. Much of this discussion is, indeed, crucial and controversial. *Ex-post* it is centered on what should be the degree of intervention by the authorities when meeting such crises to rescue (“bail out”) institutions in financial distress. The discussions on the *ex-ante* measures to prevent such crises are instead made around the role of the BIS to guarantee a solid international financial architecture and avoid systemic risk.

The literature points to two opposing effects of bailouts. The first, most discussed, is the largely negative effect that bailouts have on “moral hazard” in leading agents in the financial sector in particular by setting their “efforts” at sub-optimal levels and taking excessive risks, in anticipation of future bailouts. The second, more positive, effect is that bailouts can be favorable once a crisis has already materialized and is unfolding, by softening its effect on the overall economy and avoiding systemic risk. The choice of an optimal action for a country to avoid a crisis, when it is anticipating one in the near future, or experiencing a current one, is however in general extremely complicated. Financial crises, whatever their causes, often impose huge costs on the countries affected; nevertheless few general rules have been devised to deal with such crises and/or to prevent them. Previous authors, whether for or against bailouts, either study the government’s/central bank’s decisions on bailing out taking as given the banks’ responses to them; or study banks’ decisions regarding their portfolio taking as given the government’s responses to such decisions.

This paper will compare outcomes of implementing *ex-ante* with *ex-post* policies of monitoring and liquidity provision without “constructive ambiguity” (Freixas (2000)). Our main departure from the literature is our analysis on the role that monitoring will play when liquidity provision is made conditional on banks’ performance, as we do here. We here shift

emphasis from maturity transformation and liquidity insurance of small depositors to the “modern” form of illiquidity and insolvency, where large well-informed creditors refuse to renew their credit on the interbank market. This usually occurs when the repayment capacity of an intermediary or a number of intermediaries are in doubt. Here, the central bank will be the absolute source of liquidity (or of outside liquidity as Holmström and Tirole (2001) define) for troubled institutions to enable them to fulfill their obligations toward their depositors/investors, and continue operations. The central bank then acts as Lender of Last Resort (LOLR). We do not include here a deposit insurance corporation because, in contrast to the LOLR, it mainly concentrates in its exposure to the risk of having to compensate depositors following a bank failure. The central bank (and we) here cares about the costs of banking crises and bailing out. If we were to consider full deposit insurance, a “bailout” in our paper would imply that the central bank’s problem is only to decide when and whether or not to authorize the insolvent bank to keep its charter. Such consideration will not change the main conclusions of our paper. The main focus of our paper is on the optimal and disciplined resolution of banking crises that can at the same time give banks enough incentives to avoid moral hazard problems and remain solvent.

We make a clear distinction between i) an optimal discretionary (*ex-post*) policy regarding monitoring (and bailout¹) that takes banks’ behavior as given, and banks only anticipate central bank’s actions; and ii) a commitment (*ex-ante*) to an optimal level of monitoring (and bailout) that is made public, and both takes into account banks’ reaction to such commitment itself, and has an objective to affect the banks’ actions. Some observers may, at the outset, be tempted to discard the last policy alternative on counts of lack of credibility, unfeasibility, or have time inconsistency problems. We are convinced that it is still useful and important to compare the outcomes of having a central bank committing *ex-ante* with one that acts with

¹ As it will be shown, the levels of monitoring and bailout are determined simultaneously.

discretion. At the outset let us mention that the main advantage of committing to monitor and making it public is the reduction of banks' uncertainty over ex-post events, while giving at the same time incentives to the banks to perform well and become transparent about their operations. Would central banks be interested in deviating from their commitments when there are positive outcomes to obtain from not doing so?

Alternative policy (ii) has not been much considered in previous related literature. It is most common to consider the private sector's (i.e. banks') expectations as only formed "ex-ante", while the central bank's decisions is only made "ex-post", acting with discretion. The literature does not either consider the mutual responses between the central bank (or LOLR) and banks as we do here. A contribution of this paper is to provide a model that allows us to compare the sequence of decisions of the agents involved and outcomes, under discretion and under ex-ante commitment. To study such dynamics we find it most useful to consider a (three-stage) sequential game model. Perotti and Suarez (2002) have also considered how supervisory authorities can commit to long-term policies on entry and merging in the bank industry when banking crises are a possibility. Their model takes into account such policies to focus thereafter on the interaction between risk-taking decisions of competing banks and the prudential motive of these banks in order to take over the business of failed banks. Also in a different context, Acharya and Yorulmazer (2007) consider ex-ante and ex-post optimal endogenous policies of the central bank when dealing with banking crises. They analyze the effect of the central bank's commitment to bail out the banks if there is a low correlation between banks' investments so to minimize the likelihood of a "too-may-to-fail" ex-post situation. They show that the lack of such commitment leads to bank herding behavior (i.e. most banks lending to a specific sector or in taking exposures to a systematic risk factor). Note again that my main departure from the literature is the role that monitoring plays when central-assistance is conditioned on banks' performance.

We believe our model also includes other additional features not yet considered in the related literature. *First*, bailouts are always conditioned both on a bad shock, that occurs at the last stage of the game, and on banks not being subject to moral hazard problems. The latter means that banks should maximize their expected profit choosing their investment and effort, without making them dependent on possibilities of being bailed out, even if a bad shock is anticipated. *Second*, the central bank incurs in certain monitoring costs to detect the types of banks it faces, when liquidity provision is to be given. *Third*, with a discretionary policy, banks face uncertainty not only about the future state of the economy, but also about whether there will be monitored. With ex-ante commitments, uncertainty about monitoring (and bailouts) gets resolved. *Fourth*, the central bank always minimizes its total costs, which consist of bailout and monitoring costs as well as the dead-weight costs of banking crises. Only with ex-ante commitments, is the central bank able to minimize the costs created by moral hazard problems. In this paper there will be banking crises when a bad shock occurs and there is no central bank intervention, or when a bad shock occurs and banks cannot keep their charters because they are found to have moral hazard problems.

Two main results are obtained. *First*, with a discretionary policy there will be multiple equilibria, “good” and “bad” equilibria. The “bad” ones are associated with the bad shock, while the “good” ones are associated with the good shock occurring. In one of the bad equilibria there will be no monitoring and the worst moral hazard problems, and all banks are bailed out (they are indistinguishable from each other). Another “bad” equilibrium is one where there will be monitoring, but the final outcome depend on the banks’ expected level of monitoring. Only if banks anticipate that there will be a great deal of monitoring, they will have incentives to reduce their moral hazard because they will know that there will be higher probabilities of detecting its type. *Second*, with ex-ante commitments, by contrast, equilibrium is unique. In such case, the optimal solution is one where the central bank will monitor more

and bail out less than when it acts with discretion. As a consequence, risk-taking behavior and moral hazard problems are ameliorated, and the banks' probability of becoming insolvent is reduced. Note also that with more monitoring, the central bank can detect more correctly banks with moral hazard. One immediate implication of this is that the unique equilibrium will be superior to any equilibrium under discretion. This, in our view, is an important new result in the related literature.

Chapter 2 presents a short overview of the related literature. Chapter 3 describes the three-stage sequential-game theoretical model. Chapter 4 interprets bank's optimal decisions, while chapter 5 presents the central bank's problem and the sub-games perfect Nash equilibria from the game between the central bank and banks, both in the case of commitment and non-commitment. Chapter 7 concludes.

