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ABSTRACT

The paper investigates the optimal design of bank bailouts. Under three types of ex post moral hazard that tempt banks to hide loan losses, the paper analyzes banking regulation via three Prompt Corrective Action instruments: prohibition of dividends, limits on compensation to managers and early closure policy. The first two have a mitigating effort on moral hazard but the last instrument has a damaging impact. As to bad debts and the cleaning of banks' balance sheets, asset insurance and equity capital motivate banks to disclose loan losses. In some cases, prohibition of dividends or limits on compensation to managers has the same effect.

JEL Classification: G21, G28

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1. Introduction

Bell (2009) reports the topical problem of hidden bad loans in the U.S.A:[1]

> "Japan's economy was paralyzed for a decade as banks failed to deal with their troubled loans. That's why it's nothing short of stunning to discover some U.S banks are doing the same thing now. Despite all the tough talk out of Washington and Wall Street about how the U.S can't repeat what happened in Japan, the reality is that banks are granting extensions to borrowers in one key category, commercial real-estate loans, so that they don't default. It's a bet that economic conditions will improve before the loans come due. ... . The maneuvering is being called "extend and pretend" in financial circles, reflecting banks' willingness to extend loan maturities because they believe – or hope – rental rates and building values could come back to levels seen during the peak of the real-estate market in 2007."

Almost identical problem is documented in Britain by Thomas (2009):

> "...85 per cent of UK loans made in the past five years are in breach of lending agreements. But banks are ignoring such problems. Instead they are rolling over loans as these near maturity, in the hope that capital value and loan-to-value (LTV) ratios will rise once again to refinanceable level."

This paper intends to construct a model of banking that can reproduce the facts of the incident portrayed above and, more commonly, to offer a model that can be used to investigate loan rollovers and alternative instruments to rescue banks. The paper poses questions such as, do banks have different disclosure/roll-over strategies. Why? What kind of problems do loan rollovers cause for bank regulation? What kind of regulatory instruments are effective to handle loan rollovers? Disclosed loan losses cause costs for a bank. This raises the fundamental question of "Why does a bank disclose loan losses at all?"

Banking theory stresses *ex ante* moral hazard. A bank either invests in excessively risky assets, e.g. Merton (1977), or, neglects monitoring, e.g. Holmström & Tirole (1997). This paper focuses on the less-well understood problem of *ex post* moral hazard; a bank that has already

[1] The problem of hidden bad loans is common, recurrent and worldwide. It is reported, for example, in Britain (Thomas, 1999), Chile (Sheng, 1996), China (Heffernan, 2005), India (Heffernan, 2005), Japan (Cargill et al., 1998; Caballero et al., 2008; Hoshi & Kashyap, 2010), Korea (Lindgren et al., 1999), Thailand (Lindgren et al., 1999) and U.S.A (Bell, 2009). For loan loss information, see also Anandarajan et al. (2003) and Hasan & Wall (2004).

been hit by a shock and is saddled with bad loans. As reported above, the bank may react to the bad loans by hiding them via loan rollovers. To avoid offering misleading recommendations, the paper explores the problem thoroughly by adopting a dynamic model with three types of moral hazard and a stochastic value of loan collateral. *Milking moral hazard* tempts the bank to hide bad loans for a short-term profit. The non-disclosing bank is officially solvent and profitable and can pay dividends, even when it possesses a large burden of hidden bad loans and is de facto insolvent. Long-term returns induce a bank to *ex post risk shifting:* it rolls over bad loans, in anticipation that their future value (the value of loan collateral) appreciates. This may represent a gamble for resurrection. In a *private benefit moral hazard* a bank manager hides bad loans to be able to keep his position. The paper identifies that each type of moral hazard is relevant, and each requires unique regulatory instruments. A healthy bank with few bad loans rolls over them only if it expects the collateral value to appreciate sufficiently. In contrast a distressed bank with plenty of bad loans optimally rolls over them also when the expected value of collateral is fixed or depreciates.

With respect to the third example de Juan (1996, p. 91), the former head of the inspection services at the central bank of Spain, in his conclusions on the causes of banking crises crystallizes his long-term experience in the following recommendation:

> "When questionable loans are converted into evergreens, they are almost never classified as doubtful or bad; they are classified as current. Supervisors should therefore focus their attention on the good loan portfolio rather than the bad one".

The recommendation may be surprising; one is likely to presume that a bank without disclosed bad loans is healthier than a bank with disclosed bad loans. We find that this presumption is correct under perfect information but under asymmetric information the findings are opposite: with each type of moral hazard, hiding incentives increases with the burden of bad loans in line with de Juan's recommendation. Thus, the credibility of loan loss information is weak.[2]

The huge number of bank failures during the Savings and Loan crises in the 1980s triggered a strong reform process in U.S banking regulation.[3] *Prompt Corrective Action (PCA)*

[2] Kim et al. (2005) find that the bank's ability to avoid loan losses may act as a strategic variable. Borrowers use high-quality low-loss banks to signal their credit-worthiness to other stakeholders. For optimal bank transparency, see also Hyytinen & Takalo (2004).

[3] Between 1980s and 1994 there were 1295 thrift failures in the USA. Over the same period, 1617 banks "failed" in the sense that they were either closed or received FDIC assistance (Heffernan, 2005).

legislation was launched in 1991. PCA rests on the insight of timely and active intervention to early warning signals. Banks are classified into 5 categories depending on capital ratios. Banks with high levels of capital are subject to minimum restrictions. A bank becomes subject to restrictions which become more demanding the lower the capital ratio: (i) prohibition of dividends, (ii) limits on compensation to managers, (iii) early closure policy for weakly capitalized banks (capital ratio 2%), (iv) requirements to attract additional capital, (v) constraints on investments and (vi) frequent regulatory supervision. PCA proved to be revolutionary and successful (Benston & Kaufman, 1997; Freixas & Parigi, 2007). This has given rise to proposals that other countries ought to modernize their regulation by implementing PCA –type of legislation (e.g. Freixas & Parigi, 2007; Dewatripont & Rochet, 2010). Therefore, it is important to investigate the benefits and drawbacks of PCA carefully.

PCA has stimulated little previous research. Freixas & Parigi (2007) advance pioneering findings. The optimal regulation a) allows well capitalized banks to invest freely, b) precludes banks with intermediate levels of capital from investing in the most opaque risky assets, and c) prevents undercapitalized banks from investing in any asset. Our paper extends research on PCA in the model of hidden bad loans emphasizing the prohibition of dividends method (i). The *prohibition policy (PP)* is a common instrument in bank rescue operations (e.g. Panetta et al., 2009; Lindgren et al., 1999; Hoshi & Kashyap, 2010) but, as far as we know, has not been investigated before. The paper discovers that PP eliminates milking moral hazard, has (almost) no effect on private benefit moral hazard, and mitigates (with some parameter values eliminates) ex post risk shifting. This means that PP is an effective instrument when owners run the bank but less effective when a hired manager runs it. In either case, PP reduces the regulator's costs and bank owners' moral hazard profits. In some cases, PP makes a bank risk-free or changes its optimal strategy from hiding to disclosure, thereby diminishing the probability of bank failures. PP supplements other regulatory instruments by strengthening the advantages of capital requirements and asset insurance. PP is most effective when collateral value is non-stochastic and less effective if it is stochastic and the bank is insolvent. With respect to the other elements of Prompt Corrective Action, limits on competition on manager's (ii) is effective only when a hired manager makes the decisions, the bank is already insolvent and collateral value is non-stochastic. Then, the instrument makes the hiding strategy unprofitable to the manager, thus motivating insolvency disclosure. Early closure method (iii) is powerless. It induces banks to hide more bad loans to avoid early closure.

According to several researchers (e.g. Caballero et al., 2008; Hoshi & Kashyap, 2010), the main factor contributing to the deep slowdown in real GDP growth in Japan since the early 1990s is that Japanese banks possessed heavy portfolios of bad loans, thereby continuing to finance insolvent companies. Bad loans must be rapidly cleaned from banks (Hoshi & Kashyap, 2010; Borio et al, 2010). Therefore, during the subprime mortgage crisis, USA channelled $700 billion to clean bad assets from banks (Troubled Asset Relief Program). This paper suggests that the following instruments are helpful in motivating banks to disclose bad loans truthfully: asset insurance for the bank's loan portfolio, high capital ratio, prohibition of dividends and limits on compensation to bank managers. This suggestion extends the hallmark findings of Aghion et al. (1999). They advocate that recapitalization should be achieved by buying out bad loans rather than through capital injections by buying out subordinated bonds.

With regard to previous theoretical research on bank bailouts, Mailaith & Mester (1994) divulge how the regulator's policy on bank closure affects a bank's portfolio choice and its failure risk. In Gorton & Huang (2004), it is shown that it is costly for private agents to be prepared to purchase plenty of assets on short notice. The government can provide liquidity and boost welfare. Freixas (2009) examines lender of last resort and constructive ambiguity. Too many to fail problem inspires Acharya & Yorulmazer (2007a, 2007b), whereas Rochet (1992) analyzes bank capital with ex ante moral hazard. There exists some captive evidence on bank bailouts. Hoshi & Kashyap (2010) report lessons from Japan and Lindgren et al. (1999) from Asia. Panetta et al. (2009) review the last crisis and Borio et al. (2010) focus on Finland, Norway and Sweden. See also Freixas & Rochet (2008).

The paper establishes two fundamental problems regarding hidden loan losses. First, it is impossible for outsiders to know whether a bank rolls over a loan to hide a loan loss or because the borrower's good project takes longer than expected. Second, sometimes it is socially profitable to roll over bad loans because their value is likely to appreciate. However, the proceeds from the rollover are split unequally. If the value of bad loans appreciates, the bank can reap the profits, but if it depreciates, the bank may fail, causing costs to the deposit insurer. This risk should be priced in the deposit insurance premium but it is demanding.

The paper proceeds as follows. Section 2 presents the model. Sections 3 and 4 are devoted to non-stochastic collateral, whereas Section 5 concentrates on stochastic collateral. Section 6 characterizes personal utility moral hazard. Section 7 examines limits on compensation to bank managers, while early closure policy is explored in Section 8. Section 9 sheds light on asset insurance and Section 10 draws conclusions.

2. Economy

Consider a risk-neutral economy with entrepreneurs (=borrowers), depositors, banks, bankers and a bank regulator. An entrepreneur maximizes his income. A bank maximizes the income of its owner (the banker). Entrepreneurs and bankers enjoy limited liability. The regulator runs a deposit insurance scheme. Its costs are covered from taxes and from the liquidation proceeds of insolvent banks. There are two periods. Period-1 begins at time point 0 and ends at time point 1. Period-2 begins at time point 1 and ends at time point 2.

2.1 Project types

There is a continuum of entrepreneurs. At the start of period-1 each of them can undertake an investment project, which requires a unit of capital input. Since he lacks capital, he must seek a bank loan. The upcoming type of a new project is uncertain at the time of the investment but the type realizes during period-1. There are three alternative types:

* *A quick project* lasts for a period. If successful, it produces $1+Y$ units of output at the end of period-1.
* *A slow project* lasts for two periods. It produces interim output Y at the end of period-1 and final output $1+Y$ at the end of period-2. Its liquidation value is $L, L<1,$ at the end of period-1.
* *An bad project* produces output Y at the end of period-1 and it has liquidation value L at the end of period-1. Its value after period-2 is stochastic or non-stochastic. If the value is non-stochastic, it is L also after period-2. The stochastic scenario is detailed later.

For both slow projects and bad projects we have $L+Y<1+r$; the sum of the liquidation value and the interim output does not cover the risk-free interest rate of the economy, $1+r,\ r<Y$.

Since an upcoming type is unknown when a project begins, a bank lends a unit of capital for a period at interest rate R_1. During period-1 the entrepreneur and the bank recognize the realized project type, which is private information and unobservable to outsiders. Suppose that the project proves to be slow. Given the low liquidation value and the great long-term output, it is optimal to reschedule the loan repayment. Therefore, at the start of period-1 the bank promises that it will roll over the original loan if the underlying project proves to be slow. The roll over process is detailed below.

We define following labels. A loan is slow (quick or bad), if the underlying project is slow (quick or bad). A borrower is slow (quick or bad) if his project is slow (quick or bad).

2.2 Loan portfolio

In period-1 the amount of loans is 1. The regulator imposes capital requirement K_1 for period-1. A bank funds its operations with equity capital, K_1, and insured deposits, $1-K_1$. The interest rate of the economy, r, represents the cost of capital and deposits. The bank pays interest on deposits at the end of each period. Thereafter, the bank profit is paid out as dividends to the banker.

Let q, s and u indicate the realized shares of quick, slow and bad projects during period-1. Each of them is random. Slow projects have support $[\underline{S},1]$, and quick and bad projects $[0,1-\underline{S}[$. Three assumptions follow.

