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Resolving banking crises — an analysis of policy options

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Abstract

This paper develops a dynamic model to examine the *ex-ante* and *ex-post* implications of five policy options for resolving bank failures when the authorities cannot observe the level of non-performing loans (NPLs) held by individual banks. Under asymmetric information, we show that the first-best outcome is achievable when the authorities can close all banks that fail to raise a minimum level of new capital. But when the authorities cannot close banks and must rely on financial incentives to induce banks to liquidate their NPLs, recapitalisation using equity (Tier 1 capital) would be the second-best policy, whereas recapitalisation using subordinated debt (Tier 2 capital) is suboptimal. If the authorities do not wish to hold an equity stake in a bank, they should subsidise the liquidation of non-performing loans rather than inject subordinated debt. We also show that the cost of this subsidy can be reduced if it is offered in a menu that includes equity injection.

JEL classification: G21, G28.

Summary

This paper develops a simple but general framework which can be used to analyse alternative policies to restructure failed banks when the authorities cannot observe banks' balance sheets. We demonstrate that without regulatory intervention, weak banks have the incentives to hold on to the non-performing loans (NPLs) and gamble for the small chance of recovering these loans ('gamble for resurrection'). But if the authorities cannot force weak banks to liquidate their NPLs because they cannot observe their balance sheets, they may have to rely on financial incentives to induce banks to liquidate their bad assets. Our paper considers the optimal design of such financial incentives, taking into account their impact both on managerial moral hazard and fiscal cost of resolution.

We first examine actual policies used in recent banking crises to clarify why certain choices have been made. Subsequently, we use a model to consider five different policy options for resolving banking failures when the authorities cannot observe the level of non-performing loans held by each bank. When faced with this asymmetric information, the first-best outcome is achievable when the authorities can close all banks that fail to raise a minimum level of new capital. But when the authorities cannot close banks and must rely instead on financial incentives to induce banks to liquidate their NPLs, equity (Tier 1 capital) injection would be the second-best policy, whereas subordinated debt (Tier 2 capital) injection is suboptimal. If the authorities do not wish to hold an equity stake in a bank, they should subsidise the liquidation of non-performing loans rather than inject subordinated debt. We also show that the cost of this subsidy can be reduced if it is offered in a menu that includes equity injection. Thus, our analysis clarifies the conditions under which each policy should be used, and provides a practical guidance to policymakers in resolving bank failures when they cannot immediately assess the problems at each bank.

1 Introduction

In the past few decades, systemic banking crises have plagued developed and developing economies alike. In some countries, it took several years to clean up the banking sector's balance sheet, in part because banks were able to hide their non-performing loans from the regulator. Such delays in restructuring the banking sector could disrupt financial intermediation and lead to a credit crunch on the non-bank private sector. Dealing with banking crises has often resulted in large fiscal outlays and, in some emerging market economies (EMEs), the bailout of the banking sector ended up seriously threatening the sustainability of the government's debt position.

Finding the most efficient resolution method is therefore a key concern for policymakers faced with a banking crisis. Policies to deal with bank failures can be split into two general types. First, there are *financial restructuring* policies that are targeted towards maintaining banks' liquidity and restoring public confidence in the banking system in the immediate aftermath of a crisis. Second, there are more medium-term *operating restructuring* policies aimed at improving balance sheets of those banks that are kept open, and ensuring closure of insolvent banks is carried out in an orderly manner. This paper focuses on the latter, and examines how operating restructuring policies can be optimally designed when banks can hide their non-performing loans (NPLs) from the authorities.

Operating restructuring should try to ensure that NPLs are liquidated with minimal disruption to the economy, while discouraging moral hazard arising from bailouts. The optimal method for achieving these objectives depends on several factors, including the systemic impact of closing a bank, the information available to the authorities, and the ability of shareholders to recapitalise their bank. Typically, the authorities must take all these factors into account when deciding whether or not to close a failing bank. And if they decide to keep the bank open, the authorities must choose between several alternative methods of providing a bailout – or 'open bank assistance' – including the injection of public capital and the purchase of non-performing loans using public funds.

This paper evaluates policy alternatives for resolving bank failures using a model of asymmetric information in which the regulator cannot observe the true states of banks' balance sheets. In our model, the bank manager, who maximises the shareholders' pay-offs, has the incentive to hide NPLs when these become large. Due to shareholder limited liability, the manager of a failing or insolvent bank has the incentive to 'gamble for resurrection' by holding on to the NPLs at the expense of the depositors, who would be better off if the NPLs were liquidated early (*ex-post* moral hazard).

Our model can be used to compare the *ex-ante* and *ex-post* welfare implications of different policy alternatives, as well as their fiscal costs. We show that when banks can hide their NPLs and thus cannot be forced to liquidate them, the authorities have to offer financial incentives to induce liquidation. But if these *ex-post* financial incentives are too generous, fiscal costs of bailout will be large and the bank manager will reduce the effort to avoid insolvency *ex ante* (*ex-ante* moral hazard). The challenge therefore lies in designing a restructuring policy to ensure that NPLs are liquidated *ex post*, while minimising both the *ex-ante* moral hazard by bank managers and the fiscal costs of bailout.

Our analysis differs from the existing literature on bank failure resolution in several ways and makes a new contribution in a number of areas. First, our analysis considers a broader set of policies in a single framework compared to the existing papers, and thus clarifies conditions under which each policy should be adopted. Specifically, we examine five policy options: closing all banks that fail to raise new capital; public capital injection using subordinated debt; public capital injection using equity; subsidy for liquidation of non-performing loans; and finally, a combination of these policies. All these are techniques that have been used, to varying degrees, in practice in recent banking crises, and our analysis yields a clear welfare ranking between these. Whereas Corbett and Mitchell (2000), Mitchell (2001) and Osano (2002) consider only scenarios in which the regulator has decided to recapitalise banks, we aim to clarify conditions under which bailouts should be considered. We also show that a policy of subsidising the liquidation of NPLs, advocated by Aghion *et al* (1999), is dominated by other policies when the bank's shareholders are able to raise additional capital relatively cheaply.

Second, we pay careful attention to how each policy affects the pay-off of the failing banks' shareholders and thus the incentives of bank managers. Previous analyses of bank recapitalisation – such as Aghion, Bolton and Fries (1999) and Corbett and Mitchell (2000) – assume that public recapitalisation of failing banks is equivalent to a subsidy. But in reality, when the government recapitalises a bank, it is acquiring a claim on the bank rather than giving a grant. We demonstrate that if modelled as an acquisition of claims on the bank, recapitalisation does not necessarily increase the pay-offs of the bank's existing claimholders. We also examine the impact of equity (Tier 1 capital) and subordinated debt (Tier 2 capital) recapitalisation separately, and show that the two methods have a different impact on the bank manager's incentives to liquidate NPLs. Our analysis therefore goes further than Osano (2002), which only considers the impact of subordinated debt recapitalisation.

A careful modelling of recapitalisation yields some interesting new insights. We show that under limited liability, managers of weak banks refuse recapitalisation even in the absence of any reputational concerns, since the injection of new equity dilutes the claims of the existing shareholders. This explanation of why banks are frequently reluctant to accept recapitalisation is different from Corbett and Mitchell (2000), who argue that banks refuse recapitalisation because acceptance would hurt their reputation and thus future profitability. We also demonstrate that recapitalisation using subordinated debt is always dominated by other policies when the authorities cannot force banks to liquidate NPLs. This result is in contrast to Hoelscher and Quintyn's (2003) view that recapitalisation using subordinated debt is acceptable when the government does not wish to have an ownership stake in banks.

Finally, our dynamic analysis helps to clarify how each of the *ex-post* restructuring policies affects bank managers' *ex-ante* incentives to exert effort to avoid insolvencies. Several existing papers, such as Corbett and Mitchell (2000), Mitchell (2001), and Osano (2002), only consider the *ex-post* issue of how to encourage failing banks to take the appropriate action. Our analysis demonstrates that ensuring NPLs are liquidated with minimal subsidy to banks is essential for both minimising the fiscal costs of bank failure resolution as well as discouraging *ex-ante* moral hazard.

The rest of the paper is organised as follows. Section 2 discusses why certain resolution techniques were used in recent banking crises. Section 3 constructs a simple model to illustrate the problems associated with forbearance, and characterises the optimal policy under perfect information. Section 4 then examines the welfare and fiscal implications of five policy options that are feasible when the authorities are unable to observe the level of non-performing loans at each bank. Finally, Section 5 discusses the policy implications of our analysis, and Section 6 concludes.

2 The resolution of recent banking crises

What resolution techniques were used in past banking crises, and why? Before we delve into our theoretical analysis, we first examine what practical policy options are available for dealing with bank failures and why the authorities have chosen certain methods.

2.1 Regulatory forbearance

When the regulator suspects that banks are financially weak, one option is to simply allow them to continue operating in the hope that their performance will improve in the future. This policy is often called regulatory forbearance. For example, forbearance might take the form of waiving existing regulatory standards or relaxing classifications on bad loans. The authorities may be tempted to use regulatory forbearance if they are concerned about the systemic impact of closing a bank or the effect of liquidating non-performing loans on the aggregate economy. Although forbearance could reduce the current costs to the economy of liquidation, it may be at the expense of increasing future risk taking by failing banks – often called 'gambling for resurrection'.

The OECD's (2002) survey of bank resolution measures adopted in 18 member countries found that eleven had used forbearance as one policy measure. Consistent with the theory, the OECD found that forbearance has often resulted in losses accumulating in the future. The US S&L crisis is a well-known example of how forbearance can increase future losses. Some form of forbearance was also used in the East Asian crisis, although it was applied with an explicit timeline to allow banks to improve capitalisation and/or provisioning standards. In Thailand, rules on loan loss provisions and loan classification were tightened only gradually, although capital adequacy requirements were set in line with international standards (8.5% for banks and 8% for non-bank finance companies). In Korea and Indonesia, strict rules were applied on provisioning but banks were given time to adjust capital ratios upwards to 8%.

2.2 Self-recapitalisation and liquidation

When faced with a banking crisis, the authorities usually try to find a market-based solution first – ie one where the central bank or government do not inject public funds into banks – since offering public support may increase moral hazard and place the government at risk of incurring losses.

The regulator may, for example, ask the bank's existing shareholders to raise more capital, and close the bank if they are unwilling or unable to invest additional capital.