2. Overview of related literature

Much of the previous related literature argues that when insurance schemes and (implicit or explicit) bailout promises simply serve as safety nets for banks, this may create moral hazard and incentives for excessive bank risk-taking. Such arguments are provided by Schwartz (1998), Bordo and Schwartz (2000)), Corsetti et al. (1999), Schneider and Tornell (2000) and Burnside, Eichenbaum and Rebelo (2001, 2004). It is argued in particular that the 1997-98 East Asian crisis was caused by large deficits associated with implicit bailout guarantees to failing banks.

Another strand of the related literature is more positive to bailouts. As in this paper, these contributions analyze whether or not a government can eliminate confidence-driven financial collapse through liquidity provision. Freixas, Parigi and Rochet (1998), Freixas (2000), Aghion, Bolton and Fries (1999), Cole and Kehoe (2000), Cooper and Corbae (2002), Cordella and Yeyati (2003) and Rochet and Vives (2004) all find that under certain

conditions, bailing out banks can be efficient. Bolton (2003) argues that bailouts both in the domestic and sovereign context, even when a bankruptcy mechanism is in place, serve if anything an important economic role in overcoming liquidity crises and contagion. In these papers however, the optimal schemes to recapitalization do not take into account the responses of the central bank and banks to each other's actions, and are typically applied *after* the outbreak of a banking crisis. The model of Cordella and Yeyati (2003), for example, considers a LOLR that announces that it will bail out but only with certain probability and depending on the state of nature. Their formulation encompasses the "constructive ambiguity" approach. Again, in their model the banks' behavior is taken as given.

Another model of bank bailouts related to ours is Goodhart and Huang (2005), who explicitly represent the standard social cost-moral hazard trade-off. They show that the central bank has incentive to provide LOLR assistance when concerns about contagious effects of crises are weighted more strongly than moral hazard considerations. They find however that in order to minimize moral hazard, it is optimal for the central bank to use discretion in the bailout decision. Freixas (2000) finds that depending on the characteristics of the bank's balance sheets and on the social cost of bank failure, the optimal policy may be either a systematic bailout using discretion or a mixed strategy, the latter providing a theoretical foundation for the "constructive ambiguity" doctrine.

Mailath and Mester (1994) look at incentives for a distressed bank to invest in excessively risky projects, and show that when regulators can not commit to future actions, then forbearance arises as an equilibrium outcome. Boot and Thakor (1993) study problems induced by regulators' reputation incentives, and find that a reputation-seeking regulator will tend to delay bank closure. They favor a rule-based regulation instead of regulatory discretion.

Indeed, schemes for bailing out banks in distress can make the probability of surviving becomes less dependent on the bank's choice of risk, and more on the central bank's bailouts.

We here argue that bailouts should be made conditional not only on the occurrence of a bad shock but also on banks' performance, and that it is necessary to have a central bank that commits ex-ante to an optimal bailout and to a sufficient degree of bank monitoring. We will show in this paper why this should be so.

3. A three-stage sequential-game theoretical model

The model here is presented as a three-stage sequential game where the players are the central bank, which acts as the LOLR, and the banks. Banks engage in risky investment activities and exert effort to enhance productivity of their investments, which finally yield certain return that is private information of each bank. There will be two groups of banks: Some banks belong to group n_1 which *never* have moral hazard problems. These banks never have reasons to hide their type, and they are therefore easily identified by the central bank. Other banks belong to group n_2 which *always* have moral hazard problems so that even if the central bank announces that there will not be any bailout, these banks do not consider such policy to be credible. Banks in group n_2 always try to mimic the banks in group n_1 . Only monitoring by the central bank can help to identify them. If the central bank implements a high monitoring intensity, m , it increases the probability of detecting the bank type, $\rho(m)$, and only banks that are detected not to have moral hazard problems will be provided with liquidity. In addition, the higher levels of monitoring anticipated by banks in group n_2 , the more they will avoid moral hazard problems, decreasing their incentives to hide their type. That is, if these banks in group n_2 anticipate a low m and consequently low $\rho(m)$, they expect that they will not be monitored efficiently and make their own optimal decisions (on risky investment and effort) accordingly. Banks are heterogeneous in each group.

Stage 1

The central bank and banks receive probabilistic distribution about a future shock that will occur in the last stage and affect the banks' net returns, and the probabilistic distribution of detecting a bank with moral hazard for all possible levels of monitoring. The bad shock, S_1 , and the good shock, S_2 , will occur with probability q and $(1-q)$, and they will also refer to the bad and good states of nature, respectively. If shock S_1 occurs, banks will end up with negative returns on their portfolios, and become insolvent if there is not central bank intervention. This is contrary to what will happen when S_2 occurs where returns will be positive.

At this stage, the central bank announces that it will act *with discretion* when it becomes necessary to provide liquidity at the last stage (stage 3) of the game given that a bad shock occurs. Only a fraction of the banks' losses will be bailed out². Since liquidity is provided *conditional* on that bad shock occurs, and on banks are not detected to have moral hazard problems, the central bank also decides on the level of monitoring to detect the type of bank at stage 3. The idea behind imposing such conditionality is to penalize insolvency when there are moral hazard problems. Again, not committing ex-ante to a specific level of monitoring and bailout at this stage implies that the central bank will act with discretion (still imposes conditionality) at the last stage of the game. We will however also analyze the consequences of having the central bank committing credibly at stage 1 instead, to an optimal level of monitoring intensity and bailout, and compare the outcome of such policy with the outcomes of the discretionary policy.

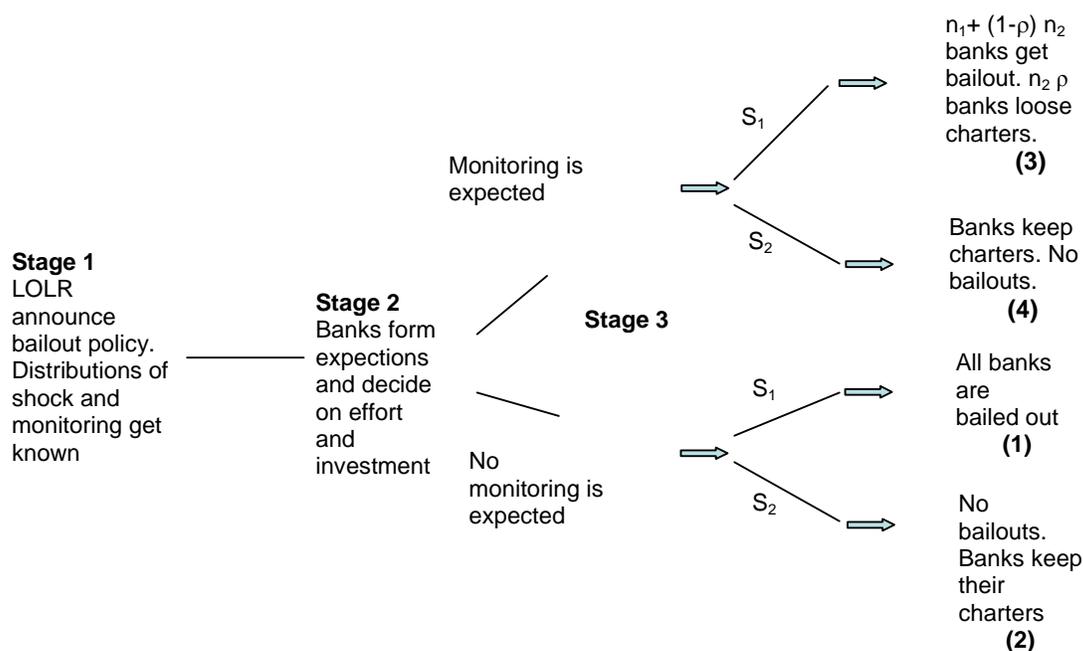
Stage 2

All banks form expectations about the type of shock it will occur at the last stage of the game, while banks in group n_2 form also expectations about whether they will be monitored.