Assumption 1. *The expected NPV of a project is positive*

$$E(q)(1+Y) \quad + \quad E(s)\left[Y+\delta(1+Y)\right] + E(u)(Y+L) > 1+r+c. \tag{2.1}$$

Here $E(q)$, $E(s)$ and $E(u)$ denote the expected shares of quick, slow and bad projects. An administrative cost per a loan unit is c and it occurs only in period-1 when the bank is formed. Assumption 1 ensures that it is optimal to start a project and Assumption 2 simplifies the model.

Assumption 2. *The interim output covers the expected costs of a project in period-1: interest rate, the administrative cost and expected loan losses.*

$$Y \geq r + c + E(u)(1-L). \tag{2.2}$$

Hence, it is possible to price the project risk in the loan interest of period-1, R_1. Since each project type produces interim output, Y, an entrepreneur can pay interest R_1 in period-1. Since projects are risk-free in period-2, the loan interest then satisfies $R_2 = r$[4].

Assumption 3 makes the bank illiquid. The liquidation value of assets at the end of period-1 is insufficient to cover the payback of deposits.

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[4] In the following, we use symbol R_2 to clarify the presentation even if $R_2 = r$.

Assumption 3. $Y + \underline{S}L + (1-\underline{S}) \; < \; (1+r)(1-K_1)$.

On the L.H.S, the first term indicates the interim project output, the second term shows the liquidation proceeds from slow loans, and the third term expresses the principal repayments from quick loans. In total, the L.H.S gives the maximal proceeds from bank liquidation after period-1. It represents the maximum for three reasons: the bank has no bad loans, the volume of slow projects is minimal and $Y \geq R_1$ (in reality, a borrower repays R_1 not Y). Assumption 3 states that even the maximum liquidation proceeds are deficient to cover the payback of deposits. The bank fails if it is liquidated after period-1, because a notable share of loans is tied in slow projects with a low liquidation value. This restricts the regulator's alternatives. Now it is possible to define the rolling over contract:

Definition 1 (Roll over). *A bank and a borrower commit to the following contract at the start of period-1. The borrower promises to repay loan interest* (R_1) *and principal* (1) *at the end of period-1. In reality, the borrower can always pay* R_1, *but if the loan becomes slow, he cannot repay the principal. Then, according to the contract, the bank can roll over the loan, which delays the repayment of the principal for a period. During period-2 the size of the rolled over loan is* 1 *and the loan interest rate is* R_2. *Thus, the borrower promises to repay* $1+R_2$ *after period-2.*

The roll-over option offers a method for avoiding the costly liquidation of slow projects. Given Assumption 3, the probability of a slow project is so high that it is unprofitable to begin a project at all if it is liquidated with certainly after period-1. Unfortunately, the roll-over option can be misused. Only the borrower and his bank observe the realized project type. The regulator does not know whether the bank rolls over a loan, because the underlying project is slow (the loan rollover is socially profitable), or to hide an bad loan (socially harmful). Since slow projects are common, the regulator cannot ignore loan rollovers (Assumption 3).

The regulator's key instrument to control banks is the *prohibition of dividend payouts* at the end of period-1. The profit of period-1 is added to the bank capital for period-2. If the return from period-1 is negative, the prohibition policy (PP) has no effect, because there are no dividends. One may think of a situation where the regulator recognizes that problems are developing in the banking sector. He does not observe the true financial condition of a bank, but he can prohibit dividend payouts. Thereafter, the bank decides on the magnitude of disclosed bad loans, u_p. It can disclose bad loans in period-1, or hide some of them by rolling over these loans. The true value of the rolled over loans surfaces at the end of period-2.

If a bank discloses bad loans in period-1 and is insolvent, the regulator closes it. We take as granted that deposits must be insured and that the regulator can commit to close insolvent banks.[5] The latter assumption is usual (e.g. Marcus, 1984). The regulator maintains the slow loans of the liquidated bank until they mature after period-2. He also maintains bad loans during perod-2 if it is socially profitable. In most cases it is not and the regulator liquidates these after period-1.[6]

Again, the initial amount of bank capital is K_1. Obviously $0 \le u_p \le u$; the magnitude of disclosed bad loans cannot exceed the true magnitude of bad loans. If u_p is large, the return from period-1, $\pi_1(u_p)$, is negative to such a degree that the bank becomes insolvent after period-1, $\pi_1 + K_1 < 0$. More precisely, solvency/insolvency is defined as follows:

Definition 2 (solvency): *A bank is* ***truly solvent*** *(****truly insolvent****) in period-1 if it is solvent (insolvent) according to the true magnitude of bad loans, u, that is, $\pi_1(u) + K_1 > 0$ ($\pi_1(u) + K_1 < 0$). The bank is* ***officially solvent*** *(****officially insolvent****) in period-1, if it is solvent (insolvent) according to the disclosed magnitude of bad loans, u_p, that is, $\pi_1(u_p) + K_1 > 0$ ($\pi_1(u_p) + K_1 < 0$).*

If a bank is truly solvent, it is officially solvent. If it sufficiently hides bad loans (= loan losses), it is considered officially solvent even if it truly insolvent. If the official return for period-1 is negative, $\pi_1(u_p) < 0$, but the bank is still officially solvent, the regulator allows it to keep on operating in

[5] Deposit insurance is needed to prevent bank panics. Obviously, there exist alternative ways to eliminate bank panics. In Niinimäki (2003) a bank can offer liquid demand deposits and avoid panics if it also offers time deposits with a low liquidation value. High-risk depositors favor demand deposits and low-risk depositors prefer more productive time deposits. Niinimäki (2010) extends the study by assuming that time deposits are resellable.

[6] More precisely, the regulator cannot separate slow and bad loans. He hires the banker to manage these loans during period-2. The regulator pays ε units to the banker after period-2 for each loan, which proves to be successful (a slow loan). The banker pays e.g. 1 unit to the regulator after period-2 for each loan, which proves to be unsuccessful (a bad loan). This policy motivates the banker to liquidate bad loans after period-1 and roll over slow loans. When ε approaches zero, the incentive problem disappears at no cost.

period-2.[7] Then, bank capital in period-2 amounts to $K_2 = \pi_1(u_p) + K_1 \; < K_1$, where $K_2 \geq 0$. The negative returns erode the capital. We make the following assumption.

Assumption 4. *If a banker knows after period-1 that the bank is truly insolvent and that it cannot be profitable in period-2, the banker discloses the insolvency.*

The bank size is not fixed. It is 1 during period-1 but in period-2 the size is equal to the magnitude of the rolled over loans.

2.3 The value of stochastic collateral

As mentioned above, after period-1 the value of a bad project is L, which consists of collateral. Two scenarios appear. In sections 3 and 4, L is fixed but in section 5 it is stochastic. It is L after period-1, but if the project is not liquidated, it can appreciate or depreciate during period-2. There are several potential reasons for the fluctuation. First, collateral is likely to incorporate real estate: e.g. production factories, office buildings, etc. The value of real estate varies substantially.[8] Second, L involves outside collateral, which often includes firm stocks with wide price variance.[9] For simplicity, we model this as follows. During period-2 the value of an bad project appreciates with probability h back to $1+Y$, and depreciates with probability $1-h$ to $\underline{L}$. From the lender's point of view, the expected project value after period-2 is

[7] Regulators must have precise hard evidence on insolvency before they can begin liquidation process. They cannot adopt illegal methods. The following example is from Argentina (BIS, 1999. p. 62): 'In Argentina, judges forced the central bank to compensate the shareholders on the grounds that a bank was solvent at the time of intervention, and that the insolvency actually resulted from mismanagement during the intervention.'

[8] Real estate collateral plays a crucial role in lending. According to Borio (1996), the share of loans secured by real estate is 59% in Britain, 56% in Canada and 66% in U.S.A. The value of real estate collateral varies greatly. Hilberts et al. (2001) document that in Japan commercial property prices rose over 300% in the 1980s, but declined again to the initial level over the next 5 years. Lamm (1998) reports that in Iowa, farmland value per acre soared from $319 in 1970 to $1,694 in 1982, an increase of 431 %, but then dropped 62 % by 1987. See also Niinimäki (2009, 2011).

[9] Collyns & Senhadji (2002) offer an illuminating example. During the Asian crisis in the 1990s, stock prices appreciated sharply during the boom phase: 450% in Hong-Kong, 352% in Philippines, and over 155% in Malaysia. Depreciation was dramatic during the economic downturn: -56% in Hong-Kong in a year, -53% in Philippines in 18 months and -76% in Malaysia in 18 months.

$$E(L) = h(1+R_2) + (1-h)\underline{L}. \tag{2.3}$$

Since $1+R_2 < 1+Y$, the bank receives the promised repayment.

How is L related to the expected present value, $\delta E(L)$? Should we assume $\delta E(L) = L$, $\delta E(L) < L$ or $\delta E(L) > L$? Suppose $\delta E(L) < L$. This is realistic, if collateral value is fixed, $E(L) = L$. Moreover, the physical characteristics of collateral may erode during the delay in the liquidation process: factory buildings decompose, machines become obsolete or rusty, etc., and we have $E(L) < L$. The case of $\delta E(L) < L$ is also realistic because $1+R_2 < 1+Y$. Even when the current liquidation value is equal to the expected value of the project, $L = h(1+Y) + (1-h)\underline{L}$, we have $E(L) < L$, since a lender does not obtain the whole appreciation of the project value, $1+R_2 < 1+Y$. Consider now $\delta E(L) \geq L$. Shleifer & Vishny (1992, p.1343) conclude:

> When a firm in financial distress needs to sell assets, its industry peers are likely to be experiencing problems themselves, leading to asset sales at prices below value in the best use. Such illiquidity makes assets cheap in bad times....

Their findings are confirmed by Allen & Gale (1994, p.935):

> In equilibrium, the price of the risky asset is equal to the lesser of two amounts. The first is the standard discounted value of future dividends; it applies when there is no shortage of liquidity in the market. The second is the amount of cash available from buyers divided by the number of shares being sold: it applies when there is a shortage of liquidity. In this case, assets are underpriced, and returns are excessive to the standard, discounted dividends formula.

If the risky asset of Allen & Gale (1994) is the same as L in our model, it is possible that $\delta E(L) > L$, because the asset is now underpriced. In bad times the price of assets, L, may sink to an excessively low level and the expected proceeds from assets are excessive, $\delta E(L) > L$. Thus, both cases, $\delta E(L) < L$ and $\delta E(L) \geq L$, are realistic! Importantly, the regulator does not know the realized value of $E(L)$, which is the same in the whole economy and observable only to entrepreneurs and their bank.

2.4 Time line

1.1 The regulator determines the equity capital requirement, K_1.

1.2 A bank is established. It maintains K_1 units of capital and attracts the $1-K_1$ units of deposits.

1.3 The bank grants loans.

1.4 The types of the financed projects (quick, slow, bad) are realized.

1.5 The end of period-1: quick projects mature and these loans are repaid.

1.6 The regulator decides whether or not he prohibits dividend payouts (step 1.9). He makes the decision public.

1.7 The bank rolls over slow loans. It may also roll over bad loans. The magnitude of disclosed bad loans determines whether or not the bank is officially profitable in period-1. If the bank is officially insolvent, the regulator closes it. Otherwise, the bank goes on to point 1.8.

1.8 The bank attracts deposits for period-2 and pays back the deposits of period-1.

1.9 If the regulator does not prohibit dividends, the bank pays them to the banker. Otherwise, the dividends are added to the bank capital. Negative returns in period-1 erode bank capital.

2.1 Period-2 begins.

2.2 At the end of period-2, all loans mature and the bank is closed down. It pays back deposits and the banker receives the remaining returns.

We adopt this model to study the optimal strategy of the bank. When does it hide/disclose bad loans? If the banker profits by hiding bad loans – under scenarios in which it is socially optimal to disclose them, $\delta E(L) < L$ - we say that the banker earns moral hazard profits or that he makes excessive profits. Moral hazard behaviour adds to the regulator's costs, leads to unprofitable project liquidation due to the delay in the liquidation process and multiplies bank failures. When $\delta E(L) > L$, it is socially profitable to roll over bad loans and the roll-over decision does not represent moral hazard.

The regulator aims to eliminate moral hazard so that banks roll over loans only if it is socially profitable. The elimination of moral hazard reduces his costs. In some special cases the regulator's costs would be lower if a bank disclosed bad loans and bad projects were liquidated even when $\delta E(L) > L$. Yet, the regulator does not adopt this socially unprofitable liquidation strategy. His goal is to ensure that banks pursue the socially optimal strategy. This increases the regulator's costs from deposit insurance but he can recover the costs by taxing banks.

The paper examines alternative instruments for eliminating moral hazard. In most cases it is possible only to mitigate, not eliminate, moral hazard. To begin with, Section 3 studies milking moral hazard, which appears even when the collateral value is fixed. Section 4 demonstrates how this type of moral hazard can be eliminated.

