Why Does Information Disappear in Crisis Times?

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Abstract. The recent financial turmoil, and financial crises in general, have shown that information in financial markets disappears in crisis times. This leads to market unraveling and makes market discipline an inefficient regulatory instrument. I provide a theoretical model explaining this fact. In my model, information disappears because banks have incentives to overstate their financial condition in periods of financial distress. Information vanish when it is mostly needed and this leads banks to engage in opportunistic behaviors ex-ante. I consider three policies (asset buybacks, debt guarantees and equity injections) to strengthen market discipline. All the three succeed in giving incentives to disclose information, but at the cost of opportunistic behaviors by banks. It turns out that the three policies are equivalent. It is efficient to implement them when tax distortions are low and inefficiencies from the lack of information are large.
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1. INTRODUCTION

Financial crises have shown that information in financial markets gets scarcer in crisis times. Very little was known about the exposure of banks to toxic assets at the onset of the recent financial turmoil. Stress tests have been necessary to resolve this uncertainty. In many and less recent bank run episodes, the lack of information about the solvency of banks is what caused the run according to some authors[1]. My paper aims at explaining this fact and recommending policies to make sure information exists in crisis times. This is interesting because of efficiency and regulatory reasons. As regards the first, it is well known that the lack of information might lead to the unraveling of a market when there is adverse selection. It actually did that in the bank run episodes I have just mentioned and, according to some authors [2], also in the recent financial crisis. These authors claim that the lack of information

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[1]See, for example, Calomiris-Mason (1997) about bank run episodes in Chicago in 1932, Gorton (1988) and Park (1991) for a survey of U.S. episodes.

[2]See Heider, Hoerova, and Holthausen (2008) for a theoretical model

about banks' exposure to toxic assets caused the interbank market freeze. As regards the second, investors will not be able to discipline banks through the cost and availability of funds if they do not know their riskiness. This makes market discipline, which is the Third Pillar of Basel 2, an ineffective regulatory instrument.

My point is that information is available in a market only if there are incentives to disclose it. In crisis times, the negative effects of revealing bad information weaken those incentives and make information disappear. I formalize this intuition in a model where a bank is seeking funds to refinance a portfolio of loans. A fraction $1-\beta$ of banks is hit by an asset shock, which I model as a high fraction of non performing loans in banks' portfolio. Lenders do not know which banks are hit by the shock. They base their lending decisions on the amount of non performing loans charged off by the bank. Non performing loans yield 0 at the end of the period, but the bank gets the recovery value L per loan at the beginning of the period if it charges them off. A trade off between borrowing costs and recovery value from non performing loans arises for the bank. If the bank charges off all its non performing loans, it recovers the most possible from them but borrows at a high interest rate because the high fraction of impaired assets makes lending risky. If it hides some of them, the bank recovers less from its non performing loans but borrows at a lower risk premium because it signals a better financial condition. When the shock is small, the shocked bank charges off all non performing loans because the gain from a lower debt repayment is lower than the cost of hiding non performing loans. As the shock gets worse, the shocked bank has an incentive to overstate its financial condition, but the good bank finds it worth signaling itself by charging off a lower amount of non performing loans such that it can separate. When the shock is very bad (crisis), the incentive of the shocked bank to overstate its financial condition is so strong that separation becomes impossible since it would require a negative charge off choice. I consider three policies to strengthen market discipline: asset buybacks, debt guarantees and equity injections. They all succeed in eliciting information disclosure, but at the cost of a lower effort level ex-ante. It turns out that the three policies are equivalent. It is efficient to implement them when tax distortions are low and inefficiencis from the lack of information are large.

My paper is related to different strands of literature. Heider, Holthausen and Hoerova (2008) show that interbank markets may collapse when the adverse selection problem among borrowers of different quality gets more severe. My focus is more on the reason why adverse selection arises especially in bad times rather than on the effect of adverse selection on financial markets. Close to my paper is also the literature on endogenous liquidity[3]. In a context where borrowers of different quality are hit by a liquidity shock and need to raise funds from uninformed investors, this literature predicts that financial markets are more liquid in good times than in bad times because adverse selection is lower. In good times, that is when the return on investments is high, investments are more likely to be liquidated because of a liquidity shock rather than bad news about returns. The opposite happens in bad times. My paper is different in that I allow for borrowers to signal themselves, whereas pooling is implicitly assumed in the previous literature both in good and bad times. I take the incentives to disclose non performing loans from Aghion-Bolton-Fries (1999) and Mitchell (2001). They build models where bank managers might want to overstate bank's financial condition in order to avoid regulator's intervention. The authors design bail out plans in a way to give the bank incentives to reveal its financial condition truthfully. My paper is also related to the literature about the short term bias of managers [4] in that banks sacrifice the long term value of their assets (by hiding non performing loans) in exchange of a larger short term gain (lower interest rate). Finally, my paper is related to the literature about the optimal design of policies to cope with financial crises [5].

Three empirical predictions arise from my model. First, banks tend to overstate their financial condition in bad times. This is consistent with the literature on accounting discretion. Huizinga-Laeven (2009) document that banks used accounting discretion in the recent financial crisis in order to overstate the book value of their capital. Gunter-Moore (2003) find that the worse the financial condition, the more banks are likely to understate their financial losses. Second, the relation between balance sheet indicators of risk (non performing loans) and interest rates is stronger in good times than in crisis times. My model predicts a positive relation between risk and interest rate in good times and no relation in crisis times. This is

[3]Eisfeldt (2004) for example
[4]Most notably Stein (1988)
[5]Bhattacharya-Nyborg (2010), Philippon-Schnabl (2009), Philippon-Skreta (2010) and Tirole (2010).

consistent with the empirical literature on market discipline [6]. Third, liquidity is higher in good times than in crisis times. My model predicts that the non shocked bank borrows at an adverse selection premium in bad times and in the costly separation regime. This is similar to the predictions of the endogenous liquidity literature.

The paper is structured as follows. Section 2 contains the model setup and Section 3 the derivation of the equilibrium. Section 4 presents the welfare and policy analysis. Section 5 draws the conclusions.

2. THE MODEL SETUP

I consider a one period model with a bank and a continuum of mass D of risk neutral investors. At the beginning of the period, the bank inherits a portfolio of size one of loans that will pay off at the end of the period, equity 1-D and a stock of debt D to roll over. The portfolio consists of a fraction p of successful loans and a fraction $1-p$ of non performing loans. The fraction p depends on bank's effort θ, with $\theta \epsilon\, [0,\, 1]$, and on a random variable η which can take the value 1 with probability β and ρ (< 1) with probability $1-\beta$. The realization of the random variable is private information of the bank. I assume that $p = \theta\eta$ and that effort is non contractible and costs $c(\theta) = \frac{1}{2}\theta^2$. Successful loans yield either Y_H with probability α or Y_L (with $Y_L < Y_H$) with probability $1-\alpha$. Non performing loans yield 0 at the end of the period because the borrower is going to default and has no assets that can be seized. The bank can charge off these loans and invoke a bankruptcy procedure to recover L per non performing loan at the beginning of the period [7].

The game has two stages. In the first, the bank chooses effort. In the second, the bank learns the fraction $1-p$ of non performing loans and has to roll over the outstanding debt D. The fraction p is bank's private information relevant for investors' lending decision. Few non

[6] For example, see Levy Yeyati-Martinez Peria-Schmukler (2003) and Flannery (1998)

[7] More generally, I could have assumed that the defaulting firm has some assets at the end of the period, but lower than the recovery value L. This is the case when the defaulting firm engages in opportunistic behaviors that dissipate the value of the assets. For example, the manager of the defaulting firm might undertake projects that yield private benefits but are not efficient for the firm, or sell firms' assets at very low prices to other firms where she has a stake.

performing loans in the balance sheet signal a good financial condition and low bank's default risk. This generates a trade off in the management of non performing loans. The bank has two options: charging off or hiding non performing loans. By hiding non performing loans, the bank overstates its financial condition and can borrow at a lower interest rate at the cost of giving up the recovery value L. Charging off all its non performing loans, the bank gets the recovery value L but borrows at a higher interest rate. Investors decide whether to lend or not to the bank and at which interest rate looking at bank's balance sheet, knowing the distribution of loans' return and the structure of the game. If investors decide not to lend, the bank can not roll over its outstanding debt D and is forced to liquidation.

This setup tries to represent a bank in normal and crisis times through a simple binomial random variable. In normal times, bank's performance is a function of effort. In a crisis, the effect of bank's effort on performance is hurt by a negative shock. An alternative interpretation is that banks differ in the exposure to a macroeconomic shock η that hits the economy. A fraction β of banks is resilient to the shock, whereas the complementary fraction of banks suffers a drop in the value of assets. In what follows, I will use this interpretation because it is consistent with the fact that banks are differently exposed to systemic risk factors. I will refer to the bank not hit by a shock, i.e. for which $\eta = 1$, as good bank, and to the bank hit by a shock, i.e. for which $\eta = \rho$, as bad bank.