² There will be then recapitalization up to an optimal standard in accordance to the central bank's objectives.

As mentioned, banks' returns are private information to each bank.³ Note however that the probability distribution of the returns in the population of banks in group n_1 and n_2 , becomes known to the central bank. When a bank in group n_2 reports its return (or losses), the central bank cannot directly recognize to which return distribution the bank belongs to, *unless it engages in some monitoring*. More intensive monitoring will raise the probability of detecting the bank type, and thus the return distribution to which this bank belongs to. This asymmetric information problem on the banks' returns and the banks' uncertainty about the monitoring intensity will give banks in group n_2 incentives to have moral hazard problems.

Figure 1. Game tree describing the possible strategies in the three-stage sequential game



Stage 3

Here, only the central bank moves and selects its strategies. A stochastic shock, either S_1 or S_2 , occurs and affects the net returns of the banks. When the central bank acts *with discretion*, it takes necessarily banks' decisions as given. *If banks expect no monitoring*, the central bank's best response is not to monitor the banks. Agents' strategies in this case lead to two

³ This again implies that investment and effort are also private information to each firm.

perfect sub-game Nash-equilibria. One of these is associated with a bad shock, and all banks become indistinguishable from each other and receive bailouts independent on whether or not they have moral hazard problems. The banking system in this case remains fragile because banks in group n_2 have set effort to inefficient levels and the returns are too negative. The other equilibrium occurs when there is a good shock and there are not bailouts. Such sub-game perfect equilibria are illustrated in nodes (1) and (2), respectively in Figure 1. These equilibria resemble the standard results obtained in the related literature, where the LOLR decides ex-post, discretionally and without any discipline device on bailing out. Banks, like the ones in group n_2 here, rationally anticipate low or no monitoring at all, giving them few incentives to make decisions independent of future bailouts. This will hold even though the central bank announces that there will not be any bailout because such policy is not easily viewed as credible. Moral hazard problems are not eliminated or reduced.

Others sub-game perfect equilibria arise when *monitoring is expected* and the central bank acts with discretion. In such a case, the central bank's best strategy is to monitor the banks. If a bad shock occurs, banks will report their returns to receive a bailout. The central bank's monitoring intensity increases its own probability of recognizing to which return distribution a bank's return belongs to. Node (3) represents such solution. Node (4) is attained in the good state.

The main conclusion here is that moral hazard problems are not resolved with a discretionary policy. A discretionary policy does not provide a mechanism to resolve banks' uncertainty about the level of monitoring, which could lead to a large number of banks having moral hazard problems. We here suggest that the central bank could pursue a policy that lead banks to expect a high monitoring intensity to obtain a better solution. We will show that if *ex-ante commitments to have high levels monitoring at stage 1* are optimal and possible to implement, the central bank will be able to provide the best ex-ante incentives to banks to

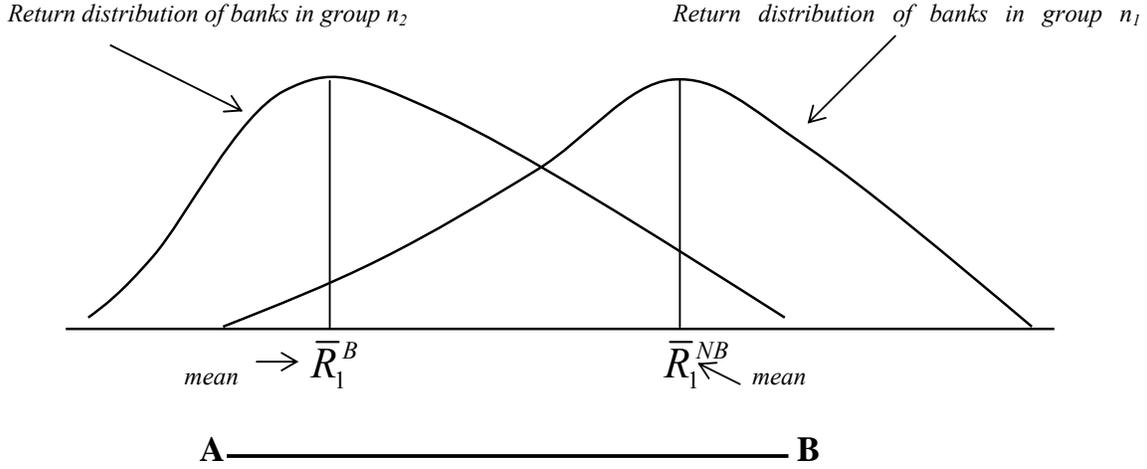
avoid moral hazard problems and insolvencies. Also, only in this case, the central bank will be able to internalize in its objective function the banks' responses to such commitment.

4. Banks' Problem

Each bank decides optimally on its amount of risky investment, L , and effort, e . *In the absence of commitment*, they react optimally in anticipation to the central bank's actions.

When a good shock (S_2) occurs, all banks will obtain *positive* returns. Those that belong to group n_1 (have no moral hazard problems) will obtain $R^{NB}_2(j)$ ($j=1, \dots, n_1$), while the return of those in group n_2 (with moral hazard problems) will obtain $R^B_2(i)$ ($i=1, \dots, n_2$). On the other hand, when a bad shock (S_1) occurs, banks in group n_1 will obtain *negative* returns $R^{NB}_1(j)$, but they will be able to repay their obligations and continue their operations (i.e. keeping their charters) if the central bank intervenes. Banks in group n_2 however, will obtain a return $R^B_1(i)$. In both states, the returns of some banks in group n_2 can be equal to, smaller or greater than the returns of banks in group n_1 . When their type is detected, they will not be bailed out and lose their charters. The returns across banks in each group and state have distributions with means $\bar{R}_2^{NB} (>0)$, $\bar{R}_2^B (>0)$, $\bar{R}_1^{NB} (<0)$ and $\bar{R}_1^B (<0)$, with corresponding variances. Again these distributions are public information. The following figure illustrates the *distributions of returns in the bad state* of banks in group n_1 (on the right) and group n_2 , (on the left), respectively:

Figure 2. Distributions of returns in state 1 across banks in groups n_1 and n_2



Note that the above figure could be conservative because the right-hand side distribution could have a tail farther to the left, or the left-hand side distribution could have tail farther to the right, in which case the segment AB will be larger. Thus, when a bank in group n_2 reports its losses, the central bank cannot directly recognize to which return distribution the bank belongs to. Monitoring raises the probability of detecting the return distribution to which this bank belongs to.