But the authorities are often reluctant to close a bank that has failed to raise new capital, for two reasons. First, closure of large banks may have systemic implications. Second, selling the assets of failed banks may not be easy if the authorities face difficulties in evaluating banks' net worth. Managers of failed banks and their corporate clients often have incentives to conceal the true value of assets, especially if connected lending is involved. Poor accounting standards applied to NPLs and provisioning may also hinder accurate evaluation of asset values. Evaluation of the impaired assets and collateral may be especially difficult in the case of large complex financial institutions (LCFIs) that operate across a range of product markets and countries.

Due to these difficulties, this solution has usually been applied only to small banks or when failures are due to idiosyncratic factors, such as fraud, not thought likely to have system-wide implications (see Hoggarth, Reidhill and Sinclair (2004)). In the East Asian banking crises, for example, Thailand and South Korea liquidated only one and five commercial banks respectively. Instead, liquidations were concentrated in smaller financial firms – 56 finance companies in Thailand and 17 merchant banks and over 100 non-bank financial institutions in South Korea (see Lindgren *et al* (2000) and Table A, Appendix B).

2.3 Public capital injection

If the market-based solution is not practical, the authorities may decide to use public funds to support the banking sector. Before injecting fiscal funds, the authorities often separated banks into three broad categories: i) solvent ones requiring no government support; ii) 'viable' banks that would likely be solvent if given government support; and iii) insolvent banks – ones unlikely to survive even with capital support – that were required to exit the system, eg via closure. In theory, public capital injection should be confined to the second group of banks, but the distinction between different groups is often not clear-cut. For instance, public sector support was considered for banks with capital ratios of between 4% and -25% in Indonesia, whereas in South Korea five commercial banks with capital ratios of less than -4% were closed down. Provision of government support has often been conditional on first imposing costs on banks' shareholders and/or managers. Shareholders might be asked to first inject more of their own capital or face having their existing equity stake drawn down to zero, whereas bank managers could be removed. Government support has also sometimes been conditional on banks helping with corporate sector debt restructuring.

According to the OECD study, public capital injection has most frequently taken the form of purchasing subordinated debt (Tier 2 capital) rather than equity capital (Tier 1) in developed economies, although EMEs such as Mexico, Thailand and Turkey have also used subordinated debt to recapitalise their banks. Tier 2 capital injection has often been preferred when governments did not want to take an ownership stake in the banking system. In some cases, governments have imposed conditionality when purchasing banks' subordinated debt to ensure that they could exercise control over the recapitalised banks when their balance sheets deteriorated further. In Mexico, for instance, public funds were used to purchase banks' subordinated debt conditional on it being converted into equity after five years or sooner if in the meantime capital deteriorated beyond a particular threshold. Similarly in Turkey, the debt would also be convertible into Tier 1 capital if the bank's capital adequacy ratio fell below a certain threshold.

However, in recent banking crises governments have also taken equity stakes, for example, in Finland, Sweden, Japan, Korea, Norway, Poland and Spain among OECD countries. Also in the recent emerging-market banking crises in East Asia and Turkey, governments have injected Tier 1 capital (see Table A, Appendix B). In some cases, governments have assumed temporary ownership of large failed banks to restructure their balance sheets before on-selling to the private sector (so-called 'bridge' banks). To prevent banks remaining in the public sector for many years, rules in several countries have set a limit on how long institutions can stay in public hands.(1)

Tier 1 capital is more advantageous for bank liquidity compared to Tier 2 capital since dividend payments can be delayed until a bank's capital and income are restored. In addition, we demonstrate in the next section that unlike subordinated debt purchases, equity injection is likely to strengthen the incentive of weak banks to liquidate their non-performing loans.

(1) In the United States, the FDIC Federal Deposit Insurance Act specifies that bridge banks have to be dissolved after two years. (In exceptional circumstances they can be continued up until a further three-year period.) This technique was used to resolve a number of failed banks in Texas and New England in the early 1990s. Similar techniques were also used by the Swedish and Finnish authorities in the Nordic banking crises of the early 1990s.

2.4 Purchasing non-performing loans/subsidising NPL liquidation

The authorities could also help improve the quality mix of a bank's assets by purchasing its non-performing loans (NPLs) in exchange for government bonds. This method has been used in a number of countries, for example, in Mexico in the mid-1990s and more recently in the Indonesian and South Korean banking crises (Table A, Appendix B). This not only improves the quality mix of banks' assets but also their income given that government bonds earn interest.(2) Importantly, once purchased, governments have used various vehicles, such as asset management companies, to improve NPLs (and more generally corporate sector balance sheets) before selling them on to other banks. But we show in the next section that this method is potentially expensive for the government and could exacerbate moral hazard by bank managers.

3 Model

How should the policymakers choose between these alternatives? To address this question, we construct a simple model to analyse the welfare implications of different policies. In dealing with a failing bank, the authorities may not be able to observe the underlying value of individual bank balance sheets unless they first intervene and close the bank (pre-intervention information asymmetry). Worse still, they may not be able to easily ascertain the value of a bank's assets even after intervening (post-intervention information asymmetry). Hence, our analysis pays careful attention to the nature of information asymmetry between the managers of the failing banks and the authorities, and shows that the appropriate policy depends on the nature of this information asymmetry.

3.1 Set-up of the model

Consider a three-date model ($t = 0, 1, 2$) with $i = 1...N$ *ex-ante* identical banks. Each bank is controlled by a manager who maximises the shareholders' expected pay-off. Thus, we abstract from the possibility of a principal-agent problem between the shareholders and the manager. But due to shareholder limited liability, the manager does not care about losses suffered by the depositors when the bank becomes insolvent, so that her choice of action may deviate from the social optimum. We assume that deposits are fully insured by the government, so that depositors

(2) But interests on recapitalisation bonds have sometimes been set below market rates to ensure that banks share some of the costs.

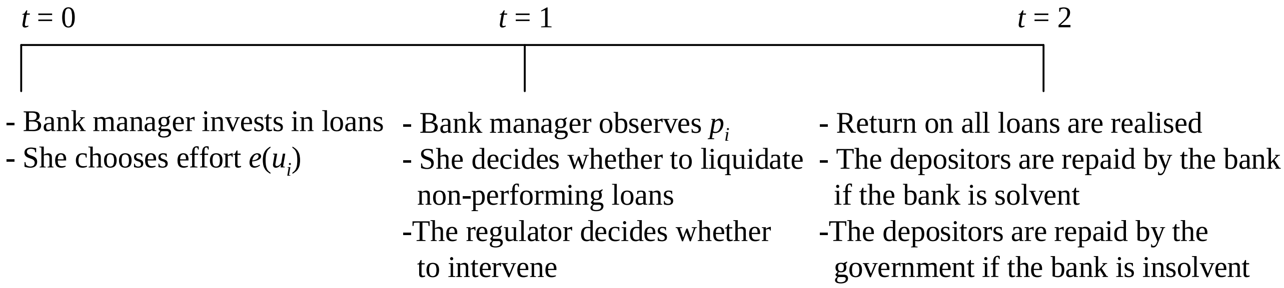

Chart 1: Timing of the game

are passive in our model. The timing of the game is described in Chart 1.

At $t = 0$, bank manager invests in loans l, which are financed by deposits d and equities k. The amount of lending at $t = 0$ is normalised to 1, so that the balance sheet identity implies $l = 1 = d + k$. The safe rate of return is also normalised to equal 1, and the loan repayment is due at $t = 2$. The depositors withdraw their money at $t = 2$, although they are repaid earlier if the bank is closed at $t = 1$. The manager also chooses the level of effort, $e(u_i)$, which affects the probability of the bank's solvency. We will explain later how this effort affects the probability of the bank's solvency.

At $t = 1$, the manager of bank i learns that a fraction p_i of the loan portfolio is 'performing', whereas a fraction $1 - p_i$ is 'non-performing'. Performing loans will repay $r > 1$ at $t = 2$ with certainty. Non-performing loans will repay r with probability q at $t = 2$ but 0 with probability $1 - q$. But if the bank liquidates its NPLs at $t = 1$, it can recover $\beta < d$. We assume that $q < \frac{\beta}{r}$, so that non-performing loans have negative net present values and it is socially optimal to liquidate them at $t = 1$.(3) For now, we assume that q, r, β are common across banks and are known to the regulator, although banks differ in p_i. We will consider later the implications of asymmetric information over q.

The regulator decides at $t = 1$ whether to intervene in a bank, and which policy to adopt. Each policy option, indexed by j, is evaluated on the basis of its *ex-ante* and *ex-post* welfare implications and fiscal costs of resolution. Policy j is optimal *ex post* if it maximises the value of

(3) We restrict our attention to the case in which $q < \frac{\beta}{r}$, since the need for regulatory intervention does not arise when $q \geq \frac{\beta}{r}$.

each bank's assets given the state of its balance sheet at $t = 1$. Thus, an optimal *ex-post* policy achieves the liquidation of all non-performing loans at $t = 1$, while preserving the going-concern values of all performing loans. A policy is optimal *ex ante* if it induces the socially optimal level of managerial effort, which maximises the net present value of the bank at $t = 0$. In what follows, the *ex-ante* social welfare and fiscal costs of policy option j are denoted W_j and G_j, respectively.

3.2 Problem with forbearance

Consider first the case in which the regulator does not intervene at $t = 1$. Due to limited liability, the manager of banks holding large amounts of NPLs may fail to liquidate these bad loans at $t = 1$ even though they have negative net present value. To illustrate this, suppose that the share of performing loans p_i at $t = 1$ differs across banks, such that $p_i \in [p_L, p_H]$ for all i. There are three different types of banks depending on the value of p_i. The first set of banks are 'insolvent' and are unable to repay their depositors if they liquidate their NPLs at $t = 1$. Banks are 'insolvent' when p_i is sufficiently low such that $p_i r + (1 - p_i)\beta - d < 0$, or $p_L \leq p_i < a$ where a is defined as:

$$a \equiv \frac{d - \beta}{r - \beta} \tag{1}$$

Under limited liability, the shareholders do not need to repay the depositors in full if the bank's net worth becomes negative. So the shareholders of an insolvent bank receive a pay-off of zero if the NPLs are liquidated at $t = 1$, but they receive an expected pay-off of $q(r - d)$ if they are not liquidated. This is because with probability $1 - q$, the NPLs yield zero at $t = 2$ and the government (or the deposit insurer) – instead of the bank's shareholders – will have to incur the cost of repaying the depositors. Hence, the manager of an insolvent bank does not liquidate its NPLs at $t = 1$ in the absence of regulatory intervention. We assume that $p_L < a$, so that there are always some insolvent banks.