3. Non-stochastic collateral

The section deals with the bank's optimal action at the end of period-1 when it learns the shares of different loan types and the collateral value is fixed. The bank's optimal action is shown to depend on the magnitude of bad loans. If it is low so that the financial health of the bank is good, the bank discloses bad loans in period-1. If it is large so that the bank is insolvent, the bank hides bad loans. In the intermediate case, the bank is solvent but possesses numerous bad loans. The optimal choice (disclose/hide) also depends on the amount of bank capital and on the liquidation value of bad loans.

Consider a benchmark case with perfect information. The regulator discerns the magnitude of bad loans, instructs banks to disclose them, closes insolvent banks liquidating their bad loans and maintains slow loans during period-2. A conclusion follows:

Lemma 1. *With perfect information, the magnitude of disclosed bad loans declines with the financial condition of the bank.*

Healthy banks disclose less bad loans. Later we obtain the opposite result with asymmetric information.

Let us turn to asymmetric information. A bank learns the magnitude of bad loans, u, and chooses the magnitude of disclosed bad loans, u_p, $u_p \leq u$, so that the banker's life-time income is maximal. The choice is easy, because no more loan defaults take place in period-2. Given u_p, the bank hides $u - u_p$ bad loans by rolling over them. It also rolls over slow loans. This yields the following return from period-1

$$\pi_1(u_p) = R_1 \; - \; u_p(1-L) \; - \; (1-K_1)r - c. \tag{3.1}$$

Here R_1 is the loan interest from period-1, the second term shows costs from the disclosed bad loans (lost loan principal), and the third term indicates payments to depositors. If $\pi_1 > 0$, the bank is officially profitable and can pay out the profit as dividends. If $\pi_1 < 0$, the negative return erodes bank capital. The bank can keep on operating in period-2 only if it is officially solvent; otherwise the regulator closes it after period-1. If it is officially solvent in period-1, the return from period-2 is

$$\pi_2 = s(1+R_2) \ + (u-u_p)L \ - (u-u_p+s-K_2)(1+r) \ . \tag{3.2}$$

The first term indicates repayments from slow loans. The second term is the value of hidden bad loans, which surface in period-2. The last term displays payments to depositors. If $u-u_p+s<K_2$, bank capital exceeds the need for funds and the bank attracts no deposits for period-2. Instead, it invests the surplus in government bonds at the interest rate r. The return from period-2 may be positive or negative. In the latter case, the bank is insolvent. If solvent, the banker receives the profit.

We can now sum the banker's life-time income. If profitable, the bank pays the profits as dividends to the banker after period-1. Since he enjoys limited liability, his income in period-1 is $Max\,\{0,\,\pi_1\}$. If officially solvent in period-1, the bank can keep on operating in period-2, the banker earns $Max\,\{0,\,\pi_2\}$, and his life-time income totals $Max\,\{0,\,\pi_1\}$ $+\,\delta\,Max\,\{0,\,\pi_2\}$, where $\delta = 1/1+r$ marks the discount factor. Appendix A provides the following result.

Proposition 1. (i) *When the magnitude of bad loans is so large that a bank is truly insolvent in <u>period-1</u>, there exists no such a division of disclosed bad loans between the periods that the bank is truly solvent in both periods.*

(ii) *When the magnitude of bad loans is so large that a bank is truly insolvent in <u>period-2</u> and if the bad loans surface then, there may be such a division of disclosed bad loans between the periods that the bank is truly solvent in both periods.*

(iii) *When the magnitude of bad loans is so small that the bank is truly solvent in period-2 and if the bad loans surface then, the bank is truly solvent in both periods under any division of disclosed bad loans between the periods.*

Intuitively, by hiding bad loans, the bank avoids a loss $1-L$ in period-1. In period-2 it bears a larger loss $1+r-L$, because it needs to finance the rolled over loans during period-2 by raising costly deposits. Since $1-L<\delta(1+r-L)$, hiding is expensive. Put differently, if a bad loan is liquidated in period-1, the bank obtains L. If it hides the loan loss for a period, the present value of the liquidation proceeds is smaller, δL. *The socially optimal policy is to disclose bad loans at* *once.*[10] This implies results i-iii. In (i) the bank is insolvent if bad loans surface in period-1. Any other division of the loan loss information between the periods increases the costs and the bank cannot be solvent in both periods. In (iii), the bank is solvent in both periods even when the costs from bad loans are maximal, that is, they surface in period-2. Any other division of loan loss information between the periods decreases the costs and the bank is solvent in both periods. In (ii) the bank is insolvent in period-2 if the bad loans surface then. Thus, the bank is insolvent if the costs from bad loans are maximal. Any other division of loan loss information reduces the costs and the bank may be solvent in both periods.

Given Proposition 1, it is easy to find out the profit maximizing magnitude of disclosed bad loans. Three cases occur depending on the materialized magnitude of bad loans:

Proposition 2. *The true magnitude of bad loans, u, is so large that the bank is insolvent in period-1 if it discloses the bad loans then. The optimal strategy is to hide each loan loss in period-1, make a profit and fail in period-2. This case is possible only if the realized magnitude of bad loans is so low that* $K_1 - u(1-L) < 0$.

Proof. Recall case (i) in Proposition 1. It is impossible to divide information on bad loans between the periods so that the bank is profitable in both periods. If the bank does not sufficiently hide bad loans, it fails in period-1 and the banker's life-time income is zero. If the bank hides sufficiently bad loans, it fails in period-2, and the banker's life-time income consists of the bank profit from period-1. This profit is maximized by the bank. Given (3.1), each disclosed loan loss reduces the profit from period-1. The bank optimally hides each loan loss in period-1. True insolvency, $\pi_1(u) + K_1 < 0$, and (3.1) together imply $K_1 - u(1-L) < 0$. *Q.E.D*

[10] Suppose that a bank operates forever and can hide a loan loss forever via loan rollovers. The bank finances the rolled over loan by attracting a unit of deposits. It pays interest r on deposits. The NPV of the deposit payments, $(\delta + \delta^2 + \delta^3 + ...)r$, where $\delta = 1/1+r$, is 1. The costs are lower if it discloses the bad loans at once, $1-L$. Suppose that the bank is solvent forever and can hide loan losses for t, $1 \le t < \infty$, periods. The expected costs from the hiding strategy amount to $(1-\delta^t)\delta r/(1-\delta)$ + $\delta^t(1-L)$, which exceeds $1-L$. A solvent bank discloses loan losses optimally at once. Only insolvency and limited liability motivate banks to hide loan losses! Importantly, stochastic collateral generates different results.

The true financial condition of the bank, insolvency, becomes public in period-2.[11] The banker enjoys limited liability and the regulator incurs the costs of the insolvency, because he indemnifies the deposits. The scenario differs considerably from standard moral hazard, in which the moral hazard choice is made ex ante and the bank gambles with future risks. Now the moral hazard choice is made ex post, when the risk has been realized. There is no gamble at all, because the magnitude of bad loans is given. The bank hides bad loans so that it is officially profitable and can pay out (good) dividends. In reality, the bank is unavoidably insolvent. We label this type of behaviour *milking moral hazard*. In the social optimum, the bank discloses bad loans in period-1, the regulator closes it, liquidates the bad loans and seizes slow loans by maintaining them during period-2. Hiding boosts the banker's income by $R_1 - (1-K_1)r - c$ and increases the regulator's costs by the same amount. In addition, the regulator's costs increase by $L(1-\delta)$ due to the delay in the liquidation process. We now turn to the next group of banks.

Proposition 3. *The true magnitude of bad loans, u, is so small that the bank is solvent in period-2 if the bad loans surface then. The bank optimally discloses the bad loans in period-1 and is solvent in both periods. This case is possible only if the realized magnitude of bad loans is so low that $K_1 - u(1-L) > 0$.*

Proof. Case (iii) in Proposition 1 indicates that the bank is solvent in both periods with any division of loan loss information between the periods. Hence, it maximizes $\pi_1 + \delta\pi_2$. We obtain

$$\frac{d}{d u_p} \pi_1 + \delta\pi_2 = -(1-L) + \delta(1+r-L) = L(1-\delta) > 0. \tag{3.3}$$

The bank discloses bad loans in period-1. In addition, (3.2) implies $K_1 - u(1-L) > 0$. *Q.E.D*

Intuitively, since the bank is solvent in both periods, it does not benefit from limited liability. Instead, it incurs full costs from bad loans. As a result, it discloses them at once. Disclosure is

[11] Sheng (1996, p.151) gives an example of effective hiding in Chile: "Auditors for Banco Espanol qualified their report for 1979 by stating that 37% of loans could not be evaluated because of lack of information on the debtors' ability to pay – even though the loans had been rolled over repeatedly." Consequently, when the hidden bad loans surface and the true financial condition of the bank finally becomes public, the bank is insolvent.

socially optimal and the regulator bears no costs. Proposition 3 implies the following interjection, which determines the banker's life-time income. The proof is in Appendix B.

Lemma 2. *A bank acts so that it is solvent in both periods and discloses bad loans in period-1. Whether the return of period-1 is positive or negative,* $\pi_1(u_p = u) > 0$ *or* $\pi_1(u_p = u) < 0$*, the life-time income of the banker amounts to* $K_1 + \pi_1(u_p = u)$*, that is,* $R_1 - (1-K_1)r - u(1-L) + K_1 - c$*.*

Next we revert from the interjection, Lemma 2, to the final group of banks. The following proposition is proved is Appendix C.

Proposition 4. *Suppose that the magnitude of bad loans is such that the bank is solvent in both periods if it discloses them in period-1, but insolvent if the bad loans surface in period-2. If* $K_1 > u(1-L)$*, the bank optimally discloses the bad loans in period-1 and is solvent in both periods.* If $K_1 < u(1-L)$*, it hides the bad loans in period-1, earns profits and fails in period-2.*

This is an intermediate case. In Proposition 2 a bank is solvent in period-1 and insolvent in period-2, and in Proposition 3 it is always solvent. Now it is able to choose the solvency (Recall (ii) in Proposition 1). If it hides bad loans, it is solvent only in period-1. If it discloses them, it is solvent in both periods. When $K_1 > u(1-L)$, the solution – disclosure - is socially optimal. When $K_1 < u(1-L)$, the choice – hiding - is not socially optimal since it leads to bank failure in period-2. Hiding increases the banker's income but the increase is based on moral hazard. Moreover, the increase in the regulator's costs is larger due to the delay in the liquidation of bad loans.

In sum, Section 3 examines one type of ex post moral hazard: milking. It compounds bank failures (Proposition 1ii, Proposition 4), leads to socially unprofitable (late) liquidations of bad projects, and adds to the regulator's costs. It also generates excessive moral hazard profits for the banker. [12] Two corollaries follows.

[12] Lindgren et al. (1999, p.94) discover captivating evidence from Thailand: "Thus, the reported capital adequacy ratios were grossly misleading since loans were not appropriately classified and provisioned for. For example, financial institutions had built up large loan portfolios of increasingly questionable quality, secured by generally overvalued asset collateral. These loans were often simply restructured ("evergreened") when payment problems arose and not reclassified. Interest on non-performing loans continued to accrue and, hence, significantly overstated financial sector earnings. This had made it possible to pay dividends, bonuses and taxes on nonexisting profits effectively decapitalizing these institutions."

Corollary 1. *Consider two banks under asymmetric information with non-stochastic collateral. A solvent bank discloses more loan losses (bad loans) in period-1 than an insolvent bank.*

Corollary 1 rests on Propositions 2 and 3, and it is opposite to Lemma 1: solvent banks disclose less bad loans than insolvent banks with perfect information. Corollary 1 is in the line with the de Juan's argument, which was mentioned in the Introduction. Consequently, moral hazard creates the need for effective regulation. To begin with, the regulator can have an influence on the probability of different outcomes through the equity capital requirement, K_1.

Corollary 2. *The regulator can eliminate milking moral hazard by determining a sufficiently high capital requirement, K_1, for banks.*

Proof. Consider Proposition 4. When K_1 is high, the case of $K_1 - u(1-L) < 0$ is unlikely. Furthermore, let $\bar{u}$ denote the upper limit for u ($\bar{u}$ is at most $1-\underline{S}$). It is possible to choose K_1 so that the bank never hides bad loans, $K_1 - \bar{u}(1-L) > 0$. The moral hazard problem is eliminated with certainty (recall Propositions 2-4). *Q.E.D.*

4. Prohibition of dividends with non-stochastic collateral

It is necessary to develop instruments to mitigate moral hazard. This section explores the effects of one commonly adopted instrument. The regulator can prohibit dividend payouts after period-1. Does the prohibition policy (PP) motivate a bank to forgo the hiding strategy? Does it reduce the regulator's costs or the banker's income from hiding? Does it limit bank failure? In this model we know that the regulator's expected costs decrease only if the banker's excessive income decreases. Lemma 3 is confirmed in Appendix D.

Lemma 3. *Under the prohibition policy, bank capital in period-2 is $K_2 = K_1 + \pi_1(u_p)$ whether $\pi_1(u_p) < 0$ or $\pi_1(u_p) > 0$. In both cases the bank optimally discloses bad loans in period-1,*

$u_p = u$, and earns $(1+r)\lfloor K_1 + \pi_1(u_p = u) \rfloor$ in period-2. If the bank is truly solvent (insolvent) in period-1, it is also truly solvent (insolvent) in period-2.