I will assume that the bank tells the truth when it is indifferent between telling the truth and lying (Assumption 1), that $(1-\alpha)Y_L > L$ (Assumption 2), and that $(1-\alpha)(Y_H - Y_L) + L > L\frac{Y_H}{D}$ (Assumption 3). Assumption 1 is standard. Assumption 2 means that the recovery value is much lower than the return of successful loans in the worst case. Assumption 3 has no particular economic meaning but makes the analysis easier. In what follows, I will denote p_L and p_H the fraction of successful loans of the bad and good bank. Since I will do comparative statics on ρ, in what follows I will use also the equivalent expression $\rho\theta$ and θ to denote the fraction of successful loans of the bad and the good bank. The fractions $\hat{p}_L$ and $\hat{p}_H$ will represent the charge off choice of the bad and good bank. Note that $\hat{p}_j \geq p_j$, or alternatively $1 - \hat{p}_j \leq 1 - p_j$. The bank can not charge off more non performing loans than what it has in the portfolio, but can hide some of them.

3. THE EQUILIBRIUM

An equilibrium is an effort choice and a fraction of charged off loans that maximizes bank's profit taking into account investors' reaction. The game has two stages and can be solved as usual by backward induction. I start solving for the optimal charge off choice by following these steps. I assume an equilibrium, derive investors' beliefs, calculate bank's profit and check the incentives to deviate. When the bank has no incentive to deviate, the assumed equilibrium is actually an equilibrium. Having solved the second stage, I go back to the first stage which I solve by maximizing bank's utility with respect to effort since effort is non contractible. The problem is concave, so that the first order condition yields a maximum. Investors anticipate bank's effort choice and decide how much to lend and at which rate in the first period.

3.1. **Separating equilibrium.** In a separating equilibrium, the charge off choice signals whether the bank is good or bad. Denote $1-\hat{p}_L$ and $1-\hat{p}_H$ the fraction of loans charged off by the bad and good bank. Investors learn that bank's assets can take the following values:

$$A(p_{_L},\, \hat{p}=\hat{p}_L) = \begin{cases} p_{_L} Y_L + (1-\hat{p}_L)\, L \equiv A_L(p_{_L},\, \hat{p}=\hat{p}_L) & w.p.\ 1-\alpha \\ p_{_L} Y_H + (1-\hat{p}_L)\, L \equiv A_H(p_{_L},\, \hat{p}=\hat{p}_L) & w.p.\ \alpha \end{cases}$$

when $\hat{p}_j = \hat{p}_L$ and

$$A(p_{_H},\, \hat{p}=\hat{p}_H) = \begin{cases} p_{_H} Y_L + (1-\hat{p}_H)\, L \equiv A_L(p_{_H},\, \hat{p}=\hat{p}_H) & w.p.\ 1-\alpha \\ p_{_H} Y_H + (1-\hat{p}_H)\, L \equiv A_H(p_{_H},\, \hat{p}=\hat{p}_H) & w.p.\ 1\alpha \end{cases}$$

when $\hat{p}_j = \hat{p}_H$. In general, $A(p_j,\, \hat{p}=\hat{p}_i)$ denotes the assets of a bank with p_j good loans which charges off $1-\hat{p}_i$ non performing loans. For example, the assets of the bad bank are equal to the sum of the return on good loans (either Y_H or Y_L on p_L good loans) and the liquidation proceeds of non performing loans (L on $1-\hat{p}_i$ charged off non performing loans).

Investors use this information to decide whether to lend or not and at which interest rate. Lemma 1 summarizes investors' decision.

Lemma 1. *When the bank charges off* $1-\hat{p}_L$ *non performing loans, investors lend at the risk free rate if* $\rho \geq \frac{D-L-(1-\hat{p}_L)L}{\theta Y_L}$*, do not lend if* $\rho > \frac{D-L-(1-\hat{p}_L)L}{\theta E(Y)}$ *and lend at the rate* $R(\hat{p}=\hat{p}_L) = \frac{D-(1-\alpha)A_L(\theta_L,\hat{p}=\hat{p}_L)}{\alpha D}$ *if* $\rho \,\epsilon\, (\frac{D-L-(1-\hat{p}_L)L}{\theta Y_L},\ \frac{D-L-(1-\hat{p}_L)L}{\theta E(Y)}]$.

When the bank charges off $1-\hat{p}_H$ *non performing loans, investors lend at the risk free rate if* $D \leq A_L(p_{_H},\ \hat{p}=\hat{p}_H)$*, do not lend if* $D > E[A(p_{_H},\ \hat{p}=\hat{p}_H)]$ *and lend at the rate* $R(p_{_H},\ \hat{p}=\hat{p}_H)) = \frac{D-(1-\alpha)A_L(p_{_H},\hat{p}=\hat{p}_H)}{\alpha D}$ *if* $D\epsilon(A_L(p_{_H},\ \hat{p}=\hat{p}_H),\ E[A(p_{_H},\ \hat{p}=\hat{p}_H)]]$.

Proof: *all the omitted proofs are in the appendix.*

Lemma 1 illustrates investors' break even condition. Observing bank's charge off choice, investors learn that assets can take two values. Lending is safe if the state of the economy is so good that the bank is able to pay back the debt even when the lowest return realization occurs. Investors are better off not lending to the bank when the state of the economy is such that bank's expected assets are lower than debt. The interest rates in Lemma 1 are those making investors indifferent between lending and taking risk and not lending to the bank. The interest rate charged to the bad bank depends positively on debt and negatively on ρ. Intuitively, the larger debt, the larger the loss in case of default, and the higher the required compensation for risk. The smaller the fraction of good firms in bank's portfolio (ρ), the lower the value of assets in case of default and the larger the risk premium. The shock does not affect the good bank, which can borrow at an interest rate that depends only on debt.

The bank calculates profits taking into account the interest rate required by investors. The couple $\hat{p}_L,\ \hat{p}_H$ is an equilibrium if the bad bank prefers charging off $1-\hat{p}_L$ non performing loans and the good bank prefers charging off $1-\hat{p}_H$ non performing loans. Typically, signaling games yield a continuum of separating equilibria which can be narrowed down by refining out of equilibrium beliefs. These refinements imply that the worst type always goes for the least costly action. Proposition 2 illustrates the implications in this case.

Proposition 2. *Type B bank charges off all its non performing loans in equilibrium.*
Proof: *Type B, which has the largest amount of non performing loans, will always reveal itself in a separating equilibrium. It is not worth wasting assets in costly signaling.*

Given the result in Proposition 2, I focus on the separating equilibria with $\hat{\theta}_L = \theta_L$. Proposition 3 illustrates the range of separating equilibria.

Proposition 3. *There is a separating equilibrium for the following parameter constellations:*

(1) $\rho = \underline{\rho}_{CS_L}$ *and* $\hat{p}_H \leq \underline{\hat{p}}_1$

(2) $\rho = \underline{\rho}_{CS'_L}$ *and* $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1, 1\right]$

where: $\underline{\rho}_{CS_L} = \frac{(1-\alpha)(D-L)-\alpha\hat{p}_H L}{\theta((1-\alpha)Y_L-L)}$, $\underline{\rho}_{CS'_L} = \frac{(1-\alpha)\theta Y_L-\hat{p}_H L}{\theta((1-\alpha)Y_L-L)}$, *and* $\underline{\hat{p}}_1 = \frac{\theta Y_L}{L} - \frac{D-L}{L}$

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Proof: *all the omitted proofs are in the appendix.*

Separation is an equilibrium when the incentive constraint of both the good and the bad bank is satisfied. The good bank must prefer the charge off choice allowing separation, which might require hiding some non performing loans, rather than charging off all the non performing loans and borrowing and the bad bank interest rate. The bad bank must prefer revealing its financial condition rather than mimicking the good bank and borrowing at a lower interest rate. I show in the appendix that the incentive constraint of the bad bank is satisfied when $\rho \geq \underline{\rho}_{CS_L}$ in case (1) and $\rho \geq \underline{\rho}_{CS'_L}$ in case (2) of Proposition 3. When ρ is large enough, the fall in the value of the assets is such that the bad bank prefers revealing its financial condition because the gain from borrowing at the good bank interest rate is lower than the liquidation proceeds the bad bank would lose mimicking the good bank. In the appendix, I also show that the incentive constraint of the good bank is satisfied when ρ is smaller than a threshold in both cases of Proposition 3. When ρ is small enough, the impairment of the assets of the bad bank is such that the good bank prefers bearing the cost of hiding a fraction of non performing loans rather than borrowing at the bad bank interest rate. I show in the appendix that, for a given $\hat{p}_H$, there is a range of ρ for which both incentive constraints are satisfied. Equilibrium refinements destroy all the separating equilibria but the one for which the bad bank is indifferent between revealing itself and lying. This is the least costly separating equilibrium, which is dominant for the good bank.