The second group of banks are 'solvent but failing'. These banks can repay their depositors if they liquidate their NPLs at $t = 1$. But like insolvent banks, their managers do not have the incentive to do so in the absence of regulatory intervention since their shareholders are better off by keeping the NPLs on the bank's balance sheet. For 'solvent but failing' banks, the share of performing loans p_i satisfies the condition:

$$0 \leq p_i r + (1 - p_i)\beta - d < q(r - d) \tag{2}$$

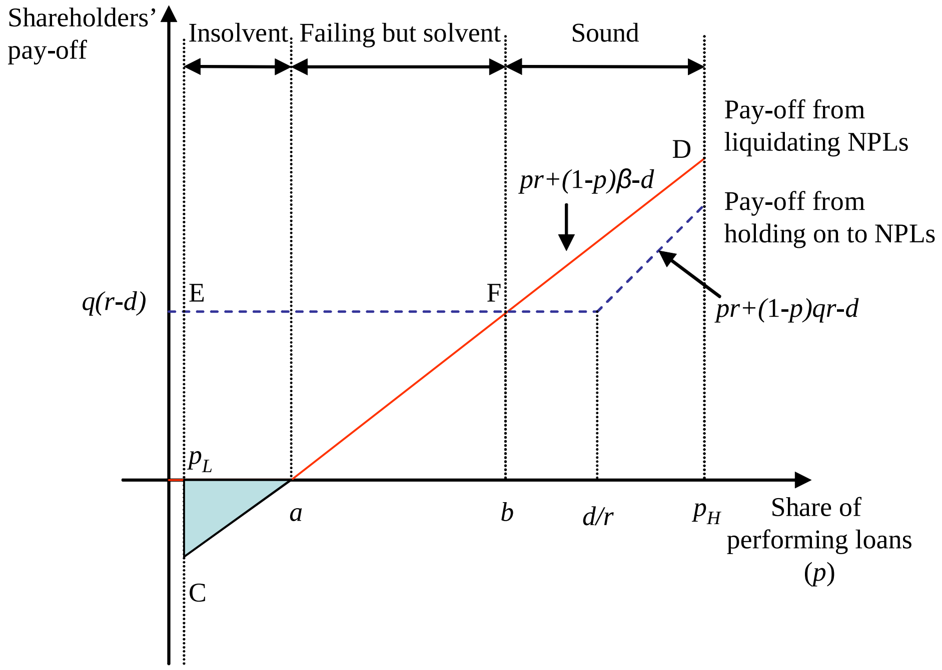

Chart 2: The bank manager's incentive to liquidate NPLs

The left-hand side is the shareholders' pay-off from liquidating NPLs at $t = 1$, whereas the right-hand side is their expected pay-off from keeping them on the bank's balance sheet. Thus, a bank is solvent but failing if $a \leq p_i < b$, where:

$$b \equiv \frac{d - \beta + q(r - d)}{r - \beta} \qquad \textbf{(3)}$$

It can be shown that $p_i r < d$ for all banks with $p_i < b$ (see Appendix A).

The third group of banks are 'sound' with $p_i \geq b$, and they liquidate their NPLs even in the absence of regulatory intervention.

Definition 1 Bank i is 'sound' at $t = 1$ if $p_i \in [b, p_H]$, 'solvent but failing' if $p_i \in [a, b)$, and 'insolvent' if $p_i \in [p_L, a)$, where $a \equiv \frac{d-\beta}{r-\beta}$, $b \equiv \frac{d-\beta+q(r-d)}{r-\beta}$, and $0 \leq p_L < p_H \leq 1$.

The absence of regulatory intervention at $t = 1$ – often called 'forbearance' – is inefficient *ex post* since insolvent banks and solvent but failing ones do not liquidate their NPLs. Chart 2 gives a graphic illustration of the bank manager's incentives under forbearance. The shareholders' pay-off from liquidating NPLs is given by the red solid line, whereas their pay-off from holding on to them is given by the blue dotted line. The blue dotted line has a kink at $\frac{d}{r}$ because when $pr > d$, the bank will have enough money to repay depositors even if its NPLs yield zero at $t = 2$, and so the shareholders' pay-off from holding on to the NPLs becomes $pr + (1 - p)qr - d$. The bank manager will liquidate NPLs if and only if the red solid line is above the blue dotted line, ie when $p \geq b$.

To examine the *ex-ante* welfare implications of regulatory forbearance, we first solve for the socially optimal level of the manager's *ex-ante* effort. Let u_i be the probability that the bank will be 'sound', and assume that the manager can increase this probability by exerting effort $e(u_i)$, where $e'(u_i) > 0$ and $e''(u_i) > 0$. The socially optimal managerial effort maximises the net present value of the bank, which is the sum of shareholders' and deposit insurer's expected pay-offs, given that all NPLs are liquidated at $t = 1$ (so the society's *ex-post* pay-off is given by the line CD in Chart 2):

$$\max_{u_i} \; W = u_i Z_i + (1 - u_i) V_i^* - e(u_i)$$

where Z_i and V_i^* are defined as:

$$Z_i \equiv \int_b^{p_H} (p_i r + (1 - p_i)\beta - d) dp_i \tag{4}$$

$$V_i^* \equiv \int_{p_L}^{b} (p_i r + (1 - p_i)\beta - d) \, dp_i \tag{5}$$

Let $W^* \equiv W(e^*)$ be the *ex-ante* social welfare under the socially optimal effort $e^*(u^*)$, which solves the following first-order condition:

$$e'(u_i) = Z_i - V_i^* \tag{6}$$

Thus, policy j is *ex-ante* optimal if it induces the bank manager to choose $e^*(u_i^*)$ at $t = 0$. Note that the second-order condition is satisfied by the assumption that $e''(u_i) > 0$.

The bank manager chooses her effort level to maximise shareholder value under regulatory policy

j, denoted S_j:

$$\max_{u_i} \; S_j = u_i Z_i + (1 - u_i) V_j - e(u_i)$$

where V_j is the shareholders' pay-off under policy j if the bank's performing loans, p_i, is in the range of $p_L \leq p_i < b$. Hence, the manager's effort choice under policy j solves the following first-order condition:

$$e'(u_i) = Z_i - V_j \quad \textbf{(7)}$$

Proposition 1 Policy intervention j at $t = 1$ reduces social welfare by lowering *ex-ante* managerial effort relative to the social optimum ($e_j^* < e^*(u^*)$) whenever $V_j > V_i^*$, where V_j is the pay-off of the shareholders when the bank's performing loans is in the range of $p_L \leq p_i < b$.

Proof. A comparison of **(7)** with **(6)** shows that the bank manager's effort choice under policy j, denoted e_j^*, will be lower than the social optimum given by the solution to **(6)** whenever $V_j > V_i^*$.

Proposition 1 has an intuitive explanation. If a particular policy gives a high pay-off to shareholders even when the bank is performing poorly, the bank manager has little incentive to exert effort *ex ante*.

Under forbearance, the pay-off of shareholders of a bank with $p_L \leq p_i < b$, denoted V_f, is given by:

$$V_f \equiv \int_{p_L}^{b} q(r - d) dp_i \quad \textbf{(8)}$$

Comparing **(8)** with **(5)**, $V_f > V^*$ holds given the definition of b as in **(3)**. Chart 2 shows that the bank manager does not fully internalise the potential losses to the deposit insurer when choosing the effort level, since the line EF, which is $q(r - d)$ in **(8)**, is always above the line CF, which is $p_i r + (1 - p_i)\beta - d$ in **(5)**. Hence, forbearance reduces social welfare by lowering the *ex-ante* managerial effort relative to the optimal level. Since deposits are fully insured, the expected fiscal cost per bank under forbearance policy, denoted G_f, is given by:

$$G_f = \begin{cases} 0 & \forall\, b < p_i < p_H \\ (1-q)(d - p_i r)\ \forall\, p_L < p_i < b \end{cases} \quad \textbf{(9)}$$

We will demonstrate subsequently that forbearance is *ex ante*, *ex post* and fiscally inefficient and is dominated by other policies.

3.3 Perfect information benchmark

Suppose first that at $t = 1$, the regulator can observe the balance sheet of each bank, given by p_i (the share of performing loans) and q_i (the recovery probability of NPLs). If bank closures are not socially costly, the *ex-post* optimal policy is to order all banks to liquidate their NPLs and close down those that fail to comply or have negative net worth after liquidating their NPLs. This policy forces insolvent banks with $p_i < a$ to close down at $t = 1$. The regulator may either liquidate the assets of an insolvent bank, or sell the bank as an entity to another sound bank ('purchase and assumption'). Since the authorities have perfect information about the bank's asset quality, they can sell the bank's good and bad assets at their fair values – r and β, respectively – by offering a buy-back guarantee on good assets, so that any adverse selection problem in the asset market can be overcome. Such a buy-back guarantee is costless in equilibrium.

Under this policy, the pay-off of the shareholders of a bank with $p_L \leq p_i < b$ is:

$$V_p = \int_a^b (p_i r + (1-p_i)\beta - d)dp_i \quad \textbf{(10)}$$

A comparison of **(10)** with **(5)** shows that $V_p > V^*$ since $\int_{p_L}^a (p_i r + (1-p_i)\beta - d)dp_i < 0$. But comparing **(10)** with **(8)**, $V_p < V_f$ given the definition of b as in **(3)**. Hence, $W^* > W_p > W_f$, where W_p is the *ex-ante* social welfare achieved under this perfect information policy. This policy increases the bank manager's *ex-ante* effort and thus social welfare relative to forbearance, but the *ex-ante* social optimum is not achieved since she does not internalise losses suffered by the deposit insurer when the bank becomes insolvent. In Chart 2, these social losses that are not internalised by the bank manager is shown as the shaded triangle Cap_L.

The fiscal cost of this policy is given by:

$$G_p = \begin{cases} 0 & \forall\, a < p_i < p_H \\ d - p_i r - (1 - p_i)\beta & \forall\, p_L < p_i < a \end{cases} \qquad \textbf{(11)}$$

Comparing **(11)** and **(9)**, it can be shown that $G_p < G_f$ (see Appendix A). Hence, this policy reduces the fiscal cost of bank failure resolution relative to forbearance, G_f. In what follows, we refer to this outcome as the 'constrained first best' – ie the best achievable outcome given limited liability.