Obviously, the effects of PP depend on what the bank's optimal strategy would have been without it. Since the optimal strategy depends on u, it is necessary to study PP with different values of u.

Corollary 3. *Suppose that a bank is truly solvent in period-1. If $K_1 > u(1-L)$, it is solvent in both periods with and without the prohibition policy (PP) and PP has no effect on the regulator's costs, banker's life-time income or the disclosure of bad loans. If $K_1 < u(1-L)$, the bank hides bad loans in the absence of PP, pays dividends in period-1 and fails in period-2. With PP, the bank discloses bad loans in period-1, is solvent in both periods and the regulator avoids the costs of deposit insurance in period-2. Thus, PP converts the optimal strategy from hiding to disclosure, prevents bank failures, reduces both the regulator's costs and eliminates excessive bank profit.*

Proof. Case $K_1 > u(1-L)$, can be observed from Propositions 3 and 4 and Lemmas 2 and 3. For the Case $K_1 < u(1-L)$, see Proposition 4 and Lemma 3. *Q.E.D*

If $K_1 > u(1-L)$, PP alters only the timing of the banker's income flows. Now we turn to the next group. A bank is initially insolvent. Corollary 4 is derived from Proposition 2 and Lemma 3.

Corollary 4. *Suppose that a bank is truly insolvent in period-1. Without PP, it hides bad loans in period-1, pays out (good) dividends and fails in period-2. With PP, the banker knows that the bank will be insolvent in period-2 with certainty and discloses bad loans in period-1. Using PP, the regulator converts the optimal strategy from hiding to disclosure and reduces the banker's excessive profits and regulator's cost to zero.*

Consequently, the bank discloses bad loans in period-1 and the regulator liquidates them at once. He retains slow loans during period-2 until they mature.

In sum, the impact of PP is positive. It eliminates milking moral hazard. Banks do not hide bad loans, liquidation time is socially optimal and the regulator's costs fall. The banker's expected income drops since his moral hazard profits are eliminated. The number of bank failures declines. Unfortunately, PP is less efficient with other types of moral hazard in the next sections.

5. Stochastic collateral

So far the value of collateral has been fixed, L. Henceforth, it changes during period-2 if the project is not liquidated after period-1. With probability h it appreciates from L to $1+R_2$ and with probability $1-h$ it depreciates from L to $\underline{L}$. The expected value is $E(L)$.

As above, *milking moral hazard* is present. In addition, the second form of moral hazard, *ex post risk shifting*, appears: a bank may roll over a bad loan to gamble with the future value of collateral even when the roll-over decision is not socially optimal, $\delta E(L) < L$. If the collateral value appreciates, the returns from period-2 increase. If it depreciates, the returns decrease, the bank fails and the regulator bears the costs of the gamble. With regard to the gambling incentives, the magnitude of bad loans, u , proves to be crucial. The larger the burden of bad loans, the more willing a bank is to hide problems via loan rollovers. PP reduces gambling incentives and sometimes eliminates them. Unfortunately, the worst banks always hide their bad loans.

To show this, let $\bar{u}_2(u_p)$ denote the maximal magnitude of surfacing bad loans in period-2 so that a bank is solvent if the liquidation value is non-stochastic, L . Let $\bar{u}_D(u_p)$ mark the maximal magnitude of surfacing bad loans in period-2 so that the bank is solvent if the liquidation value is $\underline{L}$. With depreciation, the return from period-2 is

$$\pi_D = s(R_2 - r) + (u - u_p)\left[\ \underline{L} - (1+r)\right] + K_2(1+r) \quad . \tag{5.1}$$

When $u - u_p = \bar{u}_D$, π_D is zero, and when more bad loans surface in period-2, $u - u_p > \bar{u}_D$, π_D is negative and the bank fails. If the collateral value appreciates, the returns from period-2 are $\pi_A = (u + s - u_p)(R_2 - r) + K_2(1+r)$, that is, $\pi_A = K_2(1+r)$. Three scenarios occur depending on the magnitude of bad loans.

5.1 Scenario $u \le \bar{u}_D$

When $u \le \bar{u}_D$, the magnitude of bad loans is so low that a bank is truly solvent in both periods. It does not fail in period-2 even with minimal returns: bad loans are rolled over and collateral value depreciates. We learn that the bank pursues the socially optimal liquidation policy with and without PP.

Without PP: The expected return in period-2 is $\pi_{2E(L)} = h\pi_A + (1-h)\pi_D$, that is,

$$\pi_{2E(L)}(u_p) = (u-u_p)\left[E(L) - (1+r)\right] + K_2(1+r). \qquad (5.2)$$

The banker's life-time income totals $Max(\pi_1,0)+\delta\pi_{2E(L)}$ (here π_1 is given by (3.1) and $\pi_{2E(L)}$ by (5.2)). If $\pi_1 > 0$, we have $K_1 = K_2$ in (5.2) and the life-time income simplifies to

$$R_1 - (1-K_1)r - c - (1-L)u_p + K_1 + (u-u_p)\left[\delta E(L) - 1\right]. \qquad (5.3)$$

If $\pi_1 < 0$, $Max(\pi_1,0)+\delta\pi_{2E(L)}$ simplifies to $\delta\pi_{2E(L)}$ in which $K_2 = K_1 + \pi_1$. Again, (5.3) gives the life-time income. The banker chooses u_p to maximize the income in (5.3). The F.O.C provides

$$-(1-L) - \delta\left[E(L)-(1+r)\right] , \qquad (5.4)$$

or $L-\delta E(L)$. Suppose $L > \delta E(L)$. Then $u_p = u$, and (5.3) gives $R_1-(1-K_1)r-c-(1-L)u+K_1$. The fact that the collateral value is stochastic has no effect, since bad loans are liquidated in period-1. Only if $L < \delta E(L)$, is the roll-over decision profitable. Then, the bank earns $R_1-(1-K_1)r-c$ in period-1, and in period-2 either $\delta\pi_A = K_1$ with appreciation or $\delta\pi_D = u(\delta\underline{L}-1) + K_1$ with depreciation.

With PP: The returns from period-1 are added to the capital, $K_2 = K_1 + \pi_1(u_p)$. The present value of returns from period-2 is $\delta\pi_{2E(L)}$ in which $K_2 = K_1 + \pi_1(u_p)$. The life-time income is the same as in (5.3) and the bank pursues the socially optimal liquidation policy. PP has no effect on the liquidation policy or life-time income. Conclusions follow.

Proposition 5. *When the magnitude of bad loans is so small that a bank is solvent in both periods with certainty, it discloses bad loans if* $L > \delta E(L)$ *and rolls over them if* $L < \delta E(L)$*. PP has no impact on the disclosure decision, on the banker's life-time income or on the regulator's costs (which are zero) but it does postpone the banker's dividend income.*

Since the bank is risk free, there is no benefit from limited liability. It bears full costs from the loan liquidations. Hence, it rolls over bad loans only if it is socially optimal and the regulator has no reason to deny loan rollovers or adopt PP. However, since he cannot observe the magnitude of bad loans and the realized value of $E(L)$, he is unable pursue this optimal policy.

5.2 Scenario $u > \bar{u}_D$ and truly solvent in period-1

5.2.1 The choice of the bank

We turn to the next best group with regards to the share of bad loans, $u > \bar{u}_D$. A bank is truly solvent in period-1 but fails in period-2 if it rolls over bad loans and their value depreciates during the period. If the value appreciates, the bank is successful. Since the bank is truly solvent in period-1, it can avoid failure by disclosing bad loans. Yet, its profit maximizing policy may be to gamble with collateral. If successful, the returns are high. If unsuccessful, the bank fails and the regulator incurs the cost of the gamble. PP mitigates the problem and in some scenarios eliminates it.

Without PP: Consider a bank, which hides so few bad loans that it does not fail in period-2 even with depreciation, $u - u_p \le \bar{u}_D$. An extra rolled over bad loan increases returns by $\delta\left[(1+R_2)-(1+r)\right]+(1-L)$ during appreciation and by $\delta\left[\underline{L}-(1+r)\right]+(1-L)$ during depreciation with an expected value $\delta E(L) - L$. If the bank diminishes the magnitude of disclosed bad loans so that more bad loans surface in period-2, $u - u_p > \bar{u}_D$, the bank fails in period-2 with depreciation but its returns increase with appreciation. Each extra rolled over bad loan boosts the returns during appreciation but has no impact on the returns during depreciation because the bank fails. The expected returns from an extra rolled over bad loan are $h(1-L)$. Due to limited liability the *ex post risk shifting* problem is present. Lemma 4 is confirmed in Appendix F.

Lemma 4. *The optimal magnitude of the rolled over loans is either* 0 *or* u.

It is sufficient to investigate both ends, $u_p = 0$ or $u_p = u$. Suppose, first, that the bank discloses bad loans, $u_p = u$, and Lemma 2 displays the banker's life-time income

$$R_1 - u(1-L) - (1-K_1)r - c + K_1 \quad . \tag{5.5}$$

If the bank hides bad loans, the expected life-time income is (here $h\delta\pi_A(u_p = 0) = hK_1$)

$$R_1 - (1-K_1)r - c + h\delta\pi_A(u_p = 0) \ . \tag{5.6}$$

Here $R_1 - (1-K_1)r - c$ is the income from period-1 and $h\delta\pi_A(u_p = 0)$ is the present value of the expected income from period-2. Due to hiding, no bad loans appear in period-1. If the collateral value appreciates, no bad loans appear in period-2 either. If the collateral value depreciates, the bank fails. Disclosure is optimal if (5.5) exceeds (5.6)

$$K_1 - \ u(1-L) - \ h\delta\,\pi_A \ > \ 0. \tag{5.7}$$

Recall Proposition 4 from Section 3. With milking moral hazard, disclosure is optimal if $K_1 - (1-L_1)u > 0$. Since $h\delta\pi_A > 0$, hiding is now more profitable because the value of bad loans appreciates with probability h. The following lemma is derived in Appendix F.

Lemma 5. *When $u > \overline{u}_D$ and the bank is truly solvent in period-1, it rolls over bad loans if* $\delta E(L) - L \quad + \ (1-h)\delta\left[-\underline{L} \quad - K_1(1+r)/u + (1+r)\right] \ > 0$, *where the term in the brackets is positive. The bank is more eager to roll over bad loans than in subsection 5.1, where it is solvent and does not profit from limited liability.*

Recall that it is socially optimal to roll over bad loans if $\delta E(L) > L.$ Even when this inequality is not satisfied, the bank rolls over loans if the term $-\underline{L} \quad - K_1(1+r)/u + (1+r)$ is sufficient. The bank take s excessive risks. It is solvent but its financial condition is so bad (the true amount of bank capital is low due to a large burden of bad loans) that the bank is willing to roll over bad loans and gamble with collateral. A conclusion follows.

Proposition 6. *Two conditions are satisfied. First, the magnitude of bad loans is so small that a bank is truly solvent in period-1 if it discloses bad loans. Second, if they surface in period-2, the bank fails if their value depreciates. The bank discloses bad loans if* $K_1 - u(1-L) - h\delta\pi_A > 0$. *The roll-over incentives of milking moral hazard are strengthened by the ex post risk shifting incentives. Even if the disclosure is socially optimal, limited liability tempts the bank to delay disclosure so that the bank can gamble with the future value of collateral.*

5.2 .2 The regulator's costs

Suppose $L < \delta E(L)$. It is socially optimal to roll over bad loans. Unfortunately, the returns from the loan rollover are split unequally between the bank and the regulator. If the collateral value appreciates, the bank can reap the proceeds but if it depreciates, the bank fails and the regulator must indemnify deposits. Since the expected returns from the loan rollover are positive, it is not optimal to deny the rollover. Instead, deposit insurance should be priced correctly so that the bank incurs a fair part of the expected losses.

Suppose, now, that $L > \delta E(L)$. It is socially optimal to disclose bad loans. Yet, the ex post risk-shifting problem appears. The correct pricing of deposit insurance would eliminate the gamble. Unfortunately, the regulator cannot price deposit insurance accurately, because he cannot detect the difference between slow projects and bad projects. Those rolled-over loans, which are allocated to finance slow projects, are risk free and they should be excluded from the deposit insurance premium. In addition, the socially optimal solution cannot be achieved because the regulator cannot detect $E(L)$.

5.2.3 The effects of the prohibition policy (PP)

PP adds bank capital by π_1 when $\pi_1 > 0$. If the collateral value appreciates, the additional capital is unimportant, since the bank is successful even without it. Assume next that the collateral value depreciates. With PP, the returns from period-2 are

$$\pi_D^{PP}(u_p) = -(u-u_p)\left[1+r-\underline{L}\right] + K_1(1+r) + (1+r)\pi_1(u_p) \ . \tag{5.8}$$

The returns decrease with u and increase with u_p. If the returns are non-negative with each u_p, PP adds so much capital that the bank is risk-free in period-2. As observed above, a risk-free bank discloses bad loans if $L > \delta E(L)$.