Proposition 3 features two parameter constellations for which separation occurs. The difference between case (1) and (2) comes from the condition on $\hat{p}_H$. When $\hat{p}_H \leq \underline{\hat{p}}_1$, separation does not make the good bank riskier, in the sense that its assets are large enough to make lenders charge the risk free rate when they observe such a charge off choice. When $\hat{p}_H > \underline{\hat{p}}_1$, the cost of separation is so large to make investors require a risk premium for lending to the good bank. Since the good bank interest rate is the interest rate the bad bank would pay in case of mimicking, the incentive constraint of the bad bank changes in the two cases. Note that both thresholds are increasing in debt and decreasing in $\hat{p}_H$. A larger debt implies a larger gain from mimicking the good bank and hence a lower range of ρ values for which separation is possible. The smaller ρ, the worst the financial condition of the bad bank, the stronger its incentive to mimic the good bank, and the more costly separation. Consistently, note that $\underline{\rho}_{CS'_L} < \underline{\rho}_{CS_L}$ when $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1,\ 1\right]$.

Proposition 2 defines two scenarios. The first (perfect separation (PS) regime) is a corollary of Proposition 3. When ρ is greater than $\underline{\rho}_{CS_L}$ evaluated in $\hat{p}_H = p_{_H}$, the good bank separates at no cost by charging off all non performing loans in the portfolio. Intuitively, the shock is so small that the bad bank has no incentive to mimic the good bank. The gain from borrowing at the good bank interest rate would even be smaller than the cost of hiding $(1-\rho)\theta$ non performing loans. The second scenario (costly separation (CS) regime) features a larger shock and a worse financial condition for the bad bank. The incentive to mimic the good bank to save on borrowing costs gets stronger, and the good bank is forced to hide a fraction of non performing loans to signal its better financial condition. As shown in Proposition 3, the bigger the shock the more costly separation. Since $\hat{\theta}_H \leq 1$, it is clear that separation will not always be feasible and an uninformative equilibrium will exist. Next section defines such a scenario (pooling (P) regime).

3.2. **Pooling equilibrium.** Denote $1-\hat{p}_p$ the fraction of non performing loans charged off by both types of bank. $\hat{p}_p$ must be greater or equal than $p_{_H}$ because the bank with $p_{_H}$ good loans can not charge off more than $1-_{_H}$ loans. Investors know that assets can take the following values:

$$A(\hat{p}=\hat{p}_p)=\begin{cases} p_{_H}Y_H+(1-\hat{p}_p)\,L\equiv A_L(p_{_L},\,\hat{p}=\hat{p}_p) & w.p.\ \beta\alpha \\ p_{_H}Y_L+(1-\hat{p}_p)\,L\equiv A_H(p_{_L},\,\hat{p}=\hat{p}_p) & w.p.\ \beta(1-\alpha) \\ p_{_L}Y_H+(1-\hat{p}_p)\,L\equiv A_L(p_{_H},\,\hat{p}=\hat{p}_p) & w.p.\ (1-\beta)\alpha \\ p_{_L}Y_L+(1-\hat{p}_p)\,L\equiv A_H(p_{_H},\,\hat{p}=\hat{p}_p) & w.p.\ (1-\beta)(1-\alpha) \end{cases}$$

As in the previous section, bank's assets are the sum of the return on good loans and of the liquidation proceeds of non performing loans, but the charge off choice is not informative about bank's type in this case. Investors can only use the prior to decide how much and at which rate to lend. Lemma 3 summarizes investors' decisions.

Lemma 4. *When the bank charges off $1-\hat{p}_p$ loans independently of the true θ, investors charge the following rates:*

$$R(\hat{p}=\hat{p}_p)=\begin{cases} 1 & if\ \rho\geq\overline{\rho}_1 \\ \frac{D-(1-\beta)(1-\alpha)A_L(p_{_L},\,\hat{p}=\hat{p}_p)}{D(\alpha+\beta(1-\alpha))} & if\ \rho\ \epsilon\ \left[\overline{\rho}_1,\ \overline{\rho}_{R_1}\right] \\ \frac{D-(1-\beta)\alpha A_H(p_{_L},\,\hat{p}=\hat{p}_p)-(1-\beta)(1-\alpha)A_L(p_{_L},\,\hat{p}=\hat{p}_p)}{D\beta} & if\ \rho\ \epsilon\ \left[\overline{\rho}_{R_1},\ \overline{\rho}_{R_2}\right] \\ \frac{D-(1-\beta)\alpha A_H(p_{_L},\,\hat{p}=\hat{p}_p)-(1-\beta)(1-\alpha)A_L(p_{_L},\,\hat{p}=\hat{p}_p)-\beta(1-\alpha)A_L(p_{_H},\,\hat{p}=\hat{p}_p)}{D\beta\alpha} & if\ \rho\ \epsilon\ \left[\overline{\rho}_{R_2},\ \overline{\rho}_{nl}\right] \\ No\ lending & if\ \rho>\overline{\rho}_{nl} \end{cases}$$

where:

- $\overline{\rho}_1=\frac{D-(1-\hat{p}_p)L}{L}$
- $\overline{\rho}_{R_1}=\frac{D-(1-\hat{p}_p)L}{(\alpha+\beta(1-\alpha))_H+(1-\beta)(1-\alpha)_L}$
- $\overline{\rho}_{R_2}=\frac{D-(1-\hat{p}_p)L-\beta\theta Y_L}{(1-\beta)\theta E(Y)}$
- $\overline{\rho}_{nl}=\frac{D-(1-\hat{p}_p)L-\beta\theta E(Y)}{(1-\beta)\theta E(Y)}$.

Proof: *all the omitted proofs are in the appendix.*

The intuition is the same as for Lemma 1, except for the fact that there are 4 possible asset realizations and hence 5 risk intervals in this case. Lending is safe when the state of the economy is so good that the bad bank can pay back the debt even when the lowest return realization occurs. Investors do not roll debt over when they expect not to be repaid at the end of the period. Differently from Lemma 1, there are 3 debt intervals in which lending is risky. The interest rates in Lemma 4 are those making investors indifferent between lending and not lending.

The bank calculates the profit from pooling and compares it to the profit from any other charge off choice. Pooling is an equilibrium if it yields the maximum profit. I assume out of equilibrium beliefs equal to the prior when the refinement criteria do not suggest they are unreasonable. The intuition is that a charge off choice $1 - \hat{p}_p > 1 - p_H$ can come from both types of banks, unless it is a dominant strategy for the bank in some state. This assumption leads to the result in Proposition 5.

Proposition 5. *In a pooling equilibrium,* $\hat{p}_p = p_H$.
Proof: *imagine a pooling equilibrium with* $\hat{p}_p > p_H$. *Both banks will find it worth deviating and charging off* $1 - p_H$ *non performing loans. The bank will not bear the cost of hiding non performing loans and, at the same time, will still borrow at the pooling rate by doing this deviation. In fact, the deviation could be attributed either to the good or bad bank with probability equal to the prior*[8].

Proposition 5 implies that I can focus only on the pooling equilibrium with $\hat{p}_p = p_H$. This is an equilibrium if the bad bank does not find it worth charging off all its non performing loans and if the good bank does not find it worth separating (or it can not). Proposition 6 states the conditions under which pooling is an equilibrium.

Proposition 6. *There exists a pooling equilibrium if:*

(1) $\rho < \underline{\rho}_{p_L}$ *and* $\beta \epsilon \left[\underline{\beta}_1, \underline{\beta}_2\right]$

(2) $\rho < \underline{\rho}_{NS}$ *and* $\beta \epsilon \left[\underline{\beta}_2, \underline{\beta}_3\right]$

It holds that $\underline{\beta}_1 < \underline{\beta}_2$ *if* $\theta > \underline{\theta}_1$. *The thresholds are given by the following expressions:*

(1) $\underline{\rho}_{p_L} = \frac{\beta(1-\alpha)(D-L)-\alpha\theta L}{\beta(1-\alpha)\theta(Y_L-L)-\alpha\theta L}$

(2) $\underline{\rho}_{NS} = \frac{(1-\alpha)(1-\beta)D-(1-\theta)L}{(1-\alpha)(1-\beta)\theta Y_L}$

(3) $\underline{\beta}_1 = \frac{L}{(1-\alpha)(D-L)(Y_H-Y_L)}\left[\theta E(Y) + (1-\theta)L - D\right]$

(4) $\underline{\beta}_2 = \frac{(1-\alpha)(\theta Y_L-D)+(1-\theta)L}{(1-\alpha)(Y_L-D)}$

(5) $\underline{\beta}_3 = 1 - \frac{Y_H(1-\theta)L}{(1-\alpha)(Y_H-Y_L)D}$

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[8]If I assumed investors to believe that a deviation from pooling comes from the bad bank, multiple pooling equilibria would arise for a given value of ρ. The equilibrium stated in Proposition 5 always exists, but there could also be a pooling equilibrium where the good bank prefers hiding some non performing loans rather than deviating and borrowing at the bad bank interest rate. I rule out multiple equilibria because they make predictions impossible and complicate the policy analysis.