4 Policy options under asymmetric information

Unfortunately, the regulator rarely has perfect information about the financial position of weak banks, especially – although not only – in the context of emerging market economies (EMEs). Quite frequently, regulators in EMEs must decide on a strategy without being able to ascertain the full extent of the problem at each bank.

To examine the effect of information asymmetry, suppose now that the bank manager learns p_i privately at $t = 1$. The regulator cannot observe the fraction p_i at each bank, and only knows that $p_i \in [p_L, p_H], \forall i$. For simplicity, we assume that q (the recovery probability of NPLs), β (the interim liquidation value of NPLs) and r (the return on performing loans at $t = 2$) are the same across all banks and known to the regulator. We will later consider the policy implications when q varies across banks and is not observable to the regulator.

4.1 Option 1: 'Raise new capital or face closure'

We first consider a policy under which the regulator closes all banks which fail to raise a minimum amount of new capital. Suppose the regulator asks all banks to raise additional new capital equal to κ which must be invested in safe assets, and closes all those that fail to comply. Assuming that the opportunity cost of investing in the bank is given by the safe rate equal to 1 and the newly raised capital is invested in safe assets, shareholders of an insolvent bank prefer closure to raising new capital if: (4)

$$q(r + \kappa - d) \leq \kappa$$

(4) We consider later in this section how the results change if banks cannot raise new capital at the safe rate.

The left-hand side is the shareholders' pay-off from investing the newly raised capital and the right-hand side is the cost of raising new capital. Thus, an insolvent bank prefers to face closure if it is asked to raise new capital which exceeds $\hat{\kappa}$, where:

$$\hat{\kappa} \equiv \frac{q(r-d)}{1-q} \tag{12}$$

Proposition 2 A policy which involves closing all banks that failed to raise a minimum amount of capital $\hat{\kappa} = \frac{q(r-d)}{1-q}$ achieves the constrained first-best outcome, provided that banks' shareholders can raise additional capital at the safe rate and the assets of closed banks can be sold at their full going-value, r.

Proof. We have already shown that if asked to raise $\hat{\kappa}$, insolvent banks prefer to close down, but what about solvent but failing banks? Assuming first that the manager of a solvent but failing bank chooses to raise additional capital rather than face closure, she prefers to liquidate NPLs after raising new capital κ if and only if:

$$q(r+\kappa-d) \leq p_i r + (1-p_i)\beta + \kappa - d$$

Solving for κ, it can be shown that the manager of a solvent but failing bank will liquidate NPLs if:

$$\kappa \geq \hat{\kappa} - \frac{p_i r + (1-p_i)\beta - d}{1-q}$$

Since $p_i r + (1-p_i)\beta - d \geq 0$ for solvent banks, solvent but failing banks will liquidate NPLs if they are ordered to raise new capital $\hat{\kappa}$ given by **(12)**.

Next, we show that solvent but failing banks prefer to raise new capital rather than to face closure. Since $p_i r + (1-p_i)\beta + \hat{\kappa} - d \geqslant \hat{\kappa}$ for all solvent banks, they prefer to raise new capital and liquidate their NPLs rather than face closure. For the same reason, sound banks raise new capital under this policy. Thus, this policy is *ex-post* optimal, and induces different equilibrium behaviour for solvent and insolvent banks.

The pay-off of the shareholders of a bank with $p_L \leq p_i < b$ under this policy is given by:

$$V_s = \int_a^b (p_i r + (1-p_i)\beta - d)\, dp_i \tag{13}$$

Comparing **(13)** with **(10)**, $V_s = V_p$, so this policy achieves the same *ex-ante* welfare outcome as under perfect information ($W_s = W_p$).

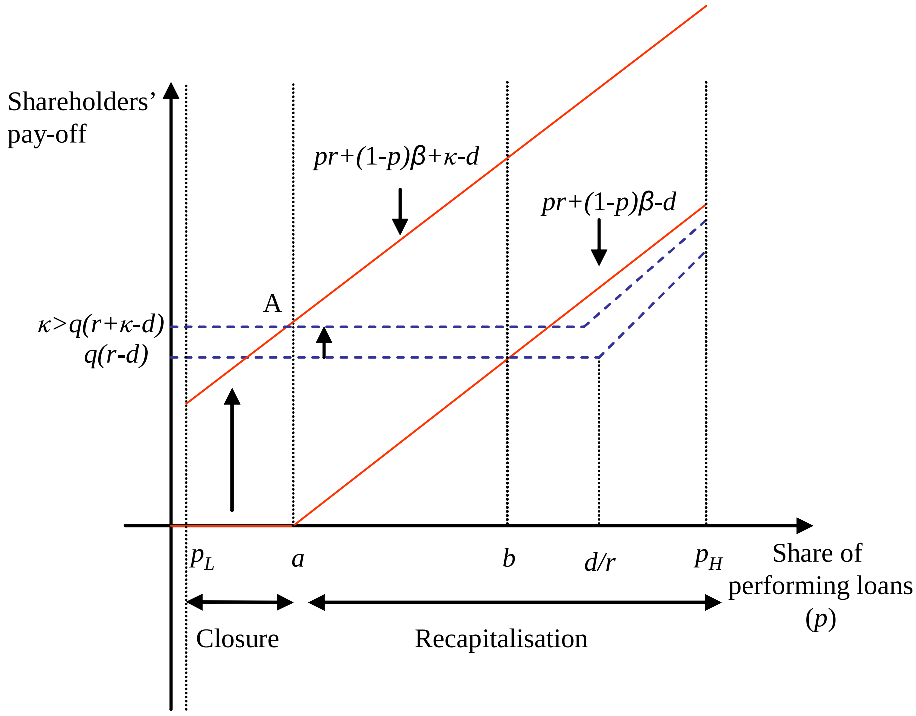

Chart 3: Impact of forcing banks to raise new capital

The fiscal cost of this policy is given by:

$$G_s = \begin{cases} 0 & \forall\, a < p_i < p_H \\ d - p_i r - (1 - p_i)\beta & \forall\, p_L < p_i < a \end{cases}$$

Since $G_p = G_s$, this policy achieves the 'constrained first best' welfare and fiscal cost as under the perfect information benchmark ($W_s = W_p$ and $G_s = G_p$) (QED).

Chart 3 shows that raising new capital shifts both the shareholders' expected pay-off from liquidating NPLs (red solid line) and their pay-off from holding on to them (blue dotted line) upwards, but the former shifts by more than the latter. If $\hat{\kappa}$ is set sufficiently high, then all solvent banks with $p_i \geq a$ (to the right of point A) will liquidate the NPLs whereas all the insolvent ones decide to close down. Note that banks with high levels of NPLs do not have the incentive to raise additional capital unless ordered by the regulator. For a bank with $p_i < b$, the net pay-off from raising new capital is $p_i r + (1 - p_i)\beta - d$ whereas its pay-off from not doing so is $q(r - d)$, so that all these banks will choose not to raise additional financing in the absence of regulatory intervention.

Closing an insolvent bank, however, may be too costly if it is likely to cause systemic repercussions. Even where bank closure is possible, this policy can achieve the first-best outcome only if the regulator can sell the good assets of the closed bank at their full going-concern value, r, and this may not be possible for two reasons. First, the regulator and the market may not be able to ascertain the value of insolvent banks' assets immediately after they are closed down. Second, transfer of loans from a bank to another party – be it another bank or the regulator – could result in loss of value, as vital information about the borrower may be lost in the process (Mitchell (2001)). If so, the good assets of the insolvent banks cannot be sold at their full going-concern value, making this policy both *ex-post* inefficient and fiscally costly.

4.2 Option 2: Public capital injection using equity (Tier 1 capital)

If bank closure is too costly, the regulator must choose between options available for 'open bank assistance'. Suppose now that the regulator instead orders all banks that failed to raise their own capital to issue new equity equal to κ, which is purchased by the government. This acquisition of bank equity entitles the government to receive a share $\frac{\kappa}{k+\kappa}$ of the bank's profit at $t = 2$. After receiving equity injection equal to κ, banks with $p_i < b$ are willing to liquidate NPLs if and only if:

$$q(r + \kappa - d)\frac{k}{k + \kappa} \leq (p_i r + (1 - p_i)\beta + \kappa - d)\frac{k}{k + \kappa}$$

The above expression shows that the bank's existing shareholders receive only a fraction $\frac{k}{k+\kappa}$ of the bank's profits after equity injection, since the government takes the remaining $\frac{\kappa}{k+\kappa}$ as the bank's new shareholder. Solving the above for κ, it can be shown that banks will liquidate NPLs if they receive a capital injection greater than $\kappa^*(p_i)$ where:

$$\kappa^*(p_i) \equiv \frac{q(r - d) - (p_i r + (1 - p_i)\beta - d)}{1 - q} \qquad \textbf{(14)}$$

Since $\frac{\partial \kappa_i^*}{\partial p_i} < 0$, only a small capital injection is required to induce banks with relatively small amounts of NPLs to liquidate them, whereas a larger injection is needed for weaker banks. Thus, if the regulator cannot ascertain the level of NPLs at each bank, it has to offer a capital injection $\kappa^*(p_L)$, which is sufficiently large to induce the weakest bank to liquidate its NPLs, where:

$$\kappa^*(p_L) = \frac{q(r-d) - (p_L r + (1-p_L)\beta - d)}{1-q} \quad \textbf{(15)}$$

Since all banks will liquidate their NPLs after receiving a capital injection equal to $\kappa^*(p_L)$, this policy is *ex-post* efficient. But since $\kappa^*(p_i) < \kappa^*(p_L)$ for all banks with $p_i > p_L$, the regulator must offer a larger capital injection than necessary to induce banks with $p_i > p_L$ to liquidate their NPLs. Thus, the information asymmetry about p_i raises the fiscal cost of recapitalisation.