Suppose that PP does not add enough capital to make the bank risk free. There is a critical value, $\bar{u}_{DD}(u_p)$, such that (5.8) is zero when $u - u_p = \bar{u}_{DD}$. When $u - u_p > \bar{u}_{DD}$ the bank fails in period-2 under depreciation. Does the bank disclose bad loans? With the disclosure strategy, the NPV of the returns from period-2 (recall Lemma 3) is $K_1 + \pi_1(u_p = u)$ or

$$R_1 - u(1-L) - (1-K_1)r + K_1 - c. \tag{5.9}$$

With the hiding strategy, the NPV of the expected returns from period-2 is

$$h\delta \left\{ (1+r)K_1 + (1+r)\pi_1(u_p = 0) \right\}, \tag{5.10}$$

or $h\left[R_1 - (1-K_1)r - c\right] + \delta h \pi_A(u_p = 0)$. The bank avoids failure only if the collateral value appreciates. Whether or not it discloses bad loans, it pays dividends after period-2 due to PP. It is optimal to disclose bad loans if (5.9) exceeds (5.10), or

$$K_1 - u(1-L) + (1-h)\left[R_1 - (1-K_1)r - c\right] \geq \delta h \pi_A , \tag{5.11}$$

or $-u(1-L)h + (1-h)\left[R_1 - (1-K_1)r - c + K_1 - u(1-L)\right] \geq 0$. Here (5.11) is almost the same as in (5.7).The effect of PP is given by $(1-h)\left[R_1 - (1-K_1)r - c\right]$. PP makes hiding less profitable by eliminating a dividend payout after period-1, that is, by removing milking moral hazard. Without PP, the banker receives the profits from period-1 as dividends after period-1. With PP, the banker receives the profits from period-1 only after period-2 if the collateral value appreciates, that is, with probability h. Obviously, this makes hiding less profitable. Put differently, PP adds to the bank capital, thereby lessening limited liability benefits and eroding profits that accrue from risk taking. Using Appendix F, it is possible to restate (5.11); the bank discloses bad loans if

$$u\left[L - \delta E(L) \right] + \delta \pi_D^{PP}(u_p = 0) \geq 0. \tag{5.12}$$

Here $\pi_D^{PP}(u_p = 0)$ is negative (recall (5.8)). Hence, (5.12) reveals that the bank is very willing to roll over bad loans. In section 3, PP eliminates moral hazard but now it is unable to do so. In Section 3, only milking moral hazard is present and PP eliminates it. Now the ex post risk shifting problem is also present and PP can only mitigate, not eliminate, it.

How does PP influence the regulator's costs? As observed above, sometimes PP adds so much capital that the bank becomes risk free. Even if the amount of capital is lower, PP may change the optimal strategy from hiding to disclosure (compare (5.7) and (5.11)). Alternatively, moral hazard may be concern with PP. Under the hiding strategy, the regulator's expected costs amount to $-\delta(1-h)\ \left[\pi_D^{PP}(u_p = 0)\ +(1+r)\,\pi_1(u_p)\right]$ without PP, and $-\delta(1-h)\ \left[\pi_D^{PP}(u_p = 0)\right]$ with PP. These costs are lower with PP. The difference is $(1-h)\pi_1$. The profit from period-1 is maintained in the bank and it adds to the bank capital, reducing the volume of deposits and thereby the costs of deposit insurance. A conclusion follows.

Proposition 7. *PP alleviates moral hazard. First, it eliminates milking moral hazard, because it is not possible to pay dividends after period-1. Second, by adding capital it may make the bank risk free, thereby eliminating incentives for ex post risk shifting. Third, even when the additional bank capital is insufficient to make the bank risk free, it lessens the limited liability benefits, thereby reducing moral hazard profits. This may make the disclosure strategy profitable. Since PP eliminates moral hazard in a few cases, it also reduces the regulator's costs and limits bank failures. Even when the moral hazard problem is present, PP reduces the regulator's costs and the banker's excessive profits.*

5.3 The case of $u > \bar{u}_D$ and truly insolvent in period-1

Next, we turn to the third bank group. The burden of bad loans is so large that a bank is insolvent after period-1 at the given liquidation value *L*.

Social optimum: If $\delta E(L) \le L$, it is socially optimal to close the bank and liquidate bad loans in period-1. If $\delta E(L) > L$, but $E(L)$ is low, the expected value of the bank in period-2 is negative and it should be closed in period-1. Yet, it is not optimal to liquidate bad loans. The regulator should retain both slow and bad loans until they mature in period-2. If $\delta E(L) > L$ and $E(L)$ is sufficiently large, the expected bank value in period-2 is positive. We argue that the bank should not be liquidated in period-1 and it should roll over bad loans. The collateral value is likely to appreciate so that the bank is solvent in period-2.[13] Again, the socially optimum cannot be achieved since the regulator does not observe the realized value of $E(\overline{L})$.

5.3.1. The bank's choice

We begin with the following lemma:

Lemma 6. *When $u > \overline{u}_D$ and a bank is truly insolvent in period-1, it is impossible that the bank hides so few bad loans in period-1 that is successful under depreciation in period-2.*

Proof. Proposition 1i.) states: if a bank is insolvent in period-1, no such a division of bad loans exists between the periods so that the bank is solvent in both periods, when the value of bad loans is fixed, L. With depreciation, the value of bad loans is lower, $\underline{L} < L$, in period-2. *Q.E.D*

Without PP: the bank maximizes the returns from period-1 and period-2 during appreciation (because it fails during depreciation). Consider the banker's expected life-time income, $Max(0,\pi_1) + \delta h \pi_A$. If $Max(0,\pi_1) = 0$, the life-time income simplifies to hK_2 or

$$h\left\lfloor K_1 + \pi_1(u_p) \right\rfloor, \qquad \overline{\overline{u}}_1 \le u_p \le \overline{u}_1. \tag{5.13}$$

Here $\overline{u}_1$ ($\overline{\overline{u}}_1$) is the upper limit of u_p so that the bank is solvent (profitable) in period-1. Given $\overline{\overline{u}}_1 \le u_p \le \overline{u}_1$, the maximal returns are $h\left\lfloor K_1 + \pi_1(\overline{\overline{u}}_p) \right\rfloor$, that is, hK_1. If $Max(0,\pi_1) = \pi_1$,the life-time income can be expressed as $\pi_1 + \delta h \pi_A$, where $u_p \le \overline{\overline{u}}_1$, or

$$R_1 - u_p(1-L) - (1-K_1)r - c + \delta h\left\{ (s+u-u_p)\left[1 + R_2 - (1+r)\right] + K_1(1+r) \right\}. \tag{5.14}$$

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[13] Cargill et al. (1998, p.183) shed light on hiding in Japan: " banks made additional loans to enable borrowers to pay interest on previous loans, so the nonperforming loan amount is understated". On p. 188 they detail Jusen banks: "…Ministry of Finance made the first on-site examinations of Jusen in 1991-1992. Those examinations revealed that 67 percent of loans made to the largest 50 borrowers were already nonperforming: however, the ministry allowed the Jusen companies to operate on the assumption that land prices would rise in the future. Instead land prices continued to decline and the Jusen problem increased in magnitude: in the subsequent four years nonperforming loans in the Jusen increased by 75 percent." Hence, regulators anticipated that the collateral value would appreciate but it did not.

The optimal level of disclosed bad loans can be solved from (5.14). The F.O.C. provides

$$-(1-L) < 0, \quad when \quad u_p \leq \overset{=}{u}_1 . \tag{5.15}$$

The bank hides the bad loans in total, $u_p = 0$, earns $R_1-(1-K_1)r-c$ in period-1 and gambles in period-2 with collateral. Only if the gamble is successful, the bank is profitable in period-2. This strategy yields the expected life-time income $R_1-(1-K_1)r-c+hK_1$. Hence, the bank optimally hides loan losses, $u_p = 0$.

With PP: Given Lemma 3, the bank capital in period-2 is $K_1+\pi_1(u_p)$. If the collateral value depreciates, the returns of period-2 are given by (5.8), $\pi_D^{PP}(u_p)$, or

$$(1+r)\left\{-(u-u_p)(L-\delta\underline{L}) + \left[K_1 + R_1-(1-K_1)r-c-u(1-L)\right]\right\}, \quad u_p \leq \bar{u}_1 . \tag{5.16}$$

The term in brackets is negative, because the bank is initially insolvent. Thus, (5.16) is negative; the bank fails with depreciation. Given $K_2 = K_1+\pi_1$, the present value of the expected returns from period-2 with appreciation, $h\delta\pi_A$, that is, hK_2, can be restated as

$$hK_1 + h\left\lfloor R_1-(1-K_1)r-c-u_p(1-L)\right\rfloor . \tag{5.17}$$

The bank optimally hides bad loans, $u_p = 0$. It is truly insolvent after period-1 and it can be resurrect only if the collateral value appreciates. To maximize the expected returns from the gamble, the bank rolls over bad loans in total. Their expected value in period-2, $E(L)$, is inefficient. Neither has PP affected the hiding incentives. Given $u_p = 0$ in (5.17), the expected returns from period-2 are

$$hK_1 + h\left[R_1-(1-K_1)r-c\right] . \tag{5.18}$$

How does PP work? Without PP, the returns are $R_1 - (1-K_1)r - c + h\ K_1$ (recall (5.14) with $u_p = 0$). Now (5.14) and (5.18) together reveal that the returns are higher without PP. The difference is $\left[R_1 - (1-K_1)r - c\right](1-h)$. With PP, the bank cannot pay out the returns from period-1 from the bank until after period-2. The banker obtains the returns from period-1 only if the collateral value appreciates in period-2, that is, with probability h. Without PP, the banker receives the returns from period-1 after period-1. Put differently, without PP the bank can operate with a lower capital ratio in period-2. PP also reduces the regulator's costs when the bank fails. Since failure happens with probability $1-h$, the regulator's expected benefit is $\left[R_1 - (1-K_1)r - c\right](1-h)$. This is equal to the banker's expected loss due to PP.

Proposition 8. *When a bank is truly insolvent and $u > \overline{u}_D$, it always hides bad loans. If the bank disclosed bad loans, it would fail. By hiding bad loans, it profits in period-1. If the collateral value later appreciates, the profits from period-2 are also positive. PP cannot eliminate hiding, but it reduces the regulator's costs and the banker's excessive income.*

In sum: we explore the effects of PP when bank owners (instead of a hired manager) select the bank's strategy. The materialized magnitude of bad loans proves to have a crucial impact on the optimal strategy. Three scenarios appear. If the bank is solvent, PP has no effect on the bank's liquidation decision, the banker's life-time income, the regulator's costs (which are zero) or the likelihood of bank failure (zero). If the bank is insolvent, it hides bad loans. PP has no effect on the likelihood of bank failure but PP does reduce both the regulator's costs and the banker's moral hazard profits. In the intermediate scenario, PP may make the bank risk free or change its optimal strategy from hiding to disclosure. With certainty, PP reduces the regulator's costs and the banker's moral hazard profits.

With symmetric information, a solvent bank discloses less bad loans than an insolvent one (Lemma 1). Under asymmetric information the scenario is more complex. When the collateral value is fixed, Corollary 1 indicates that a solvent bank discloses more bad loans than an insolvent one. This contradicts Lemma 1. When the collateral value is stochastic, we get the following result:

Corollary 5. *The larger the magnitude of bad loans, the more willing the bank is to hide them, when the future value of bad loans is stochastic.*

Proof. Section 5 includes three bank types in the following order of financial condition: a solvent bank with $u \le u_D$, a solvent one with $u > u_D$ and an insolvent bank with $u > u_D$. Without PP, the first bank rolls over loans if $\delta E(L) > L$, the second bank rolls over them if $\delta E(L) - L + (1-h)\delta\left[-\underline{L} \;\; - K_1(1+r)/u + (1+r)\right] \;\; > 0$ (the term in the brackets is positive and increases with u) and the third bank always rolls over bad loans. With PP, the first bank rolls over loans if $\delta E(L) > L$, the second bank rolls over them if $\delta E(L) - L - \delta\pi_D^{PP}(u_p = 0)/u \; > 0$, that is, $\delta E(L) - L - \{-(1-\delta\underline{L}) + \left[K_1 + \; R_1 - (1-K_1)r - c\right]/u\} > 0$. The term in the parenthesis is negative and decreases with u. Hence, the incentives to hide increase with u. The third bank always rolls over bad loans. *Q.E.D*

Intuitively, the larger the burden of bad loans, the lower the true level of bank capital. The lower the true level of capital, the more profitable it is to take excessive risk by gambling with collateral. If $\delta E(L) > L$, each bank in the banking sector rolls over bad loans. The official amount of loan losses is zero. In contrast, $\delta E(L) < L$, a few banks disclose bad loans while the others make no loan losses public. The latter group consists of the worst banks.