(6) $\underline{\theta}_1 = \frac{D-L}{Y_L - L}$

Proof: *all the proofs are in the appendix.*

In both case (1) and (2), a pooling equilibrium exists if ρ is smaller than a threshold and if β takes values within a range. The first condition requires the shock to cause a consistent fall in the value of assets of the bad bank. The two thresholds on ρ refer to the incentive constraint of the bad and the good bank. When $\rho < \underline{\rho}_{p_L}$, the bad bank prefers mimicking the charge off choice of the good bank rather than revealing its financial condition. The reduction in the value of assets is so large that, in case the bad bank revealed it, the risk premium required by investors would be larger than the cost of hiding $(1-\rho)\theta$ non performing loans. When $\rho < \underline{\rho}_{NS}$, separation is not feasible for the good bank because it would require charging off a negative fraction of non performing loans. I show in the appendix that the good bank can separate from the pooling charging off a fraction $1 - \hat{p}_d$ non performing loans, with $\hat{p}_d = \theta + \frac{(1-\alpha)(1-\beta)}{(\alpha+\beta(1-\alpha))L}\left[D - \rho\theta Y_L - (1-\theta)L\right]$. Note there is a negative relation between ρ and $\hat{p}_d$ because the worse the financial condition of the bad bank, the stronger its incentive to mimic the good bank, and the more costly separation. When $\rho < \underline{\rho}_{NS}$, separation is so costly that the fraction $\hat{p}_d$ gets larger than 1. Note that both thresholds are increasing in debt, meaning that the larger debt, the stronger the incentive to mimic the good bank, and the wider the range of ρ values for which pooling exists.

Which of the two thresholds actually matters for the pooling equilibrium depends on how β compares to $\underline{\beta}_2$. In case (2), β is larger than $\underline{\beta}_2$ and the threshold $\underline{\rho}_{NS}$ matters. This means that there is a range of ρ values for which the bad bank prefers pooling but the good bank can separate. Intuitively, the bad bank enjoys large profits from pooling when β is high because adverse selection is not severe. This makes it easier for the good bank to separate because the bad bank finds it less worth mimicking a deviation that yields a profit lower than pooling. In case (1), the opposite is true. There is a range of ρ values for which the good bank can not separate but the bad bank does not find it worth pooling. When β takes such values, the profits from pooling for the bad bank are so low that separation is not possible for the good bank, but even the bad bank prefers revealing itself rather than pooling. The conditions $\beta \geq \underline{\beta}_1$ and $\beta \leq \underline{\beta}_3$ make sure that the bad bank enjoys positive profits in equilibrium. If not, the bad bank would deviate from the pooling by Assumption 2. Note that the interval $\beta \epsilon \left[\underline{\beta}_1, \underline{\beta}_2\right]$ is non empty if $\theta > \underline{\theta}_1$. This is a condition on effort which depends on the effort choice made by the bank in the first stage. I will get back to this in the next section.

3.3. **The choice of effort.** Having found the equilibrium in the second stage, I proceed solving for the choice of monitoring effort by the two banks. The optimal effort choice maximizes bank's expected profit in each regime. The difference of bank's expected profits across regimes is due to the liquidation proceeds resulting from the charge off choice. In the PS regime both banks charge off all their non performing loans, whereas the good bank is forced to hide $\hat{p}_H - p_H$ non performing loans in the CS regime. Both banks charge off $1 - p_H$ non performing loans in the P regime. Proposition 7 illustrates the optimal choice.

Proposition 7. *The optimal effort chosen by the bank is the following:*
$\theta_{PS} = (\beta + \rho(1-\beta))(E(Y) - L)$
$\theta_{CS} = \beta E(Y) + \rho(1-\beta)(E(Y) - L)$
$\theta_{P} = (\beta + \rho(1-\beta))E(Y) - L$
Proof: *results are obtained from the maximization of the second stage expected profits net of effort cost with respect to* θ_j.

A marginal increase in effort raises the cost of effort by θ and the gain of effort by the expression on the right hand side. Broadly speaking, the marginal gain of effort is given by the expected return on the additional good loans ($E(Y)$ for the good bank and $\rho E(Y)$ for the bad bank) net of the liquidation proceeds L that the bank forgives because of the lower amount of non performing loans. Since all non performing loans are charged off in the PS regime, the bank takes into account that liquidation proceeds are going to be lower by L if it will be a good type and by ρL if it will be a bad type. In the CS regime, the marginal gain of effort of the good type is not affected by the charge off decision because it always charges off $1 - \hat{p}_H$ non performing loans. A marginal increase in effort does not determine a reduction in the liquidation proceeds from non performing loans for the good type. It does only for the bad type. This implies that $\theta_{CS} > \theta_{PS}$ given a value of ρ. Since the CS regime exists for lower values of ρ than the PS regime, it is not clear which of the two effort levels is the largest. In the P regime, both types of bank always charge off $1 - p_H$ non performing loans. A marginal increase in effort implies a reduction by L in the liquidation proceeds of both types of bank. This and the fact that the P regime exists for lower values of ρ than the

PS regime imply that $\theta_P < \theta_{PS}$.

Rational investors anticipate banks' choice of effort when deciding how much and at which interest rate to lend in the first period. They know the conditions defining the PS, CS, and P regimes as a function of exogenous variables, but can not distinguish the good from the bad bank in the first stage. In case a perfect separation equilibrium exists, investors anticipate that both the bad and the good bank will pay back the debt and hence charge the risk free rate. The same is true when a costly separation equilibrium exist because the bad bank is able to repay its debt. When a pooling equilibrium exists, however, investors anticipate there will be no new information coming. They charge the pooling interest rate already in the first period and keep lending at the same rate also in the second period because no news arrives. The actual values of the interest rate result from substituting the optimal effort chosen by the good and the bad bank in the results of Lemma 4.

3.4. **Simulation.** Substituting the optimal choice of effort in the solution of the second stage, I can find the thresholds delimiting the three regimes as a function of exogenous variables. I provide numerical solutions of these functions since analytical solutions are difficult to interpret. I simulate the model assuming the following values for the parameters: $Y_L = 1$, $Y_H = 2$, $\alpha = 0.4$, $L = 0.2$, $D = 0.7$, and $\beta = 0.3$. The following graphs show the charge off choice and the non performing loans of the good and the bad bank as a function of ρ.

FIGURE 3.4.1: The charge off choice and non performing loans of the good bank

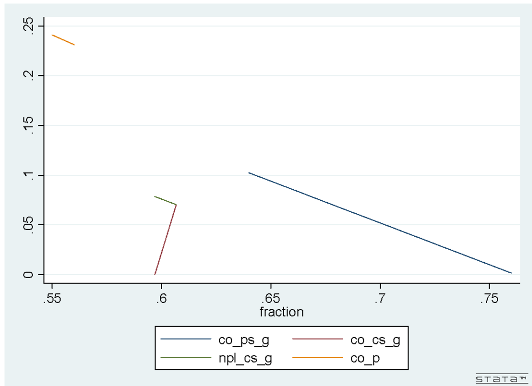
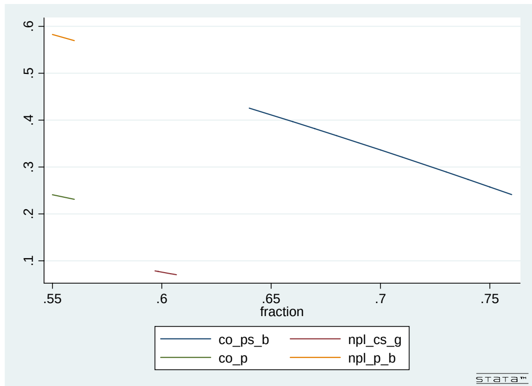


FIGURE 3.4.2: The charge off choice and non performing loans of the bad bank



There exists a perfect separation regime for $\rho \, \epsilon \, [0.63, \; 0.76]$. Both banks charge off all the non performing loans. Non performing loans decrease with ρ since effort is an increasing function of ρ. When $\rho\epsilon \; [0.59, \; 0.61]$ there is a costly separation regime. The bad bank charges off all the non performing loans. The good bank hides a fraction of non performing loans in order to separate. The cost of separation increases with ρ. It takes the maximum value when $\rho = 0.59$, for which the good bank has to hide all the non performing loans. When

$\rho \in [0.55,\ 0.56]$ there is a pooling regime. Both banks charge off the same fraction of non performing loans, but only the bad bank hides a fraction of them.

4. Welfare analysis

Welfare equals the sum of the expected profits of the two types of bank and investors. This coincides with the expected value of banks' assets net of the effort cost. Proposition 8 states the welfare function in the three regimes.