4.1 Banks' optimal decisions on effort and lending independent of bailout policy

Banks of group n_1 make their (risky) investment and effort decisions independent of any bailout and monitoring. Each of them ($j=1, \dots, n_1$) maximizes the following expected net return function $E(R^{NB})$, where we will drop the j indicator to make the exposition fluent, and denote R^{NB} as the return to a bank with no moral hazard problems:

$$E(R^{NB}) = qR_1^{NB}(L, e) + (1-q)R_2^{NB}(L, e) - C^{NB}(e); \quad (1)$$

The return functions, R_1^{NB} and R_2^{NB} are concave in the control variables L and e . q and $(1-q)$ are the probabilities that S_1 and S_2 will occur respectively. $C(e)$ is the cost function of effort where $C_e > 0$, and $C_{ee} \geq 0$.

From maximizing (1) with respect to L , one obtains the following first order condition:

$$\frac{R_{1L}^{NB}}{R_{2L}^{NB}} = - \left[\frac{(1-q)}{q} \right] < 0 \quad (2)$$

The left-hand side in (2) is the ratio between the marginal returns on the portfolio L in the bad (R_{1L}^{NB}) and good (R_{2L}^{NB}) states respectively, and it is negative. This implies that either R_{1L}^{NB} or R_{2L}^{NB} is negative. If we think that it is more likely that the optimal L (obtained from (2)) is less profitable in the bad state than in the good state, we should expect that at this optimal level of L, the marginal return to this L will be negative in the bad state ($R_{1L}^{NB} < 0$) but positive in the good state ($R_{2L}^{NB} > 0$).

By maximizing (1) with respect to e, we find the first order condition with respect to e:

$$qR_{1e}^{NB} + (1-q)R_{2e}^{NB} = C_e^{NB}(e) \quad (3)$$

Without losing generality, we can consider that banks' returns are an increasing function of effort for given L, that is, $R_{1e}^{NB} > 0$ and $R_{2e}^{NB} > 0$.

4.2 The banks' optimal decisions depend on bailout policy

These banks belong to group n_2 . We keep in mind that the central bank will bail out a fraction Φ [$\Phi \in (0, 1)$] of the net losses (or negative returns) that a bank reports. Each of them ($j=1, \dots, n_2$) will maximize the following expected net return function $E(R^B)$, where R^B will denote the return to banks that have moral hazard problems:

$$E(R^B) = q \left\{ (1-\Phi)(1-\rho(m))R_1^B(L, e) + \rho(m)R_1^B(L, e) \right\} + (1-q)R_2^B(L, e) - C^B(e) \quad (4)$$

If there is a probability $(1-\rho(m))$ of not being detected to have moral hazard, (4) indicates that banks in group n_2 will face losses equal to $(1-\Phi)R_1^B(L, e)$ after being bailed out with probability $q(1-\rho(m))$. However, if they are detected (which will occur with probability $\rho(m)$), they will have losses equal to $R_1^B(L, e)$ with probability $q(\rho(m))$.

Maximizing (4) with respect to L yields the following first-order condition for L:

$$\frac{R_{1L}^B}{R_{2L}^B} = - \left[\frac{(1-q)}{q(1-\Phi(1-\rho(m)))} \right] < 0 \quad (5)$$

(5) is similar to equation (2) except that now Φ , and $\rho(m)$ affect ratio (5). Here, it is not only the case that high levels of L is less profitable in the bad state than in the good state (e.g. at the optimal solution for L, $R_{1L}^B < 0$ and $R_{2L}^B > 0$), but also that R_{1L}^B will be more negative than R_{1L}^{NB} (from (2)). This must imply that L will be higher for banks in group n_2 than for banks in group n_1 . We will show below not only that bailout causes moral hazard problems (i.e. increases L), but also that the greater is Φ , the more negative is (5), which indicates that the level of L will be higher if a higher bailout (Φ) is anticipated.⁴ We will also demonstrate that a low monitoring probability of detecting the banks with moral hazard, $\rho(m)$, (which occurs with lower levels of m) will also increase L and contribute to a more negative ratio (5).

Maximizing (4) with respect to the banks' effort, e, yields the following first-order condition for e:

$$qR_{1e}^B((1-\Phi(1-\rho(m)))) + (1-q)R_{2e}^B = C_e^B \quad (6)$$

We get similar results to (3), for $R_{1e}^B > 0$ and $R_{2e}^B > 0$. However, at equilibrium in the bad state, the marginal return with respect to e will be higher for banks in group n_2 than for banks in group n_1 .⁵ Thus, when banks make decisions in basis of an anticipated level of bailout, their optimal level of effort will be lower than for banks whose decisions are independent of bailouts.

We conclude that if Φ is expected to be zero or close to zero, and/or m is expected to be very large (and $\rho(m)$ closed to one), the optimal decisions of banks in group n_2 will be very similar to those banks of group n_1 . It should then become clear that the central bank should have many incentives to monitor as much as possible and to give as little bailout as possible to

⁴ One could also argue that (5) becomes more negative because R_{2L}^B decreases, for given R_{1L}^B . But also in this case, L will be higher when banks have moral hazard problems.

⁵ Note that C_e^B is likely higher than C_e^{NB} , since banks in group n_2 set their effort at lower levels.

reduce or avoid moral hazard. By doing so, the central bank will increase at the least the average returns of banks in group n_2 in the *bad state* and consequently \bar{R}_1^B . The distribution of these returns will necessarily shift to the right, causing the segment AB in figure 2 to become smaller, and putting the central bank in a better position to distinguish the bank type.

We can now take a closer look at how moral hazard problems are affected by the levels of monitoring and bailouts. From (5), the bailout affects L as follows:

$$\frac{\partial L^B}{\partial \Phi} = \frac{q(1-\rho(m))R_{1L}^B}{q[1-\Phi(1-\rho(m))]R_{1LL}^B + (1-q)R_{2LL}^B} > 0 \quad (7)$$

Since $R_{1L}^B < 0$ (from (5)), and given that $R_{1LL}^B < 0$, $R_{2LL}^B < 0$ by the concavity of the return functions, (7) indicates that when Φ is anticipated to increase, the banks will choose a portfolio with higher L. Moreover, if the central bank's monitoring intensity is low, the moral hazard effect of bailing out in terms of higher L, will become stronger.

From (6) we can find how the bailout will affect effort e:

$$\frac{\partial e^B}{\partial \Phi} = \frac{qR_{1e}^B(1-\rho(m))}{q[1-\Phi(1-\rho(m))]R_{1ee}^B + (1-q)R_{2ee}^B - C_{ee}^B} < 0 \quad (8)$$

Since $R_{1e}^B > 0$ (from (6)), and given that $R_{1ee}^B < 0$ and $R_{2ee}^B < 0$ from the strict concavity assumption of the return function, and that $C_{ee} > 0$ due to the strict convexity of the cost function for effort, we find that the greater the bailout the lower effort the banks will exert. This effort will be further reduced with lower monitoring intensity, worsening moral hazard problems.