Corollary 2 states that when collateral is non-stochastic, the hiding problem can be eliminated by raising the capital requirement, K_1. From (5.1) it is easy to observe that the same instrument can be utilized now with stochastic collateral. When $K_1 = \overline{u}(1-\delta\underline{L})$, the limited liability option ceases to exist and the bank pursues the socially optimal liquidation strategy. With PP, an equal level of bank capital can be solved from (5.8), $K_1 = -\delta(R_1 - r - c) + \overline{u}\delta(1-\delta\underline{L})$, that is, $K_1 = \overline{u}(1-\delta\underline{L}) \; - \; \delta(R_1 - r - c) \; - \; \overline{u}(1-\delta)(1-\delta\underline{L})$. Hence, PP reduces the need for bank capital.

6. Personal utility moral hazard

So far the banker owns the bank for maximizing his dividend income. Assume an alternative ownership structure. The bank has numerous owners, who employ a risk-neutral manager to run it. She is the only one to learn the realized values of u and $E(L)$. She does not own bank stocks and runs it according her personal preferences. The bank pays wage w to her after period-1 if the bank is officially solvent so that it can keep on operating in period-2. If the bank is insolvent after period-2, she suffers a negative stigma, $-\beta$. The manager can earn w only in period-1 (if the bank is officially solvent) and she can suffer the negative stigma in period-2. This simplified wage system can capture the key characteristics of realistic job markets. The manager aims to avoid insolvency in order to earn wage income and avoid the stigma of being incompetence. Above, the bank bears an administrative cost c in period-1. In the following, c consists of w. Two scenarios appear depending on the type of collateral.

6.1 Non-stochastic collateral

We investigate the manager's optimal strategy with and without PP.

6.1.2 Without PP

Again three cases occur, depending on the magnitude of bad loans. It is illuminating to compare the manager's and owners' optimal strategies.

First, the magnitude of bad loans, u, is so small that the bank is solvent in both periods. The manager earns w in period-1 and avoids $-\beta$ in period-2 with any level of disclosed bad loans and is thus indifferent between the strategies. The owners favor the disclosure strategy (Proposition 3).

Second, u is so large that the bank is truly insolvent. Without hiding, the regulator closes it, the manager earns nothing and suffers $-\beta$ in period-2. By sufficiently hiding bad loans she can keep the bank officially solvent in period-1, earn w and face $-\beta$ after period-2 when the bad loans surface. Let $\bar{u}_1$ again denote the maximal magnitude of disclosed bad loans so that the bank is officially solvent in period-1. The manager chooses the magnitude of disclosed bad loans, u_p, so that $u_p \in [0, \bar{u}_1]$. She is indifferent between these values. The owners will hide bad loans in all (Proposition 2).

Finally, u is at the intermediate level. The bank is solvent if it discloses bad loans in period-1, but insolvent if they surface in period-2. Proposition 4 states that the following strategy maximizes the owners' income: disclosure if $K_1 > u(1-L)$ and hiding if $K_1 < u(1-L)$. This strategy does not maximize the manager's utility, because she bears $-\beta$ in period-2 when the bank fails. She optimally discloses at least $u_p = u - \bar{u}_2$ bad loans in period-1 so that $\bar{u}_2$ ones surface in period-2. Here $\bar{u}_2(u_p)$ denotes the maximal magnitude of the surfacing bad loans so that the bank is solvent in period-2. Hence, the bank is solvent in both periods, the manager earns w in period-1 and avoids $-\beta$ in period-2.

The manager's and the owners' attitudes differ slightly. If the bank is solvent (insolvent) it is ready to disclose (hide) bad loans in total. In the intermediate case, the manager will sometimes pursue a safer strategy (disclosure) than the owners (hiding), since she benefits only if the bank is solvent. And then her benefit is fixed.

6.1.2 With PP

How does PP influence the manager's decisions? We go over the same three scenarios as above. First, when u is so small that a bank is solvent in both periods, the manager is indifferent between the strategies. The owners prefer disclosure (Lemma 3, Corollary 3). In the intermediate case, the bank is risk-free and the manager is indifferent between the strategies, whereas the owners will disclose bad loans (Lemma 3, Corollary 3).

Finally, the bank is insolvent. With PP, the owners, knowing that they cannot obtain income from the bank in either period, are indifferent between the strategies and are ready to disclose bad loans (Corollary 4). Yet, the manager favors hiding in order to earn w. PP cancels dividend payouts in period-1 but does not prevent wage payments. Hence, the manager favors the hiding strategy even if the owners are ready to disclose the insolvency. She chooses u_p so that $u_p \in \left[0, \bar{u}_1\right]$. Again, $\bar{u}_1$ denotes the maximum magnitude of disclosed bad loans so that the bank is officially solvent in period-1.

The owners' and manager's strategies are almost identical. If the bank is solvent (insolvent) both of them are ready to disclose (hide) bad loans. In the intermediate case, they accept the disclosure strategy. A conclusion follows.

Propostion 9. *Without PP, the manager and the owners have oppositional optimal strategies only in the intermediate case: the manager will pursue a safer strategy than the owners by* *disclosing sufficiently bad loans in period-1. With PP, the manager's and owners' optimal strategies are never contradictory. PP has a minimal effect on the manager's preferences: in the intermediate case, the magnitude of the disclosed loans, u_p, satisfies $u_p \in [u - \bar{u}_2, u]$ without PP and it is satisfies $u_p \in [0, u]$, $\bar{u}_2 < u$, with PP.*

It is impossible to know the impact of PP exactly. It is possible that in the intermediate scenario, the bank discloses bad loans with or without PP. In that case, PP is insignificant. Whatever the case in the intermediate scenario, the magnitude of hidden loan losses is always so small that the bank does not fail in period-2. Thus, PP has no impact on the probability of bank failures. Neither does it motivate the manager to disclose the insolvency. Yet, it reduces the regulator's costs and the owners' excessive profits when the bank is insolvent.

6.2 Stochastic collateral

6.2.1 Without PP

Three scenarios appear depending on the magnitude of bad loans.

When u is so small that the bank is solvent in both periods, the manager earns w in period-1 and avoids $-\beta$ in period-2 with any magnitude of disclosed bad loans. She is indifferent between the strategies. The owners prefer the disclosure strategy if $L > \delta E(L)$.

Next, the bank is insolvent. The manager earns w only by sufficiently hiding bad loans. Thus, she also gambles with collateral. If it appreciates, the bank becomes solvent again and the manager avoids $-\beta$ in period-2. She will disclose so few bad loans that the bank is officially solvent in period-1, $u_p \in \left[0, \bar{u}_1\right]$. The bank is solvent in period-2 with certainty when the collateral value appreciates. The owners will hide the bad loans in total (Proposition 8).

Finally, suppose that u is at the intermediate level. The bank is solvent if it discloses bad loans in period-1, but insolvent if it rolls over them and their value depreciates. Under some parameter values, the owners roll over bad loans to gamble with collateral. Yet, the manager averts the gamble. By disclosing bad loans she earns w in period-1 and avoids $-\beta$ in period-2. By rolling over sufficiently bad loans, she makes the bank risk-prone in period-2. Obviously, this is not her optimal policy. Recall that $\bar{u}_D$ marks the maximum magnitude of surfacing bad loans in period-2 so that the bank is solvent, even if the collateral value depreciates. The manager hides at most $\overline{u}_D$ bad loans in period-1 and thus she is indifferent with each $u_p \in \left[u - \overline{u}_D, u\right]$.

When the bank is solvent, both the manager and owners agree that the bank discloses loan losses only if $L \geq \delta E(L)$. If the bank is insolvent, they accept the hiding strategy. Only in the intermediate scenario could they favour oppositional preferences. From the owners' point of view the manager's strategy is too cautious.

6.2.2 With PP

If u is so small that the bank is always solvent, the manager is indifferent between the strategies. Owners will disclose bad loans if $L > \delta E(L)$. PP has no effect on the manager's choice.

When u is so large that the bank is truly insolvent, the manager will hide at least so many bad loans that the bank is officially solvent in period-1, $\overline{u}_1$. Then, the bank is solvent in period-2 if the collateral value appreciates. The manager is indifferent with respect to larger magnitudes of hidden bad loans. The owners will hide bad loans in all (Proposition 8). PP has no effect on the manager's optimal choice.

Suppose that u is at the intermediate level. PP adds to bank capital. The addition may make the bank risk-free. Then, the manager is indifferent between the strategies. When the addition is insufficient to make the bank risk-free, she rolls over at most $\overline{u}_{DD}$ bad loans in period-1 so that the bank is solvent in period-2 even in depression. She is indifferent as regards to the magnitude of disclosed bad loans, u_p, when $u_p \in \left[u - \overline{u}_{DD}, u\right]$. Note that $\overline{u}_{DD} > \overline{u}_D$. The manager's and owners' optimal strategies may differ. The owners may wish to gamble with collateral (Proposition 6) but the manager will not.

Again, when the bank is solvent or insolvent the manager and the owners are ready to choose the same strategy. Only in the intermediate scenario could they favour opposite preferences. From the owners' point of view, the manager's strategy is too cautious.

Proposition 10. *The manager and owners favor opposite strategies only in the intermediate case: the manager will pursue a safer strategy than the owners by disclosing bad loans sufficiently in period-1 so that the bank is solvent in period-2 with certainty. The owners may wish to gamble with collateral. PP has a minimal effect on the manager's preferences: in the intermediate case, the* *magnitude of rolled over loans,* u_p*, satisfies* $u_p \in [u - \bar{u}_D, u]$ *without PP and it satisfies* $u_p \in [u - \bar{u}_{DD}, u]$, $\bar{u}_D < \bar{u}_{DD}$*, with PP.*

Intuitively, the manager's income is fixed when the bank is solvent, and her penalty is fixed when the bank is insolvent. Thus, she attempts foremost to keep the bank solvent. She will not take any risks if the bank is solvent in period-1. She will take risks only if the bank is insolvent in period-1 in order to gamble for resurrection. The owners' preferences are different, because their income is not fixed and they enjoy limited liability.

Whether or not collateral is stochastic, it is unlikely PP alters the manager's strategy. PP adds capital and so the bank can hide more bad loans in the intermediate scenario without making the bank risk-prone in period-2. Yet, the manager has no reason to hide any bad loans in the intermediate scenario. We know for certain that PP has no impact on the probability of bank failures. However, PP decreases the regulator's costs and the owners' moral hazard profits.

When bankers own and operate banks, solvent banks disclose more bad loans than insolvent ones whether collateral is non-stochastic (Corollary 1) or stochastic (Corollary 5). In this section the results are quite similar even when hired managers run banks. Solvent and intermediate banks are ready to disclose loan losses but insolvent banks hide at least a part of them.

Now, the manager does not maximize the owners' income. They should design a better contract, which insures the manager against the stigma. The manager could, for example, receive a golden handshake β if the bank fails. The wage, w, could be replaced with a compensation packet, consisting of bank stocks. Thereafter, the manager's and owners' preferences and optimal strategies are identical. Shleifer & Vishny (1996, p. 744) note that this type of problem is common:

> "When contracts are incomplete and managers possess more expertise than shareholders, managers typically end up with the residual rights of control, giving them enormous latitude for self-interested behavior. In some cases, this results in managers taking highly inefficient actions, which cost investors far more than the personal benefits to the managers."

Hence, it is important to study the optimal strategy of a hired manager. Furthermore, in the models on this topic, a manager often maximizes her personal utility (see Aghion et al., 1999).

From the regulator's point of view, the manager prefers a safer strategy than the bank owners. Yet, she does not adhere to the socially optimal liquidation rule. Further, when a bank is insolvent, she hides loan losses. Hence, her strategy is not socially optimal.

7. Limits on compensation to managers

Let us now turn to the second instrument of Prompt Corrective Action: *limits on compensation to managers (LOC).* Here we detail LOC as follows. The regulator can deny wage payment in period-1. The bank must pay the agreed wage to the regulator, who retains it for a period. If the bank is solvent after period-2, the manager receives $(1+r)w$. If it is insolvent, she receives no income and bears the stigma. How does LOC affect the manager's choices? Since it is realistic to assume that the regulator applies PP at the same time, we focus on this alternative.

Non-stochastic collateral: When the share of bad loans is small or at the intermediate level, the bank is always solvent and the manager is indifferent between the strategies. LOC is insignificant. It merely postpones the wage income. Suppose that the share of bad loans is so high that the bank is insolvent. Without LOC the manager sufficiently hides loan losses in period-1 to earn a wage income but she cannot avoid $-\beta$ in period-2. With LOC the manager knows that both strategies yield the same utility: no wage income and $-\beta$ after period-2. Hence, she is indifferent between the strategies and ready to disclose loan losses. Now LOC changes the optimal strategy.