Proposition 8. *The equilibrium of the game yields the following welfare functions:*

$$W_{PS} = \frac{1}{2}\theta^2_{PS} + L$$

$$W_{CS} = \frac{1}{2}\theta^2_{CS} + L - \beta\hat{p}_H L$$

$$W_P = \frac{1}{2}\theta^2_{P} + L$$

Proof: *Welfare is obtained just by plugging the optimal effort in the utility function which I have stated in the Proof of Proposition 7.*

Welfare equals the first best in the PS regime. The equilibrium of the game in the CS and P regime has two inefficiencies: the charge-off and monitoring effort choice. In the CS regime, the good bank hides $\hat{p}_H - p_H$ non performing loans in order to signal its better financial condition. The good bank chooses an inefficiently large level of effort ex-ante to minimize the signaling cost. In the P regime, the bad bank mimics the good bank by hiding $p_H - p_L$ non performing loans. The bank chooses an inefficiently low level of effort because it anticipates that, if it will be good, it will subsidize the bad bank.

The P regime represents the worsening of the adverse selection problem in bad times and provides a framework for policy recommendations. Given that adverse selection arises because of poor incentives for information disclosure, policies should aim at giving bad banks these incentives. Incentives induce a suboptimal effort level ex-ante and generate distortions from taxation because they require the government to raise funds. The optimal policy is the one that gives the bad bank incentives to reveal itself at the lowest cost. It involves a trade off between efficiency and tax distortions: the more non performing loans the policy makes the bad bank reveal, the greater the costs of the policy. The optimal solution depends on the distortions implied by taxation. Three policies have been widely employed in the recent financial crisis: bank's assets purchases, debt insurance and equity injections. I consider these policies and investigate which of them is better suited to restore market discipline in a financial crisis. I consider a framework where the government designs the optimal policy ex-ante by maximizing welfare taking into account how the bank will react in terms of effort.

4.1. **Asset purchasing scheme.** Asset purchasing schemes (APSs) have been widely used in the recent financial crisis to revive the secondary market for toxic assets and give liquidity to troubled banks. They turn out to be useful in solving the adverse selection problem in the P regime since they give incentives to the bad bank to charge off all non performing loans. The asset purchasing scheme is a mechanism operated by the government, which offers to buy a fraction q of non performing loans at the price s and then liquidates them keeping the proceeds. The optimal triplet $(q,\ s,\ \hat{p}_H)$ is the solution of the following problem:

$$\max_{s,\,q,\,\hat{p}_H} W_{APS} = \beta\left[\theta E(Y) + (1-\hat{p}_H)L\right] + (1-\beta)\left[\rho\theta E(Y) + (1-\rho\theta-q)L + qs\right] - \tfrac{1}{2}\theta^2 - (1-\beta)(1+\lambda))q(s-L)$$

subject to:

(1) $q(s-L) = (1-\alpha)\left[D - \rho\theta Y_L - (1-\rho\theta)L\right] - \alpha(\hat{p}_H - \rho\theta)L \equiv \underline{q}_1$ if $\hat{p}_H \leq \underline{\hat{p}}_1$

(2) $q(s-L) = (1-\alpha)(1-\rho)\theta Y_L - (\hat{p}_H - \rho\theta)L \equiv \underline{q}_2$ if $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1,\ \underline{\hat{p}}_2\right]$

The last term of the welfare function denotes the cost of the APS. The government buys q non performing loans from each of the $(1-\beta)$ bad banks. It pays the price s and recovers L on each non performing loan. I assume that government's intervention implies distortions in the form of an additional cost λ. The remaining terms represent the sum of banks' expected assets net of the dis utility of effort. There are β good banks that do not participate to the APS and charge off $1-\hat{p}_H$ non performing loans. Bad banks charge off all their non performing loans. They recover L on $(1-\rho\theta-q)$ of them, and sell q to the government in exchange of the price s. Government's problem has two constraints. Equations (1) and (2) are the incentive compatibility constraints of the bad bank. The first holds when $\hat{p}_H \leq \underline{\hat{p}}_1$, in which case the good bank interest rate equals the risk free rate. When $\hat{p}_H > \underline{\hat{p}}_1$, investors require a risk premium for lending to the good bank. Both incentive constraints are binding in order to achieve information revelation at the lowest cost for the government.

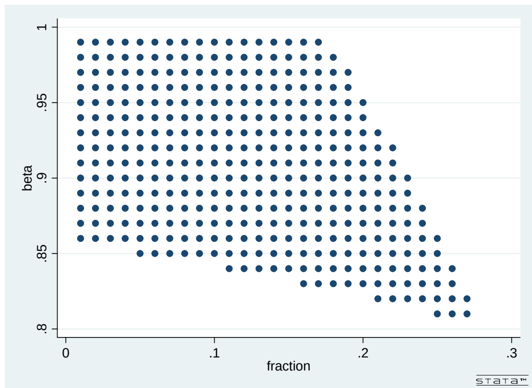
Proposition 9. *The optimal APS is characterized by:*

(1) $q(s-L)=\underline{q}_2$ *and* $\hat{p}_H=\frac{\alpha\rho\theta Y_H+(1-\alpha)\theta Y_L}{L}-\frac{D-L}{L}\equiv\underline{\hat{p}}_2$ *if* $\rho>\frac{Y_L}{Y_H}$ *and* $\beta<\frac{\alpha\lambda}{1+\lambda}$
(2) $q(s-L)=\underline{q}_1$ *and* $\hat{p}_H=\theta$ *if* $\beta>\frac{\lambda}{1+\lambda}$

Proof: *all the omitted proofs are in the appendix.*

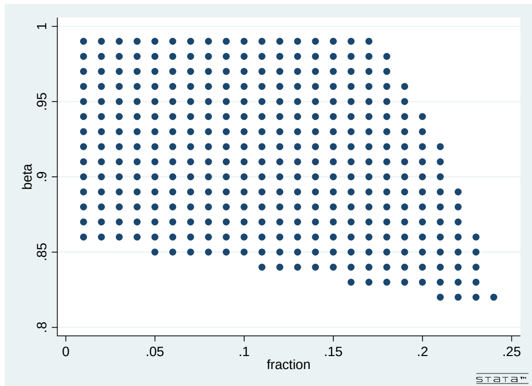
The optimal solution is calculated as follows. The government finds the optimal charge off choice $1-\hat{p}_H$ trading off efficiency gains and taxation costs. The lower the fraction of non performing loans hidden by the good bank, the less bank's assets are depleted but the larger the subsidy in order to achieve information disclosure (note constraints (1) and (2)). The government finds the optimal $\hat{p}_H$ in the range $\hat{p}_H\epsilon\left[\theta,\underline{\hat{p}}_1\right]$, where constraint (1) binds, and in the range $\hat{p}_H\epsilon\left(\underline{\hat{p}}_1,\ \underline{\hat{p}}_2\right]$, where constraint (2) binds. Given this, the government calculates the optimal effort chosen by the bank in both cases. The optimal solution is the one which yields the higher welfare, that is the one minimizing the charge off and effort inefficiencies. Proposition 9 states that it is optimal to hide all the non performing loans of the good bank when $\beta<\frac{\alpha\lambda}{1+\lambda}$. This condition on β implies that the policy is very costly because there is a large fraction of bad banks. Distortions from taxation would be so high to make it worth choosing $\hat{p}_H=\underline{\hat{p}}_2$ in order to minimize the subsidy. The condition on ρ is necessary to make sure that the case in which the good bank borrows at a risk premium actually exists. When the fraction of bad banks is lower, that is $\beta>\frac{\lambda}{1+\lambda}$, distortions would be lower and the government finds it worth paying a subsidy such that the good bank can charge off all the non performing loans. When β takes intermediate values, it is not possible to find the optimal policy analytically. Figure 4.1.1 shows the parameter constellations under which policy (2) is better than policy (1).

FIGURE 4.1.1: Values of *beta* and ρ for which policy (2) is better than policy (1)



The APS scheme gives incentives to the bad bank to reveal its financial condition at the cost of a fraction of non performing loans hidden by the good bank (in case (1)), an inefficient effort level, and distortions from taxation. The point is then to make sure whether it is efficient to implement such a policy or to bear the inefficiency cost of the P regime. It is not possible to answer this question analytically. Figure 4.1.2 shows the parameter constellations under which the APS policy is efficient.

FIGURE 4.1.1: Values of *beta* and ρ for which the APS policy is efficient



The APS policy is efficient for large values of β and small values of ρ. Large values of β mean low distortions from taxation, whereas small ρ values imply that pooling is highly inefficient.