Similarly from (5) and (6), we derive how the monitoring intensity will affect the banks' portfolio L and effort as follows:

$$\frac{\partial L^B}{\partial m} = \frac{-q\Phi\rho'(m)R_{1L}^B}{q[1-\Phi(1-\rho(m))]R_{1LL}^B + (1-q)R_{2LL}^B} < 0; \quad (9)$$

and

$$\frac{\partial e^B}{\partial m} = \frac{-q \Phi \rho'(m) R_{1e}^B}{q[1 - \Phi(1 - \rho(m))]R_{1e}^B + (1 - q)R_{2ee}^B - C_{ee}^B} > 0 \quad (10)$$

Our main conclusions at this point is that when banks make their decisions dependent on bailouts, such as banks in group n_2 , an anticipated low monitoring and/or high bailout will induce banks to have portfolios with a larger number of risky investments (higher L) and to exert less effort than banks in group n_1 . It should also become clear that greater monitoring and lower liquidity provisions by the central bank will ameliorate banks' moral hazard problems (see (7)-(10)).

5. The central bank's problem

5.1 Discretionary policy

The central bank decides on bailout and monitoring policies to avoid banking crises. Bailing out and monitoring banks are however expensive. When acting with discretion, the central bank's payoff at states 1 and 2 will be $W_1[S_1]$ and $W_2[S_2]$, respectively. The payoff W_2 needs no much explanation as in state 2 there will be no crisis and the central bank will be passive. W_1 will be rather influenced by the bailout Φ , and monitoring, m . W_1 will depend on the functions V , Ψ and Ω :

$$W_1(S_1, \Phi, m) = V[S_1, \Phi, m] - \Psi \left[S_1, \underbrace{\Phi \bar{R}_1^{NB} + (1 - \rho(m)) \Phi \bar{R}_1^B}_{BC} \right] - \Omega[S_1, m] \quad (11)$$

Recall that the central bank can only observe the means of the distributions of the returns across banks in group n_1 and n_2 in each state, as for example \bar{R}_1^{NB} and \bar{R}_1^B .

The central bank derives a value $V > 0$ from monitoring because sufficient high monitoring will both allow the central bank to recognize to which return distribution a bank belongs to, and reduce the banks' moral hazard problems. At the same time, by providing liquidity to the "correct" banks (i.e. detected "correctly" not to have moral hazard), the central bank will also

increase its value function V . Bailing out the correct banks will then increase the value V because resources are used properly, and unnecessary and/or inefficient banking crises are avoided. Indeed, banking crises are less likely when banks' average losses are kept down and moral hazard problems reduced, and this is only possible with sufficient monitoring.

$\Omega(S_1, m)$ is the central bank's costs of monitoring, while $\Psi[S_1, BC]$ depends in a complex manner on bailouts and banks' returns in the bad state. BC in (11) is negative valued since $\Phi \bar{R}_1^{NB} + (1 - \rho(m))\Phi \bar{R}_1^B < 0$. Ψ is then a decreasing convex function of BC . Keep in mind that when acting with discretion, the central bank takes \bar{R}_1^B (and \bar{R}_1^{NB}) as given.⁶ A low monitoring will make the expected bailout costs, BC , more negative because (i) \bar{R}_1^B is more negative (due to moral hazard problems), and (ii) $\rho(m)$ (the probability of detecting banks with moral hazard) becomes smaller. As a result, Ψ will be higher which implies that bailouts become more costly.⁷ This is in contrast to the return distribution of banks in group n_1 (and \bar{R}_1^{NB}) which is always invariable to the level of monitoring (and bailout).

We will now derive optimal bailout and monitoring intensity at stage 3 under discretion. We first consider the case when no monitoring is expected and then when it is expected.

5.1.1 Banks expect no monitoring by the central bank

In the good state as mentioned, the central bank's payoffs will equal $W[S_2]$ and we do not need to discuss it any further. In the bad state the central bank's payoff function in the absence of monitoring is:

⁶ We will show in section 5.2 that when the central bank can commit ex-ante to certain level of monitoring, \bar{R}_1^B will depend on such commitment. In which case \bar{R}_1^B will not anymore be taken as given by the central bank.

⁷ The more negative the banks' returns are, and higher the bailouts might need to be, the more costly is for the central bank in terms of larger fiscal deficit or higher tax payments from the private sector.

$$W_1(S_1, \Phi, 0) = V[S_1, \Phi, 0] - \Psi \left[S_1, \underbrace{\Phi(\bar{R}_1^{NB} + \bar{R}_1^B)}_{BC} \right] \quad (12)$$

By maximizing (12) with respect to Φ , we obtain the first-order condition $dW_1/d\Phi=0$, from which we can obtain the following expression:

$$\frac{dW_1}{d\Phi} = V_\Phi[S_1, \Phi, 0] - \underbrace{\frac{\partial \Psi}{\partial BC}}_{(-)} \bullet \frac{\partial BC}{\partial \Phi} = V_\Phi[S_1, \Phi, 0] - \underbrace{\frac{\partial \Psi}{\partial BC}}_{(-)} \bullet \underbrace{(\bar{R}_1^{NB} + \bar{R}_1^B)}_{\frac{\partial BC}{\partial \Phi}} = 0 \quad (13)$$

(13) indicates that the more negative is \bar{R}_1^B , the larger is the marginal value of bailing out, V_Φ . The implication is that with no monitoring, the more negative are the returns, the smaller the bailout will be.

We can now determine the sub-game perfect equilibria in the absence of commitment when no monitoring is expected. For that we need to use the backward induction method. We have the following propositions:

Proposition 1

When *no monitoring from the central bank is expected*, there will be the following non-cooperative Nash equilibria which are also illustrated in figure 1: (i) Node (1) if a bad shock occurs where the central bank will not monitor any bank and all banks will be bailed out; and (ii) node (2) if a good shock occurs and the central bank is passive.

Proof

- The central bank will not monitor banks when no monitoring is expected. If the central bank does monitor, banks will anticipate this and make optimal decisions accordingly.
- If a *bad shock* occurs, all banks in groups n_1 and n_2 will each report their own negative returns, and the central bank will not be able to recognize to which of the two distributions of returns each reported loss comes from, since there is no monitoring.

- When a *good shock* occurs, no banks will receive any bailout. Banks in group n_1 and group n_2 will obtain positive returns.

5.1.2 Banks expect to be monitored by the central bank

The optimal level of Φ is obtained by minimizing (11) with respect to Φ . From the first-order condition with respect to Φ ($dW_1/d\Phi=0$) we find that:

$$\frac{dW_1}{d\Phi} = V_\Phi[S_1, \Phi, m] - \underbrace{\frac{\partial \Psi}{\partial BC}}_{(-)} \bullet \underbrace{(\bar{R}_1^{NB} + (1 - \rho(m)\bar{R}_1^B))}_{\frac{\partial BC}{\partial \Phi}} = 0 \quad (14)$$

We can now interpret (14) and compare it to (13). For given m and Φ (and \bar{R}_1^B), the central bank here derives smaller marginal value for bailing out more when it engages in monitoring than when it does not (see (13)). The implication is that with monitoring (different than zero), the less negative are the returns, the larger the bailout will be. Here, at equilibrium, bailouts should be then higher than with no monitoring. This is intuitive because the central bank, when it monitors, will have incentives to bail out more the banks that it detects to be “well-behaved” but unluckily affected by a bad shock, and so to avoid a banking crisis. The policy is straightforward; monitor more in order to justify more bailout. Note again, that with discretion, the central bank has no possibilities of taking into account how \bar{R}_1^B will be affected by monitoring more and bailing out more, because banks could never know *for certain* that there will be more monitoring and bailout at the last stage of the game.