Stochastic collateral: When the share of bad loans is small, the bank is risk-free, the manager is indifferent between the strategies and LOC is insignificant. It merely postpones the wage income. When the share of bad loans is at the intermediate level, the manager chooses the risk-free strategy without LOC, earns a wage in period-1 and avoids the stigma in period-2. LOC only postpones the wage income. Finally, suppose that the bank is insolvent. Without LOC the manager hides bad loans sufficiently so that the bank is officially solvent in period-1, the manager earns a wage income and gambles for resurrection in period-2. LOC does not change this strategy. Yet, the manager receives income only if the collateral value appreciates in period-2.

Proposition 11. *When a hired manager runs the bank, the limits on compensation to managers -method generates only one change in the manager's optimal strategy. It takes place with non-stochastic collateral when the bank is insolvent. The method makes the hiding strategy unprofitable so that the manager is indifferent between the strategies.*

Thus, the manager is ready to disclose the insolvency. The effect of LOC is small because the manager aims to keep the bank solvent even without it. We can draw the following conclusions.

Corollary 6. *Consider non-stochastic collateral. Both manager's and owners' non-disclosure incentives can be eliminating by using simultaneously two instruments: limits on compensation to managers and prohibition of dividends.*

With these instruments both owners and managers are indifferent whether or not to disclose loan losses. They cannot obtain any income from the bank in period-1 because of the instruments. And in period-2 the insolvency becomes public eliminating income accruing to them. To make the disclosure strategy strongly profitable to these parties, the regulator might wish to pay a tiny reward for voluntary insolvency disclosure. The regulator benefits if the reward is lower than the expected cost caused by the delay in the liquidation process.

In the following, we investigate a scenario, in which a banker owns and runs the bank. The analysis on hired managers provided some interesting results. Yet, the manager is mostly indifferent between the strategies and thus the analysis is not very fruitful.

8. Early closure method (ECM)

Up to now the regulator closes the bank after period-1 only when the capital level is negative. An interesting novelty of the Prompt corrective action policy is *early closure method* (ECM): the regulator can close a bank with a low capital level (2%). It is illuminating to investigate the effects of ECM in the model. ECM determines the lower limit for bank capital for period-2, $\underline{K}_2$. The regulator closes a bank after period-1 when the capital level is lower than $\underline{K}_2$, $K_1 \geq \underline{K}_2 > 0$.

In this model a bank cannot pay out initial equity capital. It can pay out only profits. Thus, $\underline{K}_2$ can be binding only if the official return is negative or zero, $\pi_1 \leq 0$. Suppose $\pi_1 \leq 0$. In detail, $\underline{K}_2$ is binding only if $\underline{K}_2 > K_1 + \pi_1(u_p^*)$ where u_p^* represents the optimal magnitude of disclosed loan losses without ECM. As observed above, with asymmetric information the worst banks hide bad loans and the best ones disclose them. Hence, ECM is insignificant for the worst banks which officially have no bad loans, $u_p^* = 0$. To determine if ECM has any impact, we need to focus on the credible good banks which would disclose bad loans even without it. Suppose that a good bank is very good so that $\underline{K}_2 < K_1 + \pi_1(u_p = u)$. Whatever the share of disclosed bad loans, $\underline{K}_2$ is not binding. It is binding only if a good bank possesses more bad loans. Consider this type of a bank with $\underline{K}_2 > K_1 + \pi_1(u_p^*)$. ECM prompts it to roll over a few unsuccessful loans so that it meets the capital requirement, $\underline{K}_2 = K_1 + \pi_1(u_p^{**})$, where u_p^{**} marks the magnitude of disclosed bad loans with ECM. Hence, ECM forces the bank to hide more loan losses than it wishes to do, $u_p^{*} > u_p^{**}$.

If a banker owns and runs a bank, the effect of ECM is negative. From the social point of view, the banker rolls over bad loans too frequently even without ECM. With non-stochastic collateral, ECM worsens the problem by postponing the disclosure of bad loans and thereby increasing their related costs. The increased costs may result in the bank changing the optimal strategy from disclosure to hiding or making it insolvent in period-2. With stochastic collateral, forced loan rollovers increase expected costs or change the optimal strategy from disclosure to hiding. Excessive rollovers drive the bank to gamble with collateral, thereby making it risk-prone.[14]

9. Revelation principle: Asset insurance motivates to disclosure loan losses

Due to disadvantages resulting from hidden bad loans (e.g. Caballero et al., 2008; Hoshi & Kashyap, 2010; Borio et al. 2010), it is important to clean them from banks' balance sheets. Above we explored four instruments. A bank discloses bad loans in the socially optimal way if its capital ratio is sufficient. Sometimes the prohibition of dividends or limits on compensation to managers generate the same outcome. In contrast, early closure policy worsens the hiding problem. Next we introduce a novel instrument.[15]

Panetta et al. (2009) and Borio et al. (2010) review recent asset insurance schemes, in which the regulator bears a share of the losses on a bank assets portfolio after the first loss – deductible - is absorbed by the bank. That is, asset insurance sets an upper limit to the bank regarding its costs from bad loans. Let D label the deductible. Since a bad loan causes a loss $1-L$, the bank must absorb losses from the first $\overline{U} = D/(1-L)$ bad loans. The insurance contract also incorporates an insurance premium. Next, we assume that the banker has paid the premium at the start of period-1 and thus it does not appear in the formulas. The bank can use asset insurance in either period. If the magnitude of bad loans, u, is smaller than $\overline{U}$, the regulator has no need to

[14] For brevity, we have omitted proofs, which are rather self evident.

[15] Obviously, equity capital eliminates risk- shifting incentives (Jensen & Meckling, 1976) . Unfortunately, banks commonly refuse from public equity assistance (Hoshi & Kashyap , 2010). As to a standard stock issue, asymmetric information makes it difficult (Myers & Majluf, 1984). Moreover, in reality recapitalized banks often keep on hiding bad loans (Hoshi & Kashyap, 2010). Thus, we suggest that asset insurance might offer a useful solution.

indemnify anything. The bank alone bears the costs of the bad loans. Suppose next $u \geq \overline{U}$. If the bank utilizes the asset insurance, it discloses bad loans (or a part of them) to the regulator. They are liquidated at once. The bank bears losses from the first $\overline{U}$ bad loans. Thereafter, the regulator pays full indemnity, 1, for each liquidated bad loan to the bank. The bank's costs from the bad loans total $\overline{U}(1-L)$. Even if the magnitude of bad loans exceeds $\overline{U}$, the bank may decide to hide them instead of utilizing the asset insurance.

Since the prohibition of dividends and limits on compensation to managers together eliminate non-disclosure incentives with non-stochastic collateral, it is possible to concentrate on stochastic collateral. As above, we attempt to find a solution in which a bank pursues the socially optimal liquidation rule. To begin, suppose that the magnitude of bad loans is at the intermediate level and the bank operates without PP. Corollary 5 shows that the banker pursues the socially optimal roll-over rule if the term in the brackets is zero

$$-\underline{L} \ \ - K_1(1+r)/u + (1+r) = 0. \tag{9.1}$$

The regulator sets $\overline{U}$ so that (9.1) is zero: $-\underline{L} - K_1(1+r)/\overline{U} + (1+r) = 0$. This implies $\overline{U} = K_1 \ /(1-\delta \underline{L})$. At the end of period-1 the bank decides whether or not to use asset insurance.

Suppose that the bank uses asset insurance in period-2. It hides bad loans in period-1 by rolling over them. If the collateral value later appreciates, the bank does not need asset insurance. Suppose that it depreciates. E.g. (5.1) indicates the returns during depression without asset insurance. With asset insurance, (5.1) can be restated as

$$\overline{U}\left[\,\underline{L} \ - \ (1+r)\,\right] + K_1(1+r) \ . \tag{9.2}$$

Substituting $\overline{U} = K_1 \ /(1-\delta \underline{L})$ into (9.2) gives 0. With asset insurance the returns during depression are zero. This is no surprise. The bank pursues the socially optimal roll-over over policy only if it does not benefit from limited liability. Therefore, the deductible is such that the bank never fails.

Consider period-1. The returns from the disclosure strategy with deductible can be solved from (5.5) as

$$R_1 - \overline{U}(1-L) - (1-K_1)r - c + K_1. \tag{9.3}$$

The asset insurance does not alter the returns from the hiding strategy (5.6), $R_1-(1-K_1)r-c+h\delta\pi_A$. Comparing this to (9.3) shows that the disclosure strategy is more profitable than the hiding strategy if $(1-h)K_1-\overline{U}(1-L)\geq 0$. Inserting $\overline{U}=K_1/(1-\delta\underline{L})$ to this implies that the bank discloses bad loans if $-\delta E(L)+L\geq 0$. The bank pursues the socially optimal liquidation rule in the intermediate scenario.

Consider the second scenario in period-1. The magnitude of bad loans is so small that the bank is solvent with certainty. This means that $\pi_D(u_p=0)\geq 0$ in (5.1) or $(1+r)\left[u(\delta\,\underline{L}-1)+K_1\right]\geq 0$. Thus, the maximal magnitude of bad loans meets $u(\delta\,\underline{L}-1)+K_1=0$. Hence, u is at most equal to $\overline{U}$. The deductible is so large that the bank, which is solvent in both periods with certainty, obtains no indemnity from asset insurance. Given Proposition 5, a solvent bank pursues the socially optimal liquidation rule.

Finally, consider the third scenario in period-1: an insolvent bank. Now (9.3) displays the returns with asset insurance. If the bank hides bad loans, its expected returns are $R_1-(1-K_1)r-c+h\delta\pi_A$. The scenario is identical to the intermediate case. Owing to asset insurance the fact that an insolvent bank has more bad loans than an intermediate bank is insignificant. Hence, asset insurance with $\overline{U}=K_1/(1-\delta\underline{L})$ ensures that an insolvent bank pursues the socially optimal liquidation rule.

In sum, with $\overline{U}=K_1/(1-\delta\underline{L})$ asset insurance guarantees that each bank type (solvent, intermediate, insolvent) pursues the socially optimal liquidation rule. When a bank uses asset insurance in period-1, it is risk free. When it does not use asset insurance, it hides bad loans. If their value appreciates during period-2, the bank is profitable. If it depreciates, the bank needs asset insurance in period-2 and earns zero returns. Regardless of whether the bank uses asset insurance in period-1 or in period-2, it is risk-free. A conclusion follows.

Proposition 12. *Consider stochastic collateral without PP. Asset insurance and deductible* $D=\overline{U}(1-L)$, where $\overline{U}=K_1/(1-\delta\underline{L})$ *make the bank risk-free. It pursues the socially optimal liquidation rule.*

Suppose that the regulator prohibits dividends. Consider the second part of Corollary 5. The bank follows the optimal liquidation rule if the term in the parenthesis is zero, $(1-\delta\underline{L})+\left[K_1+\ R_1-(1-K_1)r-c\right]/u=0$, when $u=\overline{U}$. This implies

$$\overline{U} = K_1 \ / (1-\delta \underline{L}) \ + \ \left[R_1 - (1-K_1)r \ - c \ \right] / (1-\delta \underline{L}) \,. \tag{9.4}$$

Recall that without PP, $\overline{U} = K_1 \ / (1-\delta \underline{L})$. PP strengthens asset insurance so that the hiding strategy becomes unprofitable with smaller insurance coverage. Using (5.9) and (5.10) it is possible to check that the bank pursues the socially optimal liquidation rule. It is also easy to check that the bank never pursues a strategy in which it discloses a few bad loans.

Proposition 13. *Consider stochastic collateral with PP. Asset insurance and deductible* $D = \overline{U}(1-L)$, in which $\overline{U} = K_1 \ / (1-\delta \underline{L}) \ + \ \left[R_1 - (1-K_1)r \ - c \ \right] / (1-\delta \underline{L})$ *make the bank risk-free ensuring that it pursues the socially optimal liquidation rule. PP reduces insurance coverage.*

Asset insurance makes the bank risk free. This implies two results. First, the pricing problem of deposit insurance disappears. Second, suppose that a hired manager, instead of a bank owner, runs the bank and makes the disclosure decisions. Since asset insurance makes the bank risk free, the manager has no reason to hide bad loans.

Note that the size of the deductible depends on bank capital. Hence, the regulator can offer different deductible/capital ratio combinations to banks. A bank has an option of either a large deductible together a high capital requirement or a combination consisting of a small deductible and a low capital ratio.

10. Conclusions

Krahnen (1999, p. 77) note that "...theoretical literature on financial intermediation and regulation, on the other hand, is surprisingly silent on the bank management's incentives *after* distress has occurred." His conclusions are confirmed by Aghion et al. (1999, p.51): "...few rules have been devised to deal with bank failures when they occur." This paper aims to fill these gaps in the literature by exploring a distressed bank and analyzing the incentives of its owners and management's. Thereafter, the paper concentrates on three instruments of Prompt Corrective Action - prohibition of dividends, limits on compensation to managers and early closure policy - to examine how they mitigate moral hazard and assist bank restructuring. To support these goals, the paper also investigates the impacts of capital ratio and asset insurance.