A bank prefers to raise its own capital rather than receive a capital injection if:

$$p_i r + (1-p_i)\beta - d \geq (p_i r + (1-p_i)\beta + \kappa - d)\frac{k}{k+\kappa}$$

The left-hand side is the shareholders' pay-off from investing their own capital.[5] Reorganising the above, it can be shown that the strongest banks with $p_i \geq x$ prefer to raise their own capital rather than receive a capital injection, where:

$$x \equiv \frac{1-\beta}{r-\beta} \quad \textbf{(16)}$$

and those with $p_i < x$ will opt for public capital injection. Note that x is the 'break-even' point such that $xr + (1-x)\beta = 1 = d + k$. In other words, by liquidating NPLs at $t = 1$, the bank's shareholders will make exactly zero profits.

In what follows, we assume that $a < x < b$. Comparing **(3)** and **(16)**, it can be shown that $x < b$ if $1 - \beta < d - \beta + q(r - \beta)$. Reorganising this and using the fact that $d + k = 1$, the inequality $x < b$ holds as long as:

$$k < q(r-d) \quad \textbf{(17)}$$

This is the necessary and sufficient condition for $a < x < b$, since $a < x$ given that $d < 1$.

The pay-off of the shareholders of a bank with $p_L \leq p_i < b$ under this policy is given by:

$$V_k = \int_x^b (p_i r + (1-p_i)\beta - d)\, dp_i + \int_{p_L}^x (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)} dp_i \quad \textbf{(18)}$$

Comparing **(18)** and **(8)**, it can be shown that $V_p < V_k < V_f$, so that this policy achieves the second-best outcome.

(5) Assuming that the opportunity cost of investing in the bank is given by the safe rate and the proceeds are invested in safe assets, the net cost of raising additional capital is zero for the existing shareholders.

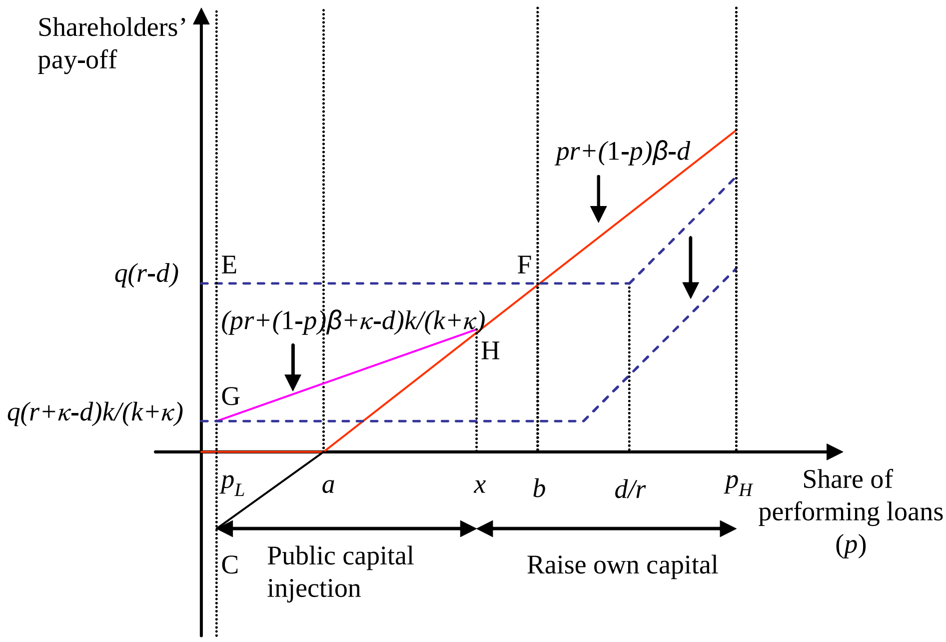

Chart 4: The impact of equity injection

Proposition 3 A compulsory equity injection equal to $\kappa^*(p_L)$ for all banks that have failed to raise own capital achieves the second-best outcome.

Proof. See Appendix A.

Hence, this policy increases the *ex-ante* effort by bank managers relative to forbearance but fails to achieve the constrained first best, so that $W_f < W_k < W_p$. The intuition is that new equity injection dilutes the claim of the existing shareholders, and hence it lowers shareholders' pay-offs from gambling for resurrection. This effect is shown graphically in Chart 4: equity injection lowers the pay-off of shareholders of a bank with $p_i < b$ from EF to GHF. The liquidation of NPLs at $t = 1$ together with profit sharing means that the government can recover part of its investment, which lowers the fiscal cost relative to forbearance. But this policy fails to achieve the constrained first-best outcome since insolvent banks are not closed down at $t = 1$.

The inequality $V_k < V_f$ also implies that the public capital injection makes the bank's existing shareholders worse off relative to forbearance because it dilutes the claim of the existing shareholders. This provides an explanation of why banks are often reluctant to accept a public capital injection. Our explanation is different from Corbett and Mitchell (2000), who model recapitalisation as a pure subsidy and argue that banks often refuse public recapitalisation because it hurts their reputation and thus future profitability. Our analysis shows that banks may refuse recapitalisation even in the absence of such reputational effects because capital injection is not a subsidy, but a claim on the bank's future profits in return for new funds today.

4.3 Option 3: Public capital injection using subordinated debt (Tier 2 capital)

We now consider public capital injection using subordinated debt (SBD), which has been used in several countries when the government did not want to hold an equity stake in a private bank. Suppose that the regulator forces all banks to issue subordinated debt equal to κ, which the government purchases. We assume that this newly issued SBD is senior to the bank's equity but junior to its deposits, and the newly raised funds are invested in safe assets yielding a unitary return. If so, banks for which $p < b$ will liquidate NPLs if and only if $q(r + \kappa - d - \kappa) \leq p_i r + (1 - p_i)\beta + \kappa - \kappa - d$, which is equivalent to **(2)**. Thus, subordinated debt injection is *ex-post* inefficient since it does not alter the incentives of failing banks to liquidate the NPLs. The intuition is that SBD is just another form of debt, and so the issuance of new SBD does not alter the incentives of the shareholders of an already insolvent bank.

Under this policy, the pay-off of the shareholders of a bank with $p_L \leq p < b$ is given by:

$$V_{sbd} = \int_{p_L}^{b} q(r - d)dp_i \tag{19}$$

Comparing the above with **(8)**, it is clear that $V_{sbd} = V_f$. Thus, this policy induces the same low level of managerial effort as under forbearance, so that $W_{sbd} = W_f$. The fiscal cost of SBD injection, denoted G_{sbd}, is given by:

$$G_{sbd} = \begin{cases} 0 & \forall\, b \leq p_i < p_H \\ (1 - q)(d - p_i r) & \forall\, p_L < p_i < b \end{cases}$$

Comparing the above with **(9)**, $G_{sbd} = G_f$, so SBD injection does not reduce fiscal costs relative to forbearance. Hence, public capital injection using SBD is both *ex-ante* and *ex-post* inefficient, and is also fiscally costly. This does not imply that the proposal to make banks hold subordinated debt as a means of pricing the deposit insurance premium, or more generally to help improve the transparency of banks' balance sheets for the market, does not have merits, see *inter alia* Calomiris (1999). Rather, our analysis suggests that in the case of failing banks, it is not efficient for the government to purchase their subordinated debt unless recapitalised banks can be forced to liquidate their NPLs.

4.4 Option 4: Subsidising NPL liquidation

Although equity injection achieves the second-best outcome, governments are often reluctant to assume ownership of a private bank. An alternative policy is to subsidise the liquidation of NPLs, given that weak banks are unwilling to sell their NPLs at their fair values β. But since sound banks with $p_i > b$ will liquidate their NPLs even in the absence of regulatory intervention, there is no need to subsidise them.

So suppose that the government offers a subsidy T which is proportional to the amount of NPLs liquidated if and only if the liquidation exceeds $1 - b$. This policy is similar to the 'conditional bailout' considered in Aghion *et al* (1999).(6) If offered a subsidy T, a bank for which $p_i < b$ will liquidate all of its NPLs if:

$$q(r-d) < p_i r + (1-p_i)\beta - d + T$$

Solving for T, the minimum subsidy required to induce a bank that holds NPLs equal to $1 - p_i$ to liquidate them is given by:

$$T^*(p_i) = q(r-d) - (p_i r + (1-p_i)\beta - d) \quad \textbf{(20)}$$

It is easy to see that $\frac{\partial T^*}{\partial p_i} < 0$, so that the required subsidy increases with the amount of NPLs liquidated. It can also be shown that under this scheme, sound banks do not have the incentive to liquidate their good assets in order to receive this subsidy (see Appendix A).

This policy is *ex-post* efficient since it leads to liquidation of NPLs at $t = 1$. But it involves the government guaranteeing a pay-off that a bank will receive under forbearance, so that:

$$V_{npl} = \int_{p_L}^{b} q(r-d) f(p_i) dp_i \quad \textbf{(21)}$$

(6) See Section 4 of Aghion *et al* (1999).

Comparing the above with **(8)**, $V_{npl} = V_f$ so that $W_{npl} = W_f$. Thus, although this policy is superior to forbearance since it encourages efficient liquidation of NPLs *ex post*, it subsidises incompetent banks and hence does not increase the bank manager's *ex-ante* effort relative to forbearance.

The fiscal cost of this policy is given by:

$$G_{npl} = \begin{cases} 0 & \forall\ b < p_i < p_H \\ q(r-d) - (p_i r + (1-p_i)\beta - d) & \forall\ p_L < p_i < b \end{cases} \qquad \textbf{(22)}$$

Thus, $G_k < G_{npl} < G_f$ (see Appendix A). This policy is fiscally more costly compared to equity injection since the government takes over all the losses of failing and insolvent banks through the subsidy, whereas equity injection imposes some of the losses on the existing shareholders. But the fiscal cost of subsidising NPL liquidation is still lower than forbearance, since the former leads to efficient liquidation of NPLs whereas the latter does not.

4.5 Option 5: The menu approach

We now consider whether the government can reduce the cost of subsidising the liquidation of NPLs by offering a menu of options to banks. Suppose now that the regulator gives each bank a menu of options, from which it must choose: either raise new capital, accept an equity injection equal to $\kappa^*(p_L)$, or receive a subsidy proportional to the amount of NPLs liquidated if the liquidation exceeds $1 - x$, where x is given by **(16)** and $\kappa^*(p_L)$ is given by **(15)**.