4.2. **Debt guarantee.** Debt guarantees (DGs) have been used in the recent financial crisis to favor banks' access to funds markets. In the economy I have modeled, debt guarantees solve the adverse selection problem in the P regime by reducing the gain of the bad bank from overstating its financial condition. Debt guarantees decrease the interest rate at which the bad bank can borrow because the government commits to refund investors in case the bank defaults. I consider a debt guarantee mechanism in which the government guarantees a fraction γ of bank's debt and promises to refund investors an amount S of the loss in case of default. Proposition 10 states the optimal debt guarantee mechanism.

Proposition 10. *The optimal DG mechanism is such that* $\gamma > 0$ *and:*

(1) $S = \underline{S}_2$ *and* $\hat{p}_H = \frac{\alpha\rho\theta Y_H + (1-\alpha)\theta Y_L}{L} - \frac{D-L}{L} \equiv \underline{\hat{p}}_2$ *if* $\rho > \frac{Y_L}{Y_H}$ *and* $\beta < \frac{\alpha\lambda}{1+\lambda}$
(2) $S = \underline{S}_1$ *and* $\hat{p}_H = \theta$ *if* $\beta > \frac{\lambda}{1+\lambda}$

with $\underline{S}_2 = (1-\rho)\theta Y_L - \frac{1}{(1-\alpha)}(\hat{p}_H - \rho\theta)L$ *and* $\underline{S}_1 = [D - \rho\theta Y_L - (1-\rho\theta)L] - \frac{1}{(1-\alpha)}\alpha(\hat{p}_H - \rho\theta)L$

Proof: *all the omitted proofs are in the appendix.*

The result in Proposition 10 comes from the solution of the following maximization problem:

$$\max_{S,\gamma,\hat{p}_H} W_{APS} = \beta\left[\theta E(Y) + (1-\hat{p}_H)L\right] + (1-\beta)\left[\rho\theta E(Y) + (1-\rho\theta)L + (1-\alpha)S\right] - \frac{1}{2}\theta^2 - (1-\beta)(1+\lambda)S$$

subject to:

(1) $S = \underline{S}_1$ if $\hat{p}_H \leq \underline{\hat{p}}_1$

(2) $S = \underline{S}_2$ if $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1, \ \underline{\hat{p}}_2\right]$

The last term in the welfare function denotes the cost of the DG. The government has to pay S to investors in case the bad bank defaults. Given there are $1-\beta$ bad banks, which default when the lowest realization of Y occurs, the government expects a monetary outlay equal to $(1-\alpha)(1-\beta)S$. This has to be raised by taxation, which determines a distortion λ and makes the social cost equal to $(1+\lambda)(1-\alpha)(1-\beta)S$. The remaining part of the welfare function denotes bank's expected expected assets net of the cost of effort. The debt guarantee mechanism consists of a subsidy S to investors in case the bad bank defaults, which indirectly means a subsidy to the bad bank through a lower interest rate. This explains the term $(1-\alpha)S$ in the assets of the bad bank. The problem of the government is subject to equation (1) and (2), which are the incentive constraints of the bad bank. The first holds when $\hat{p}_H \leq \underline{\hat{p}}_1$, in which case the good bank interest rate equals the risk free rate. When $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1,\ \underline{\hat{p}}_2\right]$, investors require a risk premium for lending to the good bank and the incentive constraint is given by equation (2). Both incentive constraints are binding in order to achieve information revelation at the lowest cost for the government.

It is optimal for the government to choose any positive value of γ. What matters is that the government guarantees a fraction of bank's debt, no matter how small it is. Incentives for information revelation are restored through the subsidy S which is given to insured investors in case of default. This result comes from investors break even condition, which I show in the appendix. Intuitively, insured investors require a lower risk premium because they will be refunded in case the bad bank defaults. Uninsured investors do the same because the subsidy leaves them more assets to pledge in case the bad bank defaults. As long as the subsidy is large enough, the solvency of the bad bank improves so much that the lending risk becomes independent of the fraction of debt that is insured.

Multiplying S by $(1-\alpha)$, it results that the optimal debt guarantee mechanism is exactly the same as the asset purchasing scheme. Both policies involve the same monetary outlay, hence the optimality conditions are the same. The same is true for the conditions under which the policy is efficient. This happens because both policies work through the same incentive constraint. As long as the subsidy is large enough to restore incentives, the type of policy implemented by the government does not matter. Moreover, the policy affects the incentives to disclose information in the second stage and the effort choice in the first stage. Consisting of the same subsidy, both policies determine the same effort ex-ante.

4.3. **Equity injections.** In the recent financial crisis, governments have injected liquidity in troubled banks also by buying bank's equity. In the economy I have modeled, equity injections (EIs) provide the additional liquidity incentivizing the bank to charge off all its non performing loans. This liquidity comes at the cost of reducing the share of profits going to the bank. The EI is a mechanism defined by the variable γ, which is the fraction of equity bought by the government, and m, which is the monetary outlay by the government. These two variables are chosen by the government maximizing the following welfare function:

$$\max_{\hat{p}_H,\, \hat{p}_L,\, \gamma,\, m} W_{EI} = \beta\left(\theta E(Y) + (1-\hat{p}_H)L - D\right) +$$
$$+ (1-\beta)(1-\gamma)\left(\rho\theta E(Y) + (1-\hat{p}_L)L - D + m\right) - \tfrac{1}{2}\theta^2 +$$
$$- (1-\beta)(1+\lambda)\left[m - \gamma\left(\rho\theta E(Y) + (1-\hat{p}_L)L - D + m\right)\right] + D$$

subject to:

(1) $m = \frac{1}{1-x}\left[(1-\alpha)\left[D - \rho\theta Y_L - (1-\rho\theta)L\right] - \alpha(\hat{p}_H - \rho\theta)L\right] + \frac{x}{1-x}\left[\rho\theta E(Y) + (1-\rho\theta)L - D\right] \equiv \underline{m}_1$ if $\hat{p}_H \leq \underline{\hat{p}}_1$

(2) $m = \frac{1}{1-x}\left[(1-\alpha)(1-\rho)\theta Y_L - (\hat{p}_H - \rho\theta)L\right] + \frac{x}{1-x}\left[\rho\theta E(Y) + (1-\rho\theta)L - D\right] \equiv \underline{m}_2$ if $\hat{p}_H \epsilon \left(\underline{\hat{p}}_1,\, \underline{\hat{p}}_2\right]$

The last term of the welfare function represents the cost of the EI. The monetary outlay equals the equity injection net of the share of profits for each of the $1-\beta$ bad banks. The term λ captures distortions from taxation. Note that the bank enjoys only the remaining share $1-\gamma$ of profits in case the policy is implemented. The problem is constrained by the two incentive constraints of the bad bank, whose interpretation is the same as for the previous policies. Proposition 13 defines the optimal mechanism.

Proposition 11. *The optimal EI mechanism is such that x can take any value lower than 1 and:*

(1) $m = \underline{m}_2$ *and* $\hat{p}_H = \frac{\alpha\rho\theta Y_H + (1-\alpha)\theta Y_L}{L} - \frac{D-L}{L} \equiv \underline{\hat{p}}_2$ *if* $\rho > \frac{Y_L}{Y_H}$ *and* $\beta < \frac{\alpha\lambda}{1+\lambda}$

(2) $m = \underline{m}_1$ *and* $\hat{p}_H = \theta$ *if* $\beta > \frac{\lambda}{1+\lambda}$

Proof: *all the omitted proofs are in the appendix.*

Proposition 14 states that the fraction x of profits retained by the government can be any number lower than 1. What matters is that the total subsidy is such that the bad bank has an incentive to reveal its financial condition. If the government would take all the profits, the subsidy would be zero and truthful information disclosure would not be possible. I show in the appendix that x disappears from the objective function once you plug the constraint into the objective function. The intuition behind the optimal equity injection m is exactly the same as the other two policies. When the policy requires a consistent monetary outlay, it is optimal to minimize the equity injection and let the good bank hiding a fraction of non performing loans. Note that results would be exactly the same as the asset purchasing scheme and debt guarantees if $x = 0$.

5. Conclusion

My paper provides a theoretical model explaining why information in financial markets gets scarcer in crisis times. I argue that the existence of information is the result of a profit maximizing decision by banks. When a shock determines a high fraction of non performing loans in the portfolio of some banks, these banks prefer hiding some of them to mimic better banks and avoid borrowing at a high risk premium or being liquidated. Information becomes blurred and does not allow investors to infer the riskiness of banks. My model's predictions find confirmation in the empirical literature. First, banks have stronger incentives to overstate their financial condition in bad times, as found by Huizinga and Laeven (2009) and Gunter and Moore (2003). Second, the relation between indicators of risk and interest rates are stronger in normal times than in crisis times, which is a result documented by the vast literature on market discipline.

The policy implication that follows is that banks hit by a shock should be given incentives for information disclosure. These incentives distort the choice of effort by banks and determine tax distortions. The optimal policy is the one that makes the bank charging off all the non performing loans at the lowest cost in terms of effort and tax inefficiencies. The three policies I consider, namely asset purchases, debt guarantees and equity injections, turn out to be equivalent. Information disclosure comes at the cost of a fraction of non performing loans hidden by the good bank when the cost of the policy are large. When they are low, incentives can be given such that the good bank can charge off all the non performing loans.