With regard to the owners' and managers' incentives, the predictions of the model are consistent with earlier reported evidence on hidden loan losses. This is encouraging. With respect to regulatory instruments, prohibition of dividends reduces in each scenario regulator's costs and banker's moral hazard profits. In few scenarios it changes the optimal strategy from hiding to disclosure or even makes the bank risk free. The prohibition policy is most effective if the collateral value is non-stochastic and bank owners, instead of a hired manager, run the bank. Unfortunately, with stochastic collateral the most insolvent banks always select the hiding strategy.

The limits-on-compensation-to-managers instrument is effective only if collateral is non-stochastic, the bank is insolvent and the hired manager makes the decisions. Then, this instrument makes the hiding strategy unprofitable to the manager, encouraging disclosure of the insolvency. With non-stochastic collateral, two instruments – limits-on-compensation-to-managers and the prohibition of dividends – in conjunction make the hiding strategy unprofitable to both bank owners and the manager. Therefore, they are ready to disclose the insolvency to regulators. The non-disclosure problem can thus be eliminated when collateral value is non-stochastic.

With asymmetric information, early closure policy is powerless. It compels the banks to hide more loan losses. In contrast, equity capital motivates the disclosure of loan losses. Unfortunately, the incentive compatible capital ratio may be high even if the prohibition of dividends policy reduces it.

Consequently, with non-stochastic collateral the problem of hidden loan losses can be eliminated by prohibiting dividends and limiting compensation to managers. With stochastic collateral, resolving the hiding problem is more demanding. The prohibition of dividends mitigates, but does not eliminate, the problem and thus regulators need to introduce complementary instruments. Asset insurance for the bank's loan portfolio may prove to be useful.

Most of all, the paper demonstrates how easily a bank can hide its true financial condition. It is difficult to develop instruments that can motivate banks to disclose loan losses truthfully. This highlights the importance of instrument (vi) in the Prompt Corrective Action policy: frequent regulatory supervision. This instrument also improves the effectiveness of the early closure policy. First, the regulator audits banks and reveals bad loans. Thereafter, he closes weakly capitalized banks.

We wish to point out some limitations of our modeling that deserve particular attention. First, the paper ignores the signaling role of dividends. Thus, the findings on the prohibition of dividends may be a bit too optimistic. Second, we assume that the regulator is ready to close insolvent banks. In reality, he may prefer to keep them open. Third, we rule out ex ante moral hazard. Asset insurance might cause this type of problem. Fourth, we neglect different forms of capital injections and asset management companies, which are commonly used in bank bailouts. These subjects can also be investigated in this model framework.

Appendix A: Proof of Proposition 1

The return from period-1 drops in u_p. The return from period-2 decreases with u and increases with u_p. Let $\bar{u}_1$ be the maximum of disclosed bad loans in period-1 so that a bank is then solvent

$$R_1 - (1-K_1)r - K_1 + \bar{u}_1(1-L) - c = 0, \tag{A.1}$$

and $\bar{u}_p$ is the minimum of disclosed bad loans so that the bank is solvent in period-2

$$-(u - \bar{u}_p)(1-\delta L) + K_2 = 0. \tag{A.2}$$

Case i. Now $u > \bar{u}_1$. We must have $u_p \le \bar{u}_1$. Two scenarios appear. In scenario A, u_p is so small that the bank profits in period-1, $R_1 - (1-K_1)r - u_p(1-L) - c > 0$. This sets $K_2 = K_1$. From insolvency, $R_1 - (1-K_1)r + K_1 + u(1-L) - c < 0$, and $R_1 - (1-K_1)r - u_p(1-L) - c > 0$ we observe that in period-1 $(u - u_p)(1-L) > K_1$, that is, $u - K_1/(1-L) > u_p$. From (A.2) we observe (when $K_2 = K_1$) that the bank is solvent in period-2 if

$$u_p \ge u - K_1/(1-\delta L). \tag{A.3}$$

This is impossible because in period-1 we have $u - K_1/(1-L) > u_p$. In scenario B, u_p is so big that the bank is unprofitable in period-1, $R_1 - (1-K_1)r - u_p(1-L) - c < 0$. Hence, we have $K_2 = K_1 + \pi_1$. From insolvency, $R_1 - (1-K_1)r + K_1 - u(1-L) - c < 0$ and $R_1 - (1-K_1)r + K_1 - u_p(1-L) - c = K_2$ we obtain that in period-1 $(u - u_p)(1-L) > K_2$, or $u - K_2/(1-L) > u_p$. Now (A.2) implies that in period-2 we have

$$u_p \ge u - K_2/(1-\delta L). \tag{A.4}$$

Yet, in period-1 we have $u - K_2/(1-L) > u_p$, which is impossible given (A.4).

Case ii. Now we have $-u\,(1-\delta L)\;+K_1\;<0$ in period-2 ($K_1=K_2$, since no bad loans appear in period-1). It is sufficient to give one example. Let u be such that $-u\,(1-\delta L)\;+K_1\;=-\varepsilon$, which gives $u\;=K_1/(1-\delta L)\;+\varepsilon/(1-\delta L)$. Inserting this to the returns of period-1 (when $u_p=u$), $R_1-(1-K_1)r+K_1\;-u\,(1-L)-c$, provides

$$R_1-(1-K_1)r+\frac{K_1}{1-\delta L}L(1-\delta)\;-\;\frac{1-L}{1-\delta L}\varepsilon\;-c\,. \tag{A.5}$$

This is positive if ε is small enough. Case ii. is possible.

Case iii. Now we have $-u\,(1-\delta L)\;+K_1\;>0$ in period-2 ($K_1=K_2$, since no bad loans appear in period-1). If the bank discloses u_p, $0<u_p\le u$ bad loans in period-1, the value of the bank after period-1 is $R_1-(1-K_1)r+K_1\;-\;u_p\,(1-L)-c$. If $u_p=u$, the bank value can be restated as

$$\left[R_1-(1-K_1)r\;\;-c\right]+\left[K_1\;-\;u(1-\delta L)\right]\;+\;\;uL(1-\delta)\;\;. \tag{A.6}$$

The terms in the brackets are positive and thus (A.6) is positive; the bank value is positive in period-1 if bad loans become then public.

Let us now turn to cases $0<u_p<u$. We know from (A.6) that if the bank discloses bad loans in total, its value is positive in both periods. Each unit of hidden bad loans increases the returns by $1-L$ units in period-1 and decreases them by $1+r-L$ units in period-2. Obviously, the return in period-1 is positive with each $0\le u_p\le u$. In period-2, the bank return is minimized when $u_p=0$. Yet, even then the return of period-2 is positive because $-u\,(1-\delta L)\;+K_1\;>0$. Q.E.D

Appendix B: The proof of Lemma 2

Suppose $\pi_1\,(u_p=u)<0$. Since π_1 is negative, the banker earns no income in period-1, and π_1 erodes bank capital, $K_2=K_1+\pi_1\,(u_p=u)<K_1$. Since $u_p=u$ and $R_2=r$, $\delta\pi_2$ simplifies to K_2 or $K_1+\pi_1\,(u_p=u)$.

Suppose $\pi_1\,(u_p=u)>0$. The bank pays this as dividends to the banker. Since π_1 is positive, there is no erosion in bank capital, $K_2=K_1$. Since $u_p=u$ and $R_2=r$, $\delta\pi_2$ simplifies to

$K_2(=K_1)$. In period-1 the banker receives π_1 and the NPV of his expected return from period-2 is K_1 , $K_1+\pi_1(u_p=u)$ in total.

Given $\pi_1(u_p=u)=R_1-(1-K_1)r-u(1-L)-c$, the banker's life-time income is $R_1-(1-K_1)r-u(1-L)+K_1-c$ in both cases *Q.E.D*

Appendix C: Proof of Proposition 3

The bank is solvent in period-1 if it discloses bad loans then, $\pi_1(u_p=u)+K_1>0$, or, $R_1-r-u(1-L)+K_1(1+r)-c>0$. Then, it is solvent also in period-2. The bank is insolvent, if the bad loans surface in period-2, $\pi_2(u_p=0)=-u(1+r-L)+K_1(1+r)<0$. Suppose first that the bank hides so few bad loans in period-1 that it is insolvent in period-2. Then, the profit maximization problem simplifies to the maximization of (3.1) and the bank hides bad loans in total, earns $\pi_1=R_1-(1-K_1)r-c$ in period-1 and nothing in period-2. Suppose now that the bank hides so few bad loans that it is solvent in period-2. The bank maximizes its returns from both periods and optimally discloses the bad loans in period-1. The banker's life-time income is $R_1-u(1-L)-(1-K_1)r+K_1-c$ (recall Lemma 2). It is optimal to disclose bad loans if

$$R_1-u(1-L)-(1-K_1)r+K_1-c > R_1-(1-K_1)r-c, \tag{C.1}$$

which gives $K_1>u(1-L)$. *Q.E.D*

Appendix D: Proof of Lemma 3

Suppose first $\pi_1(u_p)<0$. Since π_1 is negative, there are no dividends, and π_1 erodes bank capital, which is $K_2=K_1+\pi_1$ in period-2. Suppose $\pi_1>0$. Owing to PP, the positive return is added to the bank capital for period-2, $K_2=K_1+\pi_1$. In both cases we have $K_2=K_1+\pi_1$, the banker earns nothing in period-1 and after period-2 he earns dividends

$$\pi_2=s(R_2-r)-(u-u_p)(1+r-L)+K_1(1+r)+(1+r)\left[R_1-u_p(1-L)-(1-K_1)r-c\right]. \tag{D.1}$$

The last two terms sum up to $K_2(1+r)$ when $K_2=K_1+\pi_1$. Now (D.1) increases with u_p and it peaks when $u_p=u$: the bank discloses bad loans and (D.1) simplifies to (recall $R_2=r$)

$$\pi_2 = \ (1+r)\left[R_1 - u(1-L)\ -\ (1-K_1)r\ +\ K_1 - c\,\right]. \tag{D.2}$$

The term in brackets is the condition for true solvency in period-1. The bank is truly solvent (insolvent) in period-1, it is also truly solvent (insolvent) after period-2. *Q.E.D*

Appendix E: The proof of Lemma 4

The optimal magnitude of the rolled over loans is either 0 or u. Consider first $u - u_p \le \overline{u}_D$, that is, $u_p \in \left[u - \overline{u}_D, u\right]$. The magnitude of the disclosed bad loans in period-1 is so large that the bank is solvent in period-2. Put differently, so few bad loans surface in period-2 that the bank is then solvent even in depreciation. If $L > \delta E(L)$, the bank discloses bad loans in period-1, $u_p = u$, and if $L < \delta E(L)$, it rolls over them, $u_p = u - \overline{u}_D$. Consider now $u_p \in \left[0, u - \overline{u}_D\right]$. The magnitude of the disclosed bad loans is small. Since an extra rolled over bad loan increases expected returns by $h(1-L) > 0$, it is optimal to minimize u_p by choosing $u_p = 0$. We have three equilibrium candidates $u_p = 0, u - \overline{u}_D$, or u. Yet, it is easy to see that $u_p = u - \overline{u}_D$ cannot be the equilibrium. Since $h(1-L) > 0$ it is optimal to move from $u_p = u - \overline{u}_D$ to $u_p = 0$. In sum, the marginal benefit from non-disclosure rises with the magnitude of rolled over loans from $\delta E(L) - L$ to $h(1-L)$. If it is optimal to roll over at least one loan, $\delta E(L) > L$, it is optimal to roll over the rest of loans. Q.E.D

Appendix F: Proof of Lemma 5

It is optimal to disclose bad loans if $K_1 - (1-u)L\ - \delta\, h\, \pi_1(u_p = 0)\ > 0$. This can be rewritten as

$$K_1 - u(1-L)\ - \delta\, h\left[u(1+R_2) - u(1+r) + K_1(1+r)\ \right] > 0, \tag{F.1}$$

or $(1-h)K_1 - u(1-L-h)\ - \delta\, h\ u(1+R_2)\ > 0$. This can be restated as

$$(1-h)K_1 - u(1-L-h)\ - \delta\, u\left[E(L) - (1-h)\underline{L}\,\right]\ > 0, \tag{F.2}$$

or $(1-h)K_1 - u(1-L-h)\ -\ u\left[\delta E(L) - L\right] - uL\ + \delta\, u(1-h)\underline{L} > 0$. This implies

$$(1-h)K_1 - u(1-h) - u\left[\delta E(L) - L\right] + \delta u(1-h)\underline{L} > 0, \tag{F.3}$$

or

$$-u\left[\delta E(L) - L\right] + (1-h)\delta\left[u\underline{L} + K_1(1+r) - u(1+r)\right] > 0. \tag{F.4}$$

Hence, it is optimal to roll over loans if

$$u\left[\delta E(L) - L\right] + (1-h)\delta\left[-u\underline{L} - K_1(1+r) + u(1+r)\right] > 0, \tag{F.5}$$

The term in the latter brackets is positive, because the bank fails in depression. Q.E.D

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