Consider first the incentives of banks with $p_i < x$. These banks will opt for subsidy T rather than public capital injection given by **(15)** if T is set at (or slightly above) a level such that:

$$(p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k + \kappa^*(p_L)} \leq p_i r + (1-p_i)\beta - d + T$$

The left-hand side is the pay-off of banks with $p_i < x$ from receiving equity injection equal to $\kappa^*(p_L)$, whereas the right-hand side is their pay-off from opting for the subsidy. Solving the above for T, banks with $p_i \leq x$ will opt for subsidy rather than equity injection if T is set at or slightly above $T^*(\kappa^*(p_L))$, where:

$$
\begin{aligned}
T^*(p_i, \kappa^*(p_L)) &= \kappa^*(p_L)\left(\frac{k}{k+\kappa^*(p_L)}\right) - (p_i r + (1-p_i)\beta - d)\left(\frac{\kappa^*(p_L)}{k+\kappa^*(p_L)}\right) \qquad \textbf{(23)}\\
&= \kappa^*(p_L) - (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{\kappa^*(p_L)}{k+\kappa^*(p_L)}
\end{aligned}
$$

Comparing **(23)** with **(20)**, it can be shown that $T^*(p_i, \kappa^*(p_L)) < T^*(p_i)$, using the fact that:

$$
q(r-d) > (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)}, \forall p_i < x
$$

which has already been shown in the Proof of Proposition 3 (see Appendix A). Thus, offering failing banks a menu of options is less costly for the government than offering a subsidy for NPL liquidation on its own. And by making the subsidy option slightly more attractive to equity injection, the government can also avoid holding equity stake in a bank.

Next, we consider whether banks with $p_i \geq x$ will imitate those banks with $p_i < x$ in order to receive the subsidy **(23)**. We know from the previous analysis that if offered a choice between raising own capital and receiving an equity injection equal to $\kappa^*(p_L)$, banks with $p_i > x$ will opt for raising own capital. If these banks are offered a menu including the option of receiving the subsidy **(23)** by liquidating $1-x$ of their loans, banks with $p_i > x$ will liquidate part of their performing loans in order to receive the subsidy if and only if they are better off by mimicking banks with $p_i = x$:

$$
p_i r + (1-p_i)\beta - d < xr + (1-x)\beta - d + T^*(x_i, \kappa^*(p_L)) = (xr + (1-x)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)}
$$

where $T^*(x_i, \kappa^*(p_L))$ is the amount of subsidy the bank will receive by liquidating NPLs equal to $1-x$. From the previous analysis and by the definition of x as in **(16)**, we know that this inequality will never hold for any $p_i > x$. Hence, banks with $p_i > x$ will choose to raise their own capital if offered a menu consisting of raising new capital, accepting capital injection $\kappa^*(p_L)$, and receiving a subsidy $T^*(x, \kappa^*(p_L))$ by liquidating loans equal to $1-x$.

Proposition 4 A menu of options consisting of i) raising own capital; ii) receiving equity injection equal to $\kappa^*(p_L)$; and iii) receiving a subsidy proportional to the amount of NPLs liquidated through the scheme $T^*(p_i, \kappa^*(p_L))$ can achieve the second-best outcome.

Proof. The pay-off of the shareholders of a bank with $p_L \leq p < b$ under this policy is given by:

$$V_m = \int_x^b (p_i r + (1-p_i)\beta - d)\, dp + \int_{p_L}^x (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d) \frac{k}{k + \kappa^*(p_L)} dp \quad \textbf{(24)}$$

Comparing **(24)** with **(18)** and using previous results, $V_p < V_k = V_m < V_f$, so that $W_f < W_k = W_m < W_p$. The fiscal cost of this policy is given by:

$$G_m = \begin{cases} 0 & \forall\, x < p_i < p_H \\ \kappa^*(p_L) - (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{\kappa^*(p_L)}{k+\kappa^*(p_L)} & \forall\, p_L < p_i < x \end{cases}$$

Hence, $G_p < G_k = G_m < G_f$ (QED).

Chart 4 shows why offering a menu lowers the cost of subsidising the liquidation of NPLs. If the subsidy is offered on its own, the regulator will have to give a total subsidy equal to the area CEF in the chart to guarantee a pay-off equal to $q(r-d)$ for all banks. But by offering a menu, which includes an unattractive option of receiving a capital injection, the regulator can reduce the subsidy to the area CGH. This menu approach works so long as the government can credibly commit to injecting equity into a bank should it choose this option, even though it prefers not to hold an equity stake in a bank. In Appendix A, we also show that the regulator cannot reduce the *ex-ante* inefficiency further by offering a menu which includes an equity injection that is smaller than $\kappa^*(p_L)$.

4.6 Asymmetric information with unobservable continuation value of NPLs

Thus far, the probability of recovering NPLs, q, was assumed to be the same across banks and observable to the regulator. This assumption could be justified if, for example, the probability of recovering NPLs depends strongly on macroeconomic prospects which are publicly known. However, regulators typically face difficulty in assessing the recovery probability of NPLs, as this requires detailed information about the borrowers.

Suppose now that banks differ in q_i as well as p_i, and regulators are unable to observe either of these. Instead, the regulator only knows that $p_i \in [p_L, p_H]$ and $q_i \in [q_L, q_H]$, where $q_H < \frac{\beta}{R}$. It turns out that all the policies discussed previously are still feasible so long as the regulator can observe p_L and q_H, since he can tailor policies to induce the banks with the strongest incentives to hold on to their NPLs – ie those with p_L and q_H – to liquidate the NPLs. Thus, options 1, 2, 4, 5 are still feasible if the regulator designs the respective policy instruments **(12)**, **(15)**, **(20)** and **(23)** by setting $q = q_H$, as long as $q_L(r - d) > k$. As before, forbearance and recapitalisation using subordinated debt (option 3) are dominated by other policies.

Although the lack of information about q_i does not prevent the regulator from using these instruments, it raises both the *ex-ante* managerial moral hazard and the *ex-post* fiscal cost of resolution. For example, public capital injection or subsidy described under options 4-5 must be set at a sufficiently high level to induce banks with the highest q to liquidate their NPLs. This increases the government subsidy to all banks with $q_i < q_H$ relative to the situation in which the regulator knows q. In addition, the lack of information can also encourage bank moral hazard *ex ante*, since it forces regulators to be 'soft' on banks *ex post*.

4.7 Costly issuance of new capital

In the preceding analysis, we assumed that banks are able to raise new capital at the risk-free rate. However, this assumption may not be realistic if the existing shareholders do not have sufficient cash and need to go to the market to raise new money. To consider the implication of costly issuance of new capital, suppose now that banks incur a cost $\rho > 1$ per unit of new capital raised. If banks are asked to raise $\hat{\kappa}$ given by **(12)**, they still have the incentives to liquidate the NPLs once they raise capital. But now, banks will prefer to raise new capital $\hat{\kappa}$ rather than face closure if and only if:

$$pr + (1 - p)\beta - d \geq (\rho - 1)\hat{\kappa}$$

Thus, some solvent but failing banks prefer closure to raising new capital. This renders option 1 ('Raise new capital or face closure') inefficient. More generally, a policy that forces some banks to raise new capital causes a loss in social welfare if the cost of raising capital exceeds the return on the new 'safe' investments that they make.

One option would be for the government to recapitalise all 'suspect' banks at $t = 1$. Although this policy is *ex-post* efficient and the government makes profits on recapitalising banks with $p_i > x$ (see Appendix A), it is not *ex-ante* efficient since it lowers shareholders' returns on sound banks and hence lowers the bank manager's effort *ex ante*. Hence, when raising new capital is expensive for the bank's shareholders, the third-best policy would be to subsidise liquidation of NPLs (option 4).

5 Discussion

Our analysis shows the *ex-ante* and *ex-post* implications of each policy, and clarifies what conditions determine the appropriate policy response. We have shown that the optimal policy choice depends on three factors: i) the ability of the regulator to observe banks' balance sheets before he intervenes; ii) the ability of the solvent banks' existing shareholders to raise new capital cheaply; and iii) the cost of closing a bank, in terms of loss in asset values and systemic impact. When the solvent banks' shareholders can raise new capital relatively cheaply, the policy options have the following ranking (from the best to the worst) in terms of their implications for *ex-ante* social welfare:

$$W_f = W_{sbd} = W_{npl} < W_k = W_m < W_s = W_p < W^*$$

Similarly, the ranking of policies in terms of fiscal costs (from the least cost to the highest cost) is as follows:

$$G_p = G_s < G_k = G_m < G_{npl} < G_{sbd} = G_f$$

This ranking has the following implications for a regulator operating under asymmetric information. First, when the solvent banks' existing shareholders can raise new capital cheaply and the cost of closing banks is low, then the regulator should ask banks to raise new capital and close all those that fail to do so. This policy achieves the constrained first best, since it maximises the punishment on insolvent banks and thus encourages bank managers to exert effort *ex ante*, and it ensures liquidation of NPLs *ex post.* It also minimises the fiscal cost of bank resolution. Second, when bank closures are too costly and the authorities need to choose between alternatives for open bank assistance, equity injection and the menu approach achieve the second-best outcome, as they involve partial cost sharing between the government and the banks' shareholders. Finally, forbearance and subordinated debt injection are *ex-post* inefficient since they do not induce banks to liquidate their NPLs. These policies are also *ex-ante* inefficient since they encourage higher pay-offs for the shareholders of failed banks compared to other policies. Thus, these two policies are always dominated by others.

When raising new capital is too costly for the banks' shareholders, either because they face a high cost of external financing or problems of co-ordinating equity injection between themselves, the authorities should subsidise the liquidation of NPLs. This policy (option 4), which is similar to the 'conditional bailout' scheme advocated by Aghion *et al* (1999), achieves the third-best outcome: it ensures liquidation of NPLs *ex post*, but it encourages moral hazard *ex ante* compared to other intervention policies since the regulator has to give banks the same pay-off as under forbearance. Chart 5 shows how policy choice should be determined according to our model when the regulator cannot observe banks' balance sheets before intervening.