The optimal solution for the monitoring intensity will be found by minimizing (11) with respect to m , and can be obtained from:

$$\frac{dW_1}{dm} = V_m(S_1, \Phi, m) - \Omega_m(S_1, m) - \frac{\partial \Psi}{\partial BC} \times \rho'(m)\Phi\bar{R}_1^B = 0 \quad (15)$$

The optimal level of m is one where the marginal value of monitoring (V_m) equals the marginal cost of monitoring $((\Omega_m(S_1, m) + \frac{\partial \Psi}{\partial BC} \times \rho'(m) \Phi \bar{R}_1^B)$. Notice particularly that if $\rho(m)$ is increasing in m ($\rho'(m)$), the central bank will derive more value V ($V_m > 0$) from monitoring more.

We also use also the backward induction method to specify the possible sub-game equilibria when there is not ex-ante commitment and monitoring is expected.

Proposition 2

When *monitoring by the central bank is expected*, the central bank will rationally determine to monitor the banks. The non-cooperative Nash equilibrium can only be compatible with end node (3) if a bad shock occurs; and with node (4) if a good shock occurs. See figure 1. The degree of moral hazard among the banks in group n_2 will though depend on their anticipation on the level of monitoring intensity. They know that there is only $\rho(m)$ probability of finding the bank type.

Proof

- The central bank will rationally determine to monitor the banks because if it does not, banks will anticipate this and expect rather no monitoring in which case the possible equilibria will be the ones described in Proposition 1.
- When a *bad shock* occurs, for given optimal level of monitoring, m , $n_1 + (1 - \rho(m))n_2$ will be bailed out and able to continue with their charters. The rest of the banks ($\rho(m)n_2$) will lose their charters. Notice that the size of m determines the number of banks that could be (wrongly) bailed out, $(1 - \rho(m))n_2$. This equilibrium is represented by node (3) in figure 1. With low monitoring, the central bank will detect fewer banks with moral hazard (i.e. central bank overestimates the quality of the banks) and give bailouts to too many and “wrong” banks.

- When a *good shock* occurs, no banks will receive any bailout and no one lose their charters. This perfect sub-game equilibrium is represented by node (4).

When the central bank acts with discretion, we can draw the following two conclusions. *First*, banking crisis can be driven by self-fulfilling expectations in which case there will be multiple equilibria. One can reach node (1), node (2), node (3) or node (4), that will depend both on the banks' anticipated degree of monitoring intensity, and the type of shock that will finally occur. The actions of the central bank and banks are strategic complements in the terms of Bulow et al. (1985): The central bank chooses a level of monitoring that corresponds to the banks' anticipated level of monitoring. *Second*, if the central bank engages in monitoring as indicated by the Nash-equilibrium, fewer banks in group n_2 will be bailed out wrongly in comparison to the case when there is no monitoring, but bailouts will be higher. *Third*, uncertainty about the level of monitoring will be always there so that the discretionary has no effect on banks' behavior.

5.2 Can the central bank achieve an improved solution by monitoring more?

In this section, we wish to address the following question: What kind of optimal monitoring policy can the central bank implement to avoid not only the multiple equilibria outcome but also the uncertainty and moral hazard problems as the ones presented in the previous sections?

Recall that with a discretionary policy, as presented in the previous section, banks in group n_2 need to form expectations about whether the central bank will monitor them or not. There, more monitoring could reduce inefficient uses of bailouts because only the "right" banks will be provided liquidity. A discretionary policy does not however affect the banks' expectations and behavior when the central bank acts with discretion, while uncertainty about the level of monitoring remains.

We then need to think of how to implement a monitoring policy that resolves the uncertainty to whether or not there will be monitoring. By doing so, the equilibria described by Nodes (1) and (2) in figure 1 would be never attained. We will also show that if such monitoring policy is announced before the banks make (at stage 2) their optimal decisions; it will effectively affect their behavior in a desirable way. For that, it is necessary to consider a central bank that *credibly announces publicly and commits*, at the first stage of the game, to a specific optimal level of monitoring by the time a bad shock (at the last stage of the game) is realized and banks (in group n_2) need liquidity provision. A difficult question is whether the central bank can credibly commit already at stage 1 to such a *specific level of monitoring*. To gain such credibility, in practice, the central bank could be transparent about the investment costs of certain monitoring technology, say $\Omega(S_1, m^C)$, already at stage 1. Alternatively, commitment could come from a legal mandate. From our results above we know that a lower bailout and higher monitoring intensity will reduce moral hazard problems and increase \bar{R}_1^B because the decisions of banks in group n_2 regarding their investment and effort are affected positively.

Now, with commitments, is it optimal to monitor banks more or less than under discretion? As a result, would it be less or more bailout than under discretion? Note that the optimal level of monitoring intensity would be here also determined simultaneously with the optimal level of bailout. Thus, a commitment to an optimal level of monitoring implies also a commitment to an optimal bailout. Now, commitments to monitoring would be preferable to the discretionary policy, if and only if it gives the right incentives to the banks to reduce moral hazard problems. To have such positive effects, the central bank's optimal monitoring level must be higher and bailouts should be smaller than under discretion. We now need to show if this is the case with commitments. If the central bank does commit, it will need to take into account the following:

- i) That there is a probability q that it will incur in costs of bailing out and monitoring if a bad shock occurs in the last stage of the game. There will be then a probability q that the central bank will face a payoff equal to W_1 , and a probability $(1-q)$ that will have a payoff W_2 .
- ii) That the degree of monitoring intensity affects the possibilities of detecting the banks with moral hazard problems.
- iii) That to have the desirable effects on banks' behavior, the central bank should announce its policy already in stage 1.

We then consider the central bank's optimal decisions on optimal bailout and monitoring intensity at stage 1 in anticipation to a bad shock, and before banks form expectations about the shock and whether there will monitoring or not, and make their investment and effort decisions. The central bank then maximizes the payoff function $\Gamma_1 = q(W_1(\cdot))$:⁸

$$\Gamma_1 = q \left\{ V[S_1, \Phi^C, m^C] - \Psi \left[S_1, \Phi^C \bar{R}_1^{NB} + (1 - \rho(m^C)) \Phi^C \bar{R}_1^B \right] - \Omega(S_1, m^C) \right\} \quad (16)$$

Φ^C and m^C represent the optimal bailout and monitoring intensity that the central bank will announce at stage 1 and will maximize (16). The only remaining uncertainty for the banks will be on the type of shock that it will realize at the last stage of the game. Note that another way to express this problem is to say that the central bank take the lead and make its optimal decisions at stage 1, taking into account how banks would respond to Φ^C and m^C .