The conclusions from my paper are relevant for central banks and regulators. First, central banks should give banks incentives to disclose information to avoid the negative effects of market breakdowns like the interbank market freeze at the onset of the recent financial turmoil. Second, market discipline, that is the Third Pillar of Basel 2, can not be an effective regulatory instrument if policies incentivizing banks to disclose information are not implemented in crisis times.

References

[1] 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.

[2] Allen L., J. Jagtiani, and J.. Moser (2001). Further Evidence on the Information Content of Bank Examination Ratings: A Study of BHC-to-FHC Conversion Applications. Journal of Financial Services Research 19, 213-232.

[3] Bhattacharya S., and K. Nyborg (2010). Bank Bailout Menus. Swiss Finance Institute Research Paper 10-24.

[4] Calomiris, C., and C. Kahn. 1991. The role of demandable debt in structuring optimal banking arrangements. The American Economic Review 81: 497–513

[5] Calomiris C., and J. Mason (1997). Contagion and Bank Failures During the Great Depression: The June 1932 Chicago Banking Panic, American Economic Review, 87, 863-83.

[6] D'Amato L., E. Grubisic and A. Powell (1997). Contagion, Bank Fundamentals or Macroeconomic Shock? An Empirical Analysis of the Argentine 1995 Banking Problems, Banco Central de la Republica Argentina, mimeo.

[7] De Young R., M. Flannery, W. Lang and S. Sorescu (2001). The Information Content of Bank Exam Ratings and Subordinated Debt Prices. Journal of Money, Credit, and Banking 33, 900-925.

[8] Docking D., M. Hirschey and E. Jones (1997). Information and Contagion Effects of Bank Loan-Loss Reserve Announcements. Journal of Financial Economics 43, 219-239.

[9] Evanoff D. and L. Wall (2001). "Sub-debt Yield Spreads as Bank Risk Measures." Journal of Financial Services Research 20, 121-145.

[10] Evanoff D. and L. Wall (2002). Measures of Riskiness of Banking Organizations: Subordinated Debt Yields, Risk-Based Capital, and Examination Ratings. Journal of Banking and Finance 26, 989-1009.

[11] Evanoff D., J. Jagtiani and T. Nakata (2007). The potential Role of Subordinated Debt Programs in Enhancing Market Discipline in Banking. The Federal Reserve Bank of Kansas City Working Paper 07-07.

[12] Flannery M. (1998). Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence. Journal of Money, Credit and Banking 30(3), 273-305.

[13] Gonzalez-Hermosillo B. (1999). Determinants of Ex-Ante Banking System Distress: A Macro- Micro Empirical Exploration of Some Recent Episodes. International Monetary Fund, Working Paper No. 33.

[14] Gorton G. (1988). Banking Panics and Business Cycles, Oxford Economic Papers 40, 751–81.

[15] Gunter J. and R. Moore (2003). Loss underreporting and the auditing role of bank exams. Journal of Financial Intermediation 12(2), 153-177.

[16] Holmstrom B (2008). Discussion of "The Panic of 2007" by Gary Gorton.

[17] Huizinga H. and L. Laeven (2009). Accounting discretion of banks during a _nancial crisis. IMF Working Papers, WP/09/207.

[18] Jagtiani J., G. Kaufmann, C. Lemieux. The Impact of Credit Risk on Bank and Bank Holding Company Bond Yields: Evidence from the Post-FDCIA Period. Journal of Financial Research 25, 559-575.

[19] Jordan J., J. Peek and E. Rosengren (2000). The Market Reaction to the Disclosure of Supervisory Actions: Implications for Bank Transparency. Journal of Financial Intermediation 9, 298–319.

[20] Levy-Yeyati E., M. Martinez Peria, and S. Schmukler (2003). Market Discipline under Systemic Risk: Evidence from Bank Runs in Emerging Economies. Mimeo, 2003.

[21] Matutes, C., and X. Vives. 1996. Competition for deposits, fragility, and insurance. Journal of Financial Intermediation 5 (2): 184–216.

[22] Mitchell J. (2001). Bad Debts and the Cleaning of Banks' Balance Sheets: An Application to Transition Economies. Journal of Financial Intermediation 10, 1-27.

[23] Morgan D. and K. Stiroh (2000). "Bond Market Discipline of Banks: Is the Market Tough Enough?" Federal Reserve Bank of New York Staff Report, No. 95.

[24] Morgan D. and K. Stiroh (2001). "Market Discipline of Banks: the Asset Test." Journal of Financial Services Research 20, 195-208. Morris S. (2001). Political correctness. Journal of Political Economy, 109(2), 231−265.

[25] Park S. (1991). Bank failure contagion in historical perspective. Journal of Monetary Economics 28, 271-286.

[26] Philippon T., and P. Schnabl (2009). Efficient Recapitalization. NBER w.p. 14929

[27] Philippon T., and V. Skreta (2010). Optimal Intervention in Markets with Adverse Selection. NBER w.p. 15785.

[28] Schumacher L. (2000). Bank Runs and Currency Run in a System without a Safety Net: Argentina and the 'Tequila' Shock, Journal of Monetary Economics 46, 257-277.

[29] Sironi A. (2003). Testing for Market Discipline in the European Banking Industry: Evidence from Subordinated Debt Issues. Journal of Money, Credit, and Banking 35, 443-72.

[30] Slovin M., M. Sushka, and J. Polonchek (1999). An analysis of contagion and competitive effects at commercial banks. Journal of Financial Economics 54, 197-225.

[31] The U.K Financial Service Authority (2009). The turner review: a regulatory response to the global banking crisis.

[32] Tirole J. (2010). Overcoming Adverse Selection: How Public Intervention Can Restore Market Functioning. Mimeo

APPENDIX

1. Proof of Lemma 1

Observing the charge off choice $1-\hat{p}_j$, investors learn the possible asset realizations for each bank and use them to compute the break even interest rate. This is given by the following equation:

$\alpha min\left\{DR(p_j,\,\hat{p}=\hat{p}_j),\,A_H(p_j,\,\hat{p}=\hat{p}_j)\right\}+(1-\alpha)\,min\left\{DR(p_j,\,\hat{p}=\hat{p}_j),\,A_L(p_j,\,\hat{p}=\hat{p}_j)\right\}=D$

for $j=\{\,H,\,L\}$. Considering all the possible cases implied by the min function, one gets the results in Lemma 2.

2. Proof of Proposition 3

Before proceeding with the proof, it is useful to state the following Lemma.

Lemma 1. *It holds that:*
$\Pi(p_j,\,\hat{p}=\hat{p}_j)=max\{\;E[A(p_j,\,\hat{p}=\hat{p}_j)]-D,\;0\}$
for $j=\{\,H,\,L\}$.
Proof: *note that:*

$$\Pi(p_j,\,\hat{p}=\hat{p}_j)=(1-\alpha)\,max\left\{A_j(p_j,\,\hat{p}=\hat{p}_j)-DR(p_j,\,\hat{p}=\hat{p}_j),\,0\right\}$$
$$+\,\alpha max\left\{A_H(p_j,\,\hat{p}=\hat{p}_j)-DR(p_j,\,\hat{p}=\hat{p}_j),\,0\right\}$$

Substituting the interest rates obtained in Lemma 1, the previous equation can be written as:

$$\Pi(p_j,\,\hat{p}=\hat{p}_j)=\begin{cases}E[A(p_j,\,\hat{p}=\hat{p}_j)]-D & if\;D>E[A(p_j,\,\hat{p}=\hat{p}_j)]\\ \\ 0 & if\;\rho\leq\frac{D-L}{p_jE(Y)-\hat{p}_j}\end{cases}$$

Denote $1-\hat{p}_j$ the fraction of loans charged off by the bank with $_j=\{_L,\,_H\}$ good loans. Using the result in Proposition 2, I can focus on $\hat{p}_L=p_L$. Separation is an equilibrium if the following incentive constraints are satisfied:

(1) IC(L): $\max\{\ E\left[A(p_L,\ \hat{p}=p_L)\right]-D,\ 0\}\ \geq \alpha \max\{\ A_H(p_L,\ \hat{p}=\hat{p}_H)-DR(p_H,\ \hat{p}=\hat{p}_H),\ 0\}$

(2) IC(H): $\max\{\ E\left[A(p_H,\ \hat{p}=\hat{p}_H)\right]-D,\ 0\}\ \geq \alpha \max\{\ A_H(p_H,\ \hat{p}=p_H)-DR(p_L,\ \hat{p}=p_L),\ 0\}\ +(1-\alpha)\max\{\ A_L(p_H,\ \hat{p}=p_H)-DR(p_L,\ \hat{p}=p_L),\ 0\}$

The perfect (costly) separating equilibrium is such that $\hat{p}_H=(>)p_H$. In the perfect separation equilibrium, the incentive constraint of the good bank does not matter. The good bank has $1-p_H$ non performing loans. It can not deviate to a higher charge off choice because the bank can not charge off good loans. It does not find it worth deviating to a lower charge off choice because of investors' out of equilibrium belief that any charge off choice different from $1-p_H$ comes from the bad bank. Even with a more optimistic beliefs structure, the bank in normal times would not find it worth deviating because it can separate at no cost by charging off all its non performing loans. In the costly separating equilibrium, the incentive constraint of both banks matter.