The analytical results of our paper differ from the existing literature in several ways. First, by constructing a model in which several policies can be assessed simultaneously, our analysis clarifies that some commonly used policies, such as recapitalisation through subordinated debt, or subsidising the liquidation of NPLs, advocated, for example, by Aghion *et al* (1999), might in fact be dominated by other policies. Second, contrary to previous papers, such as Aghion *et al* (1999) and Corbett and Mitchell (2000), our analytical results do not rely on the assumption of private benefits experienced by bank managers in continuing to run a failing bank. Instead, the incentive of failing banks' managers to hide NPLs arises from shareholders' limited liability. Finally, unlike these existing papers, we have also modelled public recapitalisation as an acquisition of a claim on the bank by the government rather than a pure subsidy. This modelling yields some important insights. For example, we have shown that under limited liability, banks may refuse public recapitalisation because it dilutes the claim of the existing shareholders. This shows that the negative reputational effect considered by Corbett and Mitchell (2000) may not be the only, or even the main, explanation of why banks often, in practice, refuse public recapitalisation.

Note that our results do not necessarily imply that the policy choices made by crisis countries in the past have been a mistake. Our welfare results hinge on the assumption that the authorities are unable to observe banks' balance sheets and therefore cannot simply order banks to liquidate their NPLs. In reality, the authorities dealing with a crisis may have had better information about failing banks in these cases than assumed in our model. For instance, government purchases of banks' NPLs need not give rise to inefficiency if the authorities can evaluate the banks' balance sheets

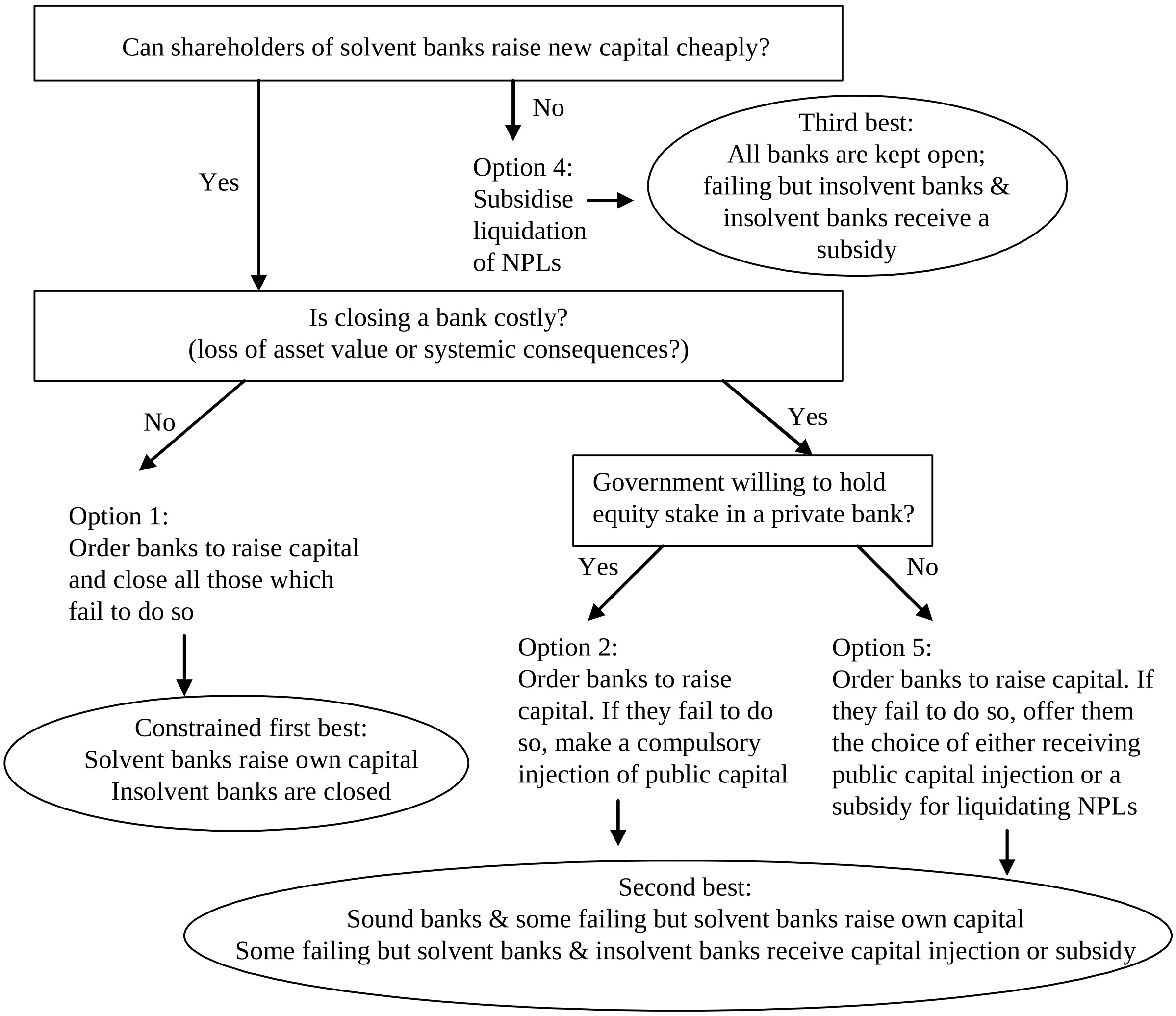

Chart 5: The optimal policy choice under asymmetric information

and force banks to sell NPLs at fair value given by β. Similarly, equity injection would be dominated by subordinated debt injection if the government can simply force banks to liquidate their NPLs after injecting capital, since, in this case, the government can recover a larger proportion of their investment if they hold subordinated debt, which is senior to equity.

6 Conclusion

Our model provides a simple but general framework in which practical policy alternatives under information asymmetry can be systematically evaluated. The novelty of our analysis is in showing that different forms of open bank assistance have different *ex-ante* and *ex-post* welfare and fiscal implications. Therefore, the authorities should carefully evaluate the available policy alternatives when closing a bank is not a viable option. In particular, our analysis suggests that certain policies that are commonly used – such as the injection of subordinated debt – are dominated by other policies when banks can hide their NPLs and the authorities have to rely on financial incentives to induce banks to liquidate bad loans. Unlike subordinated debt injection, equity injection can induce banks to liquidate their NPLs by diluting the shareholders' incentives to gamble for resurrection. So when the authorities do not wish to hold an equity stake in a bank, they could offer a subsidy for liquidating NPLs rather than injecting subordinated debt. The cost of such a subsidy could be reduced if it is offered in a menu which includes equity injection.

Our analysis also yields several other practical implications. First, it shows that a lack of information is costly both in terms of *ex-ante* social welfare and *ex-post* fiscal costs. Under asymmetric information, policies must be tailored so as to induce the bank with the weakest incentives to liquidate their NPLs to do so. As a result, the regulator must offer all other banks a subsidy which is larger than necessary to induce them to liquidate their NPLs. Thus, asymmetric information forces the regulator to be 'soft' on banks *ex post*. This in turn encourages managerial moral hazard, which reduces *ex-ante* social welfare and increases the incidence of bank failures. Hence, there is an obvious case for a strong disclosure requirement which allows regulators to verify banks' balance sheets more easily.

Second, our analysis shows that even when it is possible to close insolvent banks *ex post*, limited liability means that bank managers have a suboptimal incentive to exert effort *ex ante* to avoid failure. One solution to this might be to impose a non-pecuniary penalty on bank managers when the bank is closed down. This could be achieved, for example, if the manager is automatically fired when a bank fails, as opposed to giving her a new position when the failed bank is merged with another bank. However, such a strict policy could also strengthen the manager's incentives to hide NPLs. It may also be perceived as unfair if the bank failure is caused by an exogenous shock rather than poor management. Another possible solution to this problem might be to make part of the bank manager's compensation in the form of the bank's debt. This would both increase the bank manager's effort *ex ante* and strengthen her incentives to declare bankruptcy when the bank becomes insolvent, since she would want to increase the recovery value for creditors.

Finally, it should be noted that if the authorities only care about maximising the recovery value for insured depositors and only part of the bank's deposits are insured, they may fail to implement the optimal policy. This is likely to be an issue particularly in EMEs where explicit deposit insurance schemes are less extensive. For example, according to the database compiled by Demirgüç-Kunt and Sobaci (2000), only around one third of EMEs have explicit deposit insurance schemes in place, whereas nearly all developed economies have explicit schemes. Thus, the objective of minimising the cost to the deposit insurer alone is too narrow to be an appropriate regulatory objective, and the regulator should be given a proper incentive to intervene in order to maximise the net present value of failing banks.

Appendix A: Proofs

Proof that $p_i r < d$ for all banks with $p_i < b$:

To prove this, it is sufficient to show that $b < \frac{d}{r}$. Using the definition of b in **(3)**, the inequality holds as long as:

$$\frac{d - \beta + q(r - d)}{r - \beta} < \frac{d}{r}$$

This inequality can be reorganised and expressed as $q < \frac{\beta}{r}$, which holds by assumption (QED).

Proof that $G_f > G_p$

The inequality $G_f > G_p$ holds as long as:

$$(1 - q)(p_i r - d) < p_i r + (1 - p_i)\beta - d \quad \textbf{(A-1)}$$

In the case of solvent but failing banks, the right-hand side is always positive whereas the left-hand side is always negative. Hence this inequality holds for solvent but failing banks.

For insolvent banks, both sides are negative. We note that given $q < \frac{\beta}{r}$, the maximum value that the left-hand side of the above inequality can take is:

$$\frac{r - \beta}{r}(p_i r - d) = p_i(r - \beta) - \left(1 - \frac{\beta}{r}\right) d$$

So to prove the inequality **(A-1)**, it is sufficient to demonstrate that:

$$p_i(r - \beta) - \left(1 - \frac{\beta}{r}\right) d < p_i r + (1 - p_i)\beta - d$$

Simplifying the above, it becomes:

$$\left(\frac{d}{r}\right)\beta < \beta$$

This inequality always holds since $d < r$ (QED).

Proof of Proposition 3:

To show that equity injection achieves the second-best outcome, we need to show that $V_p < V_k < V_f$. By the definition of x, given by **(16)**, the following inequality holds for all $p_i < x$:

$$p_i r + (1 - p_i)\beta - d < (p_i r + (1 - p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k + \kappa^*(p_L)}$$

Hence, $V_p < V_k$.