If one maximizes (16) with respect to Φ^C , one obtains the following first order condition:

$$\frac{d\Gamma_1}{d\Phi^C} = q \underbrace{\frac{dW_1}{d\Phi^C}}_{=f.o.c.(14)} - q \underbrace{\frac{\partial \Psi}{\partial BC} \cdot \underbrace{(1 - \rho(m^C)) \Phi^C}_{\frac{\partial BC}{\partial \bar{R}_1^B}} \cdot \frac{d\bar{R}_1^B}{d\Phi}}_{\text{moral hazard effects of } \Phi} = 0; \quad \text{or} \quad (17a)$$

⁸ At state 2, again, the central bank is passive.

$$\frac{d\Gamma_1}{d\Phi^C} = \underbrace{V_\Phi[S_1, m^C, \Phi] - \frac{\partial\Psi}{\partial BC} \cdot (\bar{R}_1^{NB} + (1 - \rho(m^C))\bar{R}_1^B)}_{=f.o.c.(14)} - \underbrace{\frac{\partial\Psi}{\partial BC} (1 - \rho(m^C))\Phi^C \cdot \frac{d\bar{R}_1^B}{d\Phi}}_{moral\ hazard\ effects\ of\ \Phi} = 0 \quad (17b)$$

The optimal monitoring will be determined by solving the first order condition with respect to m^C :

$$\frac{d\Gamma_1}{dm} = q \underbrace{\frac{dW_1}{dm}}_{=f.o.c.(15)} - q \underbrace{\frac{\partial\Psi}{\partial BC} \cdot (1 - \rho(m^C))\Phi^C \cdot \frac{d\bar{R}_1^B}{dm}}_{\frac{\partial BC}{\partial \bar{R}_1^B} \cdot \underbrace{\phantom{\frac{\partial\Psi}{\partial BC} \cdot (1 - \rho(m^C))\Phi^C \cdot \frac{d\bar{R}_1^B}{dm}}}_{moral\ hazard\ effects\ of\ m}} = 0; \quad or \quad (18a)$$

$$\frac{d\Gamma_1}{dm} = \underbrace{V_m(S_1, \Phi^C, m^C) - \Omega_m(S_1, m^C)}_{=f.o.c.(15)} - \underbrace{\frac{\partial\Psi}{\partial BC} \cdot \rho'(m^C)\Phi\bar{R}_1^B}_{moral\ hazard\ effects\ of\ m} - \underbrace{\frac{\partial\Psi}{\partial BC} (1 - \rho(m^C))\Phi^C \cdot \frac{d\bar{R}_1^B}{dm}}_{moral\ hazard\ effects\ of\ m} = 0 \quad (18b)$$

From (17) and (18) we can notice that the central bank has q probability of facing the same first order conditions with respect to bailout and monitoring, respectively, that it faces when it acts with discretion. There are however additional effects to these first order conditions, *first*, the effect of bailing out on banks' moral hazard caused (last term in (17)), and *second*, the effect of monitoring also on the banks' moral hazard (last term of (18)). These latter effects can either decrease or increase the central bank's marginal costs (payoffs) of bailing out, and this will depend on the signs that $d\bar{R}_1^B/d\Phi^C$ and $d\bar{R}_1^B/dm^C$ take. These two terms indicate how changes in bailout and monitoring affect the mean of the payoffs distribution for banks in group n_2 , respectively. With adverse moral hazard effects of bailing out, $d\bar{R}_1^B/d\Phi^C < 0$ (the returns distribution of the banks in group n_2 would shift to the left), the overall effect of the last part of (17) ("*moral hazard effect of Φ* ") will be positive (since $\partial\Psi/\partial BC < 0$). In order to satisfy the first order condition (17a), $dW_1/d\Phi^C$ will then need to increase whenever there are adverse effects of bailing out, and this is possible if bailouts decrease. This implies that the

central bank's optimal decision should be to give a smaller bailout than under discretion in order to ameliorate the moral hazard problems. *Note that in the absence of moral hazard problems of bailing out, the bailout will be the same as with no commitment.*

Notice that we have enough reasons for having $d\bar{R}_1^B/d\Phi$ negative. This follows from the results derived in section (4.2), where we show that at the individual bank level, bailouts cause moral hazard. See for example, equation (7) and (8), where $\partial L^B/\partial\Phi > 0$, and $\partial e^B/\partial\Phi < 0$. Higher bailouts will make individual banks to involve in more risky investment and set effort at suboptimal levels, and this will obviously result in more negative returns in the bad state of the economy. Banks in group n_2 are each different from each other, but they all have moral hazard problems, and will contribute to a *more negative average return across banks*, \bar{R}_1^B , if bailout increases.

When $d\bar{R}_1^B/dm > 0$, the overall effect of the last part of (18) ("*moral hazard effect of m*") will be negative (since $\partial\Psi/\partial BC < 0$), and to satisfy the first order condition (18), $(dW_1/d\Phi)$ will need to decrease but this is only possible if the monitoring intensity increases. Thus, the central bank will, in this case, optimally monitor more than when it acts with discretion. With higher monitoring, the central bank also has higher probability of detecting the bank type which will obviously reduce moral hazard problems and shift the returns distribution of banks in group n_2 to the right. This is why $d\bar{R}_1^B/dm^C > 0$. As we discuss in section (4.2), at the individual bank level, more monitoring reduces moral hazard because $\partial L^B/\partial m < 0$, and $\partial e^B/\partial m > 0$ (see equations (9) and (10)). More monitoring gives individual banks incentives to take less risky investment and exert more effort, resulting in less negative returns in the bad state at the individual level and on average (\bar{R}_1^B).

In conclusion, it is desirable that banks, *before* they make their decisions, get to know, not only that the central bank will monitor them but that there will be *high levels of monitoring*

intensity. If this is possible, then (i) the dilemma of multiple equilibria that arises under discretionary central bank policy, gets resolved, and instead a unique equilibrium that is only contingent on the type of shock is attained; (ii) banks' moral hazard problems are reduced to a minimum; (iii) the need for bailing out is also minimized; and (iv) the banks' return increase so that fewer banks are likely to end up insolvent, thus, reducing risks of banking crises.

It then becomes essential for the central bank to make sure that a high-intensity monitoring policy becomes transparent and credible at a very early stage. This will resolve banks' uncertainty on whether there will be any monitoring at all, which is always a problem when the central bank acts with discretion. Moreover, it has the advantage of affecting positively the banks' behavior and expectations at a very early stage. One should then realize that discretionary decisions will not lead to the outcomes (i)-(iv), as stated above.

One could here clearly question the central bank's ability to establish a credible high-level monitoring policy. If this is a serious obstacle, our model at least shows that *even if the central bank finds it difficult to credibly commit at a very early stage (say at stage 1 in our game) to high levels of monitoring, it should monitor as much as possible even when acting with discretion*. Nevertheless, it should keep in mind that with a discretionary policy, any possibility of reducing banks' moral hazard is limited by the banks' uncertainty about the level of monitoring. Unless a high level of monitoring is anticipated to occur with certainty, a discretionary policy will not reduce moral hazard problems and the need for bailing out. An ex-ante commitment to high-intensity monitoring that is made public, has however the potential of reducing risk-taking and inducing higher effort that more than offsets any moral hazard effect that a bailout policy can create. This is so because high monitoring allows central bank to condition effectively any bailout to bank's performance.

A main contribution of our theoretical model relative to the literature is then to show the limitations of acting with discretion in comparison to the possibility of making commitments.

We are aware of how difficult it is in practice to make credible commitments. We still find it useful to recognize that if such commitment is possible, a much improved resolution of banking crises can be achieved.

Another way to interpret our results is via a comparison between two policies for dealing with banking crises. One is a policy where the central bank announces that there will be no bailouts; and a second one, a policy where the central bank announces credibly as early as possible that there will be high levels of monitoring when provision of liquidity becomes necessary if a bad shock occurs. With the first policy, banks with moral hazard will always expect a bailout because a no-bailout policy is not credible. This result resembles the status quo, where no bailout is promised and no commitment to monitor is made. One conclusion from our study is that a commitment to monitor may in fact eliminate most of the need for bailing out. In other words, if the central bank only commits to not bailing out, it will unlikely affect the banks' risk-taking behavior and effort exertion. If it commits at the same time to high-levels of monitoring, this policy by itself again reduces the need for bailing out, as our model shows. When the need for bailing out is there, the high monitoring offsets any moral hazard effect that such needed bailout may have when granted, because the necessary bailout will be small when there is high levels of monitoring. This is a main contribution of our theoretical model relative to the literature, which is silent on such effects.