Substituting the interest rates, and considering the ρ values in which they apply, one gets a set of inequalities on ρ satisfying both incentive constraints. Note that the two cases in Proposition 3 come from using the two possible values of $R(p_H,\ \hat{p}=\hat{p}_H)$ in the IC(L). The range of parameters for which there is a separating equilibrium can be refined using domination based refinements. If an action is dominant for some player in the game, investors should believe that this action is taken by the player for which it is dominant. This criterium can be used in my framework in the following way. Imagine for a given value of ρ, separation occurs with the choice $\hat{p}_H$ and $\underline{\hat{p}}_H$, with $\hat{p}_H \geq \underline{\hat{p}}_H$. Imagine the good bank deviates to the charge off choice $1-\underline{\hat{p}}_H$. Investors know that the bad bank would never do this deviation because its incentive constraint is always satisfied in this case. They infer that such a deviation can only come from the good bank and hence charge the good bank interest rate. As a consequence, the good bank finds it worth doing the deviation because the charge off choice $1-\underline{\hat{p}}_H$ is the least costly.

3. Proof of Lemma 4

Both the good and bad type of bank charge off $1-\hat{p}_p$ non performing loans in a pooling equilibrium. Investors can not distinguish bank's type and take decisions according to the prior. Recall that β is the probability of the bank being good and $1-\beta$ is the probability of the bank being bad. The break even condition can be written as follows:

$\beta\alpha \min\{DR(\hat{p}=\hat{p}_p),\ A_H(\hat{p}_H,\ \hat{p}=\hat{p}_p)\} + \beta(1-\alpha)\min\{DR(\hat{p}=\hat{p}_p),\ A_L(p_H,\ \hat{p}=\hat{p}_p)\} +$
$+(1-\beta)\alpha min\{DR(\hat{p}=\hat{p}_p),\ A_H(p_L,\ \hat{p}=\hat{p}_p)\} +$
$+(1-\beta)(1-\alpha) min\{DR(\hat{p}=\hat{p}_p),\ A_L(p_L,\ \hat{p}=\hat{p}_p)\} = D$

Considering all the possible cases implied by the min function, one gets the results in Lemma 4.

4. Proof of Proposition 6

Before proceeding to the proof of Proposition 6, it is useful to state the following Lemma.

Lemma 2. *The equilibrium profit of the bad bank is given by:*

$$\Pi(p_L,\ \hat{p}_p) = \begin{cases} \alpha A_H(p_L,\ \hat{p}=\hat{p}_p) + (1-\alpha)A_L(p_L,\ \hat{p}=\hat{p}_p) - D & if\ \rho > \overline{\rho}_1 \\ \frac{\alpha}{\alpha+\beta(1-\alpha)}\left((\alpha+\beta(1-\alpha))\, A_H(p_L,\ \hat{p}=\hat{p}_p)\right) + & \\ +\frac{\alpha}{\alpha+\beta(1-\alpha)}\left((1-\alpha)(1-\beta)A_L(p_L,\ \hat{p}=\hat{p}_p) - D\right) & if\ \rho\,\epsilon\ \left[\overline{\rho}_1,\ \overline{\rho}_{R_1}\right] \\ 0 & if\ \rho \leq \overline{\rho}_{R_1} \end{cases}$$

Proof: *note that:*

$\Pi(p_L, \hat{p}_p) = (1-\alpha)\, max\{A_L(p_L,\ \hat{p}_p) - DR(\hat{p}=\hat{p}_p),\ 0\} + \alpha max\{A_H(p_L,\ \hat{p}_p) - DR(\hat{p}=\hat{p}_p),\ 0\}$

The result follows from substituting the interest rates obtained in Lemma 4.

Pooling is an equilibrium when both the bad and the good bank do not find it worth deviating. Proposition 5 states that there can exist only a pooling with a charge off choice of $1-p_H$. Consider the incentive constraint of the bad bank. Note that the bad bank never finds it worth pooling when $\rho > \overline{\rho}_1$ because it can borrow at the risk free rate. Lemma 2 states that the bank in a crisis has no profit from pooling when $\rho \leq \overline{\rho}_{R_1}$. I assume that the bad bank prefers separating in this case. As a consequence, an incentive to pool for the bad bank might exist only when $\rho \epsilon \left[\overline{\rho}_1,\, \overline{\rho}_{R_1}\right]$. The incentive constraint can be written as follows:

$$\frac{\alpha}{\alpha+\beta(1-\alpha)} \max\{\, ((\alpha+\beta(1-\alpha))\, A_H\,(p_L,\ \hat{p}=p_H) + (1-\alpha)(1-\beta)A_L\,(p_L,\ \hat{p}=p_H) - D)\,,\ 0\} >$$

$$max\{\ E[A(p_L,\, \hat{p}=p_L)] - D,\ 0\}$$

where the right hand side is the profit from separating derived in Lemma 1. When both sides are positive, one gets after some algebra that the incentive constraint is satisfied if $\rho \leq \overline{\rho}_{p_L}$. When the bad bank has zero profits from revealing itself, the bad bank reveals itself by Assumption (1).

Consider now the incentive constraint of the good bank. The good bank could separate from the pooling by deviating to a charge off choice that the bad bank would not find it worth mimicking. Observing such a charge off choice, investors believe that it can only come from the good bank and hence charge the good bank interest rate. I proceed in two steps. First, I calculate the deviation that allows separation. Second, I check whether the bank in normal times finds it worth doing this deviation.

The deviation that allows the good bank to separate is the charge off choice for which the bad bank is indifferent between pooling and mimicking. It can be found as follows:

$$\frac{\alpha}{\alpha+\beta(1-\alpha)} \max\{\, ((\alpha+\beta(1-\alpha))\, A_H\,(p_L,\ \hat{p}=p_H) + (1-\alpha)(1-\beta)A_L\,(p_L,\ \hat{p}=p_H) - D)\,,\ 0\} =$$

$$\alpha max\{\ A_H\,(p_L,\ \hat{p}=\hat{p}_{dev}) - DR(p_L,\ \hat{p}=p_L),\ 0\}$$

After some algebra one finds that separation happens when $\hat{p}_d = \theta + \frac{(1-\alpha)(1-\beta)}{(\alpha+\beta(1-\alpha))L}\left[D - \rho\theta Y_L - (1-\theta)L\right]$. When $\hat{p}_d > 1$, separation becomes impossible because it would require a negative charge off choice. Substitution $\hat{p}_d = 1$ in the previous inequality, one gets that separation is impossible and pooling is an equilibrium when $\rho < \overline{\rho}_{NS}$. Substituting $\hat{p}_{dev}$ in profit function of the good bank, one gets that the good bank prefers separation whenever feasible.

Combining the incentives constraints of the good and bad bank, one gets the conditions under which pooling is an equilibrium. The conditions on β and θ stated in Proposition 6 are those making sure that the ρ intervals where pooling exists are non empty.

5. Proof of Proposition 9

Rearranging terms, the objective function can be written as follows:

$$W_{APS} = \beta\left[p_H E(Y) + (1-\hat{p}_H)L\right] + (1-\beta)\left[\rho p_L E(Y) + (1-\rho p_L)L\right] - \tfrac{1}{2}\theta^2 - (1-\beta)\lambda q(s-L)$$

subject to the constraints stated in section 4.1. Plugging the constraints in the objective function, one gets a linear function of $\hat{p}_H$. As a consequence, the solution is a boundary solution. Taking the first order conditions, one gets that:

$$(1)\ \hat{p}_H^* = \begin{cases} \underline{\hat{p}}_1 & if\ q = \underline{q}_1 \\ \underline{\hat{p}}_2 & if\ q = \underline{q}_2 \end{cases} \text{ if } \rho > \frac{Y_L}{Y_H} \text{ and } \beta < \frac{\alpha\lambda}{1+\lambda}$$

$$(2)\ \hat{p}_H^* = \begin{cases} p_H & if\ q = \underline{q}_1 \\ \underline{\hat{p}}_1 & if\ q = \underline{q}_2 \end{cases} \text{ if } \beta > \frac{\lambda}{1+\lambda}$$

Substituting the optimal solution in bank's profit maximization problem, one finds the optimal effort induced by the policy. This can be substituted back in the welfare function in order to check which of the two policies is the most efficient. The result in Proposition 9 comes from this comparison.