Comparing **(18)** and **(8)**, and using the fact that **(2)** holds for all $p_i < b$, then:

$$\int_x^b (p_i r + (1 - p_i)\beta - d)\, dp_i < \int_x^b q(r - d) dp_i$$

Hence, the sufficient condition for $V_k < V_f$ is that

$$q(r - d) > (p_i r + (1 - p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k + \kappa^*(p_L)}, \forall p_i < x \qquad \textbf{(A-2)}$$

This can be rewritten as $q(r - d)(k + \kappa^*(p_L)) > k(p_i r + (1 - p_i)\beta + \kappa^*(p_L) - d)$. Reorganising this and using **(14)**, this inequality can be expressed as:

$$\kappa^*(p_L)(q(r - d) - k) > \kappa^*(p_i)k(q - 1)$$

Since the right-hand side is negative, **(17)** is a sufficient condition for the above inequality to hold. Hence, $V_k < V_f$.

The fiscal cost of this policy is given by:

$$G_k = \begin{cases} 0 & \forall\, x < p_i < p_H \\ \kappa^*(p_L) - (p_i r + (1 - p_i)\beta + \kappa^*(p_L) - d)\frac{\kappa^*(p_L)}{k + \kappa^*(p_L)} & \forall\, p_L < p_i < x \end{cases} \qquad \textbf{(A-3)}$$

We now show that $G_p < G_k < G_f$. First, to show that $G_k > G_p$, rewrite **(A-3)** as:

$$G_k = G_p + \left(\frac{k}{k + \kappa^*(p_L)}\right)(\kappa^*(p_L) + (p_i r + (1 - p_i)\beta - d))$$

So $G_k > G_p$ as long as $(\kappa^*(p_L) + (pr + (1-p)\beta - d)) > 0$. Since $(\kappa^*(p_L) + (pr + (1-p)\beta - d))$ has the lowest value when $p_i = p_L$, it is sufficient to show that

$$\kappa^*(p_L) + (p_L r + (1-p_L)\beta - d) > 0$$

Since the right-hand side can be expressed as $\frac{q}{1-q}(r-\beta)(1-p_L) > 0$, this inequality holds. Thus, $G_k > G_p$ for all $p_L \le p_i \le p_H$.

Next, show that $G_k < G_f$. Rewrite G_k and G_f as:

$$G_k = (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)} - (p_i r + (1-p_i)\beta - d) \quad \textbf{(A-4)}$$

$$G_f = q(r-d) - (p_i r + (1-p_i)qr - d) \quad \textbf{(A-5)}$$

We have already shown that the inequality **(A-2)** holds. Since $\beta > qr$ by assumption, the inequality $G_k < G_f$ must hold. This completes the proof that $G_p < G_k < G_f$ (QED).

Proof that sound banks do not have the incentive to liquidate good loans to obtain subsidy, T

Sound banks with $p_i > b$ could liquidate performing loans equal to z such that $1 - p_i + z > 1 - b$ in order to obtain a subsidy. If the regulator observes that a fraction $1 - p_i - z$ of a bank's loan has been liquidated, it grants a subsidy equal to:

$$T^*(p_i, z) = q(r-d) - \left[(p_i - z)r + (1 - p_i + z)\beta - d\right]$$

Sound banks have the incentive to pretend to be failing banks and liquidate a proportion of performing loans to obtain subsidy if and only if:

$$p_i r + (1 - p_i)\beta - d < (p_i - z)r + (1 - p_i + z)\beta - d + T^*(p_i, z) = q(r - d)$$

Since the above inequality never holds for sound banks with $p_i > b$, sound banks do not have the incentive to liquidate their good assets in order to obtain a subsidy (QED).

Proof that $G_k < G_{npl} < G_f$

Comparing **(22)** with **(A-4)**, and using **(A-2)**, it is clear that $G_k < G_{npl}$. Comparing **(22)** with **(A-5)**, and using the fact that $\beta > qr$, it is clear that $G_{npl} < G_f$. This completes the proof that $G_k < G_{npl} < G_f$ (QED).

Proof that the regulator cannot increase efficiency by offering a menu involving $\kappa < \kappa^*(p_L)$

Suppose that the regulator offers each bank a menu of options from which it must choose: either raise own capital, accept equity injection $\kappa^*(x)$, or accept a subsidy if the amount of NPLs liquidated exceeds $1 - x$, where x is given by **(16)** and $\kappa^*(x)$ is defined to satisfy the equality:

$$q(r + \kappa^*(x) - d)\frac{k}{k + \kappa^*(x)} = (xr + (1 - x)\beta + \kappa^*(x) - d)\frac{k}{k + \kappa^*(x)}$$

such that:

$$\kappa^*(x) = \frac{q(r - d) - (xr + (1 - x)\beta - d)}{1 - q}$$

Thus, $\kappa^*(x) < \kappa(p_L)$. We know from the previous analysis that if offered this menu, banks with $p > x$ will opt for raising own capital, and banks with $p_i < x$ will not liquidate their NPLs after receiving capital injection.

The pay-off of banks with $p_i < x$ after receiving capital injection $\kappa^*(x)$ is given by $q(r + \kappa^*(x) - d)\frac{k}{k+\kappa(x)}$, since this will not induce them to liquidate their NPLs. The subsidy for liquidating NPLs in the menu must be set to ensure that banks receive at least this pay-off by taking the subsidy option. Hence, the menu option involving $\kappa^*(x)$ leads to higher pay-off for failing and insolvent banks than the menu involving $\kappa(p_L)$ if:

$$(xr + (1-x)\beta + \kappa^*(x) - d)\frac{k}{k+\kappa^*(x)} > (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)}$$

for all $p_L \leq p_i < x$. Using $xr + (1-x)\beta = 1 = d + k$, the above inequality can be reorganised as:

$$(k + \kappa^*(x))\,(1 - p_i r - (1-p_i)\beta) > 0$$

The above inequality must always hold since $p_i < x$. Hence:

$$q(r + \kappa^*(x) - d)\frac{k}{k+\kappa^*(x)} > (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{k}{k+\kappa^*(p_L)}, \forall p_L < p_i < x$$

So the menu involving $\kappa^*(x)$ leads to higher pay-off for banks compared to the menu involving $\kappa^*(p_L)$. Hence, such a menu exacerbates the *ex-ante* bank moral hazard compared to the menu with $\kappa(p_L)$. Using the same logic, this result can be shown to hold for all menus involving $\kappa^*(z)$ where $p_L < z < x$ (QED).

Proof that the regulator will make profits by recapitalising banks with $p_i > x$

The regulator will make profits by recapitalising banks by injecting $\kappa^*(p_L)$ if G_k, given by **(A-3)**, is negative, ie:

$$G_k = \kappa^*(p_L) - (p_i r + (1-p_i)\beta + \kappa^*(p_L) - d)\frac{\kappa^*(p_L)}{k+\kappa^*(p_L)} < 0$$

Reorganising this inequality, it can be shown that the above inequality holds as long as:

$$p_i > \frac{1-\beta}{r-\beta} = x$$

Hence, the government will make profits by recapitalising banks with $p_i > x$ (QED).

Appendix B: Table

Table A: Public sector intervention in recent EME banking crises

	Thailand (1997)	**Indonesia (1997)**	**South Korea (1997)**	**Turkey (2001)**
Explicit blanket guarantee	Deposits, and contingent and foreign liabilities – still in place	Deposits and contingent and foreign liabilities – still in place no removal date announced	Initially on external liabilities then to domestic deposits for 3 years (rescinded on schedule)	For all depositors and creditors (replaced July 2004 by scheme limited to savings deposits)
Viability test	Approved plan for banks to get capital ratio above 8 1/2% (8% for non-bank finance companies). Loan loss provision standards tightened only gradually[1]	Approved plan to get capital ratio back initially above 4%, then 8% then 10%	Approved plan to get capital ratio back above 6% then 8%	For private sector banks with proven positive net worth the authorities offered to match capital injection by the private sector
Closure of insolvent banks[2]	56 finance companies but only 1 commercial bank (13%)	Yes, 64 commercial banks (18%)	Yes, 5 commercial, 17 merchant banks and over 100 non-bank FIs (15%)	Seven private bank (via SDIF); one state bank and three investment banks
Merger of weak banks[2]	Yes, 5 commercial banks and 12 finance companies merged into 3 banks (16%)	Yes, 4 government-owned banks merged into 1 (54%). 7 private banks taken over by Bank Danamon (5%)	Yes, 9 commercial and 2 merchant banks merged into 4 banks (15%)	12 banks merged by SDIF (7 of which still under their control); mergers amongst private banks limited
Public sector intervention[2]	6 commercial banks and 12 finance companies (12%)	12 commercial banks (20%)	4 commercial banks[3] (14%)	21 private banks taken over by SDIF[4]
of which: Purchase of NPLs	No	Yes, with government bonds	Yes, with government bonds	No
Recapitalisation through equity	Yes, with government bonds and debt to equity conversions	Yes, with government bonds and debt to equity conversions	Yes (including preference shares), with government bonds, cash and shares in public corporations[5]	Yes, through issuing government bonds to SDIF and two state banks
Recapitalisation through subordinated debt	Yes, with bonds conditional on corporate sector restructuring[6]	No	No	Yes, 1 state bank
Public sector costs of resolution (% of annual GDP)[7]	25	51	13	32[8]
of which Recapitalisation	8	23	6	
Buying NPLs or capital for asset management companies	0	12	5	
Liquidity support	15[9]	12	0	
Interest cost	2	3	2	
Elimination or dilution of shareholder stake	Yes	Yes	Yes[10]	Yes[11]

Source: Lindgren *et al* (2000) and Hoelscher and Quintyn (2003), IMF (2004) Turkey: Article IV and selected papers, July; World Bank (2003), Batunanggar (2004).
[1] But for banks to qualify for government funds, loan loss provisions had to be provided in full upfront.
[2] % of financial system assets in brackets.
[3] These consist of banks where government-ownership was more than 90% only. However, altogether the Government owned shares in 11 banks.
[4] 7 banks were merged, 6 sold, 7 liquidated and 1 still under SDIF control – as of April 2004.
[5] The Industrial Bank of Korea was given shares in public corporations.
[6] Up to a maximum of 2% of risk-weighted assets conditional on loan write-offs (in excess of provisions) and increase lending to the private sector.
[7] As of end-1998 Thailand, mid-1999 in Indonesia and Korea and end-2002 in Turkey.
[8] About half (15%) was used to recapitalise state banks and half (17%) to resolve the intervened banks.
[9] Mainly from the Financial Institution Development Fund.
[10] Shareholders in two banks taken over by the Government – Korea First and Seoul Bank – had equity reduced to 1/8 of its original value.
[11] Although there have been delays because supervisors have been worried about being prosecuted.

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