6. Conclusions

We have studied a model that analyzes the interrelationships between banks' behavior, and the central bank's decisions regarding liquidity provision and monitoring policy. The model is presented as a three-stage sequential game where the players are the central bank and banks. The recapitalization of the bank is only up to a level such as maximizes the central bank's objective function. This recapitalization is conditional on a bad shock which occurs at the last

stage of the game, and the banks' decisions not being adversely dependent on the bailout policy itself (i.e. not showing any moral hazard). There are two groups of banks; banks in group n_1 never have moral hazard problems. The other group of banks, n_2 , is generally subject to moral hazard specially when there are not commitments to monitor them. So even when the central bank announces that there will be no bailout, these banks never consider that policy to be credible. Information about the probability distribution of future shocks (bad or good and due to occur in the final stage 3) becomes common knowledge in the first stage. The central bank cannot observe perfectly which banks have moral hazard problems, and needs to invest in some monitoring technology to deal with that problem. The probabilistic distribution of detecting the type of bank at the last stage of the game (when recapitalization is claimed) for every level of monitoring intensity also becomes common knowledge in stage 1. In stage 2, the banks form expectations about the shock and the level of monitoring before they decide on their investment and effort. We have shown that when the central bank acts with discretion, a higher level of monitoring will reduce the costs of bailing out, but it does not reduce the possibilities of bank insolvencies and the banks' moral hazard problems. It also becomes clear that an ex-post decision to monitor more does not resolve the uncertainty that banks in group n_2 may have on the level of monitoring, and this uncertainty leads to multiple non-cooperative Nash equilibria. We have however shown that if the central bank were able to announce credibly already at stage 1 that there will be high levels of monitoring intensity, it can effectively ameliorate the banks' risk-taking behavior and effort exertion. This makes it more likely for banks to remain solvent.

Our main results can be summarized as follows: *First*, when the central bank acts *with discretion* and *no monitoring is expected*, the non-cooperative Nash equilibrium implies that the central bank chooses not to monitor, in which case such expectations will be self-fulfilling. In the bad state, all banks will be bailed out since these will be undistinguishable

from each other. Such an outcome implies the worst case of moral hazard problems where banks have the greatest incentives to make their decisions dependent on future bailouts: Risky investment increases and the level of effort decreases. *Second*, when the central bank acts *with discretion* and *banks expect to be monitored*, there will be another non-cooperative Nash equilibrium where central bank actually monitors the banks and there are higher bailouts. The *higher* the monitoring intensity is, the *lower* the number of banks that will wrongly receive bailouts and be allowed to keep their charters. Again, here when acting with discretion, uncertainty about monitoring is never resolved. *Third*, we show that if the central bank is able to credibly announce early that it will engage in high monitoring intensity, it will reduce the need for bailing out and moral hazard problems. This type of measure reduces banks' insolvencies.

One of the main conclusions is then that bailouts rather precipitate financial crisis as well as worsen moral hazard problems when the central bank acts with discretion, especially when the central bank's monitoring policy is uncertain to banks. Our recommendation is that in order to provide banks the best ex-ante incentives, the central bank should *first*, monitor more, and *second*, make the level of monitoring common knowledge to have the most desirable effects in banks' behavior.

References

- Acharya V. V. and T. Yorulmazer.** (2007). To many to fail – An analysis of Time-inconsistency in bank closure policies. *Journal of Financial Intermediation*, 16(1), 1-31.
- Aghion P., P. Bolton, and S. Fries.** (1999). Optimal design of bank bailouts: The case of transition economies. *Journal of Institutional and Theoretical Economics*, 155, 51-70.
- Bolton, P.** (2003). Toward a statutory approach to sovereign debt restructuring: Lessons from corporate bankruptcy practice around the world. IMF Working paper # 13. Washington D.C. USA.
- Boot, A. and A. Thakor.**(1993). Self-interested bank regulator. *American Economic Review Papers and Proceedings* 83, pp. 206–212.

- Bordo, M. D. and Schwartz, A. J.** (2000). Measuring real economic effects of bailouts: Historical perspectives on how countries in financial distress have fared with and without bailouts. *Carnegie-Rochester Conference Series in Public Policy*, 53, 81-116.
- Bulow, J., J.D.Geanakoplos, and P.D. Klemperer,** (1985). Multimarket Oligopoly: Strategic Substitutes and Complements. *The Journal of Political Economy*, 93(3), pages 488-511.
- Burnside, C., M. Eichenbaum and S. Rebelo,** (2004). Government guarantees and self-fulfilling speculative attacks. *Journal of Economic Theory*, 119(1), 31-63.
- Burnside, C., M. Eichenbaum and S. Rebelo,** (2001). Prospective deficits and the Asian currency crises, *Journal of Political Economy*, 109(6), 1155-1197.
- Cole H.L. and T.J. Kehoe** (2000). Self-fulfilling debt crises. *Review of Economic Studies*, 67, 91 -116.
- Cooper R. and Corbae D.** (2002). Financial Collapse: A lesson from the Great Depression. *Journal of Economic Theory*, 107, 159-190.
- Cordella, T. and E. L. Yeyati.** (2003). Bank bailouts: Moral hazard vs. Value effect. *Journal of Financial Intermediation*, vol. 12, issue 4, pages 300-330
- Corsetti, G. and P. Pesanti and N. Roubini** (1999). Paper tigers: A model of the Asian currency crisis. *European Economic Review*, 41, 309-330.
- Freixas, X., Parigi B. and Rochet J.C.** (1998). Lender of last resort policy: A theoretical foundation. Unpublished manuscript, Universities Pompeu Fabra, Toulouse and Venice.
- Freixas, X.** (2000). Optimal Bail out Policy, conditionality and creative ambiguity. LSE Financial Markets Group discussion paper 327.
- Goodhart, C. and H. Huang.** (2005). The lender of last resort. *Journal of Banking and Finance*, 29, 1059-1082.
- Holmström B., and J. Tirole** (2001). Inside and Outside Liquidity. Wicksell Lectures.
- Mailath, G. and L. Mester** (1994). A positive analysis of bank closures. *Journal of Financial Intermediation* 3, pp. 272–299
- Perotti, E.C. and J. Suarez** (2002). Last bank standing: What do I gain if you fail?. *European Economic Review*, 46, 1599-1622.
- Rochet, J-C. and X. Vives** (2004). Coordination failures and the lender of last resort : Was Bahegot right after all? *Journal of the European Economic Association*, 2(6), 1116 – 1147.
- Schwartz, A.J.** (1998). Asian banking crises in the 1990s: All alike? (Ed.) G.G. Kaufman, *Research in Financial Services: Private and Public Policy* 10, JAI press, Stamford.
- Schneider, M. and A. Tornell** (2000). Balance Sheet Effects, bailout guarantees and financial crises. NBER Working Paper # 8060, Cambridge, Massachusetts, USA.